Relationship of Body Mass Index with Dynamic Balance in Flatfoot Children Aged 9-12 Years

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Keywords	Abstract
flatfoot, body mass index, dynamic balance	**Introduction**: Flatfoot is a condition in which the inner arch of the foot (arcus medialis) is not formed when the child stands. Signs and symptoms of flatfoot such as abnormal walking patterns that cause fatigue and balance disorders. Low balance ability in children makes children prone to falls and experiences obstacles during activities. **Purpose**: The purpose of This study aims to determine the relationship between body mass index and dynamic balance in flatfoot children aged 9-12 years at SDIT Ulul Albab Pekalongan City. Research **Method**: This research design is quantitative with a cross-sectional approach. The sample was obtained by total sampling with a total of 107 respondents. Data analysis used univariate and bivariate analysis with a dynamic balance measurement tool in the form of a bridge with a validity level of 0.738 and reliability of 0.629. The normality test used Kolmogorov-smirnov and the correlation test used Spearman Rank. **The results**: The results of the Spearman rank correlation test obtained a p value of 0.115 ($\rho>0.05$) and an R value of -0.153, so there is no significant relationship between body mass index and dynamic balance in flatfoot children aged 9-12 years at SDIT Ulul Albab, Pekalongan City. **Conclusion**: There is no significant relationship between body mass index and dynamic balance in flatfoot children aged 9-12 years at SDIT Ulul Albab, Pekalongan City.

INTRODUCTION

The development of children during elementary school is marked by many significant changes, both mentally and physically. This age range is between 7 to 12 years. Physical changes in elementary school children follow general growth principles, including types of changes, patterns of body growth, developmental characteristics, and individual variations among children. One characteristic physical change is proportional changes, such as increases in height and weight. During this period, children's physical growth occurs steadily and continues to change over time as they are still in a growth phase (Fikriyah et al., 2021). One observable aspect of growth is the formation of arches in the foot, known as the arcus. The formation of the arcus typically occurs between the ages of 2 to 6 years, with age 6 considered a critical period for arcus formation. Flatfoot deformity usually first appears after the age of 10, characterized by the absence of an arch in the foot or flat feet (Febri Yolanda Syafri, 2021).

Flatfoot, or pes planus, is a condition where the arch of the inner foot (arcus medialis) does not form when a child stands. This condition is marked by the collapse or loss of the medial longitudinal arch of the foot, often associated with valgus deformity in the hindfoot and an open position in the forefoot. It results from various factors such as obesity or genetics. Flatfoot typically does not cause symptoms and is considered normal in children aged 6 to 7 years (Putra et al., 2023). Flatfoot is a common case encountered in pediatric orthopedic clinics, with a prevalence ranging from 1% to 28% in certain age groups. Signs and symptoms of flatfoot include abnormal walking patterns, which can lead to quick fatigue and balance disturbances. Low balance ability in children makes them more susceptible to falls and difficulties during activities (Antara et al., 2017). For example, at an elementary school in Boyolali City, it was found that 23% of children aged 9 to 12 years experienced flatfoot (Manik et al., 2023). The prevalence of pathological flatfoot in children aged 7-14 years is approximately 10.3%, but this figure tends to decrease with age (Inayah, 2020).

Balance is a stable state in which the body can maintain an upright position or a desired position by keeping the center of mass over the base of support, despite the influence of gravity. This ability is influenced by various sensory, motor, and external processes on the nervous, musculoskeletal systems, and the surrounding environment (Nugroho & Nurulita, 2019). Biomechanical studies show that coordination between the bone structure, muscles, and connective tissues in the feet is crucial for bearing body weight and providing stability during locomotor activities such as walking and running, especially during initial foot contact with the ground (foot strike) and when the body pushes off (push-off). The wide and archless shape of flatfoot causes the body to use stiffer lever components when walking and running, which can lead to balance disturbances and quick fatigue. Children with normal feet can maintain balance and do not tire easily when walking or running because their body weight is distributed evenly across the foot (Antara et al., 2017).

Body Mass Index (BMI) is an anthropometric parameter used to classify an individual's weight status, which has important implications for assessing nutritional status and health risks. BMI is calculated by dividing body mass (in kilograms) by the square of height (in meters). If a person's BMI is over 25 kg/m², they are classified as overweight or obese. BMI conditions outside the normal range can indicate health problems. According to data from the Indonesian Ministry of Health in 2018, 18.8% of children aged 5-12 years in Indonesia were overweight, while 10.8% were obese. Excess weight can often lead to health issues, particularly musculoskeletal disorders, especially in the feet (Adiputra & Wahyuni, 2022). Individuals with BMI within the normal range tend to have better postural balance compared to those with BMI outside the normal range. The higher a person's BMI, the greater the impact on balance, increasing the risk of falls during movement. Individuals who are obese have lower stability levels than those with normal weight. This indicates that BMI is one of the factors affecting body balance (Amir & Azi, 2021). Optimal balance in children, especially those with flatfoot, supports the smoothness of their activities and development, as children are vulnerable to growth disturbances during their developmental phase. According to literature studies in Indonesia, out of 930 students who were subjects of the research, 53.3% of them experienced flatfoot while 46.7% had normal arches, within the age range of 7-12 years (Zulvania et al., 2023). Based on the description from the background above, the researcher is interested in conducting a study titled "The Relationship Between Body Mass Index and Dynamic Balance in Flatfoot Children Aged 9-12 Years at SDIT Ulul Albab, Pekalongan City."

METHODS

This study employs an observational analytical approach with a cross-sectional design. The independent (free) and dependent (bound) variables are measured simultaneously.

The population in this study consists of all students aged 9-12 years at SDIT Ulul Albab, totaling 107 children. The sampling method used in this research is total sampling, involving 107 children aged 9-12 years with the following inclusion criteria: aged 9-12 years, both male and female children with a foot arch degree of <420 Clarke's angle in both feet, and cooperative and willing to participate in the study. The exclusion criteria include children with neurological disorders and children with a history of foot surgery. This research was conducted from August 5 to August 8, 2024.

RESULTS AND DISCUSSION

Table 1. Distribution of Respondent Characteristics by Age

Age	Number	Percentage %
9	41	38.3%
10	39	36.4 %
11	22	20.6%
12	5	4.7%
Total	107	100 %

The characteristics of respondents based on age in this study show that out of 107 respondents, 38.3% are 9 years old, 36.4% are 10 years old, 20.6% are 11 years old, and 4.7% are 12 years old. 4.7%.

Table 2. Distribution of Respondent Characteristics by Gender

Gender	Number	Percentage %
Female	55	51 %
Male	52	49 %
Total	107	100 %

Based on Table 2, out of 107 respondents, there are 55 female flatfoot children (51%) and 52 male flatfoot children (49%).

Table 3. Distribution of Respondent Characteristics by Weight

Variable	Mean Median	SD	Min-Max	95% CI
Weight	32.03 30.00	9.389	20-75	30.23-33.83

Based on Table 3, the characteristics of respondents by weight in this study show that among 107 respondents aged 9 to 12 years, the average weight is 32 kg, with the most common weight being 30 kg, reported by 13 individuals.

Table 4. Distribution of Respondent Characteristics by Height

Variable	Mean Median	SD	Min-Max	95% CI
Height	1.26 1.26	0.098	1.10-1.50	1.24-1.28

The characteristics of respondents based on height in this study show that among 107 respondents aged 9 to 12 years, the average height is 126 cm, with the most common height being 120 cm, reported by 22 individuals.

Table 5. Incidence of Flatfoot at SDIT Ulul Albab

Variable	Mean Median	SD	Min-Max	95% CI
Right Flatfoot	16.94 16.00	9.819	0-43	15.06-18.83
Left Flatfoot	12.05 10.00	8.175	0-44	10.48-13.61

Based on Table 5, the measurement results for the degree of flatfoot in the right foot show a mean of 16.94 and a median of 16.00 with a standard deviation of 9.819. Additionally, the degree of flatfoot ranges from a minimum of 0 to a maximum of 43. For the left foot, the mean degree of flatfoot is 12.05, with a median of 10.00 and a standard deviation of 8.175, ranging from a minimum of 0 to a maximum of 44.

Table 6. Body Mass Index in Flatfoot Children at SDIT Ulul Albab

Body Mass Index	Frequency	Percentage
Severely Underweight	26	24.3%
Mild Underweight	20	18.7%
Normal	46	43%
Mild Overweight	4	3.7%
Severely Overweight	11	10.3%
Total	107	100%

Based on Table 6, the results show that 24.3% of respondents are classified as severely underweight, 18.7% as mildly underweight, 43% as normal, 3.7% as mildly overweight, and 10.3% as severely overweight.

Table 7. Dynamic Balance in Flatfoot Children at SDIT Ulul Albab

Dynamic Balance	Frequency	Percentage
1	17	15.9%
2	56	52.3%
3	32	29.9%
4	2	1.9%
Total	107	100%

Based on Table 7, the results show that 15.9% of respondents scored 1, 52.3% scored 2, 29.9% scored 3, and 1.9% scored 4.

Table 8. Normality Test of Data using Kolmogorov-Smirnov

Variable	Asymp.Sig	Description
Body Mass Index in Flatfoot Children	0,000	Not usual
Dynamic Balance in Flatfoot Children	0,000	Not usual

Based on Table 8, the results of the normality test using the Kolmogorov-Smirnov test show that the Asymp.Sig value for body mass index is not normally distributed (0.000 < 0.05), and the data for dynamic balance in flatfoot children is also not normally distributed (0.000 < 0.05). This indicates that the research data is not normally distributed (p<0.05), thus a Spearman rank test was conducted.

Table 9. Spearman Rank Correlation Test

Spearman Test	N	P Value	R
Relationship between BMI and Dynamic Balance	107	0.066	-0.179

Based on Table 9, the results of the statistical test using the Spearman test show a p-value (Asymp. Sig. 2-tailed) of p= 0.115 (ρ>0.05) and an R value of -0.153, indicating that H0 fails to be rejected, which means there is no significant relationship with a negative correlation, suggesting that as the body mass index increases, the dynamic balance score decreases.

Discussion

Age is the most important factor in the occurrence of flatfoot. Childhood is a time filled with play and movement exploration, which requires significant muscle work, especially in the feet. The feet play a crucial role in supporting body weight, and if they are not strong enough, the body may be more susceptible to injuries. One issue that can occur in the feet is flatfoot. Research shows that flatfoot occurs in about 45% of children before school age and 10% in children over the age of 10. At SDN Coblong 2 Bandung, a survey indicated that 6 out of 33 students (18%) showed signs of a tendency toward flatfoot (Sativani & Pahlawi, 2020).

The prevalence of flatfoot is higher in boys compared to girls, due to anatomical differences, specifically the rearfoot angle (average valgus value) being greater in boys than in girls. A pronated foot posture can lead to changes in body position that affect the shape of the medial arch of the foot, making it flatter. Boys tend to experience this posture more frequently, with flatfoot prevalence found to be between 78.9% and 22.4%. Additionally, the incidence of flatfoot tends to decrease with age (Hidayati & Noerdjanah, 2023).

According to research by Hidayati & Noerdjanah (2023), it was found that children categorized as overweight have a higher incidence of flatfoot compared to those with normal or underweight BMI. Nutritional status of being overweight and obese is associated with increased contact area, decreased medial longitudinal arch, and increased pressure on the feet, which can lead to a higher prevalence of flatfoot in children with excess weight or obesity (Aulia, 2018). Height is often related to Body Mass Index (BMI). Taller children generally have different body proportions, which can affect how body weight is distributed and the pressure experienced by the feet. Studies show that children with higher BMI (often associated with height) are more likely to experience flatfoot. Children with greater height tend to have different foot structures, such as longer feet and a lower likelihood of foot arches. These factors can influence the development of flatfoot, especially if they are also overweight (Adiputra & Wahyuni, 2022).

Although previous studies, such as Hidayati & Noerdjanah (2023), emphasized the role of obesity in increasing the risk of flatfoot due to excessive pressure on soft tissues, the findings of this study indicate that underweight conditions also need to be considered. This suggests that the mechanisms leading to flatfoot may be more complex and not solely related to excess weight. In addition to excess load, nutritional deficiencies often seen in individuals with low BMI may also contribute to the development of flatfoot. Nutrients such as calcium and vitamin D are essential for bone and joint health. Deficiencies in these nutrients can weaken foot structures and increase the risk of flatfoot, as supported by research from Sirada (2022).

Signs and symptoms resulting from flatfoot include abnormal walking patterns, which can lead to fatigue and balance disturbances. Decreased balance ability in children can increase the risk of falls and result in difficulties in walking, which can negatively impact a child's productivity. Generally, good balance has various benefits, including facilitating movement in daily activities. With optimal balance, movements in daily activities can occur more efficiently. Additionally, according to research by Nurhayati (2022), individuals suffering from flatfoot exhibit low dynamic balance, which is related to deficits in neuromuscular control, thereby increasing the likelihood of lower extremity injuries compared to individuals with optimal dynamic balance. According to Kim (2016), flatfoot conditions caused by the decrease or loss of the Medial Longitudinal Arch (MLA) can result in both structural and functional deformities. This decrease implies a reduced ability to absorb impact and a decrease or loss of balance. Consequently, stability while walking or running decreases, which can lead to difficulties in walking and reduced endurance.

Balance is the result of a complex interaction between various biomechanical and neuromuscular factors. While excess body weight can hinder physical activity in general, the results of this study indicate that there is no direct relationship between body mass index and dynamic balance in this research group. Referring to the research by Abrar (2018), the center of gravity and body composition indeed influence body balance. However, the findings of this study suggest that the relationship between body mass index and dynamic balance is not as straightforward as previously thought. These findings need to be confirmed through further research with a larger sample size and a more complex research design.

CONCLUSION

There is a negative relationship, indicating that as the body mass index increases, the dynamic balance score decreases, with an R value of -0.153 and a p-value of 0.115 (p>0.05). Therefore, it can be concluded that there is an indirect negative relationship between body mass index and dynamic balance in flatfoot children aged 9-12 years at SDIT Ulul Albab, Pekalongan City. The researcher also suggests that the results of this study can be further developed by future researchers, such as examining other factors that influence flatfoot in children, as well as providing interventions related to children with flatfoot conditions who experience dynamic balance disturbances.

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REFERENCES

Abrar, A. A. (2018). Hubungan Antara Indeks Massa Tubuh Dan *Flatfoot* Dengan Keseimbangan Pada Anak Didik Solo Mengajar.

Permenkes 2020, P. N. . T. (2020). *Peraturan Menteri Kesehatan Republik Indonesia Nomor 2 Tahun 2020 Tentang Standar Antropometri Anak. 21*(1), 1–9.

Abrar, A. A. (2018). Hubungan Antara Indeks Massa Tubuh Dan Flat Foot Dengan Keseimbangan Pada Anak Didik Solo Mengajar. *Skripsi.*

Adiputra, R., & Wahyuni, O. D. (2022). Hubungan Indeks Massa Tubuh (Imt) Terhadap Flat Foot Pada Mahasiswa Universitas Tarumanagara. *Ebers Papyrus*, *28*(1), 58.

Antara, K. A., Adiputra, I. N., & Sugiritama, I. W. (2017). The Correlation Between Flat Foot With Static and Dynamic Balance in Elementary School Children 4 Tonja Denpasar City. *Majalah Ilmiah Fisioterapi Indonesia*, *5*(3), 23–26.

Dian, A. (2018). Mengembangkan Keseimbangan Melalui Bermain Papan Titian Pada Anak Kelompok A Di Tkit Bakti Insani Sleman Yogyakarta. In *Journal of Chemical Information and Modeling* (Vol. 53, Issue 9).

Aulia. (2018). Hubungan Indeks Massa Tubuh (Imt) Terhadap Kaki Flatfoot Pada Siswa-Siswi Sekolah Dasar Negeri 01 Cibentang Bogor. *Universitas Aisyiyah Yogyakarta*, 1–14.

Azizah, F. N., & Adhe, K. R. (2019). Pengaruh Papan Titian Modifikasi Terhadap Keseimbangan Gerak Anak Usia 4-5 Tahun. *Jurnal PAUD Teratai*, *08*(03), 1–6.

Bery Hastuti, S., Alex Pangkahila, J., Irfan, M., Dewa Ayu Inten Dwi Primayanti, I., Putu Adiartha Griadhi, I., & Ali Imron, M. (2018). *Dynamic Neuromuscular Stabilization Lebih Meningkatkan Keseimbangan Dinamis Daripada Balance Exercise Pada Siswa Usia 9-10 Tahun Di Sekolah Dasar Negeri 11 Sumerta Denpasar* (Vol. 6, Issue 1).

Chromiak, J. A., & Antonio, J. (2008). Skeletal muscle plasticity. *Essentials of Sports Nutrition and Supplements*, 21–52. https://doi.org/10.1007/978-1-59745-302-8_2

Febri Yolanda Syafri, R. F. U. (2021). Towel Curl Exercise Berpengaruh Terhadap Peningkatan Keseimbangan Statis Anak Dengan Flat Foot. *Maternal Child Health Care*, *3*(3), 565. https://doi.org/10.32883/mchc.v3i3.1482

Hansen. (2023). Etika Penelitian: Teori dan Praktik Manajemen Kontrak Konstruksi View project. *Podomoro University Press*, *January*, 1–111. https://www.researchgate.net/publication/367530183

Hidayati, N. P. N., & noerdjanah. (2023). Identifikasi Angka Kejadian Flat Foot Pada Anak Sekolah Menengah Pertama. *Jurnal Kesehatan Tambusai*, *4*(3), 3201–3205.

Hsu, C. Y., Wang, C. S., Lin, K. W., Chien, M. J., Wei, S. H., & Chen, C. S. (2022). Biomechanical Analysis of the FlatFoot with Different 3D-Printed Insoles on the Lower Extremities. *Bioengineering*, *9*(10), 1–12. https://doi.org/10.3390/bioengineering9100563

Kim, E. K., & Kim, J. S. (2016). The effects of short foot exercises and arch support insoles on improvement in the medial longitudinal arch and dynamic balance of flexible flatfoot patients. *Journal of Physical Therapy Science*, *28*(11), 3136–3139. https://doi.org/10.1589/jpts.28.3136

Manik, N. M. M., Sugiritama, I. W., Widnyana, M., & Andayani, N. L. N. (2023). Derajat Flat Foot Memengaruhi Keseimbangan Statis Pada Anak Usia 10-12 Tahun. *Majalah Ilmiah Fisioterapi Indonesia*, *11*(1), 106. https://doi.org/10.24843/mifi.2023.v11.i01.p20

Marmi. (2018). Gizi Dalam Kesehatan Reproduksi. *Pustaka Belajar*, *8*, 6–15.

Masturoh Imas, A. N. T. (2018). *Bahan Ajar Rekam Medis Dan Informasi Kesehatan (Rmik) Metodologi Penelitian Kesehatan*.

Nugroho, A. S., & Nurulita, F. F. (2019). Hubungan Antara Pes Planus Dengan Keseimbangan Dinamis Pada Murid MI Nurul Karim Colomadu. *Jurnal Keterapian Fisik*, *4*(1), 6–14. https://doi.org/10.37341/jkf.v4i1.120

Nurhayati, U. A., Khotimah, S., & Ratnawati, P. (2022). Perbedaan pengaruh Short Foot Exercise dan Towel Curl Exercise terhadap keseimbangan dinamis pada remaja Flat foot. *Journal Physical Therapy UNISA*, *2*(1), 15–26. https://doi.org/10.31101/jitu.2656

Ramadany, A., & Pasaribu, S. R. (2021). Pengaruh Indeks Massa Tubuh Terhadap Indeks Lengkung Telapak Kaki Mahasiswa Dan Mahasiswi Fk Uisu. *Jurnal Kedokteran Ibnu Nafis*, *10*(2), 93–100. https://doi.org/10.30743/jkin.v10i2.171

Richard L. Drake. (2014). *Gray's Atlas of Anatomy*. Elsevier Churchill Livingstone.

Sativani, Z., & Pahlawi, R. (2020). Foot Strengthening Exercise on Postural Balance and Functional Ability of Foot on Children 6-10 Years Old with Flexible Flatfoot. *Jurnal Ilmiah Kesehatan (JIKA)*, *2*(3), 99–107. https://doi.org/10.36590/jika.v2i3.69

Sirada, A., Lengkung, B., Pada, K., Usia, A., & Akhir, M. K. (2022). Hubungan Antara Indeks Massa Tubuh (Imt) Denganbentuk Lengkung Kaki Pada Anak Usia Masa Kanak-Kanak Akhir. *Jurnal Vokasi Indonesia*, *10*(2). https://doi.org/10.7454/jvi.v10i2.1018

Srihulina, R. (2022). *Hubungan Antara Postur Flat Foot Dengan Keseimbangan Statis Pada Anak Di Lingkungan Rw 011 Kelurahan Cakung Timur, Kecamatan Cakung, Jakarta Timur*.

Wijayanti, I., & Khotimah, S. (2019). Pengaruh core stability exercise terhadap keseimbangan dinamis pada peragawati anak-anak di samurai pro modelling school naskah publikasi. *Program Studi Fisioterapi S1 Fakultas Ilmu Kesehatan Universitas 'Aisyiyah Yogyakarta*, 1–14.

Wilson. (2008). Synopsis of Causation Pes Planus September 2008 Disclaimer. *Synopsis Of Causation Pes Planus*, *September 2008*.

Zafira Jauza, F. B. (2023). Hubungan Antara Indeks Massa Tubuh (Imt) Dengan. *Jurnal Vokasi Indonesia*.