Assessment of The Foot Arch and Quality of Life in Children with Down Syndrome

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ABSTRACT

Background: Down syndrome is a genetic condition that has an impact on a person's health and development on many levels, including their feet. Children with Down syndrome frequently have flat feet and other foot deformities, which can make walking painful, uncomfortable, and challenging. **Objective:** The aim of the current study was to evaluate the foot alignment and its impact on quality of life in children with Down syndrome. **Subjects and methods:** This retrospective study included a total of 40children with Down syndrome from both genders with ages ranged from 8 to12 years old recruited from Alfolk Charity Institution, Outpatient Clinic, Intellectual Educational Schools, in Al Gharbia and Cairo Governorates. Foot arch angels were assessed by X-ray radiological assessment whereas; health status for children with foot and ankle problem, Quality of life of children with Down syndrome were assessed by the Oxford ankle foot questionnaire. **Results:** There was a significant increase in Talo-calcneal angle of the right foot of study group compared to the reference value (p = 0.001).There was a significant increase in Talo-calcneal angle of the left foot of study group compared to the reference value (p = 0.001).There was a significant increase in Bohler's angle of the right foot of study group compared to the reference value (p = 0.001).There was a significant increase in Bohler's angle of the left foot of study group compared to the reference value (p = 0.02**).**There was a significant decrease in school & play score of study group compared to the reference value (p = 0.001). **Conclusion:** This study concluded that children with Down syndrome haveproblems in their feet that affect directly their quality of life.

Keywords: Down syndrome, foot arch, X-ray, Quality of life.

INTRODUCTION

People with chromosomal abnormalities, such as Down syndrome (DS), have 47 instead of 46 chromosomes. Trisomy 21 is the most common autosomal trisomy and the primary genetic cause of severe learning impairments [(1)]. The 21st pair of chromosomes are affected by the defective cell that causes Down syndrome, either by nondisjunction (95%), translocation (3%–4%), or, less commonly, mosaicism (1%) caused by division[(2)]. Hypotonia, a small brachycephalic head, epicanthal folds, a flat nasal bridge, upward-slanting palpebral fissures, Brushfield spots, a small mouth, small ears, excessive skin at the nape of the neck, a single transverse palmar crease, and a short fifth finger with clinodactyly and wide spacing are common physical findings. Ligamentous laxity, which can result in acquired hip dislocation, chronic patellar dislocation, pes planus, and ankle pronation, are the most frequent orthopaedic issues with DS. Degenerative joint disease, osteoarthritis, and scoliosis are additional prevalent orthopaedic issues [(3)]. For appropriate gait to occur, correct foot morphology is necessary, and various foot abnormalities may be connected to more proximal lower limb defects that might considerably impede everyday activities[(4)].

The most common foot variations in DS are flat feet, including pronated flat feet, calcaneal valgus, hallux valgus, and metatarsus primus varus[(5)],but if these foot variations are not detected early, major biomechanical and postural issues may develop[(6)].Children with DS frequently have flat feet, which can lead to pain, discomfort, and walking challenges. Severe flat feet can also distort the shoe. Sometimes flatfeet can be uncomfortable, with more specific symptoms occurring after strenuous activity or lengthy walks. In the lower legs and feet, there is widespread discomfort [(7)].

Foot X-ray evaluation can offer a more complete picture of the foot anatomy and assist uncover any abnormalities that may not be obvious during a physical examination [(8)]. X-ray scans give accurate and trustworthy data in a variety of foot diseases. For diagnosis, weight-bearing AP lateral radiographs of the feet are frequently adequate[(9)]. These radiographs measure the foot arch angles. The disease can be staged and treatment choices can be made with the use of clinical and X-ray examination [(10)]. Additionally, based on the evaluation of weight-bearing radiographs of the foot and ankle, foot X-ray assessment can be utilised to assist clinical decision-making treatment programs for the management of foot abnormalities in children [(11)].

An instrument that is reliable for measuring foot pain, function, and appearance is the Oxford Ankle Foot Questionnaire. It can be used to evaluate how the child's quality of life is affected by their foot issues [(12)]. 16 items make up the questionnaire, which is divided into four categories: general foot health, footwear, foot function, and foot pain [(12)]. Healthcare professionals can assess the success of treatment initiatives and make necessary modifications to treatment strategies by monitoring improvements in quality of life over time [(13)].The Oxford Ankle-Foot Questionnaire was created to evaluate the disability associated with foot and ankle problems in kids between the ages of 5 and 16. The questionnaire's results can be used to determine how foot or ankle issues

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affect children in three different areas of their lives: physical, school and play, and emotional [14].

The therapist is more able to pinpoint the foot disability and its causes when they assess ankle and foot abnormalities in children with Down syndrome. This helps the therapist create the best treatment plan in order to improve balance, stability, reduce foot discomfort, suggest appropriate footwear, and improve walking and gait pattern, leading to an overall higher quality of life. So this study was conducted to evaluate foot arch in children with Down syndrome and its effect on their quality of life.

SUBJECTS AND METHODS

This retrospective study included 40children with Down syndrome from both genders with ages ranging from 8 to12 years old recruited from Alfolk Charity Institution Outpatient Clinic, Intellectual Educational Schools in Al Gharbia and Cairo Governorates.

Inclusion criteria: Children with Down syndrome from both genders, aged 8-12 years, having mild mental disabilities and their IQ score ranging from 50 to 69 so they can understand the commands, having no any operations in the feet and they can stand independently and walk alone.

Exclusion criteria: Children with moderate or severe mental disabilities. Their IQ score below 50. Unable to understand commands. Any surgical feet operations. Children who cannot stand-alone.

Procedures: Each child's foot arch and quality of life were assessed individually.

Radiographic Measurements (X-ray): Each kid had a plain x-ray for both ankles in antero-posterior and lateral views while standing and carrying all of their weight. A single observer analysed all of the images. The foot alignment angles from the A-P and lateral views were sketched on the acquired X-ray film, revealing the talo-calcaneal angle (25° - 40°) [15], and Bohler's angle (25° - 40°) [16] (Figure1).

(a)

(b)

Figure (1): (a & b) plain x-ray examination of the right ankle in antero-posterior view showing talo-calcaneal angle (60.5) & Bohler angle (50).

For the examination of foot alignment in the position of static weight bearing, radiographic assessment is an incredibly trustworthy criteria standard measure[11].The foot alignment angles from the A-P and lateral views were sketched on the acquired X-ray film, demonstrating the talo-calcaneal angle (25° - 40°) [15], and Bohler's angle (25° - 40°)[16].

Oxford ankle foot questionnaire for children:

The Oxford Ankle Foot Questionnaire was created to evaluate the health condition of kids with foot and ankle problems who are between the ages of 5 and 16.The Physical domain evaluates general activity restrictions like standing and walking, the school &play domain evaluates participation limitations in particular environmental contexts, and the emotional domain evaluates how much a child is concerned about their foot or ankle problem due to their appearance or how other people treat them [13].

The Oxford ankle foot questionnaire provides a valid and reliable way to measure how foot and ankle disorders affect the lives of kids aged 5 to 16 by focusing on issues that matter to kids [17]. The Oxford ankle-foot questionnaire was administered to kids and/or parents, and the results were recorded as a percentage [12].

There is no overall score the three domain scores are provided individually. The scoring system was created to determine the frequency with which each issue, represented by a questionnaire item, was a problem. Each response choice was graded on a 5-point scale from 0 to 4, with 4 denoting no difficulty and 0 denoting a persistent problem. The sum of the scale item scores divided by the maximum score for each domain (i.e., Physical 24, School & Play 16, and Emotional 16) yields the domain scores. Better functioning is indicated by a domain's score increasing[14]. The information was gathered from x-ray measurements and parents' responses to the Oxford ankle-foot questionnaire for kids.

Ethical approval: Medical Ethics Committee of Faculty of Medicine, Cairo University gave its approval to this study. Before enrolling any children in the research, the parents of all possible participants were informed of the project's aims and requested to sign an agreement. The Helsinki Declaration was followed throughout the study's conduct.

Statistical analysis

Statistical analysis was carried out using SPSS version 25 for Windows. To provide the subject characteristics, descriptive statistics using the mean, standard deviation, minimum, maximum, and frequency were undertaken. For the purpose of comparing the mean foot angle and OxAFQ-C values between the study group and the reference values, a one sample t test was used. To determine the relationship between X-ray angels and Oxford score, Pearson correlation coefficient was used. All statistical tests have a significance threshold of $p \leq 0.05$.

RESULTS

Forty children with Down syndrome participated in this study group. Their mean age was9.75 ± 1.27years with maximum of 12 years and minimum of 8 years. There were 25 (62.5%) boys and 15 (37.5%) girls as shown in table (1).

Table (1): Descriptive statistics for age and sex of study group

	Mean ±SD	**Maximum**	**Minimum**
Age (years)	9.75 ± 1.27	12	8
Sex, n (%)	**N**	**%**	
Boys	25	62.5	
Girls	15	37.5	

Talo-calcneal angle of the right foot: The mean value of talo-calcneal angle of the right foot of study group was 54.53 ± 11.29degrees, while the reference value was 32.5 degrees. The mean difference was 22.03degrees. There was a significant increase in talo-calcneal angle of the right foot of the study group compared to the reference value (p = 0.001).

Talo-calcneal angle of the left foot: The mean value of talo-calcneal angle of the left foot of study group was 55.73 ± 9.00degrees, while the reference value was 32.5 degrees. The mean difference was 23.23degrees. There was a significant increase in talo-calcneal angle of the left foot of study group compared to the reference value (p = 0.001) (Table 2).

Table (2): Comparison of mean values of Talo-calcneal angle between study group and reference value

Talo-calcneal angle (degrees)	**Study group**	**Reference value**	**Mean difference**	**t- values**	**p-values**	**Sig**
	Mean±SD					
Right foot	54.53 ± 11.29	32.5	22.03	12.33	0.001	S
Left foot	55.73 ± 9.00	32.5	23.23	16.33	0.001	S

Bohler's angle of the right foot: The mean value of Bohler's angle of the right foot of study group was 40.33 ± 5.74 degrees, while the reference value was 35 degrees. The mean difference was 5.33 degrees. There was a significant increase in Bohler's angle of the right foot of study group compared to the reference value (p = 0.001).

Bohler's angle of the left foot: The mean value of Bohler's angle of the left foot of study group was 36.93 ± 5.25 degrees, while the reference value was 35 degrees. The mean difference was 1.93 degrees. There was a significant increase in Bohler's angle of the left foot of study group compared to the reference value (p = 0.02) (Table 3).

Table (3): Comparison of mean values of Bohler's angle between study group and reference value

Bohler's angle(degrees)	**Study group**	**Reference value**	**MD**	**t- values**	**p-values**	**Sig**
	Mean±SD					
Right foot	40.33 ± 5.74	35	5.33	5.86	0.001	S
Left foot	36.93 ± 5.25	35	1.93	2.32	0.02	S

Comparison of the Oxford ankle foot questionnaire (OxAFQ-C) of children with Down syndrome (study group) with reference values:

School & play score: The mean value of school & play score of study group was 63.5 ± 20.66, while the reference value was 100. The mean difference was -36.5. There was a significant decrease in school & play score of study group compared to the reference value (p = 0.001) (Table 4).

Table (4): Comparison of mean values of 5th metatarsal base angle between study group and reference value

OxAFQ-C	Study group	Reference value	MD	t-values	p-values	Sig
	Mean±SD					
School & play score	**63.5 ± 20.66**	**100**	**-36.5**	**-11.17**	**0.001**	**S**

Relationship between Talo-calcneal angle and OxAFQ-C:
There were moderate positive significant correlation between the right talo-calcneal angle and school & play score and left talo-calcneal angle and school & play score(r = 0.401, p = 0.010) and (r = 0.380, p = 0.015) respectively (Table 5).

Table (5): Correlation between talo-calcneal angle and OxAFQ-C

	OxAFQ-C	r value	p value	Sig
Right talo-calcneal angle	School & play score	0.401	0.010	S
Left talo-calcneal angle	School & play score	0.38	0.015	S

r value: Pearson correlation coefficient
p value: Probability value, NS: Non significant

Relationship between Bohler's angle and OxAFQ-C:
The correlation between right Bohler's angle and school & play score was weak positive significant correlation (r = 0.094, p = 0.563).The correlation between left Bohler's angle and school & play score was weak positive significant correlation (r = 0.019, p = 0.906) (Table 6).

Table (6): Correlation between Bohler's angle and OxAFQ-C

	OxAFQ-C	r value	p value	Sig
Right Bohler's angle	School & play score	0.094	0.563	NS
Left Bohler's angle	School & play score	0.019	0.906	NS

DISCUSSION

Down syndrome (DS), also known as Trisomy 21, is the most common chromosomal condition characterised by the presence of all or part of a third copy of chromosome 21 [18,19].The prevalence of orthopaedic pathology in Down syndrome ranges from 25 to 30%[20,21].Foot arch problems are common in children with Down syndrome, with the prevalence of pes planovalgus (flatfoot) ranging from 2% to 6%, and this deformity correlates with ligamentous laxity[21,22], which can cause pain, instability, uneven plantar pressure distribution, gait problems, and foot fatigue [23], all of which can have a significant impact on daily activities. All of these alterations can contribute to reduced walking speed, decreased stride length and cadence, increased stance time[24] and reducing functioning and overall well-being [25, 26, 27].

This study was conducted to assess the foot deformity and its relation with quality of life especially school and play activities in the population of children with Down syndrome.

The findings of the study revealed that there were significant differences of Talo-calcaneal and Bohler's angels using X-ray assessment in children with Down syndrome when compared to the normal reference values. In addition, the score of school and play domain of Oxford ankle and foot questionnaire was significantly low. Also, there were a direct relation between the foot malalignments and quality of life for these children.

Several studies have been conducted to evaluate the relationships between foot arch angles and quality of life in children with Down syndrome, utilising X-ray measurement and the Oxford ankle foot questionnaire [26-28].

Our study revealed that in children with Down syndrome, radiographic assessment of the foot arch confirmed that they had foot deformities. This comes in agreement with **Parotti *et al.*[29]** who discovered that radiographic imaging of the foot and ankle in children with Down syndrome indicates a greater frequency of abnormalities than clinical examination.

Our study emphasized that persons with DS showed several orthopedic anomalies. This comes agreement with **Concolino *et al.*[30]**who showed a pronated flat foot, isolated calcaneal valgus, flat foot, and bony malformation of the forefoot. Additionally, our study supported the conclusion made by **Mansour *et al.*[4]** that the DS group had foot deformities such as hallux valgus, syndactyly between the 2nd and 3rd toes, grade II and grade III pes planus, joint laxity, and an enlarged space between the 1st and 2nd toes.

The OxAFQ is often used in researches to evaluate the quality of life and foot and ankle function. According to **Evans *et al.*[31],**the Oxford Ankle Foot Questionnaire (OxAFQ) for children was created as a site-specific (ankle/foot) tool and a quick and easy way to evaluate outcomes from the child's point of view. The

OxFQ questionnaire has been shown to have internal test-retest reliability and cross-sectional validity, according to **Morris *et al.*[12]**. Also, **Craxford *et al.*[32]** found that the Oxford Ankle Foot Questionnaire for children (OxAFQ_C) is a validated questionnaire that was created to measure QoL in this population.

Dynamic flat foot function was shown by **Kothari *et al.* [33]** to be related with reduced OxAFQ_C-based quality of Life. According to their findings, the bigger the maximal forefoot and hindfoot supination during walking, the greater the quality of life impairment. The severity of foot diseases and quality of life ratings are significantly inversely correlated. This is in line with the findings of our study.

Our study revealed that the children with Down syndrome had flat feet and other malalignments of different parts of their feet as pronated feet. This is consistent with the findings of **Diamond *et al.*[21],** who discovered that 20% to 27% of Down syndrome patients had musculoskeletal issues, and **Merrick *et al.*[22]** who discovered that 30% of all reported orthopaedic problems are foot abnormalities.

The current study revealed that foot malalignments had impact on the quality of life especially the play and school activities in the children with Down syndrome that had been reported by their parents. This is consistent with research by **Richter *et al.*[34]** where they found that foot diseases severely restrict patients' activities and degrades their quality of life. It is emphasised that assessing foot functions is crucial for determining how well conservative and surgical treatments are working. The findings of the current study comes in agreement with **Lim *et al.*[28]** where they discovered that flat-footed children with Down syndrome scored considerably worse on the Oxford ankle-foot questionnaire, indicating a decreased quality of life associated with foot issues. The study also discovered a link between the degree of quality of life impairment and the severity of flat feet as determined by X-ray examination. Also, the outcomes of the current study are parallel to **Irving *et al.*[35]** who reported persistent heel discomfort The findings suggest that when a person, regardless of their foot type, records a low score, they may encounter greater difficulties engaging in a variety of physical activities, become socially isolated, and lack the energy to engage in activities.

These studies reveal a relationship between the foot arch angles of children with Down syndrome and their Oxford ankle foot questionnaire-measured quality of life regarding foot issues. A foot problem's precise nature and severity may be determined by an x-ray evaluation, which can determine the best course of therapy and enhance the child's quality of life.

CONCLUSION

It can be concluded that children with Down syndrome had abnormal foot alignment detected by X-ray and affect their quality of life during school and play activities.

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REFERENCE

1. **Tsou A, Bulova P, Capone G *et al.* (2020):** Medical care of adults with Down syndrome: a clinical guideline. JAMA., 324(15): 1543-1556.
2. **Tecklin J (2015):** Pediatric physical therapy. Lippincott Williams & Wilkins, Pp: 382-92. https://www.worldcat.org/title/pediatric-physical-therapy/oclc/861470504
3. **Vázquez-Castilla M, Rodríguez-Martínez A, Arroyo-Rodríguez-NavasA *et al.* (2012):** Misalignments of lower limbs in children with Down syndrome. Physiotherapy, 34(4):140–5.
4. **Mansour E, Yaacoub J, Bakouny Z *et al.* (2017):**A podoscopic and descriptive study of foot deformities in patients with Down syndrome. Orthop Traumatol Surg Res., 103(1):123–7.
5. **Gutiérrez-Vilahú L, Massó-Ortigosa N, Rey-Abella F *et al.* (2016):** Reliability and validity of the footprint assessment method using Photoshop CS5 software in young people with Down syndrome. J Am Podiatr Med Assoc., 106(3):207–13.
6. **Concolino D, Pasquzzi A, Capalbo G *et al.* (2007):** Early detection of podiatric anomalies in children with Down syndrome. Acta Paediatr., 95(1):17-20.
7. **Fabry G (2010):** Clinical practice. Static, axial, and rotational deformities of the lower extremities in children. Eur J Pediatr., 169(5):529–34.
8. **Pourhoseingholi E, Pourhoseingholi M, Bagheri A *et al.* (2017):** Footprint as an alternative to X-ray in hallux valgus angle measurement. Med J Islam Repub Iran, 31:33. doi: 10.14196/mjiri.31.33.
9. **Raj M, Tafti D, Kiel J (2023):** Pes Planus. StatPearls. Treasure Island (FL): StatPearls Publishing. https://www.ncbi.nlm.nih.gov/books/NBK430802/
10. **Michaudet C, Edenfield K, Nicolette G *et al.* (2018):** Foot and Ankle Conditions: Pes Planus. FP Essent., 465:18-23.
11. **Davids J, Gibson T, Pugh L (2005):** Quantitative segmental analysis of weight-bearing radiographs of the foot and ankle for children: normal alignment. Journal of Pediatric Orthopaedics, 25(6): 769-776.
12. **Morris C, Doll H, Wainwright A *et al.* (2008):** Development of the Oxford ankle foot questionnaire for children: scaling, reliability and validity. Journal of Bone and Joint Surgery, 90(11): 1451–1456.
13. **Morris C, Doll H, Wainwright A *et al.* (2010):** The oxford ankle foot questionnaire for children: review of development and potential applications. Prosthetics and Orthotics International, 34(3): 238-244.
14. **Morris C, Doll H, Davies N *et al.* (2009):** The Oxford Ankle Foot Questionnaire for Children: Review of Development and Potential Applications. Qual Life Res., 18:1367-1376.
15. **Yates B (2009):** Merriman's Assessment of the Lower Limb. Häftad (Paperback), Språk Engelska, Pp:312-26.https://www.bokus.com/bok/9780702052477/merrimans-assessment-of-the-lower-limb/

16. **Lau B, Allahabadi S, Palanca A *et al.* (2021):** Understanding Radiographic Measurements Used in Foot and Ankle Surgery. J Am Acad Orthop Surg., 30(2):139-54.
17. **Morris C, Liabo K, Wright P *et al.* (2007):** Development of the Oxford ankle foot questionnaire: finding out how children are affected by foot and ankle problems. Child Care Health Dev., 33: 559–568.
18. **Elton T, Sansom S, Martin M (2010):** Trisomy-21 gene dosage over-expression of miRNAs results in the haplo insufficiency of specific target proteins. RNA Biol., 7(5):540–7.
19. **Roizen N, Patterson D (2003):** Down's syndrome. Lancet, 361(9365):1281–9.
20. **Lott I, Doran E, Nguyen V *et al.* (2011):** Down syndrome and dementia: a randomized, controlled trial of antioxidant supplementation. American Journal of Medical Genetics Part A, 155: 1939–1948.
21. **Diamond L, Lynne D, Sigman B (1981):** Orthopedic disorders in patients with Down's syndrome. Orthopedic Clinics of North America, 12(1): 57-71.
22. **Merrick J, Ezra E, Josef B *et al.* (2000):** Musculoskeletal problems in Down Syndrome European Paediatric Orthopaedic Society Survey: the Israeli sample. J Pediatr Orthop B., 9:185-192.
23. **Norkin C, Levangie P (2005):** Joint structure and function: a comprehensive analysis. 4th ed., Philadelphia, PA: F.A. Davis Co., Pp: 262-281. https://cmc.marmot.org/Record/.b2827068x
24. **Ness M, Long J, Marks R *et al.* (2008):** Foot and ankle kinematics in patients with posterior tibial tendon dysfunction. Gait Posture, 27:331-39.
25. **Otsuka R, Yatsuya H, Miura Y *et al.* (2003):** Association of flatfoot with pain, fatigue and obesity in Japanese over sixties. Nihon Koshu Eisei Zasshi., 50(10): 988–98.
26. **Pita-Fernandez S, Gonzalez-Martin C, Alonso-Tajes F *et al.* (2017):** Flat Foot in a Random Population and its Impact on Quality of Life and Functionality. Journal of Clinical and Diagnostic Research, 11(4): 22-27.
27. **Munro B, Steele J (1998):** Foot-care awareness. A survey of persons aged 65 years and older. J Am Podiatr Med Assoc., 88(5):242–48.
28. **Lim P, Shields N, Nikolopoulos N *et al.* (2015):** The association of foot structure and footwear fit with disability in children and adolescents with Down syndrome. J Foot Ankle Res., 8: 4. doi: 10.1186/s13047-015-0062-0.
29. **Perotti L, Abousamra O, del Pilar Duque Orozco M *et al.* (2018):** Foot and ankle deformities in children with Down syndrome. J Child Orthop., 12:218-226.
30. **Concolino D, Pasquzzi A, Capalbo G *et al.* (2006):** Early detection of podiatric anomalies in children with Down syndrome. Acta Paediatr., 95(1):17–20.
31. **Evans J, Smith A, Gibbons C *et al.* (2018):** The National Institutes of Health patient-reported outcomes measurement information system (PROMIS): a view from the UK. Patient Related Outcome Measures, 9: 345-352.
32. **Craxford A, Minns R, Park C (1984):** Plantar pressures and gait parameters: a study of foot shape and limb rotations in children. Journal of Pediatric Orthopedics, 4(4): 477-481.
33. **Kothari A, Dixon P, Stebbins J *et al.* (2015):** The relationship between quality of life and foot function in children with flexible flatfeet. Gait & Posture, 41(3): 786-790.
34. **Richter M, Agren P, Besse J *et al.* (2018):** EFAS Score—Multilingual development and validation of a patient-reported outcome measure (PROM) by the score committee of the European Foot and Ankle Society (EFAS). Foot and Ankle Surgery, 24(3): 185-204.
35. **Irving D, Cook J, Young M *et al.* (2008):** Impact of chronic plantar heel pain on health-related quality of life. J Am Podiatr Med Assoc., 98(4):283–289.