

## Risk factors of flat foot in children

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### ABSTRACT

**Background:** The condition of flat feet in children will affect activity, development, and weight management. Even though there are often no symptoms, if the condition leads to a severe stage, it will interfere with the function of the feet. The impacts that can be caused by flat feet include walking that is not good, being quickly tired, impaired agility, and poor balance, which affects children's activities. Therefore, knowing the factors that can affect flat feet is necessary. This study aimed to determine the risk factors for flat feet in children.

**Methods:** The study used a literature review design using secondary data from published literature. The literature search was conducted online through PubMed, ScienceDirect, and Google Scholar, using the keywords "flat foot", "plantar index", and "risk factors", which were selected based on inclusion and exclusion criteria.

**Results:** Aged 6-12 years are described as having a higher risk of experiencing flat feet. The male sex has a greater risk than women, the use of closed footwear also has a greater risk, and low physical activity is one of the risk factors. Besides that, being overweight and obese can increase the risk of flat feet.

**Conclusion:** The strongest risk factor for flat feet was age, which was also influenced by gender, footwear shape, activity, and nutritional status.

**Keywords:** child flat foot, flat foot, plantar index, risk factors.

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### Introduction

The absence of an arch in the middle of the foot characterizes flat or flat feet in children. The condition of flat feet has existed since the child was born, but the arch in the foot will begin to form from the first five years in the age range of 2-6 years. If there is a disturbance in the process of creating the arch of the foot, it can cause deformity in the foot. There are two types of flat feet.<sup>1</sup>

In general, a physiological flat foot will form a flexible flat foot and tends to disappear when the lower extremities do not bear too heavy weight. Meanwhile, a pathological flat foot will be in the form of a rigid flat foot. A stiff, flat foot is an acquired or congenital pathological foot condition such as structural, musculoskeletal, traumatic, spastic, and neurological abnormalities. Symptoms caused by flat feet can cause poor walking, easy fatigue, impaired balance, and prone to falling, affecting children's productivity.<sup>1</sup>

The global prevalence of flat foot in children varies, dominated by region, age group, evaluation method, and

nutritional status of the child population. The rate of flat-foot cases in children is influenced by age. The highest prevalence is found in children aged 2 to 6 years (21%-57%) and decreases to (13.4%-27.6%) in children of primary school age and decreases with increasing age until adulthood (5%-14%). This data is taken from research in India. Based on research conducted by Mien et al. in 2017 in the Sukajadi sub-district, 326 children were included, showing that flat foot conditions occurred in 129 (40%) children. Flat feet are more prevalent in boys (23.78%) than girls.<sup>2,3</sup> Flat feet is a common condition in children, generally the arches begin to form in the first 10 years of life. The critical period for arch formation is 6 years of age. Children with flat feet are more likely to experience pain or discomfort in the knees, hips, back, decreased mobility and impaired balance. Factors that dominate the occurrence of the flat foot are age, overweight nutritional status, gender, body composition, ligament weakness, type of footwear used, and family history.<sup>4,5</sup>

## Methods

The method used for the study was a literature review employing secondary data from published literature. An online literature search was conducted through PubMed, ScienceDirect, and Google Scholar, using the keywords "children with flat foot", "flat foot", "plantar index", and "risk factors". The literature selection was based on inclusion and exclusion criteria. The inclusion criteria for this literature review were as follows: publications from reputable organizations, literature reviews of printed books from the last ten years, content addressing two or more variables such as a child with flat foot, risk factors flat foot, and plantar index, and inclusion of pain measurement in the literature. The exclusion criteria for this literature review were publications from outside credible institutions, published more than ten years ago, focusing on only one variable, and needing more appropriate measurements. The literature included in the review met the criteria established by the author.

## Results

From the results of the literature that the author has found, five journals are relevant to the title of this research, which have been included in Table 1.

Xu et al. (2022) researched as many as 14,483 participants from 15 studies aged 6-12. The results of the meta-analysis showed that male gender had a higher risk with a value of (OR = 1.35, 95% CI: 1.11, 1.65,  $p = 0.002$ ), children who had less than nine years of age with a value of (OR = 0.54, 95% CI: 0.41, 0.70,  $p = 0.001$ ), joint relaxation (OR = 4.82, 95% CI: 1.19, 19.41,  $p = 0.03$ ), urban life (OR = 2.10, 95% CI: 1.66, 2.64,  $p < 0.001$ ), as well as lack of exercise with a value of (OR = 2.97, 95% CI: 1.46, 6.03,  $p = 0.003$ ). These are risk factors for the detection of flat feet.<sup>6</sup>

Abich et al. (2020) researched 845 respondents, utilizing the Staheli plantar arch index to measure foot arches. Children's weight was measured without shoes using a digital weighing scale (Electrolux, Korea), while height was measured to the nearest 1 cm with a stadiometer. The overall flatfoot prevalence was 17.6% among 145 individuals, with around 80% exhibiting flexible flatfoot. Flatfoot prevalence decreased with age, with 11-year-olds at a higher risk than those aged 12-15 years ( $p < 0.000$ ). Males had a greater risk than females ( $p < 0.005$ ), and the risk increased in overweight or obese children compared to those of average weight ( $p < 0.000$ ). Additionally, frequent use of shoe footwear correlated with a higher risk of flat feet than sandals ( $p < 0.000$ ). Children reporting foot pain in the past six months also faced an increased risk of flat feet ( $p < 0.000$ ).<sup>7</sup>

A similar study using footprint measurement tools (foot imprinter Apex Harris Mat Set), Staheli's Arc Index), conducted by Alsuhatmi et al. (2019), found among 403 children, the prevalence of flat feet was observed to be 29.5%, with 96.6% classified as flexible flat feet and 3.4% as rigid flat feet. Notably, a significant association was identified between age and flatfoot prevalence, particularly with a higher prevalence observed at 7-8 years of age

( $p = 0.009$ ), while prevalence tended to be more expected at 13-14 years of age. However, the analysis found no significant association between flat feet and gender ( $p = 0.660$ ), BMI classification ( $p = 0.636$ ), or history of foot pain after exertion ( $p = 0.955$ ).<sup>8</sup>

Yin et al. (2018) found Among 1059 individuals, 26.6% were found to have a flexible flat foot. No correlation was observed between the prevalence of adjustable flat foot and sex or outcomes (OR 1.01, 95% CI 0.81–1.26,  $p = 0.91$ ), and there was also no correlation with residence (OR 0.84, 95% CI 0.68–1.05,  $p = 0.13$ ). The percentage of flexible flat feet decreased from 39.5% at age 6 to 11.8% at age 12, with a significant difference between age groups ( $p < 0.01$ ), peaking at 12-13 years. Tests conducted revealed a positive relationship between flat feet and nutritional status. Children with overweight and obesity (BMI between 25-19.0) have a higher risk of flat foot compared to children with average weight, according to BMI references from the World Health Organization (WHO).<sup>9</sup>

Ezema et al., (2014). The prevalence of flat feet was highest in the age group of 6 years (45.3%) and lowest in the age group of 10 years (71%). There were 64 (40.8%) male students with flat feet; in women, only 42 (19.9%) did. There was a significant relationship ( $p < 0.001$ ) between sex and flat foot. In addition, a substantial increase in body weight also affects the prevalence of flat feet ( $p < 0.001$ ). The prevalence of flat foot was highest in the obese group at (53.4%) and the lowest in the underweight group at (13.1%). There is an influence of the development of the foot arch with age, sex, and BMI.<sup>10</sup>

## Discussion

Flat foot condition significantly impacts the walking phase in humans, particularly during the stance phase, which bears the greatest proportion of body weight during walking. In individuals with flat feet, there is an increased contraction of the tibialis posterior muscle due to elevated body mass, and sustained strain can result in dysfunction of the posterior tibial tendon.<sup>8</sup> This leads to reduced inversion of the calcaneus bone and consequent decreased inversion of the tibial bone, hindfoot eversion, forefoot abduction, and subtalar joint deformities. These deformities in the subtalar joint cause instability, while excessive eversion positioning hinders maintaining balance while standing for prolonged periods. Continuous strain leads to flattening of the medial longitudinal arch, eventually resulting in flat foot condition.<sup>1</sup>

A flat foot is a medical condition characterized by the condition of the foot that does not have a normal medial longitudinal arch when standing.<sup>11</sup> Causes of flat foot include abnormal foot structure that causes muscles, ligaments, and tendons to work heavier.<sup>10</sup> In addition, factors that can cause flat feet are age, gender, footwear shape, physical activity, and nutritional status.<sup>12</sup> Flat feet can cause problems such as bunion formation or considerable toe deformity; hammertoes are characterized by the tips of the toes swelling downwards. Flat foot is a biomechanical problem

**Table 1.** Five articles on risk factors of patellofemoral pain syndrome

Authors	Title	Methods	Results
Xu et al. (2022) <sup>12</sup>	Risk Factor of Flatfoot in Children: A Systematic Review and Meta-Analysis	Method: Systematic review and Meta-analysis (PRISMA), sample: 14,483, age: 6-12 years and, Measuring instruments: Plantar pressure tests, X-rays, FPI.	The meta-analysis showed that joint relaxation, urban living, and lack of exercise are risk factors for flat foot detection for males under nine. There were no significant results in children and adolescents aged 9-12 years ( $p = 0.02$ ), being children living in rural areas and more exercise.
Abich et al., (2020) <sup>13</sup>	Flatfoot and associated factors among Ethiopian school children aged 11 to 15 years: A school-base	Method: Cross-sectional school-based Sample: 823 participants, ages 11-15 years. Research instruments: physical examination, measurement of the soles of the feet when bearing a full load, structured questionnaires on foot pain, types of footwear, and physical activity.	Prevalence of flatfoot among children is 17.6%, with 80% showing flexible flatfoot. Risk factors include age (11-year-olds at higher risk than 12-15-year-olds, $p < 0.000$ ), gender (males $> p < 0.005$ ), weight (overweight/obese $> p < 0.000$ ), shoe type (frequent wearers $> p < 0.000$ ), and foot pain (past six months $> p < 0.000$ ).
Alsuhatmi et al. (2019) <sup>14</sup>	Flatfoot among school-age children in Almadinah Almunawwarah: Prevalence and risk factor	Method: This study used a cross-sectional analytical study method Sample: 2284 participants, age: 7-14 years a Research instruments: interview, footprint (foot imprinter Apex Harris Mat Set), SAI	From a sample of 403 children, flat feet prevalence was 29.5% ( $n = 119$ ), with 96.6% being flexible and 3.4% rigid. Age showed a significant association, with higher prevalence at 7-8 years ( $p = 0.009$ ), and more normal feet at ages 13-14. Sex ( $p = 0.660$ ), BMI classification ( $p = 0.636$ ), and history of leg pain after activity ( $p = 0.955$ ) showed no significant associations with flatfoot.
Yin et al. (2018) <sup>15</sup>	Flexible flatfoot of 6-13 year old children: A cross-sectional	Method: This study used the cross-sectional epidemiological study method Sample: 1059 participants. Age: 6-13 years Research Instruments: FootScan, SAI	Among 1059 individuals, 26.6% experienced flexible flatfoot ( $n=282$ ). No correlation found between flexible flatfoot prevalence and sex or residence ( $p=0.91$ ; $p=0.13$ , respectively). Percentage decreased from 39.5% at age 6 to 11.8% at age 12, significant differences between age groups ( $p < 0.01$ ), peaking at ages 12-13. Overweight/obese children (BMI 25-19.0) had higher risk compared to normal weight.
Ezema et al. (2014) <sup>7</sup>	Flat Foot and associated among primary school children: A cross-sectional study	Method: Cross-sectional descriptive design Sample: 474 participants Age: 6-10 years Research instruments: Physical examination and subjective assessment, PAI, BMI	Flatfoot prevalence was highest at age 6 (45.3%) and lowest at age 10 (71%). Males showed a higher prevalence (40.8%) compared to females (19.9%), with a significant relationship ( $p < 0.001$ ). Increased body weight also correlated significantly with flatfoot prevalence ( $p < 0.001$ ), with the highest prevalence in the obese group (53.4%) and lowest in the underweight group (13.1%). Age, sex, and BMI had significant influences on foot arch development.

BMI, body mass index; FPI, foot posture index; SAI, staheli arch index; PAI, plantar arch index

characterized by excessive eversion of the subtalar complex during load bearing, with plantar flexion of the talus, plantar flexion of the calcaneus about the tibia, dorsiflexion, and abduction of the navicular, forward foot supination and valgus heel posture.<sup>13</sup> Gradually flat foot can lead to foot dysfunction and plantar fasciitis.<sup>14</sup>

Age is one of the risk factors that affect flat feet. Children aged 6-12 years have a greater risk of experiencing flat feet because the arch on the sole has not been formed perfectly.<sup>15</sup> Based on research conducted by Xu et al., age has a significant relationship with risk factors that affect flat feet. It is stated that flat foot is more significantly experienced by children under six years and decreases with age.<sup>6</sup> The study results agree with Abich et al.'s research, where the highest prevalence of flat foot was found in children aged 11 years. The lowest was at the age of 15.7. Research conducted by Alsuhaymi et al. also found that the highest prevalence of flat foot occurred in children aged 7-8 years, and the lowest was at 13-14 years old.<sup>8</sup> Supported by Yin et al.'s research, which found that the prevalence of flat foot has a significant relationship with age, where the highest prevalence is found in children aged six years and the lowest at the age of 13.9. Research by Ezema et al. states that there is a significant relationship between the increase in the prevalence of flat feet and age, where the highest prevalence occurs at the age of 6 years and decreases with age.<sup>10</sup> The long-term effects of having flat feet include experiencing pain in the soles of the feet, fatigue, and limitations in walking activities due to discomfort in the ankles and knees.<sup>16</sup> During the growth process, from infancy, toddlerhood, childhood, adolescence, to adulthood, the structure of the human foot changes. Generally, the human foot has arches that develop during childhood when growth continues. During this time, the bones and ligaments are still quite flexible and vulnerable, especially until around age 8. However, some children with flat feet may complain of pain, resulting in decreased function in the lower limbs. This becomes a concern to ensure that the foot development in children meets expectations.

Gender is also one factor that influences the occurrence of flat feet, where male children have a greater risk of experiencing flat feet than children of the female sex.<sup>17</sup> This is influenced by the medial and lateral angles of the plantar arch in girls greater than in boys.<sup>18,19</sup> Based on research conducted by Xu et al., children of the male sex have a higher possibility of flat feet than girls.<sup>6</sup> Supported by research, Abich et al. found that children with the male sex have 1.5 times the likelihood of having flat feet than girls.<sup>13</sup> The study's results agree with the research of Ezema et al., which found that gender has a relationship with the condition of flat feet.<sup>7</sup> Yin & Alsuhaymi's study stated different results, stating no significant relationship between sex and the incidence of flat feet.<sup>8,9</sup>

Using closed footwear continuously has a higher risk of experiencing flat feet than using sandals.<sup>20</sup> Based on research, Xu et al. found that the use of sneakers will affect

flat feet compared to children who use sandals; the use of closed shoes will affect the development of the arch of the sole.<sup>6</sup> Supported by research, Abich et al. found that using closed shoes significantly interacts with flat feet.<sup>13</sup> This is contrary to research conducted by Yin et al., which states that physical activity does not show a significant relationship with flat feet.<sup>9</sup>

Low physical activity is one of the factors that affect flat feet.<sup>21</sup> Based research conducted by Xu et al. found. Physical activity is also related to children living in urban areas having a higher risk factor for flat foot than children who live in rural areas. Physical activity influences the occurrence of flat feet because children who lack exercise are more prone to have flat feet.<sup>6</sup> Lack of physical activity can put children at risk for flat feet due to inactivity and tight foot muscles. When inactive, the foot muscles become weaker, unable to support the arch of the foot properly, and are more likely to develop flat feet.<sup>22</sup> Inactivity can also lead to obesity, which is also a risk factor for flat feet.<sup>23,24</sup>

Children with excess weight and obesity have a greater risk of flat feet than children with average weight because children who are overweight tend to have difficulty moving freely, which will inhibit the child's physical activity and cause weight on the feet to increase.<sup>25,26</sup> Based on research conducted by Abich & Yin, it was found that obesity has a significant relationship with the prevalence of flat feet.<sup>7,8</sup> Supported by research by Ezema et al., who found that increased body weight was significantly associated with the prevalence of flat foot, where the obese group had a higher prevalence than the underweight group.<sup>10</sup> An obese individual experiences a change in the transmission of mechanical force from the extremities to the ankle due to excessive automatic loading during walking.<sup>26,27</sup> This condition is suspected to be caused by excessive fat accumulation in the medial longitudinal arch, leading to increased pressure on the arch and resulting in flat feet.<sup>26</sup> Moreover, this condition occurs persistently and may lead to more serious consequences.<sup>28</sup>

Understanding the risk factors for flat feet in children aged 6 to 10 is essential to identify potential health issues that may impact their development.<sup>29,30</sup> Flat feet can cause discomfort when walking, standing, and exercising, affecting a child's daily activities and quality of life.<sup>31</sup> Knowledge of risk factors such as obesity, family genetics, gender, and physical activity enables the implementation of appropriate preventive measures and interventions to reduce the likelihood of flat feet. It also helps provide suitable treatment for children diagnosed with flat feet.

Several factors delimit the study's scope. Firstly, the inclusion criteria were restricted to only five relevant journals, potentially overlooking pertinent research from other sources. Secondly, while the included studies offer valuable insights, they primarily concentrate on specific age ranges and may not adequately represent the broader pediatric population. Additionally, the methodologies employed across studies varied, which could introduce inconsistencies in findings and hinder direct comparisons.

Lastly, certain demographic factors, such as socioeconomic status or cultural influences, needed to be thoroughly explored in the reviewed literature, limiting the comprehensiveness of the identified risk factors.

## Conclusion

Based on the five pieces of literature collected and the discussion described above, it can be concluded that risk factors affecting flat foot in children include ages 6-12 years and decrease with age. The male sex has a higher risk than women; using closed-shoe footwear also has a higher risk than those who use sandals, and low physical activity is one of the influencing factors. Flat feet, in addition to nutritional status with excess weight and obesity, have a higher risk of experiencing flat feet than children with average weight. All of these factors influence the incidence of flat feet. Based on the discussion above, these factors significantly influence the incidence of flat feet.

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## Conflict of interest

The author states no potential conflict of interest with this article's research, authorship and publication.

## Author contributions

NKW conceived the study design and data collection and drafted the manuscript; IP and GV collected and revised the data.

## Ethical consideration

This review study used published articles that are accessible. Thus, this study did not require any informed consent or ethical consideration.

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