

# Foot health and physical fitness: investigating the interplay among flat feet, body balance, and performance in junior high school students

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## Abstract

**Background and Study Aim** Foot health and physical fitness in children are closely interconnected, playing a vital role in ensuring their overall well-being and performance. This study aims to determine the relationship between flat feet, body balance, and physical performance of junior high school students.

**Material and Methods** A total of 109 junior high school students from five schools in Surabaya, Indonesia, with ages ranging from 12 to 14 years, participated in this research. Data collection was through the wet footprint test, stork standing balance test, Bass test, Y-agility Test, and Illinois Change of Direction Test. The correlation of flat feet with static and dynamic balance and physical performance in the school environment was analyzed using the non-parametric Spearman Rank statistical test.

**Results** The results showed significant relationships between foot grade and static balance, dynamic balance, agility, and change of direction. These relationships were indicated by correlation coefficients that showed statistical significance at  $p < 0.05$ . Additionally, static and dynamic balance exhibited a negative correlation, while agility and change of direction showed a positive correlation. This suggests that higher foot grades corresponded to longer durations in static and dynamic balance tests and shorter completion times in agility and change of direction tasks.

**Conclusions** The findings of this study highlight the importance of investigating the relationship between flat feet, body balance, and physical performance among junior high school students. Understanding these correlations is crucial for optimizing the overall well-being and performance of adolescents.

**Keywords:** flat feet, static balance, dynamic balance, physical performance.

## Introduction

Flat feet, also called pes planus, are characterized by a decreased arch on the medial side of the foot so that most of the sole touches the ground when standing. The transverse and longitudinal arches maintain the appropriate shape of the legs; the transverse and longitudinal arches are flexible and have different shapes; the transverse and longitudinal arches protect other body systems by offering shock absorption and supporting the entire body while maintaining balance [1]. The performance efficiency of the foot depends on its anatomy and exceptionally well-formed transverse and longitudinal arches [2]. The main factor that causes flat feet is structural abnormalities in the bones, which can cause muscles, tendons, and ligaments to work beyond their capacity, causing an

increased risk of injury and decreased tolerance for physical activity and performance [3, 4].

Flat feet can occur in children and adults [5]. However, flat feet are higher in children [3, 6, 7, 8, 9], with an estimated 20-30% of children worldwide experiencing it [10]. A previous study investigated the incidence rate of flat feet and associated personal factors among public elementary school students [9]. Study findings revealed a significant correlation between a higher prevalence of flat feet and increasing age, with the 6-year-old group showing the highest prevalence. Boys are twice as likely to be diagnosed with flat feet as girls. In addition, children who are obese have a three-and-a-half times greater risk of experiencing flat feet than children of average weight. A previous study reported the prevalence of pes planus in children aged 7 to 14 years [11]. Their research showed that around 29.5% of the children sampled showed flatfoot deformity. This prevalence is still much higher compared to the prevalence in developed countries. In addition, a significant

association was found between children's age and the likelihood of developing pes planus. Previous studies investigated the correlation between the Foot Posture Index (FPI) version 6, comprising six items, clinical measurements, foot anthropometry, and other radiological data regarding foot position in children aged 5 to 8 [6]. The results showed a positive correlation between FPI-6 and the Navicular Drop (ND) test and Center of Pressure (COP) Sway Index (CSI) in children aged 5 to 8 years. Three prominent foot posture indicators (FPI-6, ND, and CSI) can be used effectively as primary tools or preferences in clinical practice. Research on the treatment of flat feet has been carried out by researchers from various countries, such as China [12], Spain [13], the United States [14], Japan [15], Italy [16], Greece [13] and Germany [17]. These studies emphasize the importance of early screening to detect flat feet and treatment for sufferers to maintain their physical condition and overall health.

The impact of flat feet can be felt on body balance. Body balance is divided into two types: statistical and dynamic balance. Statistical balance relates to maintaining a still posture with limited movement. In contrast, dynamic stability is the ability to perform movements while maintaining or restoring stability [18]. The condition of the feet is an essential element that can influence maintaining body balance [19].

The condition of the feet plays a vital role in maintaining an individual's performance and physical activity, especially concerning agility and change of direction, which significantly influence balance and coordination. Factors such as posture, balance, and support are reliant on the health of the feet. Abnormal foot conditions, such as flat feet, also impact physical performance and balance [20].

However, this aspect still needs more attention, especially in sports education. This is evidenced by the need for more research discussing flat feet in the context of students' physical education performance. Research that discusses the relationship between flat feet and balance and students' physical performance is limited, so the results of this research have an essential role in overcoming and preventing bad possibilities in the future.

This study aims to determine the relationship between flat feet, body balance, and physical performance of junior high school students.

## Materials and Methods

### *Participants*

Participants for this research were selected using random sampling and consisted of 109 junior high school students from five schools in Surabaya, Indonesia. Their age range is between 12-14 years. To ensure a natural situation, researchers collaborated with physical education teachers. In

addition, researchers obtained permission from the respective school principals by obtaining research permission and research ethics guidelines.

### *Research Design*

This research uses a quantitative correlation approach to determine the relationship between flat feet, body balance, agility, and student's ability to change direction in physical education. A correlational design is used to test the relationship between variables. Using this design, the study aims to determine whether there is a correlation between flat feet, body balance, and physical performance.

*Instrument Test.* In order to collect data, the researcher employed three instruments: the wet footprint test, the stork standing balance test, the bass test, the Y-agility Test, and the Illinois Change of Direction Test. Wet footprint test. Foot arch assessment is carried out using the footprint method. As seen in Figure 1, participants soaked their feet in colored ink and then pressed them against a sheet of paper. A normal foot arch occurs when at least half of the medial longitudinal arch is visible in the footprint. Pes planus, conversely, is defined as a decrease in the medial longitudinal arch that causes the medial edge of the foot to touch the ground completely. A wet imprint test that gives a positive result shows the disappearance of the depression on the medial edge of the plantar surface. To classify the severity of flat feet, a grade system is used, where grade I indicates that the medial edge of the plantar surface is still concave and is to the medial side of the foot axis; grade II occurs when the medial edge of the plantar surface becomes straight and does not cross the median axis of the foot; and grade III occurs when the medial edge of the plantar surface becomes convex and crosses the axis of the foot [21].

The stork standing balance test measured the students' static balance while standing on one foot with closed eyes [20, 22, 23]. The test was conducted three times, and the best score was recorded. The objective of this test was to maintain this position for the maximum possible duration. The modified bass test was used to measure the students' dynamic balance during and after movement with a validity of 0.83 and a reliability of 0.93 [20]. This research conducted the test three times, and the best result from the three trials was recorded. The test evaluated the students' balance performance while moving and after movement. The test was considered valid and reliable in measuring student's dynamic balance. The Y-agility Test is utilized to assess agility and is conducted reactively, as described by [24]. The best time out of eight attempts is selected for further analysis. The Illinois Change of Direction Test involves setting up a rectangular area measuring 9.3 by 7.2 meters,

as described by [25]. The best time out of three attempts is recorded as the ILL score, representing the time to complete the Illinois test.

*Statistical Analysis*

Data are presented using mean and standard deviation. Data analysis was done using non-parametric statistical tests to analyze the relationship between flat feet and students' balance and physical performance. The Spearman Rank test is used to see the significance level of the relationship between variables, the strength of the relationship, and the direction of the relationship. Variables are declared correlated if the sig value is <0.05. At the same time, the strength of the relationship uses the criteria of 0.00-0.25, very weak correlation, 0.26-0.50 moderate correlation, 0.51-0.75 strong correlation, 0.76-0.99 very strong correlation, and 1 is perfect correlation. The direction of the relationship is expressed with a positive or negative value; if the value is positive, the relationship between the two variables is in the same direction, whereas if the value is negative, the relationship is not in the same direction. The data will be analyzed and processed quantitatively using SPSS software version 24.0. Data analysis uses Spearman Rank. The results of the analysis will be presented in the form of tables and graphs for easier understanding.

**Results**

The average and standard deviation of several anthropometric parameters measured in three categories of flat feet: Normal, Grade 1, and Grade 2.

Age, weight, height, and Body Mass Index (BMI) are parameters shown in Table 1.

The difference between static and dynamic balance, agility, and change of direction is shown in Figure 2. The result shows an average static balance of 13.35±2.66, dynamic balance of 72.97±24.96, agility of 3.24±.72, and change of direction of 23.64±.90.

The average, standard deviation, minimum value, maximum value, and number of samples (N) for the four parameters measured in three levels of flat feet severity: Normal, Grade 1, and Grade 2, as well as the overall total shown in Table 2. These parameters are static balance, dynamic balance, change of direction, and speed. The data shows that the higher the severity of flat feet, the lower the average results for each parameter measured, except speed, which shows an increasing trend.

It is interpreted that Grade Feet has a significant relationship to static balance, Dynamic Balance, Agility, and Change of direction, which has a value of .000<0.05, as shown in Table 3. The strength of the relationship between grade feet and static balance is in the strong correlation category, Dynamic balance is in the strong correlation category, agility is in the strong category, and change of direction is in the strong category. The relationship's direction for static and dynamic balance is negative. In contrast, agility and change of direction are positive, which means that the better the foot grade, the longer the static balance and dynamic balance test results will be. In contrast, the resulting time will be shorter for agility and change of direction.

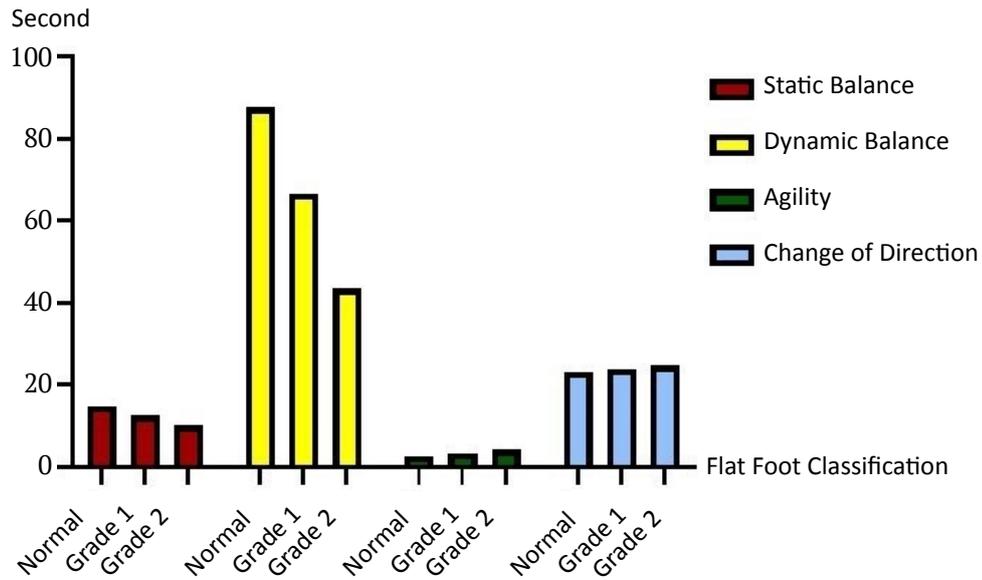


**Figure 1.** Flat Foot Classification. (A = Normal; B= Grade 1; C=Grade 2; D=Grade 3)

**Table 1.** Characteristic of Group.

Grade Feet	Age (years)	Weight (kg)	Height (cm)	BMI (kg/m <sup>2</sup> )
Normal	13.06±0.69	50.72±7.09	154.70±4.99	21.23±3.15
Grade 1	13.05±0.66	55.00±5.63	155.29±3.86	22.86±2.65
Grade 2	13.06±0.87	49.56±7.11	155.78±3.12	20.48±3.24

Data are presented as mean±SD



**Figure 2.** Result of Balance and Physical Performance Test.

**Table 2.** Description of body balance and physical performance data based on foot category

Grade Feet		Static Balance (s)	Dynamic Balance (s)	Agility (s)	Change of Direction (s)
Normal	Mean±SD	14.96±1.46	87.58±14.47	2.78±.40	23.09±.41
	Minimum	12.37	62.30	2.35	22.69
	Maximum	15.95	95.95	3.73	24.03
	N	53	53	53	53
Grade 1	Mean±SD	12.64±2.60	66.59±24.85	3.44±.67	23.87±.88
	Minimum	8.34	28.44	2.35	22.65
	Maximum	15.99	95.99	4.67	25.57
	N	38	38	38	38
Grade 2	Mean±SD	10.09±1.82	43.44±17.14	4.18±.41	24.80±.72
	Minimum	8.20	28.40	3.67	23.87
	Maximum	12.19	62.19	4.83	25.63
	N	18	18	18	18
Total	Mean±SD	13.35±2.66	72.97±24.96	3.24±.72	23.64±.90
	Minimum	8.20	28.40	2.35	22.65
	Maximum	15.99	95.99	4.83	25.63
	N	109	109	109	109

Data are presented as mean±SD.

**Table 3.** Spearman Rank Test Results

		Grade Feet	Static Balance	Dynamic Balance	Agility	Change of Direction	
Spearman's rho	Grade Feet	Correlation Coefficient	1.000	-.755	-.738	.722	.716
		Sig. (2-tailed)		.000	.000	.000	.000
		N	109	109	109	109	109

Data are presented as mean±SD; Significant, p<0.05.

## Discussion

This study investigated the correlation between flat feet on static and dynamic balance and students' physical performance in the school environment. One hundred nine students from 5 elementary schools in East Java, aged 12 to 14, participated in this research. Data was collected using measuring instruments: the wet footprint test, the stork standing balance test, the Bass test, the Y agility test, and the Illinois Change of Direction test. Spearman Rank analysis is used to analyze the correlation of flat feet with static and dynamic balance and students' physical performance in the school environment.

The results showed that flat feet were significantly correlated with students' body balance. These findings support previous research conducted by [26, 27], who revealed that flat feet significantly affect body balance. This is in balance with [19], who found that the condition of the feet significantly influences overall body balance. Imbalances in the feet can cause muscles, tendons, and ligaments to overwork, increasing the chance of injury and fatigue. How a person stands and moves can also be affected, causing stability and coordination problems. This finding aligns with research by [3, 4], who reported that foot disorders can increase the likelihood of injury and decrease physical activity and performance endurance. The results of this study also explain that the presence of flat feet has a negative effect on students' physical performance in school activities. This may be due to the body's imbalanced influence on the musculoskeletal structure, leading to the overuse of muscles, tendons, and ligaments, thereby increasing the likelihood of injury and fatigue in individuals with flat feet. However, this finding differs from [22, 28] research findings that explained no relationship between flat feet and body balance.

Another finding in this research is the positive influence of flat feet on students' agility and ability to change direction. This is because to change direction quickly, a person must have balance, coordination, and speed. Body balance is essential for human movement and activities [19, 23, 29]. Maintaining body balance relies on rapid and continuous feedback from various sensory systems. The visual system provides information about the surrounding environment, the vestibular system

provides information about body position and movement in space, and the somatosensory system provides information about pressure, touch, and body movement [18]. However, body balance is not simply a statistical process; it is dynamic, allowing movement, changing positions, and adapting to different situations. Therefore, body balance is a complex process that requires integrating various physiological systems and continuous adaptation to the surrounding environment [29, 30, 31].

Additionally, [11] emphasized that disorders that affect the condition of the feet can interfere with a person's athletic performance and increase the risk of injury. Having abnormalities in the legs can cause a decrease in physical abilities, resulting in decreased endurance and stability when exercising, and can make a person more susceptible to injury. It is essential to monitor the condition of students' feet and take steps to address underlying problems to maintain physical health and avoid injury [12, 13, 14, 15].

Compared to our findings, it is noteworthy that some previous research [22, 28] reported no significant relationship between flat feet and body balance. These discrepancies may arise from differences in sample characteristics, measurement methods, or analytical approaches. Further investigation is warranted to reconcile these inconsistencies and gain a deeper understanding of the complex interplay between foot health, body balance, and physical performance in school-aged children.

## Conclusions

this study elucidates the significant correlation between flat feet and students' body balance, as well as its impact on physical performance in school activities. These findings underscore the importance of monitoring foot health among students and implementing interventions to address underlying issues. Future research could explore additional factors influencing the relationship between flat feet, body balance, and physical performance, as well as evaluate the effectiveness of interventions aimed at improving foot health in school-aged children.

## Conflict of interest

Authors do not receive endorsement from any organization for submitted work.

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