

ORIGINAL ARTICLE

IJPHY

PREVALENCE AND ASSOCIATED FACTORS OF FLATFOOT AMONG 6 TO 10 AGED CHILDREN IN CENTRAL PROVINCE OF SRI LANKA

¹V. V. Senadheera¹B. M. Nawagamuwa¹K. Nidhya¹S. Sivappriyan¹W. M. S. M. Warnasooriya¹P. M. Madhuranga²H. R. D. Peiris

ABSTRACT

Background: Prevalence of flatfoot is highly variable in different world populations. Previous studies have found that many factors are associated with flatfoot. The objective of the present study was to investigate the prevalence of flatfoot and its association with age, gender and BMI in group of 6-10 aged children in Central province of Sri Lanka.

Method: A total of 722 children aged 6 to 10 were used to assess normalize navicular height using two clinical measurements (navicular height, truncated foot length). Weight and height of the subjects were measured to calculate body mass index. Age and gender of the children were also recorded. Calculated normalize navicular heights were plotted in a distribution curve and area under the curve between +1SD and -1SD was considered as normal foot. Area under the curve which is left to the -1SD was considered as flatfoot.

Results: Overall prevalence of flatfoot among 6-10 aged children in the present sample was 16.06%. The prevalence of flatfoot in 6,7,8,9 and 10 aged children were 26.35%, 16.19%, 12.75%, 13.57% and 11.1%, respectively. Prevalence of flatfoot was high in overweight children (21.05%). Prevalence of flatfoot among males and females were 47% and 53%, respectively.

Conclusion: This study suggests that there is a significant association between flatfoot and age ($p < 0.05$). Prevalence of flat foot decreases with advancing age. Furthermore, there is a significant association between flatfoot and body mass index ($p < 0.05$). Prevalence of flatfoot is higher in overweight children than normal weight and underweight children. There is no significant association between flatfoot and gender.

Keywords: Flatfoot, navicular height, truncated foot length, age, gender, body mass index

Received 22nd April 2016, revised 06th May 2016, accepted 21st May 2016



www.ijphy.org

10.15621/ijphy/2016/v3i3/100834

¹Department of Physiotherapy,
Faculty of Allied Health Sciences,
University of Peradeniya, Sri Lanka.

²Division of Anatomy,
Department of Basic Sciences,
Faculty of Dental sciences,
University of Peradeniya, Sri Lanka.

CORRESPONDING AUTHOR

¹V. V. Senadheera

Department of Physiotherapy,
Faculty of Allied Health Sciences,
University of Peradeniya,
Sri Lanka.

INTRODUCTION

A segmented structure can hold up weight in the most convenient way if it is built in the form of an arch. The foot has three such arches, which are present at birth: the medial longitudinal, lateral longitudinal, and transverse arches. Of the three arches, the medial longitudinal arch is the largest and clinically the most important. Flatfoot is a condition in which the medial longitudinal arch is depressed or collapsed. As a result, the fore-foot is displaced laterally and everted. The head of the talus is no longer supported, and the body weight forces it downward and medially between calcaneum and the navicular bone. The causes of flatfoot are both congenital and acquired [1]. The most common form of congenital flatfoot is asymptomatic and called pediatric flexible flatfoot. Rare and more severe forms are vertical talus, congenital calcaneal valgus and tarsal coalitions. All these conditions are more rigid (no arch with or without weight on the foot) and symptomatic. Acquired flatfoot develops over time, rather than at birth. Many factors can influence the development of flatfoot over time such as type of footwear; a child's sitting or sleeping positions, compensation for other abnormalities further up the leg, compensating for a tight Achilles tendon or severe factors such as rupture of ligaments or tendons in the foot. Most common acquired flatfoot in adults is due to posterior tibial tendon dysfunction, which develops with repetitive stress on the main arch supporting tendon over a long period of time or with aging.

Since a flatfoot is structurally looser, it can be prone to chronic muscle strain as the muscles attempt to keep the foot in a stable position. In people who have been experiencing flatfoot for a long time, muscles have likely adapted well to their normal activity level. However, when the demand on the muscles increases, pain may result.

Vergara *et al.* (2012) had reported diminished prevalence of flatfoot in children over 6 years of age and suggested that the therapeutic measures before this age are not recommended [2]. In addition, Garcia *et al.* (1999) had stated that the critical age for development of the plantar arch is 6 years, and consequently, if the prevalence of flat feet is evaluated before this age, the finding will overestimate the problem [3]. Moreover, Zoran *et al.* (2009) has stated that till 10 years of age there is possibility to reduce flatfoot with age and only in 5% of children, flatfoot may persist after 10 years of age [4]. Therefore, 6-10 aged children were selected as research subjects in the present study because that is the most appropriate age to investigate the prevalence of flat foot in a population.

Information on prevalence and associated factors of flatfoot among primary school children will be useful to physiotherapists and other medical professionals to be aware of the quantity of this deformity which sometimes does not get required attention. Prevalence of flatfoot will be important to foot orthotics production companies as shoe insoles provide valuable contribution in correction of flatfoot in children. Early detection of flatfoot is an ad-

vantage for the physiotherapist and the patient in correction or the prevention of the consequences. Though many studies regarding prevalence of flatfoot had been done in many countries, to the best of our knowledge, this is the first study conducted on prevalence of flatfoot in Sri Lanka. Age, gender and BMI have been considered as dependent variables as in previous studies done in Iran, Nigeria, Austria and Spain to assess factors associated with flatfoot. This research will be a guide for the future researchers to do modifications and explore more deeply regarding this subject.

Our study objective was to investigate the prevalence of flatfoot among a group of 6-10 aged children in central part of Sri Lanka. The association of prevalence of flatfoot with age, gender and body mass index was also investigated to determine the contributory factors.

METHODOLOGY

Participants

A descriptive cross - sectional study was conducted using 722 participants (360 males, 362 females) aged between 6 to 10 years from schools in Ganga ihala korale educational division, in the central province of Sri Lanka. Subjects were selected using stratified random sampling method. Informed consent was obtained from all participants. Furthermore, the permission and informed consent from the educational director of Ganga ihala korale educational division, principals of the schools and the parents of the subjects were taken before commencing the data collection. All the children who expressed their consent together with their parent's consent were included in the study. Children with congenital and neurological disorders, previous corrective surgical treatment, and lower extremity injuries at the time of measurement were excluded. Ethical clearance for the study was obtained from the Ethics committee of Faculty of Allied Health Sciences of University of Peradeniya, Sri Lanka.

Data collection

Two foot parameters (navicular height and truncated foot length), height and weight were taken as measurements. Foot parameters were measured in millimeters using a standard metal ruler. Navicular height (H) was measured as the perpendicular distance between the supporting surface and the most anterior inferior part of navicular tuberosity (Figure 1). Truncated foot length was measured as the perpendicular distance from first metatarsophalangeal joint to the most posterior aspect of the heel (Figure 2).Foot measurements were taken in one leg standing position (full weight bearing) [5] in both right and left legs.

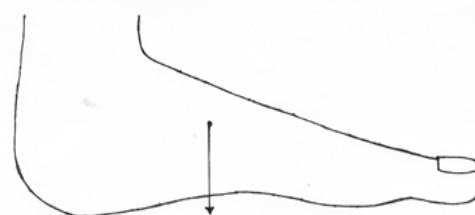


Figure 1: Navicular height



Figure 2: Truncated foot length

Normalized navicular height (Truncated) of both legs for each child was calculated according to following equation. [6]

$$\text{Normalized navicular height (NNH)} = \frac{\text{Navicular Height (H)}}{\text{Truncated foot length (L)}}$$

Weight and height of each child was measured in kilograms and meters by using a weight scale and a measuring tape respectively.

Body Mass Index (BMI) of each child was calculated according to following equation.

$$\text{BMI} = \frac{\text{Weight}}{(\text{Height})^2}$$

Reliability of measurements

In order to minimize the inter examiner error, all the foot measurements were done by one investigator (K.N). In addition, weight and height were measured by one investigator (S.S). Intra examiner error was excluded by measuring all the parameters three times and taking the average. In addition, re-measurement was done in ten randomly selected research subjects, one week after the first measurements. One week duration was considered assuming no significant growth would occur within that period. Two measurements were then compared to determine whether there was a significant difference in the measurements. The difference was not statistically significant.

Data analysis

Subjects were categorized into five groups according to their age, as 6, 7, 8, 9 and 10 years. They were also categorized into four groups as underweight, healthy weight, over weight and obese; according to their BMI, using WHO, BMI classification in children. The sample comprised only three BMI groups; underweight, healthy weight and overweight. No subjects belong to the obese category were found in the present sample. The normalized navicular height data were plotted in a distribution curve and data were normally distributed [7]. The -1SD value was taken as the cut off point for subjects with flat foot [8]. NNH values left to -1SD were taken as flat foot, -1SD to +1SD were taken as normal arched foot and NNH value right to +1SD were taken as high arched foot. Prevalence of unilateral and bilateral flatfoot was also calculated. Chi-square test was used to analyze the associations of flatfoot with age and

BMI. The t-test was used to test the difference of flatfoot between males and females. Data analysis was done using SPSS version 16.0.

RESULTS

The overall prevalence of flatfoot in the present sample was 16.06% (116). Forty three (5.95%) of them were with unilateral flatfoot and 73 (10.11%) were with bilateral flatfoot. When it is unilateral flatfoot right and left side unilateral flatfoot were found in 7.76% and 2.35% of the cases, respectively.

Table 1: Descriptive data of normalized navicular height in different age groups

Age	N	Mean	SD
6	148	0.196	0.0395
7	142	0.203	0.0354
8	149	0.205	0.0317
9	140	0.209	0.0413
10	143	0.210	0.0379
Total Sample	722	0.205	0.0375

In 6 age group, the mean normalized navicular height was 0.196 and NNH less than 0.1565 considered as flatfoot. In 7 and 8 age group mean NNH were 0.203 and 0.1733, respectively and NNH less than 0.1676 and 0.1416 considered as flatfoot. Meanwhile in age 9 group, NNH less than 0.1677 considered as flatfoot and in 10 age group less than 0.1721 considered as the flatfoot.

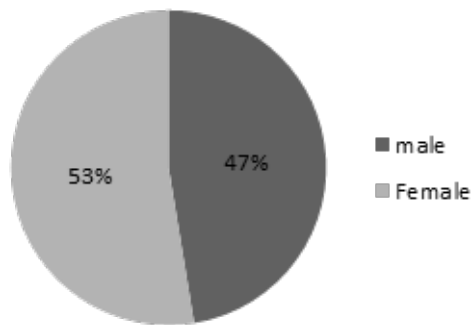
Table 2: Prevalence of flatfoot among age groups

Age	N	Number of children with flatfoot	Prevalence %
6	148	39	26.3514
7	142	23	16.1972
8	149	19	12.7517
9	140	19	13.5714
10	143	16	11.1888

Table 2 shows the prevalence of the flatfoot in different age groups. The highest prevalence of the flatfoot was seen in the 6 age group (26.35%). The prevalence of flatfoot was 23 (16.2%) in the 7 age group, 19 (12.75%) in the 8 age group. In the 9 age group flat foot was seen in 19 (13.57%) of the cases. The lowest prevalence was seen in the age group 10 (11.19%).

Therefore, a significant association between flatfoot and age ($p < 0.05$, $r = 0.110$) was observed and the prevalence of flatfoot decreased with advancing age.

The prevalence of the flatfoot in male and female is shown in graph 1. Sixty one (8.44%) males and 55 (7.61%) females had flatfoot. However, the difference was not statistically significant.



Graph 1: Prevalence of flatfoot according to gender

The minimum BMI value in the sample was 8.46 and the maximum BMI value was 28.16. The distribution had the mean BMI of 1.385 and standard deviation was 1.82. Among the 116 students with flatfoot, 45 (12.26%) students were under weight, 67 (19.94%) were healthy weight and 4 (21.05%) were overweight. (Table 3)

Table 3: Prevalence of flatfoot among BMI groups

BMI group	Number of subjects	Flatfoot present	Flatfoot absent
Underweight	367	45 (12.26%)	322
Healthy weight	336	67 (19.94%)	269
Overweight	19	04 (21.05%)	15

The present result showed a significant association between prevalence of flatfoot and Body Mass Index. ($p > 0.05$, $r = 0.019$). The prevalence of flatfoot increased as body mass index value increases.

DISCUSSION

Flatfoot has been shown to cause abnormal stresses on the foot and lower extremity [9, 10]. The abductor hallucis is one of the important muscles that support the medial longitudinal arch. As flatfoot requires more work to do activities due to the lack of medial longitudinal arch, the supporting muscles are fatigued due to excessive stress. The altered mechanical stresses on these structures can aggravate the foot deformity. There was evidence that flatfoot was positively associated with increased frontal plane motion of the rear foot. Hind foot eversion and forefoot abduction were much greater in the symptomatic population [11]. Therefore, flatfoot can cause problems related to body mechanics later in life. Flatfoot function may contribute to low back symptoms in women. Interventions that modify foot function, such as orthotics, may therefore have a role in the prevention and treatment of low back pain [12]. A research had found that there is an association of flatfoot with knee pain and medial tibiofemoral cartilage damage in older adults [13].

These consequences of flatfoot can be prevented by early detection, correction and prevention. Both congenital and acquired flatfoot can be corrected and prevented if early detection is done by parents and responsible health care professionals. Mild and moderate degree flatfoot can be corrected by conservative procedures and severe flatfoot

may require surgical correction. Mild and moderate flatfoot can be corrected by treating the primary cause (ex-genuvalgum), exercises, stretching, and by using orthotic products such as ankle foot orthosis and shoe insoles [14].

Prevalence of flat foot is highly variable in different world populations. This variability is influenced by various factors. Those can be divided into two; internal and external factors. The internal factors are age, gender, genetics and developmental milestones while external factors are type of footwear, environmental conditions and physical activity. Prevalence of flatfoot in the present sample of 6-10 aged children is in accordance with a recent study conducted to assess flatfoot in school children in Iran by Sadeghi et al. (2015), in which prevalence of flat foot was recorded as 17.1% [15]. In the cross sectional survey in Nigeria conducted by Ezema et al. (2014), prevalence of flat foot was found to be 22.4% [16]. In two studies done in Taiwan by Chang et al. (2010) and Chen et al. (2009), prevalence of 59% and 28% of flatfoot have been documented respectively [17, 18]. Kendic et al. (2007) have estimated prevalence of flatfoot in primary school children in Bosnia as 23.83% [19]. Those values are comparatively higher than our result. On the contrary, Prevalence of flatfoot in children in Spain was recorded as 2.7% by Garcia et al. (1999) and Rao and Joseph (1992) in India, had recorded prevalence of flatfoot in children aged between 6 -10 as 8.2% where those values are relatively lower than the result of our study [3,20].

In the present study, we have observed a significant association of flatfoot with age. It is postulated that flatfoot is decreasing with advancing age. The previous studies have also suggested that the prevalence of flatfoot is decreasing with advancing age. Abolarin et al. (2011) had conducted a study in south west Nigeria, using static foot prints and found that primary predictor for flatfoot was age [21]. Vergara et al. (2012) who had done a similar survey in Colombia, was found that the prevalence of flatfoot is decreasing significantly with age [2]. In an Indian survey done by Rao and Joseph (1992), prevalence of flatfoot has showed a similar trend with age [20]. The possible reason for decline of prevalence of flatfoot with age may be due to the natural development of longitudinal arch by about age five or six. Zoranet al. (2009) has stated that at until 10 years of age, there is a possibility to decrease flat foot with age. After 10 years flat foot persists in only 5% of children [4].

We observed a higher prevalence of flatfoot in females than males. But that was not statistically significant. Ezema et al. (2014) had conducted a cross sectional survey in Nigeria regarding flatfoot and prevalence of flatfoot among males was found to be twice of the prevalence of flat foot among females [16]. In a similar study, done in Taiwan by Chang et al. (2010), prevalence of flatfoot was recorded as 67% and 49% in males and females, respectively [17]. Chen et al. (2009) had found that increased flat footedness in males compared to females of same age (males – 35%, females – 20%) [18]. Mickle et al. (2008) had conducted a research to determine whether flat footedness was influenced by gen-

der and if so to determine the causes of it [22]. In that study prevalence of flatfoot among males was higher than females and it was found out to be caused by thicker plantar fat pad in medial mid foot of males than of females. Kachooosangy et al. (2013) concluded that, the prevalence of flatfoot in a total population of 945 students in Iran were 72.6% for males and 75.2% for females [23]. Eluwa et al. (2009) in Nigeria reported females have higher prevalence of flatfoot than males [24]. In both studies mentioned above, females have higher percentage of flatfoot than males which is in agreement with the result of present study. However, gender difference in the prevalence of flat foot is not very clear and controversial. One explanation for this could be that the incidence of flat foot is more common in females because of more hyper laxity of joints in females [25].

In the present study 12.26% of underweight, 19.94% of healthy and 21.05% of overweight subjects had flatfoot. In the previous studies they have founded an association between flatfoot and BMI. Chen et al. (2011), Chang et al. (2010) and Ezema et al. (2014), had found that the prevalence of flatfoot increases as the BMI increases, which is similar to findings of the present study [26,17,16]. The body weight forces the head of the talus downward and medially between calcaneum and the navicular bone. As body weight increases the downward force will increase and pushes the talus further. BMI increases as body weight increases and decreases as height increases. Thus, the occurrence of flatfoot increases with increased BMI. A research done by Ester et al. (2013) showed that overweight and obese children have a higher frequency of flatfeet than normal-weight children [27]. These children show greater foot length and forefoot width, less navicular height, and lower medial arch height compared with children with normal weight.

It is observed that recorded prevalence of flatfoot is highly variable in different populations in the world and even in the same population. Moreover, it is observed that two factors influencing flatfoot according to present study (age and BMI) are in agreement with the results of previous studies on factors associated with flatfoot. However, it was found in the present study that gender difference is not significant in occurrence of flatfoot. This fact is in agreement with some world population (Iran). But in some others (Austria, Australia and Nigeria) it was found that sexual dimorphism is significant in determining flatfoot. This variability in prevalence and associated factors of flatfoot may have influenced by various factors such as variability in anthropometric characteristics, genetic composition and environmental condition in different populations, differences in the methods that have used to measure flatfoot in different studies; weight bearing position during measurements, instruments used to get the measurements and methods used to diagnose flatfoot.

CONCLUSION

The present study concludes that the prevalence of flatfoot in 6-10 aged children in the present Sri Lankan sample

of central province is 16.06%. This study further suggests that there is a significant association between flatfoot and different ages ($p < 0.05$) and prevalence of flatfoot decreases with advancing age. In addition, significant association between flatfoot and BMI ($p < 0.05$) is also observed in the present sample. Prevalence of flatfoot is high in overweight children. However, there is no significant association observed between flatfoot and gender.

Abbreviations

BMI: Body Mass Index

NNH: Normalized Navicular Height

SD: Standard Deviation

SPSS: Statistical Package for the Social Sciences

WHO: World Health Organization

Acknowledgement

The contribution given by all authors in the preparation of manuscript and the support given by Educational director of Gampola Zone, Principals of schools, research subjects and parents of research subjects are hereby acknowledged.

REFERENCES

- [1] Snell, R.S. Clinical anatomy by regions. 8th Ed;2008.
- [2] Vergara , A.E., Sanchez, R., Posada, J., Molano, A. Prevalence of flatfoot in school between 3 & 10 Years. Study of two different populations geographically and socially. Colomb Med. 2012; 43:141- 146.
- [3] Garcia, R.A., Martin, J.F., Carnero, V.M., Gomez, A.J., Fernandez, C.J. Flexible Flatfoot in Children; a real problem? Pediatrics. 1999; 103(6):1-3.
- [4] Zoran , S.V., Dusko, V.S., Dargana, D.M., Zorica, M.Z., Vladan, B.S., Radmila, R.J. Flat feet in children. ACI/STRUCNI RAD. 2009; 58;103- 106.
- [5] Scott, G., Menz , H. B., Newcombe , L. Age related differences in foot structure and function. Gait and posture. 2007; 26(1):68- 75.
- [6] Menz, H.B. & Munteanu, S.E. Validity of 3 clinical technique forble measurement of static foot posture in older people. Orthopadic and Sports Physicaltherapy. 2005;35(8):479-565.
- [7] Bonita, R., Beaglehole, R., Kjellstram, T. Basic epidemiology. Geneva: WHO press 2nd ed;2006.
- [8] Murley, G.S. , Menz , H.B., Landorf, K.B. A protocol for classifying normal and flat arched foot posture for research studies using clinical and radiographic measurements. Journal of foot and ankle research. 2009; 2:22- 35.
- [9] Lee, J.E., Park, G.H., Lee, Y.S. A Comparison of muscles activities in the lower extremity between flat and normal feet during one leg standing. J Phys Ther Sci, 2013; 25(9):1059- 1061.
- [10] Kim, M.K. & Lee, Y.S. Kinematic analysis of the lower extremities of subjects with flat feet at different gait speeds. Journal of Physical Therapy Science. 2003; 25(5):531- 533.
- [11] Buldt, A.K., Murley, G.S., Butterworth, P., Levinger, P. Menz, H.B., Landorf, K.B. Relationship between foot posture and lower limb kinematics during walking.

- Gait and Posture. 2013; 38(3):363- 372.
- [12] Menz, H.B., Dufour, A.B., Riskowski, J.L., Hillstom, H.J., Hannan, M.T. Foot posture, foot function and low back pain. *The journal of foot and ankle research*. 2013; 52(12):2275-82.
- [13] Gross, K.D., Felson, D.T., Niu, J., Hunter, D.J., Guermazi, A., Romer, F.W. et al. Association of flat feet with knee pain and cartilage damage older adults. *Arthritis car Res*. 2011; 63(7): 937-44.
- [14] Joshi, J. & Kotwal, P. (1999). *Essential of orthopaedics and applied physiotherapy*. 2nd edition;1999.
- [15] Sadeghi, E.D., Jafarian F, Melvin, J.M.,Azadinia, F, Shamsi, F, Jafarpishe, M. Flat foot in school age children - Prevalence and associated factors. *foot ankle spec*. 2015 [Epub ahead of print]
- [16] Ezema, C.I., Abaraogu, U.O., Okafor, G.O. Flat foot and associated factors Among Primary School Children: A cross- sectional study. *Hong Kong Physiotherapy Journal*. 2014; 32(1):13- 20.
- [17] Chang, J.H., Wang, S.H., Kuo, C.L., Shen, H.C., Hong, Y.W., Lin, L.C. Prevalence of Flexible flat foot in Taiwanese school-aged children in relation of obesity, gender and age. *European Journal of Paediatrics*. 2010; 169 (4):447- 452.
- [18] Chen, I.P. , Chung, M.J., Wang, M.J. Flat foot prevalence and Foot dimension of 5-13 year old Children in Taiwan. *Foot Ankle Int*. 2009; 30(4):326- 332.
- [19] Kendic, C.,Skender, N., Catović, A., Celes, N., Dupljak, I., Catovic, S. Frequency of feet deformities in pupils attending junior grades of elementary school. *Bosn J basic Hed Sci*. 2007; 7(3):226- 256.
- [20] Rao, O.B., & Joseph, B. The influence of foot wear on the prevalence of flatfoot; A survey of 2300 Children. *J Bone Joint Sug Br*. 1992;74(4):525-7.
- [21] Abolarin, T.,Aiyegbusi, A., Tella, A., Akinbo, S. Predictive factors for flatfoot: The role of age & footwear in children in urban & rural communities in South West Nigeria. *The Foot*. 2011; 21(4):188- 192.
- [22] Mickle, K.J., Steele, J.R., Munro, B.J. Is the foot structure of preschool children moderated by gender? *J Pediatr Orthop*. 2008;28(5):593- 599.
- [23] Kachoosangy, R.A. , Aliabadi, F, Ghorbani, M. Prevalence of Flatfoot comparison between the male and female primary student. *IRJ* 2013, 11(2): 22-24.
- [24] Eluwa, M., Omini, R., Kpela, T., Ekanem, T., Akpan-tah, A. The incidence of Pes Planus Among Akwa Ibom State Students in the University of Calabar. *Internet J. Forensic science*. 2009;3(2):1-5.
- [25] Wilkerson, R.D. and Mason, M.A. Differences in mens' and womens' ankle ligementous laxity. *The Iowa Orthopaedic journal*. 2000;20:46-48.
- [26] Chen , K.C., Yeh, C.J., Kuo, J.F., Hsieh, C.L., Yang, S.F., Wang, C.H. Foot print analysis of flatfoot in Preschool aged Childrten. *European Journal of paediatrics*. 2011;170(5):611- 617.
- [27] Ester, O.J.,Aguado, X, Abellán, L.D., Mecerreyes, L., Alegre, L.M. Foot morphology in normal- weight, over weight and obese school children. *Eur J Pediatr*. 2013 May;172(5):645-52.

Citation

Senadheera, V., Nawagamuwa, B., Nidhya, K., Sivappriyan, S., Warnasooriya, W., Madhuranga, P., & Peiris, H. (2016). PREVALENCE AND ASSOCIATED FACTORS OF FLATFOOT AMONG 6 TO 10 AGED CHILDREN IN CENTRAL PROVINCE OF SRI LANKA. *International Journal of Physiotherapy*, 3(3), 310-315.