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Original Article

Effect of Foot Malalignment on Quality of Life in Children with Down Syndrome; A retrospective cross-sectional Study

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Abstract:

Purpose: The aim of the study was to explore the effect of foot malalignment on quality of life in children with Down syndrome. **Methods**: Forty children with Down syndrome from both genders with ages ranged from eight to twelve years old participated in this study. Foot angles [talo-calcaneal angle, calcaneal pitch angle, Bohler's angle, the fifth metatarsal base angle and talo-metatarsal angle] were being assessed by standing-X-ray and compared with normal references. Whereas, quality of life of children with Down syndrome was being evaluated by the Oxford ankle foot questionnaire Arabic version. **Results**: There was a significant increase in all measured angels except for both calcaneal pitch angles compared with normal references, there was a significant decrease of the Oxford ankle foot questionnaire Arabic version three domains' scores, and there was moderate positive correlation between right Talo-calcaneal angles, left Calcaneal pitch and physical score. there was moderate positive correlation between right 5th metatarsal bases angle and school & play score, while there was weak positive correlation between right Bohler's angle and physical score, left Talo-metatarsal angle and emotional score. **Conclusion**: Children with Down syndrome have a significant foot malalignment that directly affect their quality of life especially physical, school and play activities.

Keywords: Down syndrome, foot malalignment, Quality of life, X-ray, Oxford ankle-foot questionnaire.

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1. Introduction

Musculoskeletal problems are usually observed in approximately 20% to 27% of children with Down syndrome **[1],** with foot deformities accounting for 30% of all documented conditions that commonly reported as hallux valgus and pes planus (flatfoot) **[2]** that may be induced by obesity, hypotonia, ankle instability, and ligamentous laxity **[3].** While progressive ankle valgus is prevalent across many other conditions, there is a notable absence of literature addressing ankle deformities specifically in children with Down syndrome **[4].**

Despite the frequent occurrence of foot and ankle disorders among children with Down syndrome who seek care in orthopedic clinics, and the significant impact these conditions have on their gait **[5],** the primary focus tends to be on more severe issues, including upper cervical spine instability, scoliosis, hip instability, and knee malalignment

[6]. Nevertheless, it has been noted that if foot deformities associated with Down syndrome are not properly managed or treated during childhood, they may lead to significant complications in adulthood **[7].**

Since the feet serve as the foundation for an upright posture, its stability and alignment are crucial. Long-term tissue pathology will result from a failure to recognize and address ankles and feet instability and misalignment. It appears that feet misalignment is a clear gait inefficiency, since it has been demonstrated to lower propulsive phase push off muscular strength by 35% **[8].** Pain, increasing deformity, and finally a decrease in activity level are all consequences of tissue strain. This lowers the body's metabolic rate, which raises the risk of heart disease, diabetes and obesity **[9,10].**

Walking on misaligned feet is less-than-ideal as muscles will have to work harder to lift the inner arch and sooner rather than later, pain will result, causing the weight bearing activity to be discontinued **[11].**

Children with Down syndrome need to continuous assessment and evaluation throughout their lives in order to improve their movements and overall lifestyle and avoid any complications that may occur such as obesity, cardiovascular disease, and diabetes **[12].** In addition, Current studies suggested that the Quality of Life for children with Down syndrome is lower than that of their typically developing peers **[13].**

Therefore, this study was conducted to detect the effect of foot misalignments on quality of life in children with Down syndrome.

2. Materials and Methods:

Forty children with Down syndrome from both genders [25 boys and 15 girls] participated in the study, they were recruited from outpatient clinic of Alfolk Charity Institution, Al-Gharbia governorate, their age ranged from eight to twelve years, they were able to understand simple command, they were able to stand alone and walk independently. The exclusion criteria included the children with severe mental retardation, children who had any foot surgeries for the last year, and children who are unable to assume steady standing.

This retrospective cross-sectional study was conducted from November 2022 to July 2023. The study received ethical approval from the ethical committee at the Faculty of Physical Therapy, Cairo University prior to starting [No.: P.T.REC/012/004658]. The study was conducted in accordance with the principles outlined in the Declaration of Helsinki for human research. Informed consent was obtained from the parents of each child, who were thoroughly informed on the study nature, objectives, and potential benefits. They were also informed of their right to decline participation or withdraw at any time, with a commitment to maintaining the confidentiality of their information.

For the Radiographic assessment; bilateral full weight bearing ankles and feet Plain X- ray was carried out for each child in both antero-posterior and lateral views. Upon the obtained X -ray film, the foot alignment angles from A-P and Lateral view were drawn indicating; Talo-calcaneal angle (25° - 40°), and Bohler's angle (25° - 40°), calcaneal pitch angle (10°-30°), talo-metatarsal angle (-4°, 4°) & calcaneal fifth metatarsal angle (2.3°-3.8°) **[14]**.

For quality of life assessment: The Oxford Ankle Foot Questionnaire for Children-Arabic Version [OxAFQ-Ar; Alotaibi et al., 2023 **[15]** was used to evaluate foot and ankle pathologies in children aged 5–16 years old. The Arabic version of the OxAFQ-c demonstrated evidence supporting its internal consistency, test-retest reliability and construct validity as a measure to evaluate foot and ankle pathologies.

The Oxford Ankle Foot Questionnaire for Children-Arabic Version (Arabic OxAFQ-C) include three main domains; physical domain that assess activity limitations as ability to stand and walk, school and play domain that assess participations restrictions in specific environmental contexts, and the emotional domain that assess the child's concerns about ankle and foot problems.

The parent version of the Arabic OxAFQ-C was used, as it was believed that the child version would not accurately detect the participants' responses due to their intellectual disability and age (e.g., 8-12 years). Each child's parents were asked the questions of each domain and their responses were scaled from zero indicating permanent

problem to four that indicates no problems. 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. Domain scores were transformed to a percentage scale (0-100) to aid interpretation. Better functioning is indicated as the domain score increases **[16]**.

The G*POWER statistical software was used to determine the sample size. The selected parameters included 5% probability of Type I error and a desired statistical power of 0.80. Previous research on similar populations was consulted to estimate effect sizes, with a conservative estimate used for adequate statistical power. A 10% potential dropout rate was also considered. The G*POWER software calculated a sample size of 40 participants to detect a significant effect, balancing statistical power and feasibility within the study resources and period.

For data analysis; descriptive statistics, including mean, standard deviation, minimum, maximum, and frequency, summarized subject characteristics. A one-sample t-test compared foot angles means and Arabic OxAFQ-C scores between study group and reference values. Pearson Correlation Coefficient assessed correlations between foot arch angles and questionnaire items, with $p < 0.05$ significance using SPSS version 25.

3. Results

Forty children with Down syndrome (25 boys (62.5%) and 15 girls (37.5%)) participated in the study. Their mean age ± SD was 9.75 ± 1.27 years with maximum of 12 years and minimum of 8 years.

The radiographic assessment of the feet and ankles angels revealed that there were significant differences among all the measured right and left angels (talo-calcaneal, Bohler's, 5th metatarsal base, and talo-metatarsal angels) and the normal references ($p<0.05$) with no significant difference between the right and left calcaneal pitch angels and normal reference ($p>0.05$) (**Table 1).**

Table (1): Comparison of study group mean values of the feet and ankles angles and reference value.

Angel (degrees)	Side	$\overline{X}$ ±SD	Reference value	MD	p-values
Talo-calcaneal angle	Rt	54.53 ± 11.29	32.5	22.03	0.001*
	Lt	55.73 ± 9.00	32.5	23.23	0.001*
Calcaneal pitch angle	Rt	18.63 ± 7.25	20	-1.37	0.24
	Lt	19.76 ± 7.95	20	-0.24	0.85
Bohler's angle	Rt	40.33 ± 5.74	35	5.33	0.001*
	Lt	36.93 ± 5.25	35	1.93	0.02*
5th metatarsal base angle	Rt	12.67 ± 7.5	3.05	9.62	0.001*
	Lt	12.27 ± 6.02	3.05	9.22	0.001*
Talo-metatarsal angle	Rt	11.98 ± 7.86	0	11.98	0.001*
	Lt	13.53 ± 10.79	0	13.53	0.001*

Rt = Right; Lt = Left; $\overline{X}$ = Mean; SD = Standard Deviation; MD = Mean Difference; p = probability; *= Significant with p value <0.05.

The Arabic OxAFQ-C scores mean + SD of the physical score was (46.25 ± 17.69), the school and play score was 63.5 ± 20.66, and the emotional score was 57.05 ± 16.63 which indicated significant reduction of the questionnaire three domains scores ($p<0.05$).

The correlation between the ankle and feet radiographic measurements and the Arabic OxAFQ-C three domains revealed varying relationships. The right Talo-calcaneal angle shows moderate positive significant correlations with physical ($r = 0.416$, $p = 0.008$] and school & play scores [$r = 0.401$, $p = 0.010$], as well as a moderate positive correlation with emotional score [$r = 0.370$, $p = 0.019$]. The left Talo-calcaneal angle also demonstrates a moderate positive significant correlation with school & play score [$r = 0.380$, $p = 0.015$]. In contrast, the right and left Bohler's angles exhibit weak positive non-significant correlations across all scores. The right Calcaneal pitch angle shows a moderate positive non-significant correlation with physical score [$r = 0.312$, $p = 0.050$], while the left Calcaneal pitch angle has a moderate positive significant correlation with physical score [$r = 0.386$, $p = 0.014$]. The 5th metatarsal bases angles present a mix of weak positive and negative correlations, with the right 5th metatarsal bases angle showing a moderate positive significant correlation with school & play score [$r = 0.315$, $p = 0.048$]. There were no significant correlations between the right and left talo-metatarsal angels and the scores of the OxAFQ all domains.

4. Discussion:

Ankle and foot deformities i.e. Hallux valgus and pes planus are often seen in children with Down syndrome and represents about 30% of pediatric orthopedic referrals that often lasts throughout adulthood **[17]**. These deformities may cause the children with Down syndrome develop out-toeing and a larger base of support **[18].**

The radiographic study revealed that there was significant difference of all measured angels except the calcaneal pitch angels compared with the normal references which indicates that the children with Down syndrome have a significant foot malalignment that includes hind foot pronation, mid-foot flattening, hallux valgus and forefoot malalignments.

This comes in agreement with Perotti et al., 2018 **[19],** who reported that radiographic assessments of the feet and ankles in children with Down syndrome indicate a greater occurrence of deformities compared to clinical examinations findings. However, it is essential to perform foot and ankle radiographs only in symptomatic cases where the child experiences pain and alterations in gait.

The study radiographic findings are parallel with Concolino et al., 2007 **[20]** who found that children with Down syndrome often exhibit pronated flat feet, a condition linked to pes planus characterized by excessive forefoot pronation. This is typically due to the presence of a primus varus metatarsus, along with a significant calcaneal valgus, which contributes to the pronation of the subtalar joint.

The parents- reported OxAFQ- Arabic version scores indicated significant decrease of the four domains. This may be due to pressure, pain and discomfort that induced by feet malalignments that were being detected by the radiographic assessment, which may affect their quality of life especially physical, school and play activities. In addition, the lowered quality of life scores may be due to improper fitting of the shoes wear by these children that may augment pain and falling resulting in disengagement in the daily activities especially during play and school activities.

In addition, our findings are consistent with Lobo et al., 2018 **[21]** who found that the poorly fitting footwear might have adverse outcomes including the development of foot pain, which may lead to impaired health-related quality of life and altered physical performance in children with Down syndrome.

Also, the correlation among the radiographic assessment findings and Arabic parents reported OxAFQ-C scores indicated that their children may have some restrictions in their engagements in different activities especially during playing and school-based activities which may be induced by hypotonia, laxity, easy fatigability and other health conditions present in children with Down syndrome.

The results of the present study align with the findings of Lim et al. 2015 **[22],** which indicated that children with Down syndrome with foot malalignments especially hallux valgus demonstrated significantly lower scores on the Oxford ankle-foot questionnaire, suggesting a notable decline in quality of life related to foot-related complications during school and play activities.

This is parallel with the study conducted by Alhammad et al., 2024 **[23]** who concluded that children who have Down syndrome were less able to walk and were highly associated with the worst possible quality of life, which included the lowest levels of physical, social, and school functioning.

There are limitations to the current study. Firstly, we were restricted to utilizing the parent version of the Arabic OxAFQ-C due to expected challenges in having children with Down syndrome independently finish the questionnaire. Secondly, the current study did not control all potential confounding factors that could influence the results i.e., the Body Mass Index BMI. Thirdly, the study may encounter issues related to causality, as it is unable to determine cause-and-effect relationships due to the data being collected at a single point of time. Finally, the current study may have temporal bias in which changes over time are not detected, making it hard to understand the dynamics of the studied variables.

5. Conclusion:

Children with Down syndrome often experience limitations in physical activities and reduced involvement in school-related activities due to foot misalignment. This condition can be identified early through standing radiographic assessments, allowing for intervention before the onset of pain and discomfort and can be alleviated with the use of properly fitted footwear.

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Conflict of interest:
The authors declare no conflict of interest.

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