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Original Research Article

The correlation between body mass index and the type of foot arches with the risk of hallux valgus in children aged 13–14 years old

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ABSTRACT

Background: Hallux valgus is a deformity characterized by a change in the shape of the thumb with symptoms of swelling, redness and pain. Hallux valgus is progressive where there is a lump at the base of the thumb which can occur due to the weakness of the muscles and ligaments around the first metatarsophalangeal joint. The purpose of this study was to determine the relationship between body mass index and the type of foot arches on the risk of hallux valgus in children aged 13–14 years.
Methods: This research is a cross sectional analytic study with simple random sampling technique. The number of samples are 99 children (39 males, 60 females) aged 13–14 years. The variables measured were body mass index using body weight scales and a stature meter, the type of foot arches using a wet footprint test, and hallux valgus with a goniometer.
Results: Our study shows that there is no significant correlation between body mass index and hallux valgus at the level of 0.157. However, there is a significant correlation between the type of foot arches and hallux valgus at the 0.003 level. In addition, there is a significant correlation between body mass index and foot arches.
Conclusions: There was a significant relationship between body mass index and foot arches and foot arches with the risk of hallux valgus. However, body mass index is not directly related to hallux valgus condition.

Keywords: Body mass index, Foot arches, Hallux valgus

INTRODUCTION

Weight is an important factor affecting the health of the future child which is often overlooked during the child's development period.[1] Optimal body weight can be determined by measuring the body mass index (BMI). BMI measurement uses height and weight variables which are entered into the BMI calculation formula and will produce BMI values. BMI values are divided into 5 categories, namely, severe thin, thin, normal, overweight and obese.[2]

Overweight and obesity for a long-term can cause changes in leg posture. Because of the increasing body weight causes the distribution of the weight support to be unbalanced so that it can change the anatomical position of the body and cause a change in the shape of the foot arches.[3] According to the structure of the human type of foot arches, the shape of the arch on the sole of the foot is

divided into three, namely, pes cavus (high arch), pes rectus (normal arch), and pes planus (flat foot). Pes cavus is a condition on the sole of the foot where the lateral image is cut off. It is called the pes rectus when the indentation of the medial border crosses the lateral leg axis. Foot arch abnormalities that often occur in overweight and obese conditions are flat foot (pes planus).[4] Pes planus (flat foot) is a condition where the arch on the inside of the foot is flat, so that the entire foot will touch the floor or ground surface during weight–bearing activities.[5]

This flat foot condition is a physiological condition in infants and toddlers. Then the arch will develop when the child is 3-5 years old and 4% of them flat foot will remain after the child is 10 years old.[6] If beyond that age flat foot is still formed, this increases the risk factor for several other problems such as abnormal posture, decreased balance, decreased leg muscle strength, and hallux valgus condition.[7]

Hallux valgus is a deformity condition characterized by a change in the shape of the thumb or hallux in the first metatarsophalangeal joint with symptoms of swelling, redness and pain. Hallux valgus is a progressive musculoskeletal disorder in which there is a lump at the base of the thumb or hallux. These lumps can occur due to the weakening of the muscles and ligaments around the first metatarsophalangeal joint, causing deformity.[8]

In a study entitled body fat and muscle mass in Association with Foot Structure in Adolescents: A Cross-Sectional Study that aims to determine the relationship between body fat percentage and muscle mass percentage and leg structure in adolescents aged 11 to 13 years, shows that there is a significant relationship between the percentage of body fat and the percentage of muscle mass with the characteristics of the legs in adolescents.9 Then in a study conducted on adults entitled "is a flat foot associated with a hallux valgus deformity?" indicates that the worsening of the flat foot will exacerbate the hallux valgus condition.[10]

Based on this, the authors wanted to know about the relationship between body mass index and the type of foot arches on the risk of hallux valgus in children aged 13–14 years.

METHODS

The design of this study was an analytical observational cross-sectional study which analyzed the correlation between body mass index and the type of foot arches with the risk of hallux valgus in children aged 13–14 years old. Cross-sectional study is a type of research where the measurements of the variables are carried out only once, at one time.[11]

This research was conducted on junior high school children at Sekolah Menengah Pertama Negeri 10 (SMP N 10) Denpasar, Bali and it was conducted on 15th February until 22nd February 2019. Simple random sampling was used for sampling technique in this study. Inclusion criteria were children aged 13-14 years, in a healthy physical condition (based on recognition), willing and getting permission to be a sample until the research is completed (proven by filling in informed consent). Exclusion criteria were had an accident that affected the shape of the foot and have an additional job or hobby that involves excessive lifting. The total number of respondents were 99. The results were analyzed using the spearman correlation test. Statistical analyses were performed using SPSS version 16.0. All of the p values that less than 0.05 were considered to indicate statistical significance.

Body mass index

BMI measurement based on body weight and height with the formula weight (kg)/height (m2). BMI calculations for children aged 5-19 years will be interpreted using the BMI table for children issued by WHO in 2007. The classification of BMI interpretation is severe thinness, thin, normal, overweight and obese.2

Foot arches

The measurement of the height and low of the foot arches was carried out using the wet footprint test with respect to the medial border of the foot. Footprints can be seen using plain ink or water by wetting the feet, then placing them on a sheet of paper, so that the footprints will be left on the paper. The foot axis is obtained by drawing a line from the middle of the heel of the foot down to the middle of the second finger across the most convex part of the heel. The classification of the results of these measurements is pes cavus (high arches), pes rectus (normal), pes planus (flat foot).[12]

Hallux valgus

The measurement was performed with barefoot in a normal standing position. The center of rotation is placed in the metatarsophalangeal joint on the medial pedis, one goniometer arm is placed medial to the first metatarsal and the other arm is placed in the proximal hallux phalanx according to the guidelines of the American Academy of Orthopedic Surgeons. Measurements were made three times and the hallux valgus degree results were obtained from the average of these three measurements. The angle between the proximal phalanx and the first metatarsal is known as the hallux valgus angle. The normal hallux angle is below 15°.[13] The hallux valgus angle is a useful parameter for the hallux valgus classification, as follows:

1) mild deformity is hallux valgus with a hallux angle that not exceeding 20° which is about 15°-19°. 2) moderate deformity is hallux valgus with a hallux angle

of about 20°-40° 3) severe deformity is a condition with a hallux angle that is above 40°.[14]

RESULTS

Table 1 shows that the number of respondents were 99, which is dominated by female (60.6%) children aged 14 years (60.6). The mean of body mass index (BMI) was 20.7±4.73 kg/m2 and 68.7% of the subjects were within normal BMI (18,5–22,9 kg/m^2). Majority of the children have normal arches (pes rectus) (62.6%) and there are only 7 children who have a high arches (pes cavus) (7.1%). Regarding at hallux valgus, most of the children have a normal hallux valgus (46.5%) and only 13.1% children with a moderate hallux valgus.

Table 1: Characteristic of the respondents.

Characteristics	Number of respondents	Percentage (%)
Age		
13 years old	39	39.4
14 years old	60	60.6
Gender		
Male	39	39.4
Female	60	60.6
Body Mass Index		
Severe Thinness	3	3
Thinness	2	2
Normal	68	68.7
Overweight	13	13.1
Obese	13	13.1
Arcus		
High arcus (pes cavus)	7	7.1
Normal Arcus (Pes Rectus)	62	62.6
Low Arcus (Pes Planus)	30	30.3
Hallux valgus		
Normal hallux valgus	46	46.5
Mild hallux valgus	40	40.4
Moderate hallux valgus	13	13.1

In table 2 describes the calculation of the correlation between BMI and foot arches in the children. Data analysis that covered 99 children shows that the calculation of the spearman coefficient was 0.258. The obtained result of the Spearman Coefficient shows that there is a positive correlation. The test of relation significance shows that probability Sig. (2-tailed) is 0.010. This implies that there is a significant positive relation between BMI and foot arches in the children.

Table 3 presents the calculation of the relation between BMI and hallux valgus. The results show that Spearman coefficient was 0.143 for 99 children. This means there is a relationship between the variables. The test of relation significance shows that probability Sig. (2-tailed) is 0.157. This means that there is no significance in the relationship between BMI and hallux valgus in the children.

Table 2: The correlation between BMI and foot arches.

			BMI	Foot Arches
Spearman's rho	BMI	Correlation Coefficient	1.000	0.258**
		Sig. (2-tailed)	-	0.010
		N	99	99
	Foot Arches	Correlation Coefficient	0.258**	1.000
		Sig. (2-tailed)	0.010	-
		N	99	99

Table 3: The correlation between BMI and Hallux Valgus.

			BMI	Hallux Valgus
Spearman's rho	BMI	Correlation Coefficient	1.000	0.143
		Sig. (2-tailed)	.	0.157
		N	99	99
	Hallux Valgus	Correlation Coefficient	0.143	1.000
		Sig. (2-tailed)	0.157	-
		N	99	99

Table 4: The correlation between the foot arches and Hallux Valgus.

			Foot Arches	Hallux Valgus
Spearman's rho	Foot Arches	Correlation Coefficient	1.000	0.297**
		Sig. (2-tailed)	-	0.003
		N	99	99
	Hallux Valgus	Correlation Coefficient	0.297**	1.000
		Sig. (2-tailed)	0.003	-
		N	99	99

Table 4 shows the calculation of the relation between the foot arches and hallux valgus in the children. The results show that the Spearman coefficient was 0.297 for 99 respondents. This means the positive correlation. The test

of relation significance shows that probability Sig. (2-tailed) is 0.003. This implies that there is a significant positive relation between the foot arches and hallux valgus in the children.

DISCUSSION

The results showed that the highest number of respondents was in the 14 years old group as many as 60 people (60.6%). Based on gender, in this study the number of the female was more than the male. The frequency of data on women was 60 people (60.6%) while the data for men were 39 people (39.4%). For the body mass index category of respondents, children who have body mass index in the severe thinness category are 3 people (3%), 2 people (2%) in thin category, 68 people (68.7%) in normal category, overweight category are 13 people (13.1%) and the obese category as many as 13 people (13.1%). The distribution of respondents based on the type of foot arches shows that the lowest number of pes cavus types are 7 people (7.1%), normal arches with the highest number of respondents are 62 people (62.6%) and the flat foot types are 30 people (30.3%). In this study also obtained the results of the hallux valgus incident, where from a total of 99 respondents there were 46 people (46.5%) with normal conditions, 40 people (40.4%) who had mild hallux valgus and 13 people (13.1%) who experienced moderate hallux valgus.

Based on the distribution data of hallux valgus degree, the results are normal, mild and moderate degrees. Of the total number of respondents who experienced hallux valgus as many as 44 people, 29 people (25.2%) had hallux valgus with mild degrees, more than 15 people (13%), while hallux valgus with severe degrees was not found in respondents. This shows that the incidence of hallux valgus begins at an early age with a low degree so that it will progressively develop as you get older.15 Increasing age affects muscle strength where there will be a huge decrease in the abductor hallucis muscle which plays an important role in maintaining the alignment of the first metatarsophalangeal joint.[16]

Based on table 2, after the Spearman's Rho test was carried out, it was found that there was a significant relationship between body mass index and the type of foot arches with the Sig. (2-tailed) 0.010. This is similar to many previous studies which confirmed a positive correlation between arch of the foot and BMI.[17-19] Excess weight affects the structure of the feet's children and indicates that the feet of overweight and obese children have a different growth pattern than children of normal weight.[20]

The frequency of flat foot increases with a higher BMI because overweight and obese children have decreased dorsiflexion range, more prone heels and a flatter plantar arch.[4] Additional body mass indicates a decrease in the arch index of the foot and a higher overall load impacting mainly the middle leg area disproportionately.[21]

Based on table 3, after the Spearman's Rho test was carried out, there was no significant relationship between Body Mass Index and Hallux Valgus conditions with the Sig. (2-tailed) 0.157. This suggests that weight gain is not directly related to hallux valgus condition.

Overweight or obese children have a more than 70% chance of becoming obese adults.[22] Therefore, there is a high risk for children to develop musculoskeletal system disorders in adulthood including degenerative diseases of the musculoskeletal system, osteoarthritis, foot and heel pain, and low back pain syndrome.[23,24]

However, there is no research that states that there is a significant relationship between high body mass index and the incidence of Hallux Valgus. Research on the relationship between lower limb deformity and body mass by Brzeziński, et al, stated that the most common deformities were valgus heel, valgus knee, varus knee, and flat foot.[25]

Based on Table 4, after the Spearman's Rho test was carried out, it was found that there was a significant relationship between the type of foot arches and the hallux valgus condition with the Sig. (2-tailed) 0.003. The results of this study are similar to research conducted by Cheney et al in 2017, that there is a correlation between the severity of flat foot and the severity of bunion deformity which is determined by the position of the sesamoid, the hallux valgus angle and the intermetatarsal angle. As flatfoot gets worse, so do bunions.[10] Kalen and Brecher noted that the incidence of pes planus was 8-24 times greater in adolescents with hallux valgus.[26] Kilmartin and Wallace noted that the incidence of pes planus was as common in the normal population as it was in people with hallux valgus.[27]

The foot arches can be one of the etiologies of the risk of hallux valgus. More clearly, the initial collapse of the longitudinal medial arch causes a low arch of the pedis, which displaces the calcaneus and talus and pronates the pedis. In addition, there is a valgus position of the heel and forefoot, which causes midfoot pronation known as hyper-pronation. In the hyper-pronation condition, there is a change in the load transmission towards the midfoot resulting in weakness in the midfoot. The thumb or hallux compensates more so it can move steadily. Compensation for forefoot abduction continuously with changes in body weight transmission can lead to hallux valgus.[28]

Limitations

The limitation of our study is this study was limited to the age range of 13-14 years, so it could not be generalized to adults who experienced foot arches changes.

CONCLUSION

This study shows that there was a significant relationship between body mass index and the type of foot arches, and

the type of foot arches with the risk of hallux valgus. However, body mass index is not directly related to hallux valgus condition.

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