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Original Article

Flat foot at 5 to 6-year-old and history of delayed walking

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Abstract

Background Flat foot, also known as pes planus, is a common problem in daily pediatric practice. For most children, this physiologic condition gradually disappears with age. However, flat foot that persists after the age of four might have developmental coordination disorder in the future and it may relate to the history of delayed walking .

Objective To determine the prevalence of delayed walking in children with pes planus compared to children with normal foot curvature and to assess for a possible association between flat foot and history of delayed walking.

Methods This cross-sectional study was done in 120 children aged 5-6 years. Foot curvature was evaluated by wet footprint test. Inclusion criteria included children in 3 playgroups in Tangerang, Southern Jakarta, in children aged 5-6 years. Children with history of neurologic diseases, genetic disorders, chronic diseases, disorders of the lower extremities except pes planus, and obesity were excluded. Grading of pes planus refers to Olivier *et al.* criteria and evaluation of delayed walking at 18-month-old was done through history taking from their parents.

Results Of 120 children, 41 (34.2%) had pes planus while 11 (9.2%) had a history of delayed walking. Of those 11 children, 9 had pes planus. Most children with pes planus had grade I (78%). There was a significant association between pes planus and delayed walking (OR=10.8; 95%CI 2.2 to 52.9; P=0.001).

Conclusion In 5-6-year-old children, there is a significant association between pes planus grade 2 & 3 and history of delayed walking early in life. Wet footprint test screening for children with a history or signs of delayed walking may be used to identify pes planus in order to implement treatment in a timely manner.[**Paediatr Indones. 2020;60:321-7; DOI: 10.14238/pi60.6.2020.321-7**].

Keywords: *pes planus; delay in walking; wet footprint test*

Flat foot, also known as pes planus or plano valgus in children, is defined as the appearance of a lowered medial longitudinal arch, with or without rearfoot eversion.[1] The medial longitudinal arch has two functions, supporting body weight and proper stance in walking or running.[2] Flat foot is associated with reduced walking speed, higher plantar pressure distribution, difficulty in performing activities of daily living, increased risk of falls, significantly increased levels of back and lower limb pain, other deformities in future life such as scoliosis and posture problems, as well as reduced quality of life.[1,3] A study in Vienna found that 44% of children aged 3 to 6 years had flexible pes planus, while less than 1% of them suffered from pathological pes planus with boys (50.8%) predominated over girls

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(49.2) in the study. Flexible flat foot was defined as a valgus position <20° and active correction is possible, whereas pathological flat foot is defined by a valgus position >20°.[4] A Taiwanese study found that 28% of 1,024 children aged 5-13 years suffered from pes planus, with a reduced incidence as age increased.[5] In Indonesia, few studies have been done to assess the prevalence of flat foot. A previous study reported that 18% of children aged 9 to 12 years had flat foot, in a primary school study of 33 subjects.[6]

Flat foot is normal for most children up to eight years of age, due to osseous and ligamentous laxity, immature neuromuscular control, and increased adipose tissue.[7-9] However, there are some children with flat foot that need more clinical attention to ensure their future motoric development. The formation of the arch is associated with complete development of foot bones, ligaments, and muscles, and it plays a role in static and dynamic stability.[10] The lack of a stable foot structure to support and maintain posture may lead to delayed motor development.[11] In addition, ligamentous laxity was reported to be a risk factor for pes planus, which in turn, causes ankle instability and hence, delayed walking.[12]

Delayed motor development is defined as a delay in gross motor or fine motor skills.[13] A study reported that 13.9% of children with developmental delay had delayed motor development.[13] Another study found that 2.3% of children suffer from global developmental delay, with a chief complaint of delayed walking.[14] Motor development is also influenced by environmental factors, family socioeconomic status, schooling, interaction between family members and the child's social-cultural context, and the availability of intervention movement programs.[15] As such, it is imperative to differentiate whether the delayed walking is due to pes planus or delayed motor development, as the treatments differ.

To our knowledge, there have been no studies on pes planus and delayed walking in Indonesia. We aimed to determine the prevalence of pes planus in children with history of delayed walking compared to children with normal foot curvature and if the grade of the flat foot was associated with delayed walking. Children with pes planus require multidisciplinary care between pediatricians, physiotherapists, and orthopedists. It is important for clinicians to know when a referral to an orthopedic specialist is indicated and which treatments may be offered to the patients as treatment of pes planus will improve future motoric development, such as developmental coordination disorder (DCD).[16] Moreover, in children with DCD that is characterized by a neurodevelopmental disorder with impaired motor coordination and awkward gait, pes planus and joint mobility are frequent self-reported findings. This disorder needs to be identified in children with pes planus as treatment and rehabilitation for children with pes planus with neurological deficits will be different compared with children who have pes planus without neurological deficits.[17]

Methods

This was a cross-sectional study done in 3 playgroups [*Pendidikan Anak Usia Dini*/PAUD schools) in Tangerang, Southern Jakarta, from January to August 2018, in children aged 5-6 years. Children with history of neurologic diseases, genetic disorders, chronic diseases, disorders of the lower extremities except pes planus, and obesity were excluded.

Delayed walking was defined as not walking until after the age of 18 months. After obtaining written informed consent from subjects' parents prior to data collection, the parents will be asked to recall on history of delayed walking using pre-screening development questionnaire developed by *Indonesian Ministry of Health*.[18] If the child started walking before the age of 18 months and could walk without falling after the age of 18 months, the child was considered normal.[18]

Weight and height measurements were taken using standardized and calibrated weighing scale and measuring tape, respectively. Each measurement was repeated twice by the examiner (TS) and an average between two measurements was taken as the final weight and height measurement. Weight against height was then plotted into *World Health Organization* curve for 5-year-old children and *Centres for Disease Control and Prevention* (CDC) weight against height curve for children who are above 5-year-old. Normal nutritional status was defined as *z*-score between -2 standard deviation (SD) up to 2 standard deviation. Underweight was defined as *z*-score between -3 SD up to -2 SD while overweight was defined as *z*-score above 2 SD.[18,19]

Foot curvature was assessed by the foot print method.[20] As shown in **Figure 1**, subjects dipped a foot into a tub of colored ink, then stamped their foot on a sheet of paper. Footprints were assessed by a physiotherapist using Olivier *et al*.[21] criteria. Normal foot curvature was defined as the appearance of at least half of medial longitudinal arch in the footprint. Pes planus was defined as decreased medial longitudinal arch which causes the medial border of the feet to completely touch the ground[4] while positive wet footprint test was defined as loss of concavity of the medial border of the plantar surface.[21] Flat foot grading used Olivier G's classification: grade I if medial border of the plantar surface was concave and was located at the medial side of the foot axis; grade II if medial border of the plantar surface was rectilinear and did not cross the median of the foot axis; and grade III if medial border of the plantar surface was convex and crosses the axis (**Figure 2**).[21]

The primary outcome variable was whether there was a possible association between pathological flat foot in 5-6 years age and the history of delayed walking when those kids were 18-month-old. Descriptive statistics were used for demographic and clinical variables. Analysis of flat foot grade and delayed walking was done with Chi-square test (or Fisher's exact test when the prerequisite for Chi-square was not met). Statistical analyses were performed using the *Statistical Package for the Social Sciences (SPSS) version 23* (*IBM Corp.*, Armonk, NY, USA). The study protocol was approved by the Ethics Committee at the University of Pelita Harapan, Tangerang, Indonesia.

Results

A total of 120 children aged 5-6 years were involved in this study. Subjects' demographic data are shown in **Table 1**. Subjects had a mean age of 5.5 (SD 0.5) years and compared between the age group, there was no significant association to delay in walking (P=0.373) (**Table 2**). There were more girls (57.5%) in our study than boys (42.5%) and compared between the sexes, there is no significant association between sex and delay in walking (P=0.052) (**Table 2**). Subjects' nutritional status categories were normoweight (115;95.8%), underweight (3; 2.5%), and overweight (2; 1.7%) (P<0.001). Of 120 subjects, 41 (34.2%) were flat footed. Pes planus was more prevalent in boys (30; 73.2%) than girls (11; 26.8%) (**Table 2**). Of the 41 flat footed children, 9 children (7.5%) had delayed walking previously in life. Using Olivier's pes planus grading classification,[21] 32 children (78%) had grade I, 7 children (17.1%) had grade II, and 2 children (4.9%) had grade III.

Figure 1. Wet footprint test (A) Child standing in front of ink tub and paper; (B) Example of a normal wet foot print; (C) Example of pes planus grade 3

Figure 2. Flat foot classification according to Olivier *et al.*[21] (A) Normal; (B) Grade 1; (C) Grade 2; (D) Grade 3

Table 1. Subjects' characteristics

Characteristics	(N=120)
Gender, n (%)	
Male	51 (42.5)
Female	69 (57.5)
Age, n (%)	
5 years	61 (50.8)
6 years	59 (49.2)
Current nutritional status, n (%)	
Normal	115 (95.8)
Underweight	3 (2.5)
Overweight	2 (1.7)
Delayed walking at 18-month-old, n (%)	
Yes	11 (9.2)
No	109 (90.8)
Pes planus, n (%)	
Yes	41 (34.2)
No	79 (65.8)

Table 2 shows the analysis of the wet footprint test results and the variables. It was found that different age group (5 year old *vs.* 6 year old) has no significant association with positive wet footprint test (P=0.109). Significantly more boys had pes planus than girls (P<0.001). Also, there were significantly more underweight and overweight subjects in the pes planus group than in the normal feet group (P=0.0342 and P =0.104 respectively). Separately, only current nutritional status, both underweight and overweight, had a significant association with delayed walking with P value 0.015 and 0.0053, respectively.

Bivariate analysis revealed a significant association between pes planus and delayed walking (OR 10.8; 95%CI 2.2 to 52.9; P=0.001). The pes

Table 2. Analysis of pes planus and delayed walking with age, gender, nutritional status

Variables	Wet footprint test				Walking development			
	Normal (n=79)	Pes planus (n=41)	Total (N=120)	P value	Normal (n=109)	Delayed (n=11)	Total (N=120)	P value
Age, n(%)								
5 years	36 (45.6)	25 (61.0)	61 (50.8)	0.109	54 (49.5)	7 (63.6)	61 (50.8)	0.373
6 years	43 (54.4)	16 (39.0)	59 (49.2)		55 (50.5)	4 (36.4)	59 (49.2)	
Gender, n(%)								
Male	21 (26.6)	30 (73.2)	51 (42.5)	0.001	43 (39.4)	8 (72.7)	51 (42.5)	0.052
Female	58 (73.4)	11 (26.8)	69 (57.5)		66 (60.6)	3 (27.3)	69 (57.5)	
Nutritional status, n(%)								
Normal	79 (100)	36 (87.8)	115 (95.8)	REF	108 (99.1)	7 (63.6)	115 (95.8)	REF
Underweight	0 (0)	3 (7.3)	3 (2.5)	0.0342	1 (0.9)	2 (18.2)	3 (2.5)	0.015
Overweight	0 (0)	2 (4.9)	2 (1.7)	0.1036	0 (0)	2 (18.2)	2 (1.7)	0.0053

planus grade composition of subjects with delayed walking was significantly different from those with no history of delayed walking as children with grade 2 pes planus was 51.3 times more likely (95%CI 6.6 to 399.6; P=0.0002) to develop delayed walking compared with their normal counterparts (**Table 3**).

From our 41 subjects with pes planus, the majority had grade I (32; 78%). Only six children (14.6%) had grade II pes planus, and 3 children (7.4%) had grade III. Similarly, an Indonesian study of 196 subjects with pes planus reported that the majority had grade I (88.3%).[19]

Table 3. Analysis of wet footprint test results and pes planus grade with delayed walking

Variables	Walking development		Total	P value	OR (95%CI)
	Normal (n=109)	Delayed (n=11)			
Wet footprint test, n (%)					
Normal	77 (70.6)	2 (18.2)	79 (65.8)	0.001	10.8 (2.2 to 52.9)
Pes planus	32 (29.4)	9 (81.8)	41 (34.2)		
Pes planus grade, n (%)					
Normal	77 (70.6)	2 (18.2)	79 (65.8)	REF	REF
Grade I	29 (26.6)	3 (27.3)	32 (26.7)	0.143	3.98 (0.6 to 25.1)
Grade II	3 (2.8)	4 (36.4)	7 (5.83)	0.0002	51.33 (6.6 to 399.6)
Grade III	0 (0)	2 (18.2)	2 (1.7)	0.0019	N/A

Discussion

In our study, we found a 34.2% prevalence of pes planus in children aged 5-6 years. This finding was slightly lower than a study that found a 44% prevalence (365/835 children) of flexible flat foot and less than 1% (7/835 children) prevalence for pathological flat foot in children aged 3-6 years in Vienna, Austria.[4] Of 41 children with pes planus, 30 (73.2%) were male and 11 (26.8%) were female. A previous study also noted that pes planus prevalence was more common in boys (52%) than girls (36%). Boys may be more susceptible to pes planus compared to girls because the angle of boys' legs is greater than the angle in girls.[4] Furthermore, the growth of valgus legs in boys is usually slower by one year compared to girls.[4]

A study in India found that pes planus tended to decrease with age. Of 297 children, 40.32% of children with pes planus were less than 5 years of age, followed by 22.15% of children aged 5-10 years, and 15.48% of children over 10 years.[22] Additionally, a previous study found that the probability of pes planus percentage decreased by 36.8% annually.[4] We noted that of the children with pes planus, 25 (61%) were in the 5-year-old group and 16 (39%) were in the 6-year-old group. This results suggest that as a child gets older, the prevalence of pes planus tends to decrease although the result is not significant (P=0.109).

Nutritional status also plays an important role in pes planus and the development of walking in children. Children with nutritional problems such as those who are below or above normal, as in severely underweight, underweight, overweight and obese, are more likely to experience pes planus. Overweight and obesity may increase the pressure applied to the longitudinal arch during walking. In such children, the midfoot area is most affected by contact of the sole and the ground surface, which receives more pressure during weightbearing. This results in the lower height of the longitudinal arch in obese children.[23] A previous study showed that underweight and severely underweight children experienced twice the risk of having pes planus, while overweight children had 27% greater risk and lastly, obese children had as much as three times the risk compared to children with normal nutritional status.[4] In contrast, a study found that the prevalence of flat feet was lower in underweight children. The mechanism for flat feet in this German population was thought to be from their slender, and long feet that might predispose underweight children to flat feet while robust and flat feet predispose overweight children to flat feet.[2]4

In our study, 11 children (9.2%) had a history of delayed walking. Pes planus and history of delayed walking had a significant association (OR 10.8; 95%CI 2.2 to 52.9; P=0.001). A study in Taiwan found that prevalence of flat foot in children with developmental

motor delays were 1.5 times that of children with normal developmental (OR=1.511; 95%CI 1.14 to 2.01; P=0.005).[10] This result supports our hypothesis that there is an association between flat feet with delayed walking with consideration that delayed walking is seen as a representative for developmental motor delays.

There were several limitations in this study. First, it was conducted in children aged 5-6 years, an age when physiologic pes planus can still be found. It would have been preferable to use children older than 8 years, but they are mostly in primary school, without their mothers waiting for them at the school. This might create a challenge in data collection, as the larger age gap between 18 months and 8 years might make it more difficult for mothers to recall their child's age at walking, as well as their assistance with the conducting the wet footprint test. Second, we used only the wet footprint test to assess foot curvature. Radiological examination and arch height index (AHI) would have been more accurate. However, in the end we opted for these two data collection methods because of practicality. Lastly, we did not evaluate other aspects of development such as cognitive, language, fine motor, and other gross motor skills.

In conclusion, pes planus at age 5-6 years is significantly associated with delayed walking at age 18 months. In addition, the grade of pes planus in subjects with history of delayed walking is significantly different from those without such history. Although in most cases pes planus improves with age, delayed walking due to pes planus that persisted over the age of four may need more specific treatments to prevent further motor delay or disorder in the future. Healthcare providers should note that if a child found to have flat foot at the age of 5-6 years, a history taking around motoric development, including walking should be taken and further evaluations might need to be done.

Conflict of Interest

None declared.

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