Pilot Study: Effect of Developmental Dysplasia of the Hip on the Gait.

Veronika Vasilcová[1,2], Moqfa AlHarthi[2], Nadrah AlAmri[2], Ayman H. Jawadi[3],Martin Zvonař[1]

[1]*Faculty of Sport Science, Masaryk University in Brno, Czech Republic*

[2]*Pediatric Rehabilitation Service, King Abdullah Specialized Children Hospital, Riyadh, Saudi Arabia*

[3]*King Saud bin Abdul-Aziz University for Health Sciences, Riyadh, Saudi Arabia,*

ABSTRACT

Background: The objective of this pilot study was to assess the effect of Developmental Dysplasia of the Hip (DDH) on gait, in pediatric participants, between the age of one to four years. Few studies are investigating the effect of DDH on the walking pattern within the pediatric rehabilitation practice. From an early age, children are developing a longitudinal foot arch. Constantly changing pediatric foot posture must be assessed. Gait pattern and foot posture are one of the most common parental concerns.

Methods: The retrospective review of gait analysis, performed on 410 lower limbs, took place in King Abdullah Specialized Children Hospital (KASCH) in Riyadh, Kingdom of Saudi Arabia, from April 2020 until September 2020. All participants were diagnosed with DDH by pediatric orthopedics physicians in KASCH. Gait analysis was done by a physical therapist twice within three months, using The Wee Glasgow Gait Index (WeeGGI) and foot assessment was done once using Foot Postural Index (FPI-6). The WeeGGI compares eleven gait parameters. Each parameter has a choice of three figures, where each one has a clear explanation and/or value. The FPI-6 evaluates the foot as multi-segmental complex, in double leg support, characterizing pronation with + (plus) and supination with - (minus) numbers. Scoring is 2 (two) points in all six factors it is divided into rearfoot and forefoot assessment in transverse, frontal/transverse, frontal, and sagittal planes.

Results: From all gait analyses (n = 410). We included only 292 (71%) lower limbs with DDH and had to exclude 60 (15%) after hip surgery, 30 (7 %) with another diagnosis, 18 (4%) without conservative treatment of DDH, and 10 (3%) with age above 48 months. According to the scoring of the Wee Glasgow Gait Index within the optimum/normal limits (score 0 – zero), we had 50 (17%), mild deviation (score 1–11) 236 (81%), and gross deviation (score 12–22) had 6 (2%) limbs within first gait analysis. With second gait analysis, 40% of lower limbs

were within optimum/normal limits, 60% with mild deviation in gait, and zero within gross deviation. Every limb assessment for gait had the Foot Postural Index as well. Within normal limits (0 till +5) 143 (49%) feet, pronation (+6 till +9) was presented in 97 (33%) and high pronation (more then +10) had 52 (18%) pediatric feet. This sample did not present supination (-1 till -4) or high supination (-5 till -12). Limping was observed within 102 (35%) of the legs. The frequency of W-sitting presented in 47% of the results. The first and second gait analysis suggest an effect of DDH on the gait with a small difference between the right and left leg, although the left side was affected more within both gait analyses.
Conclusion: Pathological gait pattern with DDH was detected in 83% within the first gait analysis, 60% within the second gait analysis, and Foot Postural Index revealed pronation of 51% feet. Among Saudi participants, a relatively high effect of DDH on gait patterns is reported in this pilot study.

Keywords: DDH, gait, FPI-6, physiotherapy, WeeGGI

INTRODUCTION

Developmental Dysplasia of the Hip (DDH) can be described as an abnormality of the articular or/and periarticular structures. The biomechanical point of view is defined by hip instability, acetabular abnormalities, and capsular laxity (Marinela, 2013). The posture of the pediatric foot had been explained by footprint in many published research. From early childhood, children are developing a longitudinal foot arch, in compare with the adult arch. Constantly changing pediatric foot posture must be assessed, during every milestone stage, and any change in patient health, such as hypotonia, hypermobility - developed as non-specific, or other syndromes, such as Down syndrome, must be noted in a patient chart (Gijon-Nogueron, Martinez-Nova, Alfageme-Garcia, Montes-Alguacil, & Evans, 2019).

Zgoda et al. in 2009, published a study, about the effect of DDH conservative treatment, with abduction braces, and the effect on locomotion, in comparison with the healthy group. The conclusion revealed that conservative treatment of DDH does not cause locomotor delay and participants with DDH start to walk, only three weeks later than healthy participants (Zgoda, Wasilewski, Wasilewska, & Golicki, 2009).

Pediatric patients with treated DDH in comparison with healthy children are showing abnormal gait pattern with its effect on posture, knee and ankle joints. Repetitive high loading rates at lower limb joints were presented at heel-strike phase (Lee, Chen, Hung, Wang, Chang, & Lu, 2021).

Evans (2012) critically reviewed, in her commentary, the importance of foot screening for pediatric candidates based on screening programs developed by the World Health Organization (WHO). It's revealed that screening for flat feet in a pediatric patient, should be as important as screening for DDH (Evans, 2012). Gijon-Nogueron et al. (2019) mentioned the absence of flat feet definition, which is leading to different opinions and a lack of unity on the best treatment plan. Gait pattern and foot posture are one of the most common parental concerns. Regardless of the evidence, that flat feet at pediatric age are a concern of many parents, the published treatment plan is weak (Gijon-Nogueron, Martinez-Nova, Alfageme-Garcia, Montes-Alguacil, & Evans, 2019). Limping gait is another reason for a parent to make an appointment with a general physician or other health care professionals (Raja, Khan, & Waheed, 2020). Every foot deviation may indicate the pathology or dysfunction in other body sections (Oleksy, Mika, Łukomska-Górny, & Marchewka, 2010).

Early physical therapy for DDH infants presents an extensive role in developing proper milestones. Parent plays an essential role in physical therapy treatment plan, especially with Vojta therapy, as a home program. The results revealed improvement in complex factors in local and general milestone development (Marinela, 2013).

The aim of this pilot study was to assess the effect of DDH on gait and feet posture, in pediatric participants, between the age of one to four. Project hypothesis were: H1 DDH affect gait and foot posture of children from one to four years. H2 DDH affects lower limb and feet unilaterally. There are few studies investigating the outcome of DDH on gait appearance within the pediatric rehabilitation practice. They focused on a different part of the gait pattern.

METHODS

The pilot study was conducted at the Pediatric Rehabilitation Clinic at King Abdullah Specialized Children Hospital (KASCH) Riyadh, Kingdom of Saudi Arabia (KSA). King Abdullah International Medical Research Study, Riyadh, KSA we obtain IRB approval number SP21R/364/06 and the Ethics Committee, approval EKV-2021-018 by The Masaryk University Research Ethics Committee, Brno, Czech Republic. We retrospectively reviewed 410 gait analysis from April 2020 until September 2020. All participants were followed by one of the outpatient physiotherapists, with a physician referral from one of the outpatient clinics in KASCH. We suggest using gait and foot analysis to improve pediatric physiotherapy outcome measures and enhance patients' discharge. Physical therapists performed gait analysis at least twice within three months using the Wee Glasgow Gait Index (WeeGGI).

- Including criteria:
    - a) participants one to four years of age,
    - b) DDH diagnosis,
    - c) at least two gait analyses within three to six months.
- Excluding criteria:
    - a) hip surgery,
    - b) less than two gait analyses,
    - c) age above four years,
    - d) participants with other diagnoses.

The corridor of the Pediatric Rehabilitation Unit in KASCH was prepared for gait analysis, and foot posture was observed in one of the treatment rooms. Participants were assessed barefoot on a hard floor, walking for at least ten steps independently without support or holding a wall/parent/walker, and with no specific equipment. Parents agreed with gait and feet analysis by signing informed consent Ethical approval.

The WeeGGI is a gait assessment and screening tool intended for the clinical setting and any clinicians. It is an easy observational tool to assess any gait deviation from normal at specific phases of the cycle, a demonstrative form on two A4 pages (Tennant, Wiggins, Read, & Meadows, 2012). The WeeGGI is comparing eleven gait parameters. Each parameter has a choice of three figures, where each one has a clear explanation and/or value. Scoring is for every parameter or figure is a must, optimum/normal position is marked by zero (0), a mild deviation is one (1), and two (2) is for gross deviation. The scale of 22 points considers scoring of all eleven parameters. The highest score suggests affected gait pattern, and it should be the indication for physical therapy (Tennant, Wiggins, Read, & Meadows, 2012).

The FPI-6 evaluate the foot as multi-segmental complex, in double leg support, characterizing pronation with + (plus) and supination with - (minus) numbers. Scoring is 2 (two) points in all six factors it is divided into rearfoot and forefoot assessment in transverse, frontal/transverse, frontal, and sagittal planes. Rearfoot analysis content Talar head palpation in the transverse plane, curves above and below the lateral malleolus in frontal/transverse position, and inversion/eversion of the calcaneus in frontal view. Forefoot factors were prominence in the region of the talonavicular joint (TNJ) in the transverse face, congruence of the medial longitudinal arch in the sagittal plane, and abduction/adduction forefoot on rearfoot in transverse view (Redmond, Crane, & Menz, 2008) (Gijon-Nogueron, Martinez-Nova, Alfageme-Garcia, Montes-Alguacil, & Evans, 2019).

DDH was diagnosed by the pediatric orthopedics clinic in KASCH using pelvic radiographs. In Saudi Arabia, a pelvic radiograph was performed by a radiography technician supervised by a radiology consultant, and the results are inserted in Best Care Medical System by a radiographic physician (Vasilcova, et al., 2022). The acetabular angle using the Hilgenreiner line should be <28° at birth. It should become progressively shallower and measure <22° beyond one year of age (Weerakkody, 2005).

The collected data were entered, reviewed, and analyzed. Descriptive statistics are presented as frequencies and percentages (%). Statistical analysis was carried out using Statistical Package for Social Science version 24 (IBM Corp., Armonk, New York, USA).

RESULTS

We review 410 gait analyses done by the pediatric physiotherapy team in KASCH. Each reported assessment was for the right or/and left lower limb. From all gait analyses (n = 410), only 292 (71%) with DDH included and 60 (15%) after hip surgery, 30 (7%) with another diagnosis, 18 (4%) without conservative treatment of DDH, and 10 (3%) above 48 months we excluded (Table 1). Among attendants with DDH were 56 (19%) males and 236 (81%) females (Table 2).

Table 1 Demographic information

Gait analyses	Total sample (%)
DDH	292 (71%)
Hip surgery	60 (15%)
Another diagnoses	30 (7%)
No conservative treatment	18 (4%)
Above 48 months of age	10 (3%)

The youngest attendant had 11 months of age, one male and three females, and the oldest was male 29 months old. The median age for males was 13,5, and the median for females was 14 months. Right side DDH presents in 128 (44%), left DDH in 140 (48%), and bilateral DDH had 24 (8%) hips. We Collected demographic information on avascular necrosis of the femoral head, which presented in only 0,5%. Limping was observed within 102 (35%) of the legs. Lower limb discrepancy is present in 8 (3%). According to our collection of demographic information the frequency of the W-sitting presented in 47% of the results. More demographic data are in Table 2.

Table 2 Demographic information

Demographic information	Categories	Total sample (Median, %)
Age	Male	13,5
	Female	14
Gender	Male	56 (19%)
	Female	236 (81%)
Side of DDH	Right side	128 (44%)
	Left side	140 (48%)
	Bilateral DDH	24 (8%)
Step position	In-toeing	14 (5%)
	Out-toeing	68 (23%)
Coxa valga/vara presentation	Coxa valga bilateral	8 (3%)
	Coxa valga Rt	4 (1%)
	Coxa valga Lt	4 (1%)
	Coxa vara Rt/Lt/bilateral	0
Avascular necrosis of the femoral head	–	2 (0.5%)
Limping gait pattern	–	102 (35%)
Lower limb discrepancy	–	8 (3%)
W-sitting position	–	138 (47%)

According to the scoring of The Wee Glasgow Gait Index within the optimum/normal limits (score 0 zero), we had 50 (17%), mild deviation (score one until 11) had 236 (81%), and gross deviation (score 12 till 22) had 6 (2%) lower limbs within first gait analysis. With second gait analysis, we received 242 filled forms with results: 40% with optimum/normal limits, 60% with mild deviation in gait, and zero with gross deviation (Table 3). Every leg assessment for gait had the Foot Postural Index too. Within normal limits (0 till +5) we had 143 (49 %) feet, pronation (+6 till +9) was presented in 97 (33%) and high pronation (more then +10) had 52 (18%) pediatric feet. Supination (-1 till -4) or high supination (+5 till -12) was not detected within this sample (Table 3).

The project hypothesis assumes the effect of DDH on gait and foot posture. Another hypothesis concludes that DDH affects the feet unilaterally results described in graphs 3 and 4. We assess both lower limbs for gait analysis separately to see if DDH affects gait unilaterally. In line with our results no big difference between the right and left limbs. Within the first gait analysis (n = 292), optimum/normal results had 24 (8%) right and 26 (9%) left legs, mild deviation presented 119 (41%) right and 117 (40 %) lower limbs, and gross deviation showed 2 (0,5%) right and 4 (1%) left legs (Table 3). During the second round of gait analysis from the same sample, we had 242 (first gait n = 292) results for evaluation.

Optimal/normal results were observed in 49 (20%) the right and 48 (20%) left lower limbs, mild deviation presented in 65 (27%) right and 80 (33%) left legs, and gross deviation of zero on the right and left limbs (Table 3). The first and second gait analysis suggest effect of DDH on the gait with a small difference between the right and left leg, although the left side was affected more within both gait analyses. These results support our hypothesis. However further studies are required and needed.

Table 3 Right and left lower limb with first and second gait analysis.

Lower limb side	WeeGGI 1 normal	WeeGGI 2 normal	WeeGGI 1 mild deviation	WeeGGI 2 mild deviation	WeeGGI 1 gross deviation	WeeGGI 2 gross deviation
Right LL	24 (8%)	49 (20%)	119 (41%)	65 (27%)	2 (0.5%)	0
Left LL	26 (9%)	48 (20%)	117 (40%)	80 (33%)	4 (1%)	0

*Results are in total number of lower limbs and %.

Every leg with gait analysis (n=292) had FPI-6 as well. Within normal limits (0 till +5) we had 143 (49%) feet, pronation (+6 till +9) was presented in 97 (33%) and high pronation (more then +10) had 52 (18%) pediatric feet. Supination (-1 till -4) or high supination (+5 till -12) was not detected in this sample (Figure 4). FPI-6 was done separately for the right and left foot. Results in normal range had 70 (24%) right and 73 (25%) left, pronation was measured in 49 (17%) right and 48 (16%) left and high pronation had 27 (9%) right and 25 (9%) left feet (Table 4, Figure 4). The right foot posture was more affected than the left foot. Although more research is needed, these results support our hypothesis that DDH affects foot posture unilaterally.

To detect the effect of DDH, we divide both analyses for the right and life sides and compare them (Table 4, Figure 4). The highest difference was within the result of gross deviation and high pronation. WeeGGI for the right lower limb was 2 (0,5%) FPI-6 high pronation in 27 (9%) of right feet. 4 (1%) left pediatric legs had gross gait deviation, and 25 (9%) had high left pronation. The result suggests no effect of high pronation on the gait pattern. Outcomes for mild gait deviation and feet pronation, the right WeeGGI 119 (41%) and right FPI-6 49 (17%), for left WeeGGI 117 (40%) and left FPI-6 48 (16%) with outcomes that mild gait deviation is not affecting the foot posture on either side. These results suggest that feet posture may not affect the gait and vice versa, but both gait and feet posture might be affected by DDH.

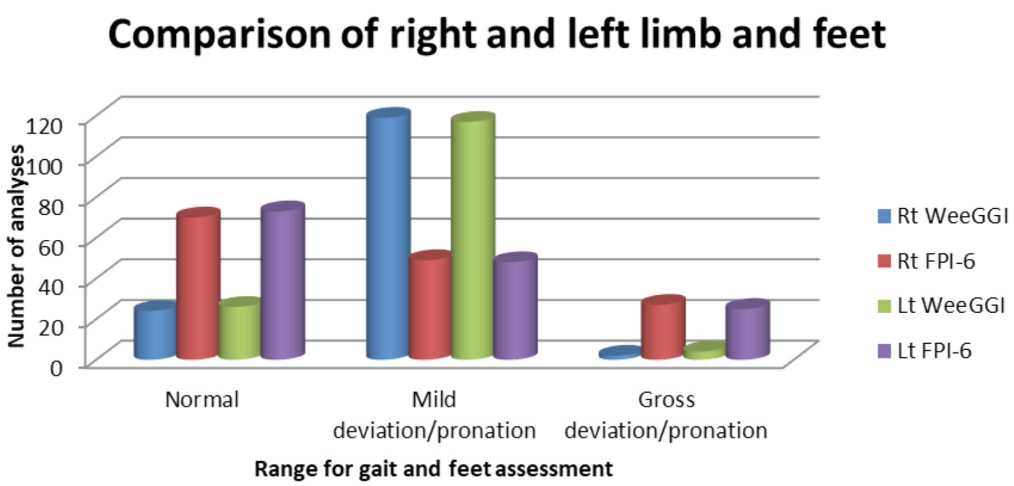

Figure 4. The Wee Glasgow Gait Index and Foot Postural Index analysis comparison

Table 4 The Wee Glasgow Gait Index and Foot Postural Index analysis comparison

Results description	Right WeeGGI	Right FPI-6	Left WeeGGI	Left FPI-6
Normal	24 (8%)	70 (24%)	26 (9%)	73 (25%)
Mild deviation/pronation	119 (41%)	49 (17%)	117 (40%)	48 (16%)
Gross deviation/pronation	2 (0.5%)	27 (9%)	4 (1%)	25 (9%)

*Results are in total number of lower limbs and %.

DISCUSSION

This Pilot study revealed the effect of DDH on gait in pediatric participants between the age of one to four years. Zgoda et al. (2010) focused on DDH's influence on sitting and walking according to milestones. In our study, we did not collect data for sitting, but our youngest patients for gait analysis were one male at 11 months old and three females' same age. Zgoda et al. (2010) mean age of walking for DDH patients was 12 months and two weeks, with considerable difference between males and females. Another study by Kamath (2004) states the delay between DDH and the healthy group for one month. Our study did not notice a delay in walking. Where Dunn's (1990) publication states that 53% with abnormal gait pattern and walk delay up to 18 months (Zgoda, Wasilewski, Wasilewska, & Golicki, 2009) (Kamath & Bennet, 2004) (Dunn, 1990).

Oleksy et al. (2010) highlight the importance of foot assessment and the effects of other deformities in the body. They are not specifying diagnoses or other pathology. Oleksy et al.(2010) article describes the efficiency of FPI-6 and suggests its accuracy. Together with other authors, they demonstrate an easy use for any clinic and profession (Oleksy, Mika, Łukomska-Górny, & Marchewka, 2010). We were able to use only one FPI-6, as the second analysis contain missing information due to rotation of the staff in our services or covering primary therapist during vacation or leave, that is why we agree with the statement of Oleksy et al. (2010) that one of the crucial aspects on proper measurement is "the experience of each therapist" for a particular age of participants.

Our gait and foot pathology correlates with a description of gait pattern for DDH patients in Lee at all (2021) publication. Heel-strike transition increased the swift in the ground reaction force (GRF) with the impact of the foot when the velocity dropped to zero. By revising the force at which the foot (endpoint) and the limb proceed to the floor, we can control the GRF. Besides, the inaccurate swing phase of lower limb joints leads to elevated loading of GRF (Lee, Chen, Hung, Wang, Chang, & Lu, 2021). Toddlers and preschoolers are growing and learning gross motor skills. Therefore, with any diagnosis or disease, they are exposed to compensation movement. With DDH, a problem in the hip joint, their gait pattern is affected. The foot control is significant for heel contact during the heel-strike phase to reduce GRF loading rates on other joints.

Our study includes patients after conservative treatment of DDH. De Pellegring et al. (2021) research focused on double diapering for a newborn to avoid adduction and extension of lower limbs at newborn age (De Pellegrin, Damia, Marcucci, & Moharamzadeh, 2021). Their article describes the difference between some populations and the occurrence of DDH. African population culture keeps newborns in flexion, abduction hip position, without DDH presence in newborns or adults. But cold climate countries such as Canada, Japan, and Northern China are swaddling newborns with extended and adducted hips/lower limbs with increased risk of DDH. The same swaddling technique is popular in Saudi Arabia as well. To improve the awareness of swaddling DDH and foot pronation among the kids, it's necessary to start with parents and public education at the clinic and through social media too (De Pellegrin, Damia, Marcucci, & Moharamzadeh, 2021) (Para, Batko, Ippolito, Hanna, & Edobor-Osula, 2021).

These publications, research, and projects are opening doors to many new ideas in preventing possible complications for all pediatric patients with DDH or with a high risk of DDH. After reviewing gait analysis for DDH patients within this pilot study, it is clear that participants with left hip DDH are at risk of developing gait pathology on the same lower limb. Comparison of gait analysis between participants with DDH and healthy participants will be the most appropriate next step within this project.

Further studies should include all participants with developmental dysplasia of the hip, diagnosed with other diagnoses after surgery, and referred orthopedic and other clinics. One of the projects is to create a gait screening tool for all patients at rehabilitation practice in KASCH, to prevent further complications and to establish a discharge tool.

Limitations

As with any analysis study, this study has limitations. The main limitation was that multiple therapists analyzed gait and foot posture and missing information in patient documentation. This study was carried out during the Covid-19 pandemic. The follow-up booking for patients was limited to acute patients, and many booked appointments were canceled. A therapist with different experience levels may need help analyzing gait or foot pathologies, what was during the Covid-19 pandemic problem due to limited therapists at the pediatric physiotherapy outpatient clinic.

CONCLUSION

Pathological gait pattern was detected in 83 % within the first gait analysis, 60 % within the second gait analysis, and Foot Postural Index revealed pronation of 51 % feet. Among Saudi participants, a relatively high effect of DDH on gait patterns is reported in this pilot study.

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Corresponding Author:

veronika.vasilcova@gmail.com;