ORIGINAL ARTICLE

The Relationship of Flat Foot to Agility in Children Aged 7-10 Years

Hubungan *Flat Foot* terhadap Kelincahan pada Anak Usia 7–10 Tahun

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ABSTRACT

Background
Lower extremity deformity could cause changes in the anatomical structure of the body, one of which was a flat foot. It was stated that 90% of the clinic visits for foot problems were related to flat foot. Studies still showed controversy regarding the relationship between flat foot and agility especially in children. This study aims to see the relationship between the incidence of flat foot and the level of agility in children aged 7 to 10 years.

Methods
A cross-sectional study was conducted on children aged 7-10 years who attend primary school in Jakarta. Sampling used simple random sampling with inclusion criteria for research subjects who had a normal BMI, were cooperative, and were willing to take part in the study. Exclusion criteria included children with special needs, children with pain or a history of lower extremity injuries, those having a cavus foot, and children in unhealthy conditions. The research was carried out from February to April 2023. Assessment of flat feet used the wet footprint test and shuttle run test was being used to measure the children's agility. Bivariate data analysis used the Chi-square test with a significance level of $p < 0.05$.

Results
As 168 respondents were studied, it was found that 58.3% had flat feet. Measurement of agility with the shuttle run test results in 51.8% of respondents who have below-average agility. The results of the Chi-Square test showed that there was a significant relationship between flat feet and agility ($p<0.05$).

Conclusions
There is a relationship between *flat foot* and agility in children aged 7-10 years.

Keywords: Agility; Child; Flat Foot

ABSTRAK

Latar Belakang

Deformitas ekstremitas bawah dapat menyebabkan perubahan pada struktur anatomi tubuh salah satunya adalah *flat foot*. Terhitung 90% kunjungan ke klinik dengan permasalahan kaki diakibatkan oleh flat foot. Studi yang telah ada masih menunjukkan perbedaan pendapat tentang hubungan *flat foot* dapat memengaruhi kelincahan seseorang terutama pada anak-anak. Penelitian ini bertujuan untuk melihat hubungan kejadian *flat foot* dengan tingkat kelincahan pada anak usia 7 hingga 10 tahun.

Metode

Penelitian potong lintang dilakukan pada anak usia 7–10 tahun yang bersekolah di SD Negri Jakarta. Pengambilan sampel menggunakan cara *simple random sampling* dengan kriteria inklusi subjek penelitian yaitu memiliki IMT normal, kooperatif, dan bersedia mengikuti penelitian. Kriteria eksklusi berupa anak yang berkebutuhan khusus, anak dengan nyeri atau riwayat cedera ekstremitas bawah, memiliki *cavus foot*, dan anak dalam kondisi tidak sehat. Waktu penelitian dilakukan pada bulan Februari hingga April 2023. Penilaian *flat foot* menggunakan *Wet footprint Test* dan *shuttle Run Test* digunakan untuk mengukur kelincahan anak. Analisis data bivariat menggunakan uji Chi-square dengan tingkat kemaknaan p<0.05.

Hasil

Sebanyak 168 responden yang diteliti, didapatkan 58.3% memiliki kondisi *flat foot*. Pengukuran kelincahan dengan *shuttle run test* mendapatkan hasil 51.8% responden memiliki kelincahan di bawah rata-rata. Hasil uji *Chi-Square* menunjukkan adanya hubungan signifikan antara *flat foot* terhadap tingkat kelincahan (p<0.05).

Kesimpulan

Terdapat hubungan *flat foot* terhadap kelincahan pada anak usia 7–10 tahun.

Kata Kunci: Kelincahan; Anak; *Flat Foot*

INTRODUCTION

Children's gross motor skills are a development that involves the arms and legs as large muscles. Movements that require gross motor skills include balance, coordination, agility, walking, and running.[1] Agility is defined as the body's willingness and ability to change direction and position responsively without hindering awareness or balance of body position.[2,3] This definition indicates that Agility consists of perception and decision-making factors, as well as a change of direction component.[4]

One of the factors that influences movement agility is the musculoskeletal system, especially in the lower extremity region which functions as a support for the body. If changes or deformities occur in the lower extremities, it can cause changes in the musculoskeletal structure which will ultimately have an impact on the ability to move the body.[5]

Lower extremity deformities are common in children. Approximately 90% of clinic visits for foot problems are caused by flat feet.[6] Flat foot or pes planus is a relatively common foot deformity characterized by the loss of the archus pedis which touches or almost touches the ground.[7] Usually the archus pedis develops in the first 5 years and lasts for ages 2 to 6 years. The critical period for the formation of the archus pedis is 6 years of age.[8,9] So if there is interference with the archus pedis in children aged 7 years and over, it can affect the child's agility.

The prevalence of flat feet in children and adolescents varies. The research results of Xu L, et al. in 2022 found that the detection rate of flat foot tends to decrease with age.[10] In 2020, Yohanes said that younger people are more likely to suffer from flat foot. [11] Several studies also show that

there is a decrease in the incidence of flat foot in children, from 72.6% to 37.9% between ages 7 and 12 years.[12]

In 2017, research conducted by Sahri, et al. stated that there is a correlation between the archus pedis (flat foot) and agility in elementary school children.[13] Meanwhile, research conducted by Anita Faradilla Rahim, et al. gives different results, namely that there is no relationship between the medial longitudinal curve or flat foot and agility in children aged five to six years.[14] Due to the differences in various studies that discuss flat foot on agility in children there is still a lack of similar research. In the case of flat feet on agility in elementary school children, researchers are interested in researching the relationship between flat feet and agility in children, especially children aged 7-10 years.

METHODS

This research is an observational analytical study with a cross-sectional design. The sample in this study was 168 children aged 7-10 years at SDN Tomang 1 Pagi, West Jakarta, DKI Jakarta who met the inclusion criteria the sampling method used was simple random sampling with probability sampling techniques. Children included in this study were children who were cooperative and had a normal Body Mass Index (BMI). The exclusion criteria in this study were children with special needs, children with pain or a history of lower extremity injury, having a cavus foot, and unwell children. This research uses a wet footprint test to see whether a child has flat feet. The examination is carried out by wetting the feet with water mixed with ink and then placing the feet on a piece of plain white paper to print footprints. The assessment of degree of the pedis arch was assessed based on the Chippaux-Smirak Index (CSI) calculation. This index is obtained by comparing the largest foot width (f) with the narrowest foot width (h) and expressed in percentage units. If the CS Index ranges from 45.1% to 100% then it is grouped as flat foot.
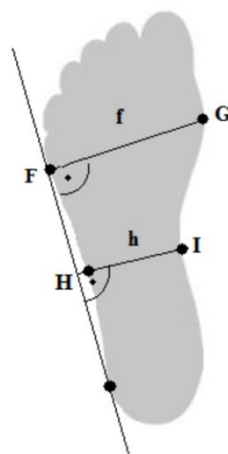

Figure 1. Chippaux-Smirak index (CSI)[15]

Agility assessment uses the shuttle run test. The running test is carried out on a flat running track with both ends connected by a straight line with a distance of 10 meters for 3 rounds back and forth. If the time required to complete the track is 17.27 seconds then it is concluded that he has an average level of agility. However, if the time required to complete the track is more than the time mentioned above then it is included in the category of having below-average agility. Data

analysis was carried out using the Chi-Square test in the SPSS program. This research has passed an ethical test with letter number: 40/KER-FK/I/2023.

RESULTS

Table 1. Frequency distribution of characteristics

Frequency distribution	Frequency (n = 168)	Percentage (%)
Sociodemographic Characteristics		
Gender		
Man	85	50.6%
Woman	83	49.4%
Age		
7 – 8 Years	81	48.2%
9 – 10 Years	87	51.8%
Arcus Pedis		
Normal Foot	70	41.7%
Flat Foot	98	58.3%
Agility		
Average	81	48.2%
Below average	87	51.8%

Based on sociodemographic data (Table 1), it was found that the proportion of boys (50.6%) and girls (49.4%) was almost the same. Likewise, with the division of age groups, an almost equal proportion was found between the group of children aged 7-8 years (48.2%) and the group of children aged 9-10 years (51.8%).

Of the total 98 children who had flat feet, it was found that there were slightly more cases in boys (54.08%) than in girls (45.92%). If we look at the division of age groups, it is found that the 9 – 10-year age group has a slightly higher percentage of flat feet (51.02%) compared to the 7-8-year age group (48.98%). It was found that 48 children aged 7 - 8 years had flat feet and 50 children aged 9 - 10 years had flat feet. And judging from the existing data, 78 children with flat foot have below-average agility, and 20 flat-foot children have average agility. Categorized by degree of flat foot, there were 23 children with grade 1 flat foot (23.5%), 41 children with grade 2 flat foot (41.8%), and 34 children with grade 3 flat foot (34.7%) out of a total of 98 flat foot children.

In the group of children who had a level of agility below the average, it was found that there were more boys (46 children) than girls (41 children) and a higher percentage of cases were found in the 9-10 age group—years (52.87%).

Table 2. Relationship between sociodemographic characteristics and agility in children aged 7 – 10 years

Characteristic	Child Agility					*p-value*
	Average		Below average		Total	
	n	%	n	%	n	
Gender						
Man	39	45.9%	46	54.1%	85	0.540
Woman	42	50.6%	41	49.4%	83	0.540
Age						
7 – 8 Years	40	49.4%	41	50.6%	81	0.770
9 – 10 Years	41	47.1%	46	52.9%	87	0.770

* = p<0.05 significant

From Table 2 it can be seen that the percentage of boys who have below-average agility is slightly higher (54.1%) when compared to girls (49.4%). Likewise, if we look at the division of age groups, we find a slightly higher percentage (52.9%) in the 9 - 10 year age group who have below-average agility.

Overall it was seen that boys and the 9-10 year age group had slightly lower levels of agility. However, statistical testing showed insignificant results regarding the relationship between age and gender on children's agility levels. Statistically, there is no significant relationship between age and agility in children aged 7–10 years (p=0.770>0.05), as well as between gender and agility in children aged 7–10 years (p=0.540>0.05).

Table 3. Relationship between arcus pedis and agility in children aged 7 – 10 years

Characteristic	Child Agility					p-value
	Average		Below average		Total	
	n	%	n	%	n	
Arkus Pedis						
Normal Foot	61	87.1%	9	12.9%	70	0.000*
Flat Foot	20	20.4%	78	79.6%	98	

* = p<0.05 significant

Based on Table 3, data can be seen regarding the relationship between the archus pedis and the level of agility of children aged 7 - 10 years. It can be seen that the percentage of children with flat feet who are in the below-average agility category is higher (79.6%) when compared with normal feet (79.6%).

After analyzing using the Chi-Square statistical test and fulfilling the requirements, a significant p-value was obtained (p=0.000<0.05). Based on these results, a conclusion can be drawn if the null hypothesis (H0) is accepted or if there is a significant relationship between the arcus pedis and the agility of children aged 7 - 10 years.

DISCUSSION

The results of this study show that a slightly higher percentage of boys and the 9-10 year age group have below-average levels of agility when compared to girls and the 7-8 year age group. However, the results of statistical tests prove that there is no significant relationship with the value p=0.540 (p>0.05). Therefore, it can be concluded that there is no significant difference between genders in the level of agility possessed by children aged 7 to 10 years.

According to existing references, the level of agility can be influenced by many aspects, namely muscle strength, joint flexibility, balance, and neuromuscular coordination, and the soles of the feet as support and levers. Other factors that also influence agility include age, gender, body weight, and agility training. Research by Arifiyanti revealed that boys have higher gross motor strength than girls.[16] Children's motor skills develop through various games and activities during recess at school and through children's participation in class physical activities during education. Boys tend to be more physically active than girls so their physical and motor development is much better. This affects all physical development such as muscles, joints, and bones in children, so that boys may have better agility than girls.[17] However, these results are not in line with the research of Kennedy, et al. which involved 26 boys and 20 girls where it was concluded that there was a significant correlation between gender and a person's agility. Research was carried out on 26 boys and 20 girls.[18] The difference with this research is the age range studied in this research. are children aged 7 to 10 years who are still at the same stage of development so there is no significant difference between girls and boys. Research conducted by Kennedy, et al. involving the late adolescent and young adult age groups where the developmental phase has been completed and significant differences between activities influenced by gender are visible.

The results of this study show that the percentage of the 9 to 10-year-old group has a slightly higher level of agility than the 7-8-year-old group. However, the results of statistical testing

proved that the relationship was not significant (p=0.770). This concludes that there is no significant difference between age groups in the level of agility possessed by children aged 7-10 years. Different results from research conducted by Zemkova and Hamar, their research revealed that agility will increase linearly in children as they develop until the age of 7 years and begins to decline exponentially at the age of 7 years as they get older. The results of this research show that there are differences in agility between the group of children aged 7-10 years and the group of children aged 10-14 years.[19] The difference with this research is that this study was only carried out on children aged 7-10 years and what was compared was between the three age groups. In this study, no differences were seen between large age groups of children. If the results of this study are compared with research by Ezema CL, et al. who also looked at the same age group, namely 9-10 years, the results showed that there was no significant difference in the prevalence of flat foot on agility in children between the ages of 9 years and 10 years.[20]

The clinical opinion that is currently believed is that the age for perfect archus pedis formation starts from the age of 7 to 10 years. [21] It is said that the development of the archus pedis begins to potentially stabilize at the age of 7 years and will be completely formed at around 10 years of age.[22,23] Some references say that children's arches are perfect even at an earlier age, namely 8 years.[24] Therefore, research by Ezema, et al. which investigated the relationship between the prevalence of flat-foot and the age of children in Nigeria, starting from Nigerian elementary school children aged 6-10 years.[20] In this study, researchers decided to take research samples from the elementary school children population, and in Indonesia itself, the age of elementary school children started from 7 years. The final limit for this research sample is children aged 10 years according to the reference above.

Based on the research results of Ezema, et al. also showed that there was no significant difference in the prevalence of flat foot between 9 years and 10 years of age. Researchers say that if the condition of flat feet is visible at the age of 9 years, usually this condition will persist. However, the researcher still recommends conducting a prospective cohort study to prove this hypothesis.[20]

The results of research that has been carried out show that a higher percentage of flat-foot children have below-average levels of agility compared to children who have normal feet. Likewise, the results of statistical tests prove a significant relationship with a value of p=0.000 (p<0.05). This concludes that there is a significant difference between flat feet and the level of agility of children aged 7-10 years. These results are in line with Sahri, et al.'s research in which there was a correlation between the arcus pedis and agility (p=0.025) in students in grades 1, 2, and 3 of SD Negeri Duren 1 Bandungan.[13] Research by Maharani, et al. also got the same results, namely that there was a correlation in agility between normal foot and flat foot in children aged 10 to 12 years at SD Negeri 8 Dauh Puri Denpasar. [25] Research by Rahim, et al. obtained different results, where there was no correlation between the medial longitudinal arch and the agility of children aged 5 to 6 years. [14] The explanation given in this study was that the medial longitudinal arch had not fully developed in children under 7 years of age and children -Children in this category are still in the motor development phase so many other things can also contribute to a child's agility apart from the condition of their pedicel.

In accordance with the theory proven in research by Sahri, et al. which states that a person's lack of mobility in their movements is one of the things that is generally caused by archus pedis abnormalities. [13] An example of a dominant abnormality in the archus pedis is flat foot, where an individual has a flat foot which affects their agility.[26] Theoretically, Flat foot or pes planus is a condition where the arch or longitudinal angle of the foot decreases. Flat foot is categorized into two conditions, namely physiological flat foot and pathological flat foot. 6 Physiological flat foot is a structural deformity that is common in children and occurs in the first year of life. If this

disorder persists into adulthood, it can be defined as a pathological flat foot with a prevalence of 3% in the adult population.[27]

Children and toddlers tend to have flat feet due to fat accumulation in the medial longitudinal arch. This deformity will disappear and become normal with age. Generally, foot arches will begin to form between the ages of two and five years.[28] A survey conducted on school children in India involving 297 schools found that 40.32% of children under five, 22.25% of children aged between 5 and 10 years, and 15.48% of children aged over 10 years old with bilateral flat feet.[6] Agility is the ability to change the direction of movement quickly and appropriately while moving but without losing balance and awareness of position. The foot is a part of the limb that plays an important role in carrying out every activity because it functions as a recipient of deformation forces, as a result, the morphology of the soles of the feet plays a very significant role in physical activities or is directly related to a person's agility. This agility is influenced by muscle strength, joint flexibility, balance, and neuromuscular coordination as well as the soles of the feet as support and levers. So the archus pedis has a relationship with body movements that include leg movements and the rapid transformation of existence known as agility.[29] During the terminal support phase when walking and standing, pressure will be focused on the medial side of the foot or the archus pedis. In flat foot conditions, the function of the archus pedis as a dynamic stabilizer does not function properly, so this is what causes a decrease in agility in flat feet.[30]

Overall, this study shows that there is a significant relationship between flat feet and agility in children and to ensure that there are no confounding factors that could influence a child's agility other than the condition of flat feet, the examiner included confounding factors as exclusion criteria. However, due to time constraints, in this study, a direct physical examination was not carried out to check the muscle strength of the trunk and lower extremities and to ensure whether there was ligament laxity which could be factors that influence a child's agility. Differences in shoe use between students can also be a factor that influences a child's agility when moving.

CONCLUSION

Based on the results of this research, it was found that more than half of the students had flat feet and more than half of the students also had below average agility levels. A significant relationship was found between the condition of flat feet and the agility of children aged 7-10 years. In connection with these results, this researcher suggests further research in the form of a cohort study to look further at the progression of children's decline in agility due to flat feet. Researchers also suggest that other studies be carried out that look at other foot arch conditions, namely pes cavus, which is associated with children's agility.

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AUTHORS CONTRIBUTION

Idea owner of this research: RA, NS ; writing and submitting manuscript: RA; editing and approval of final draft: all author

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

REFERENCES

1. Setiyaningrum E. Buku Ajar Tumbuh Kembang Anak Usia 0-12 Tahun. Indomedia Pustaka. 2017
2. Prasetyo A, Suhartini B. Kemampuan Motorik Peserta Ekstrakurikuler Bolabasket SMA N 3 Bantul. Medikora. 2014;XII(1). DOI:10.44.11
3. Jayadi W, Sukamto A, Hasbunallah D. Latihan Kelincahan dan Keterampilan Menggiring Bola Pada Permainan Sepak Bola. Jurnal Penelitian Pendidikan INSANI. 2015;18(2):137–42.
4. Young WB, Dawson B, Henry GJ. Agility and Change-of-Direction Speed are Independent Skills: Implications for Agility in Invasion Sports. Int J Sports Sci Coach. 2015;10(1):159–69. DOI: 10.1260/1747-9541.10.1.159
5. Ariani L, Wibawa A, Muliarta IM. Aplikasi Heel Raises Exercise Dapat Meningkatan Lengkungan Kaki Dan Keseimbangan Statis Pada Anak-Anak Flat Foot Usia 4-5 Tahun Di Tk Aisyiyah Bustanul Athfal 3 Denpasar. Majalah Ilmiah Fisioterapi Indonesia. 2014;4(4). DOI: 10.24843/MIFI.2015.v03.i03.p11
6. Halabchi F, Mazaheri R, Mirshahi M, et al. Pediatric flexible flat foot; Clinical aspects and algorithmic approach. Iranian J Pediatr. 2013;23(3):247–60.
7. Setyaningrahayu F, Rahmanto S, Multazam A. Hubungan Kejadian Flat Foot terhadap Keseimbangan Dinamis Pada Pelajar Di SMAN 3 Malang. PhysioHS. 2020;2(2):83–9.
8. Karandagh MM, Balochi R, Soheily S. Comparison of Kinematic Gait Parameter in the 16-18 years Old Male Studients with the Flat and Normal Foot. Indian Journal of Fundamental and Applied Life Sciences. 2015;5(S1):5165–72.
9. Mien VA, Mayasari W, Chaidir MR. Gambaran Faktor Risiko Flat Foot pada Anak Umur Enam sampai Sepuluh Tahun di Kecamatan Sukajadi. Jurnal Sistem Kesehatan. 2017 Dec 22;3(2):97–102. DOI: 10.24198/jsk.v3i2.15010
10. Xu L, Gu H, Zhang Y, et al. Risk Factors of Flatfoot in Children: A Systematic Review and Meta-Analysis. Int J Environ Res Public Health. 2022; 19(14): 8247. DOI: 10.3390/ijerph19148247
11. Abich Y, Mihiret T, Akalu TY, et al. Flatfoot and associated factors among Ethiopian school children aged 11 to 15 years: A school-based study. PLoS One. 2020;15(8): e0238001. DOI: 10.1371/journal.pone.0238001
12. Peng Y, Wong DWC, Wang Y, et al. Immediate Effects of Medially Posted Insoles on Lower Limb Joint Contact Forces in Adult Acquired Flatfoot: A Pilot Study. Int J Environ Res Public Health. 2020 Mar 26;17(7):2226. DOI: 10.3390/ijerph17072226
13. Sahri, Sugiarto, Widiantoro V. Hubungan Lengkung Telapak Kaki dengan Kelincahan (Studi Pada Siswa SD Negeri Duren 1 Bandungan Kab. Semarang). Jendela Olahraga. 2017;2(1):120–8.
14. Rahim AF, Amaliyah MN, Irwandi I. Correlation Between Agility and Flat Feet in Children 5–6 Years Old. Proceedings of Surabaya International Physiology Seminar. 2017;234–7.
15. Tománková K, Přidalová M, Gába A. The impact of obesity on foot morphology in women aged 48 years or older. Acta Gymnica. 2015 Sep 25;45(2):69–75. DOI: 10.5507/ag.2015.010
16. Arifiyanti N. The Gross Motor Skill Differences Between Preschool Boys and Girl. Aulad: Journal on Early Childhood. 2020 Dec 7;3(3):115–20. DOI: 10.31004/aulad.v3i3.78
17. Adriyani R, Iskandar D, Camelia LS. Gender Differences in Motor Coordination and Physical Activity. Atlantis Press SARL. 2020;21:122–6. DOI: 10.2991/ahsr.k.200214.034

18. Kennedy B, Tinduh D, Utami DA, et al. Comparison of agility between the flat foot annormal foot in East Java Puslatda athletes. Bali Medical Journal. 2023;12(1):369–73. DOI: 10.15562/bmj.v12i1.3955

19. Zemková E, Hamar D. Age-Related Changes in Agility Time in Children and Adolescents. International Journal of Science and Research. 2014;3(11):280–5.

20. Ezema CI, Abaraogu UO, Okafor GO. Flat foot and associated factors among primary school children: A cross-sectional study. Hong Kong Physiotherapy Journal. 2014;32(1):13–20.

21. Cappello T SK. Determining treatment of flatfeet in children. Curr Opin Pediatr. 1998 Feb;10(1):77–81.

22. Uden H, Scharfbillig R, Causby R. The typically developing paediatric foot: How flat should it be? A systematic review. Vol. 10, Journal of Foot and Ankle Research. BioMed Central Ltd.; 2017. DOI: 10.1186/s13047-017-0218-1

23. Carr JB, Yang S, Lather LA. Pediatric pes planus: A stateofthe-art review. Pediatrics. 2016 Mar 1;137(3). DOI: 10.1542/peds.2015-1230

24. Thomson P VR. Introduction to Podopediatrics. Philadelphia: Churchill Livingstone; 2001.

25. Maharani AAAA, Wibawa A, Adiputra IN. Perbedaan Kelincahan antara Normal Foot dan Flat Foot pada Anak Usia 10-12. MIEI. 2020;6(3):7–11. DOI: 10.24843/MIFI.2020.v08.i03.p05

26. Devi IGASP, Saraswati NLPGK, Widnyana M, et al. Medial Longitudinal Arch (MLA) terhadap Kelincahan Atlet Basket Anak di Denpasar. Majalah Ilmiah Fisioterapi Indonesia. 2022 May 9;10(2):79–83. DOI: 10.24843/mifi.2022.v10.i02.p04

27. Atik A, Ozyurek S. Flexible flatfootness. North Clin Istanb. 2014;1(1):57–64. DOI: 10.14744/nci.2014.29292

28. Sonia J, Nadia L, Manel A, et al. Children Flat Foot and Lower Limb Rotational Profile: A Cross-Sectional Descriptive Study. Open J Orthop. 2015;5:326–35. DOI: 10.4236/ojo.2015.510044

29. Depdiknas. Pedoman dan Modul Pelatihan Kesehatan Olahraga bagi Pelatih Olahragawan Pelajar Jakarta: DEPDIKNAS; 2000.

30. Kim MK, Lee YS. Kinematic analysis of the lower extremities of subjects with flat feet at different gait speeds. J Phys Ther Sci. 2013;25(5):531–3. DOI: 10.1589/jpts.25.531