

Measurement Accuracy of Foot Arcus in Children Aged 8-12 years: Mobile Application vs Goniometer

Rahma Dani Nurhidayah*, Adnan Faris Naufal

Physiotherapy Department, Universitas Muhammadiyah Surakarta, Surakarta, Indonesia

Corresponding author: J120220229@student.ums.ac.id

ARTICLE INFO

Article history

Submitted:
22 July 2025

Revised:
30 September 2025
19 November 2025

Accepted:
24 November 2025

Keywords:

Clarke angle;
Elementary school;
Foot arch abnormalities.

ABSTRACT

Foot arch deformities are common in school-aged children and may interfere with posture and lower-limb biomechanics if left undetected. Preliminary observations at Madrasah Ibtidaiyah Muhammadiyah Gonilan indicated that several students showed signs of decreased medial longitudinal arch, suggesting the presence of foot arch abnormalities in the school environment. This study aimed to evaluate the accuracy of a mobile application compared to a conventional goniometer in measuring the Clarke angle. This quantitative research used a cross-sectional design with a population of 150 students aged 8–12 years. A total of 109 children were recruited using nonprobability purposive sampling, based on predetermined inclusion and exclusion criteria. Clarke angle measurements were taken using two instruments: the quick angle physio mobile application and a standard goniometer. Data were analyzed using Spearman correlation because the measurement data were not normally distributed. The results showed a strong and significant correlation between the mobile application and the goniometer measurements ($r=0.964-0.989$, $p<0.001$). These findings indicate that the mobile application provides accurate measurements comparable to the conventional method. The mobile application may serve as an efficient and practical alternative for Clarke angle assessment, supporting early detection of foot arch abnormalities among school-aged children, particularly in school settings such as Madrasah Ibtidaiyah Muhammadiyah Gonilan.



This work is licensed under a Creative Commons Attribution-NonCommercial 4.0 International License.

INTRODUCTION

Children commonly experience musculoskeletal disorders during their growth and development, particularly in the form of foot deformities (Anggriani & Utomo, 2024). The longitudinal arch plays an essential role in distributing body weight proportionally, maintaining balance, and supporting movement activities (Anumillah et al., 2020). A study by Jaya et al. (2020) reported that the prevalence of flat feet among children aged 7-12 years was 53.3%, with the highest incidence at age 7 (22%). This high prevalence is a significant concern because abnormalities in foot arch development can influence posture, gait patterns, and overall biomechanics of movement (Yamashita et al., 2021). Therefore, early detection of medial longitudinal arch abnormalities is crucial to prevent future musculoskeletal issues (Purnama et al., 2024).

One of the most frequently used methods to evaluate the medial longitudinal arch is the Clarke angle, which helps classify foot type into normal, flat foot, or cavus foot (Hegazy et al., 2021). Clarke angle assesment provides information about arch height and intergrity, which are essential for weight bearing, balance walking running, and daily activities (Sari et al., 2022). Traditionally, the Clarke angle can be measured manually using agoniometer (Muhammad et al., 2024). Although the goniometer is simple and inexpensive, this method has notable limitations, including difficulty maintaining consistent anatomical positioning, longer measurement time, and greater dependency on examiner skill, leading to variations in inte-rater result (Hanks & Myers, 2023).

Along with advancements in digital technology, particularly smartphone-based health applications (Andreanto & Handayani, 2022), new tools have been developed to support clinical practice. Mobile applications are now widely used for monitoring physical activity, exercise, diabetes management, and posture assessment (Muttaqin et al., 2021). Similarly, smartphone-based applications for clark angle measurement have begun to emerge. One such application is quick angle physio, which offers practicality, accessibility, and automated visual guidance for identifying foot structure. This technology may reduce operator error, improve efficiency, and provide consistent results. However, its performance still depends on image quality, lighting, and examiner technique.

Considering these advantages and limitations, it becomes essential to evaluate whether digital tools can truly serve as accurate and reliable alternatives to conventional manual measurements. Validity and reliability are key components of any measurement instrument (Sugiono et al., 2020). Validity ensures that the measurement tool accurately measures what it purports to measure, while reliability ensures that the results are consistent across repeated administrations (Ramadhan et al., 2024). Thus, comparing mobile application measurements with goniometer results is necessary to determine whether the digital method can be trusted in clinical and screening settings.

Given the high prevalence of foot arch abnormalities in school-aged children, the need for early detection, and the limitations of manual measurements, this study aims to evaluate the accuracy of foot arch assessment using a mobile application compared to a goniometer. In addition, the study analyzes the level of agreement and correlation between the two tools to ensure that digital technology can be applied practically and clinically as an effective alternative in the assessment of pediatric foot arch conditions.

METHOD

This research is a quantitative study with observational methods and a cross-sectional design. The cross-sectional design was chosen because data collection was conducted at a single point in time, without follow-up or further monitoring of the subjects (Abduh et al., 2022). The method used is direct observation (Wang & Cheng, 2020). The observational approach was used because this study only aims to observe the results of measuring the arch of the foot using two methods without providing intervention or special treatment to the subject (Inggriyani et al., 2022).

A population is a collection of subjects or objects with specific qualities and properties, chosen by researchers for examination and from which conclusions are drawn (Subhaktiyasa, 2024). The population in this study consisted of all students aged 8-12 years registered at Madrasah Ibtidaiyah Muhammadiyah Gonilan, totaling 150 children. The sampling technique used was non-probability purposive sampling, in which samples were selected based on predetermined criteria using the Solvin formula, resulting in 109 children who met the inclusion and exclusion criteria. The sample size calculation using the Slovin formula is as follows:

$$n = \frac{N}{1 + N \cdot e^2}$$

$$n = \frac{150}{1 + 150 \cdot (0,05)^2} = \frac{150}{1 + 0,375} = 109$$

To anticipate data loss, an additional 41 reserve participants were included. The inclusion criteria in this study were students aged 8-12 years, registered as active students at Madrasah Ibtidaiyah Muhammadiyah Gonilan, and willing to participate in all stages of the study. Exclusion criteria included children who experienced leg pain during the measurement process or who did not obtain their parents' or guardians' permission.

Data collection was conducted at Madrasah Ibtidaiyah Muhammadiyah Gonilan through direct measurement of children aged 8–12 years who served as research subjects. Each subject was instructed to stand on a footprint board in a standardized anatomical position to ensure consistent measurements. Wet footprint examination was used to assess the condition of the

medial longitudinal arch and identify abnormalities such as flatfoot, cavus foot, or normal foot (Safira et al., 2024). This technique works by projecting the foot's shape onto a mirror, allowing visualization of pressure distribution and structural deviations. The procedure begins with the subject standing on the mirror board, after which the physiotherapist captures an image of the arch reflection. The obtained footprint is then evaluated using the Clarke angle method with classifications defined as: normal foot (42° – $<54^{\circ}$), flat foot (30° – 41°), and cavus foot ($>54^{\circ}$) (Hegazy et al., 2021).

Clarke angle measurements were subsequently performed using two methods: the mobile application (quick angle physio) and a conventional goniometer. The goniometer is a standard instrument widely used in physiotherapy to measure joint angles (Octabery et al., 2021), with measurement performed by aligning the tool along the Clarke angle reference lines (Hasdianti & Rahman, 2022). The use of both the quick angle physio application and the goniometer was conducted over two days. Each measurement using the application required approximately 3 minutes, starting from uploading the footprint image, determining the anatomical reference points, and obtaining the automated angle result. Meanwhile, measurements using the goniometer required approximately 4 minutes per subject, including identifying the Clarke angle landmarks, drawing the intersecting lines, positioning the goniometer arms on the angle lines, and manually reading the degree measurement. Analyzed using a statistics app.

Data were analyzed using a statistics app. Normality was tested using the Kolmogorov–Smirnov and Shapiro–Wilk tests. The correlation between Clarke angle measurements obtained from the application and the goniometer was analyzed using the Spearman correlation test. Inter-measure reliability was assessed using the intraclass correlation coefficient (ICC), and differences between right and left foot measurements were examined using the Wilcoxon Signed Ranks test. The research has been accompanied by informed consent from parents, approval from enumerators, and a research permit from the Faculty of Health Sciences, Universitas Muhammadiyah Surakarta, No. 725/KEPK-FIK/XII/2024. Ethical clearance is demonstrated through the inclusion of attachments to the consent form and the research permit.

RESULTS

Table 1. Spearman's rank correlation test

Measurement	Correlation	p-value
Application right foot vs. Goniometer right foot	0,989	<0,001
Application left foot vs. Goniometer left foot	0,964	<0,001
Application right foot vs. Application left foot	0.658	<0,001
Goniometer right foot vs. Goniometer left foot	0.658	<0,001
Application right foot vs. Goniometer left foot	0.668	<0,001
Application left foot vs. Goniometer right foot	0.650	<0,001

Univariate analysis shows that most respondents were in the 8–10 age group, with the remainder in the 11–12 age group. The majority of respondents were female. The 25–30kg category dominated weight distribution, while height was most prevalent in the 130–139cm category. In Clarke angle measurements using both the application and goniometer, most respondents were in the normal foot curvature category for both the right and left feet.

As shown in Table 1, the Spearman correlation test showed a very strong, significant relationship between foot arcus measurements obtained with the app and those obtained with the goniometer on both the right and left sides. The correlation between the right-foot measurements obtained with the app and the goniometer was $r=0.989$ ($p<0.001$), whereas on the left foot it was $r=0.964$ ($p<0.001$). This value indicates that the higher the arcus measurement with the app, the higher the goniometer measurement, and vice versa.

In addition, the correlation between the measurement results of the right and left feet in each method also showed a relatively strong and significant relationship (app: $r=0.662$; goniometer: $r=0.658$; $p<0.001$), indicating a bilateral consistency in the arcus structure of the feet of children aged 8-12 years. The cross-correlation between application and goniometer

measurements on different sides (e.g., proper application with the left goniometer) was also significant, although slightly lower ($r=0.668$ and $r=0.650$, respectively).

Table 2. Interclass correlation coefficient test

Variable	Interclass correlation	95% Confidence Interval		Value	F test with true value 0		
		Lower bound	Upper bound		df1	df2	sig
Single measure	0.799	0.742	0.848	16.864	107	321	<0.001
Average measure	0.941	0.920	0.957	16.854	107	321	<0.001

As shown in Table 2, Inter-rater reliability was evaluated using the intraclass correlation coefficient (ICC) based on a two-way mixed effects model (raters as random effects, measurements as fixed effects). Results showed an ICC value for a single measurement of .799 (95%CI:0.742-0.848), which indicated good and significant inter-rater reliability ($F(107,321)=16.864$, $p<0.001$). This C-type ICC evaluates the consistency of inter-rater ratings on each item.

Improved reliability was observed when the mean of the measures was used, with an ICC of 0.941 (95% IK: 0.920-0.957; $F(107,321)=16.864$, $p<0.001$). This value reflects excellent reliability for the mean score. The ICC estimates for the mean measures were assumed to be without rater-item interaction effects.

Overall, the ICC test results indicated good to excellent levels of inter-rater reliability for the measurement instruments used. Good reliability in a single measurement and a significant improvement in the measurement mean support the consistency and reliability of the collected data. These findings reinforce the validity of using the instruments in this study.

Table 3. Wilcoxon signed ranks test

Variable	Median (°)	Z	p-value
Application right foot	35		
Application left foot	31	-4.275	< 0.001
Goniometer right foot	35		
Goniometer left foot	30	-3.721	< 0.001

As shown in Table 3, the Wilcoxon signed ranks test results indicate a significant difference between the left and right foot arch measurements. In measurements using the application, the median clarke angle of the left foot was lower than that of the right foot (31° vs. 35°), and the Wilcoxon test showed a significant difference ($Z=-4.275$, $p<0.001$). The same pattern was observed in measurements using a goniometer, where the median for the left foot (30°) was also lower than that for the right foot (35°) with a statistically significant difference ($Z=-3.721$, $p<0.001$). These findings indicate that in both measurement methods, the left foot arch tended to be lower than the right foot arch in most subjects.

DISCUSSION

This study demonstrated that clarke angle measurements obtained using both the quick angle physio application and a manual goniometer in children aged 8–12 years were not normally distributed, as indicated by the Kolmogorov–Smirnov and Shapiro–Wilk tests ($p<0.001$). Therefore, non-parametric statistical methods were used. The Spearman correlation analysis revealed a very strong and significant correlation between the two measurement methods on both the right ($r=0.989$; $p<0.001$) and left foot ($r=0.964$; $p<0.001$). These findings indicate that the quick angle physio application demonstrates high agreement with conventional instruments and supports the validity of digital technology in assessing foot arch structure.

Inter-rater reliability was analyzed using the Intraclass Correlation Coefficient (ICC) test. The results showed ICC values of 0.799 for single measurements and 0.941 for average measurements, categorized as good to excellent reliability. This suggests that measurements

obtained with both the application and the goniometer were consistent and reproducible. These results align with previous studies that emphasize the reliability and efficiency of digital tools in obtaining clarke angle measurements.

The Wilcoxon signed ranks test was conducted to assess differences between right and left foot measurements (Fadilatunnisya et al., 2024). The Wilcoxon signed rank test revealed significant differences between the right and left foot measurements in both methods ($p < 0.001$), with the left foot presenting lower arch values. This may reflect natural bilateral variation commonly seen in school-aged children and highlights the need for clinicians to consider side-to-side differences when interpreting pediatric foot assessments.

The present findings are in line with those of Latifah et al. (2021), who demonstrated the potential of digital applications to enhance objectivity and replicability in clarke angle measurements. Similarly, studies using 3D smartphone-based foot-scanning systems in older adults also support the premise that mobile-based digital assessment can serve as a reliable alternative to manual measurements across age groups.

A key contribution of this study is analyzing the factors that led to the application producing consistent, stable results. First, the footprint medium using a box angle improved visualization of the plantar arch through mirror reflection, providing clearer reference landmarks for digital analysis. Second, smartphone-based imaging enabled static and well-captured foot documentation, minimizing movement-related variability that commonly affects manual goniometer measurements. Third, digital determination of clarke angle points reduces reliance on examiner experience, resulting in more objective angle calculation. Finally, the automated interpretation feature within the application minimizes subjective judgment, thereby improving consistency. Together, these factors explain the superior measurement stability of the application compared to conventional tools.

Theoretically, this study contributes to the growing evidence supporting digital measurement validation in pediatric foot biomechanics. Practically, the findings highlight the potential of mobile applications as efficient, non-invasive, and accessible tools for mass screening in school and primary care settings. Health professionals may benefit from integrating such technology to support early identification of arch abnormalities and planning appropriate interventions.

However, the study has several limitations. Radiographic methods, which represent the gold standard for foot structural assessment, were not included for comparison. The study sample was also limited to a single educational institution, potentially restricting generalizability. Future studies should involve broader populations and include radiologic comparisons to strengthen the validation of digital instruments.

Overall, the quick angle physio application can be considered a reliable and efficient alternative to conventional goniometric measurements for assessing pediatric foot arch structure.

CONCLUSION

The results of this study show that the quick angle physio application has excellent accuracy and reliability in measuring the arches of the feet of children aged 8-12 years, with high conformity to conventional goniometer methods. This finding indicates that the digital application can serve as a valid and efficient alternative screening tool for children's foot arches, especially in primary health care and school environments. As a follow-up, it is recommended that similar studies be conducted across more diverse populations and that measurement results be compared with gold standards, such as radiographs, to strengthen the validity of digital instruments. In addition, technical training for health workers is needed to ensure the application is used optimally and produces consistent data across various service settings.

AUTHOR'S DECLARATION

Authors' contributions and responsibilities

RDN: Research conceptualization, data collection (data acquisition), formal analysis, original draft writing, visualization of research results; **AFN:** Main research supervision, data validation, draft review & editing, conceptual thinking, methodological guidance.

Funding

This research received no external funding.

Availability of data and materials

All data generated or analyzed during this study are available from the corresponding author on reasonable request.

Competing interests

The authors declare no competing interests.

ACKNOWLEDGEMENT

The authors would like to thank Madrasah Ibtidaiyah Muhammadiyah Gonilan for providing permission and facilities for the implementation of this research. Thanks also go to the teachers and students who have actively participated in the data collection process. The highest appreciation is given to all parties who have provided support, both in the form of time, energy, and constructive suggestions, so that this research can be carried out well.

REFERENCES

- Abduh, M., Alawiyah, T., Apriansyah, G., Sirodj, R. A., & Afgani, M. W. (2022). Survey Design: Cross Sectional dalam Penelitian Kualitatif. *Jurnal Pendidikan Sains Dan Komputer*, 3(01), 31–39. <https://doi.org/10.47709/jpsk.v3i01.1955>
- Andreanto, D. D., & Handayani, A. N. (2022). Pelayanan Kesehatan Masyarakat Melalui Pemanfaatan Teknologi Digital Society 5.0. *Jurnal Inovasi Teknologi Dan Edukasi Teknik*, 2(5), 220–223. <https://doi.org/10.17977/um068v2i52022p220-223>
- Anumillah, R. A., Suciati, Y., & Saleh, A. Y. (2020). Hubungan arkus pedis dengan keluhan nyeri punggung bawah pada perawat rumah sakit islam jakarta tahun 2019. *Jurnal Kedokteran Vol*, 8(1). <https://doi.org/10.37304/jkupr.v8i1.1495>
- Anggriani, A. F., & Utomo, P. C. (2024). Penyuluhan Dan Implementasi Penggunaan Rigid Custom Foot Orthosis Dalam Mengurangi Derajat Flatfoot. *Jurnal Indonesia Mengabdi*, 3(1), 01–22. <https://doi.org/10.55080/jim.v3i1.797>
- Fadilatunnisya, F., Fakhirah S, R., Fasha, E. A., Putri, A. K., & Putri, D. A. J. D. (2024). Penggunaan Uji Wilcoxon Signed Rank Test untuk Menganalisis Pengaruh Tingkat Motivasi Belajar Sebelum dan Sesudah Diterima di Universitas Impian. *IJEDR: Indonesian Journal of Education and Development Research*, 2(1), 581–587. <https://doi.org/10.57235/ijedr.v2i1.1887>
- Hanks, J., & Myers, B. (2023). Validity, Reliability, and Efficiency of a Standard Goniometer, Medical Inclinator, and Builder's Inclinator. *International Journal of Sports Physical Therapy*, 18(4), 989–996. <https://doi.org/10.26603/001c.83944>
- Hasdianti, A. U., & Rahman, F. (2022). Program latihan peningkatan kemampuan fungsional pada sprain ankle lateral grade I akut (A case report). *Journal of Innovation Research and Knowledge*, 2(7), 2829–2838. <https://bajangjournal.com/index.php/JIRK/article/view/4222>
- Hegazy, F., Aboelnasr, E., Abuzaied, M., Kim, I. J., & Salem, Y. (2021). Comparing validity and diagnostic accuracy of Clarke's angle and foot posture index-6 to determine flexible flatfoot in adolescents: A cross-sectional investigation. *Journal of Multidisciplinary Healthcare*, 14, 2705–2717. <https://doi.org/10.2147/JMDH.S317439>

- Inggriyani, C. G., Putra, teuku romi I., & Sagala, K. nadya A. (2022). Perbedaan Tingkat Pengetahuan, Sikap, dan Perilaku mengenai Pencegahan Covid-19 pada Mahasiswa Medis dan Non-Medis di Universitas Syiah Kuala. *Jurnal Kesehatan Masyarakat Indonesia*, 17, 13–19. <https://jurnal.unimus.ac.id/index.php/jkmi/article/view/8183>
- Jaya, A. A. S. K., Wardana, I. N. G., & Karmaya, I. N. M. (2020). Prevalensi Flatfoot pada Anak Usia 7-12 Tahun di Sekolah Dasar Cipta Dharma Denpasar. *Jurnal Medika Udayana*, 9(12), 21-24. <https://doi.org/10.24843.MU.2020.V9.i12.P04>
- Latifah, Y., Naufal, A. F., Nafi'ah, D., & Astari, R. W. (2021). Hubungan Antara Postur Flat Foot Dengan Keseimbangan Statis Pada Anak Usia 12 Tahun. *FISIO MU: Physiotherapy Evidences*, 2(1), 1–6. <https://doi.org/10.23917/fisiomu.v2i1.10039>
- Muhammad, I., Rahayu, U. B., & Kingkinnarti. (2024). Pengaruh Pemberian Intervensi Ultrasound Dan Stretching Plantar Fascia Pada Penderita Faciitis Plantaris Di Rsud Dr. Harjono S Ponorogo. *Jurnal Ilmiah Fisioterapi Muhammadiyah*, 3(1), 38-44. <https://journal.um-surabaya.ac.id/Jar/article/view/21730>
- Muttaqin, A. R., Wibawa, A., & Nabila, K. (2021). Inovasi Digital untuk Masyarakat yang Lebih Cerdas 5.0: Analisis Tren Teknologi Informasi dan Prospek Masa Depan. *Jurnal Inovasi Teknologi Dan Edukasi Teknik*, 1(12), 880–886. <https://doi.org/10.17977/um068v1i122021p880-886>
- Octabery, E., Agung Sucipto, P. W., & Paronda, A. H. (2021). Goniometer Pintar Untuk Observasi Gerak Lutut Pasien Pasca Tindakan Fiksasi. *Jurnal Ilmiah Fisioterapi*, 4(02), 16–26. <https://doi.org/10.36341/jif.v4i02.1978>
- Purnama, R., Apriyanto, W., Trybuana, S., Anshari, R., & Zairima, M. (2024). Deteksi Dini Dan Edukasi Flat Foot Pada Anak Di SDN Puro DIMAS : *Jurnal Pengabdian kepada Masyarakat* 3. 1(1), 8–13. <https://ejurnal.unism.ac.id/index.php/dimas/article/view/509>
- Ramadhan, M. F., Siroj, R. A., & Afgani, M. W. (2024). Validitas and Reliabilitas. *Journal on Education*, 6(2), 10967–10975. <https://doi.org/10.31004/joe.v6i2.4885>
- Sari, R. T., Abdullah, A., Kasimbara, R. P., & Fau, Y. D. (2022). Pengaruh Perubahan Legheel Alignment terhadap Lordosis Lumbal pada Penderita Overweight Di Komunitas Senam Aerobik Blukid Sidoarjo. *Jurnal Keperawatan Muhammadiyah*, 7(1). <https://journal.um-surabaya.ac.id/JKM/article/view/10876>
- Subhaktiyasa, P. G. (2024). Menentukan Populasi dan Sampel : Pendekatan Metodologi Penelitian Kuantitatif dan Kualitatif. *Jurnal Ilmiah Profesi Pendidikan*, 9, 2721–2731. <https://doi.org/10.29303/jipp.v9i4.2657>
- Sugiono, N., & Wahyu. (2020). Uji Validitas dan Reliabilitas Alat Ukur SG Posture Evaluation. *Jurnal Keterampilan Fisik*, 5(1), 55–61. <https://doi.org/10.37341/jkf.v5i1.167>
- Wang, X., & Cheng, Z. (2020). Cross-Sectional Studies: Strengths, Weaknesses, and Recommendations. *Chest*, 158(1), S65–S71. <https://doi.org/10.1016/j.chest.2020.03.012>
- Yamashita, T., Yamashita, K., Sato, M., Kawasumi, M., & Ata, S. (2021). Foot-surface-structure analysis using a smartphone-based 3D foot scanner. *Medical Engineering and Physics*, 95(August), 90–96. <https://doi.org/10.1016/j.medengphy.2021.08.001>