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ORIGINAL ARTICLE

Comparing the Effectiveness of an Insole against the De-Torsion Straps on Symptomatic in-Toeing Gait of Children Presented at the Iraq Orthosis/Prosthesis Centres

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ABSTRACT

Background: *In-toeing gait sometimes may leads to increase the susceptibility of fall in growing children. Rotational profile of the lower limbs usually follows a pattern toward the improvement with time. As a result, most children with in-toeing gait do not require intervention and if any it is minimal and should be withdrawn upon disappearance of its indication.*

Objectives: *The purpose of this study is to present the effect of two types of orthoses, de-torsion straps and an insole, to reduce risk of fall. In addition to compare these effects on children.*

Patients and methods*: A 50 children with in-toeing gait were assigned randomly into two groups. The control group children were prescribed a de-torsion strap orthosis, while those in the study group was prescribed a medial wedge insole. Children with a pathological cause of the in-toeing gait were excluded. Those include children with cerebral palsy, Blount's disease, a metabolic cause and those with surgical intervention. A goniometer was used to measure the angles of rotation and range of motion. The data that were collected included age, gender and consanguinity, internal and external hip rotation angles, thigh foot angle and foot progression angle.The efficacy of an orthosis was assessed one month after using it by a questionnaire.*

Results: *A total of 50 children enrolled in the study with a mean age of 5.7 years, 70% were females. The mean of the foot progression angles before using the orthosis was -9.8 degree and after using it became 1.4 degree. The fall had been reduced from its mean of 2.7 times per day to 2.2 times per day. The average number of hours that the children wear an orthosis was 3.7 hours per day.*

Conclusion: *It has been found that both types of orthoses that used in the study were effective in reducing the chance of fall. However, the insole was used over a longer period in the day which reflect the children preference to it which in part may be because of its low profile. Also, the longer the orthosis worn the lower the average number of falls.*

Keywords: ***In-Toeing Gait, Symptomatic, Treatment, Insole, De-Torsion Straps, Children, Iraq***

1. INTRODUCTION

In-toeing gait is one of the most common gait deformities in children, which has an incidence of 4.6 to 30 percent. It is defined as the inward rotation of the foot relative to the line of progression of the body during walking. Children with this type of gait pattern commonly walk with the feet turned inward as if they were searching for the opposite feet. It could be caused by a combination of several reasons including femoral anteversion, internal tibial torsion, metatarsal adduction, resulting in a lower quality of life and restriction of previous physical activities (1). In-toeing gait could also have a psychological impact on children because of the tendency to be teased by friends for “funny walking”. Despite this disorder is usually seen in early childhood, some children are still unable to get rid of this gait pattern after they become school-aged. After screening for the said category, these children are considered symptomatic in-toeing gait. Upon reviewing relevant studies on the treatment of symptomatic in-toeing gait, only two conservative treatments have been recognized: insoles and ankle-foot orthoses (de-torsion straps). There were inconsistent choices and results of using these two treatments across various studies treating the same category of children (2,3). Thus, this study focuses on comparing the effectiveness of insoles and de-torsion straps in treating symptomatic in-toeing gait in children. In order to understand the mal alignment of the lower limbs, a doctor must have the knowledge of the embryologic development of the musculoskeletal system (4). First, the limb buds begin to develop in the 5th week of gestation (5). Then, in the next week flattening of the buds would occur which would lead to the formation of the terminal hands and feet plates. The plates represent the basic shape of the external limbs. Eventually, the axes of the upper and lower buds become parallel to each other. This happens in the 7th week of gestational age. These buds would continue to rotate in a specific pattern, the upper buds rotate externally while the lowers rotate internally. The rotational movement brings the big toes to the midline (4,6). The intrauterine development would cause hip external rotation, tibial internal rotation, while the feet could rotate in either direction (5,6). At birth there is 30-40 degrees of femoral ante-version. This degree would decrease by the adolescence to reach 10-15 degree. However, most of this rotation accomplished before the age of 8 years (6,7). Child evaluated through full history and physical examination.The

importance of the natural history lies in the fact that a doctor must decide which case is normal (version) and which is abnormal (torsion) (6). Functional problems could rise from the in-toeing gait and the most common one of them is frequent tripping and falling (8). According to Staheli, the child rotational profile should be documented (9). The profile consists of five angles; internal and external hip rotation angle, thigh-foot angle, transmalleolar angle, heel bisector angle and foot progression angle. Each angle are specifically measured. Thigh foot angle and transmalleolar angle are used to measure tibial version, (9–13). The heel bisector angle is used to determine the foot deviation direction (in-toeing or out-toeing) and its degree (14,15). The foot progression angle is assessed during walking. It lies between the straight line of gait and the line that cross the foot. It is negative if there is an in-toeing (5,16). History and physical examination are usually sufficient to plan an approach. However, imaging sometimes needed if there is a pathological cause or when the torsion is progressive and requires a surgery for correction. Antero-posterior view X-ray of the pelvis could delineate a coxa valgus due to femoral ante-version (17). Functional evaluation of the degree of the femoral ante-version is possible by the fluoroscopy. It is evaluated by rotating the femur until a true antero-posterior view is gained (18). The best imaging used to measure the femoral ante-version is the computed tomography. However, because of the radiation, its use is limited to complex deformities or when surgery is planned (19,20). When the angle of the femoral ante-version is significant, ultrasonography is less accurate and underestimating the actual degree (21). On the other hand, ultrasonography is regarded as more accurate and reliable than clinical methods when assessing the true tibial torsion apart from tibiofibular torsion (22). Management includes two approaches are there: conservative and surgical; mainstay of Non-surgical approach is the reassurance (23). The fact that should be reinforced is that twister cables, night splints, special shoes or orthotics should not be prescribed especially, to an in-toeing gait due to femoral ante-version or tibial torsion. This is because of the natural benign course of these conditions (24,25). However, children who fall could benefit from insoles to reduce the possibility of tripping but not reversing the ante-version or the tibial torsion (26). In addition, some of the patients who have a congenital condition or those with CP could be prescribed an orthosis to help them with gait problems

(27,28). The surgical intervention of choice is de-rotation osteotomy which reserved for conditions with severe and persistent rotational abnormalities (29,30).

2. METHODOLOGY

This was a randomized controlled trial performed at Sader Al-Qanat's Center for Prosthetics and Orthotics/Baghdad during the period between January 2021 and October 2021. An approval from the Iraqi Board for Medical Specializations have been granted upon a proposal presentation.

The study included 50 randomly selected children

Inclusion criteria

1. Children had idiopathic in-toeing gait not associated with any congenital or acquired syndrome or disease with a parents' concern due to falling.
2. Age range from 3 – 10 years.
3. Both genders

Exclusion criteria

A child was excluded if he/she

1. Never fall
2. Child with metatarsal adductus
3. Any child with CP, Blount's disease, metabolic diseases or those who had a surgery for club foot.

The children then assigned randomly into two groups with 25 children in each;

1. Control group received the traditional de-torsion strap orthosis,
2. Study group received a medial wedge insole.

Data collected through full history taken and thorough clinical examination, Demographic data had been collected, include the name, age, gender and consanguinity (a parent or a relative). A clinical examination was conducted on the children. A goniometer was used to measure the range of motion angles.

After obtaining a consent from the parents, an orthosis or insole was prescribed. The de-torsion strap orthosis consists of a waist belt attached to it two elastic straps of a length that

allows them to twist around the leg and being fixed to the outer surface of shoes, it is prescribed to the control group.

In the study group, a medial wedge insole had been prescribed.

A questionnaire also used to assess the efficacy of either orthoses. The questionnaire consists of four questions which were rated on a scale from 1 to 5 for each question, according to Likert's method (31). One of the questions examined the parents' satisfaction by scaling the response into 1: effective, 2: rather effective, 3: rather ineffective, 4: ineffective, 5: do not know. The other three questions measured the number of falls before and one month after wearing each orthosis, in addition to the number of hours of wearing it according to both parents and the child response.

The ROM angles that had been collected include right and left internal hip rotation angle, right and left external hip rotation angle, right and left thigh foot angle (for tibial torsion). The immediate foot progression angles of the bare feet and that after wearing the orthosis also collected for the right and left feet.

Statistical analysis was performed with SPSS software version 28, and appropriate statistical tests and analyses were performed accordingly at a level of significance of ≤ 0.05.

3. RESULTS

A total of 50 children enrolled in the study, 25 of them were in the control group and 25 in the study group. 70% of all children were female (35) while only 30% were male (15). The mean age was 5.782 years and the standard deviation was 1.7692. Among the 50 children, 74% were accompanied by their parents, whereas 26% were accompanied by a relative (**Table 1**). The parent satisfaction was an ordinal variable. The parents gave a response about the effect of the orthosis on their children susceptibility to fall. More than half of the responses were effective (52%). 36% of the responders stated that the orthosis was rather effective. Only 3 of the responders stated that orthosis was rather ineffective and 2 of them stated it was ineffective, (**Table 2**). The angles of the range of motion of all children were similar in the left and right sides. For that reason, a single measure, which is of the right side, had been used to obtain the descriptive results and in different statistical tests. The mean of the foot progression angle of the feet before wearing the orthosis was at -9.86 degree. After wearing either type of orthoses, the mean became 1.44 degree. Average fall of the children

was 2.72 times per day before any intervention which reduced to 2.28 times per day after wearing either type of orthoses. The children were using both types of orthoses for an average of 3.7 hours in 24 hours A paired t-test was conducted between the means of the falls before and after wearing both orthoses. The result of the test was highly significant with a P value of <0.001). An independent t-test comparing the means of the number of falls before and after wearing each type of orthosis (the de-torsion straps and the insole) was calculated. The P value for the fall before the orthosis was 0.365, while that of fall after orthosis was 0.143. Another independent t-test compared the means of the number of hours wearing the orthosis of both the de-torsion straps and the insole, (P value <0.001). A chi-square test was used to investigate the results of the parents' satisfaction between the control and the study group across all responses. 26 of the responders said the orthosis was effective, 18 said it was rather effective, 3 said rather ineffective and 2 gave an ineffective response. The result of the chi-square test was a P value of 0.057 between the control and the study groups. A Pearson correlation test was checked the relation between the foot progression angle without orthosis and hip internal rotation angle once and a second test assessed the relation between the foot progression angle and the thigh foot angle. The results were -0.311 and 0.110 respectively. Another correlation test examined the association between fall after wearing orthosis and number of hours wearing it. The result of the test was significant at -0.356 (**Tables 3,4,5 & 6**).

Table 1. Baseline characteristics of the studied group (N=50)

Variable		No.	%
Age (year) / mean (SD)		5.78 (1.77)	-
Gender	Female	35	70.0
	Male	15	30.0
Consanguinity	Parents	37	74.0
	Relatives	13	26.0

Table 2. Parents' satisfaction table of responses

Satisfaction	No.	%
Effective	26	52.0
Rather effective	18	36.0
Rather ineffective	3	6.0
Ineffective	2	4.0
Don’t know	1	2.0

Table 3. Changes in right Bare FPA and number of falls before and after orthosis and the mean number of hours wearing orthosis

Variable		Mean	P. value*
Right Bare FPA	Before orthosis	-9.86	<0.001
	After orthosis	1.44	
Number of falls	Before orthosis	2.72	<0.001
	After orthosis	2.28	
Number of Hours wearing orthosis		3.70	-

*paired t test used in comparison

Table 4. Comparison of number of falls before and after orthosis in both studied groups

Variable		Control (n = 25)		Study (n = 25)		P. value
		Mean	SD	Mean	SD	
Number of falls	Before orthosis	2.76	0.831	2.68	0.802	0.937
	After orthosis	2.44	1.083	2.12	1.013	0.554
Hours of wearing orthosis		3.08	0.64	4.32	0.557	<0.001

Table 5. Cross tabulation of the parents' satisfaction

Parents' satisfaction	Control (n = 25)		Study (n = 25)		Total	
	No.	%	No.	%	No.	%
Effective	18	72.0	8	32.0	26	52.0
Rather effective	6	24.0	12	48.0	18	36.0
Rather ineffective	1	4.0	2	8.0	3	6.0
Ineffective	0	0.0	2	8.0	2	4.0
Don't know	0	0.0	1	4.0	1	2.0
Total	25	100.0	25	100.0	50	100.0

Pearson Chi-Square = 9.179, P. value = 0.057,
Likelihood Ratio = 10.485, P. value = 0.033

Table 6. Results of bivariate correlation analysis of different studied parameters

Parameter	statistics	FPA	Fall After Orthosis
Right Hip IRA	R	-0.311*	-
	P. value	0.028	-
Right TFA	R	0.11	-
	P. value	0.446	-
Number of hours wearing orthosis	R	-	-0.356*
	P. value	-	0.011

FPA: Right Bare Foot FPA, R: Pearson Correlation, *significant

4. DISCUSSION

While in-toeing gait in children could be caused by many congenital, developmental and metabolic pathologies, the idiopathic one is regarded as a natural variant which implies no need for intervention with just reassurance (32). However, when a child starts to fall more often due to tripping with the other foot, this could herald a change in the normal developmental milestones. As a result, an orthosis could be used to reduce or prevent a fall. The usual type of orthosis that prescribed in Iraq orthosis and prosthesis centers for such a condition is the de-torsion straps (another name is de-rotator. This orthosis was originally indicated for an in-toeing gait due to CP (33). This study introduced another type of orthosis

which is an insole, a medial wedge insole specifically. Originally, this type of orthosis is prescribed to patients with knee joint osteoarthritis (34). The insoles are more subtle type of orthosis, easer to manufacture, movable so it can be refitted within different shoes and may be more acceptable by a child. The sample of the study showed that 2/3rd of the randomly selected children was of a female gender. Verch R et al also noticed in their large cohort study that gender is a major influencer (35). The age of the presentation was around 6 years which is agreed with the results of a study by Thackeray and Beeson (36). It is partly explained by the fact it is one of the stages of developmental progression. Most of the children included in this study were accompanied by their parents, about (¾th) which could reflect their feelings about the seriousness of the condition. The correlation of the negative foot progression angle (an in-toeing gait) with the degree of internal rotation angle of the hip was highly significant, while with thigh foot angle was not. This interpreted as the femoral ante-version is the most common cause of in-toeing gait. This relation also recorded by Fabry G et al. (13). To examine the hypothesis proposed by this study, the effectiveness of both orthoses had been tested. It has been found that the insole orthosis was effective in reducing number of falls as well as the de-torsion straps, which was confirmed by the paired t-test. Although most of the studies on the de-torsion straps was conducted on the children with cerebral palsy, it showed a good response to treatment with favorable effect on gait pattern (33). In addition, the medial wedge insole measure of effectiveness was comparable to a study conducted by Mouri et al. (26) and confirmed by its biomechanical effect on the foot by a study conducted in Boston university (37). Of note, there was no significant difference between the effectiveness of both orthoses by the independent t-test results. This would provide the freedom of choosing either orthosis to reduce the number of falls in children with in-toeing gait. It was noticeable that the children who wear an orthosis, whether a de-torsion straps or an insole, more hours in the day benefit the most. This had been confirmed by the correlation test between the number of hours and the number of falls after wearing of both orthoses. When breaking this result down further by the independent t-test, it can be found that children who prescribed the de-torsion straps wear it less than those who prescribed the insole. The mean of number of hours in the control group was about 3 hours a day, while that of the study group was more than 4 hours a day.

When combining the previous results of the effectiveness in term of number of falls after wearing the orthosis and the number of hours wearing it, it can be concluded that children could be more comfortable with the insole orthosis and thus would benefit from it more than that with de-torsion straps. The comfortable level of an insole is related to its pressure reducing effect on the foot (38). Although most of the parents stated that the orthosis was effective for both groups, the control group responders outnumbered those of the study group. This could be explained by the more subtle effect of the insole in the study group and the more apparent and immediate effect in the control group. The drawbacks of this study include the small number of the sample which is limited by the time frame of the study. Also, the subjective response of the participants and their parents about the susceptibility and number of falls. Another part is the bias in how the children was selected for each group which could compromised the blindness of the study. On the technical side of view, the reliance on the clinical methods in measuring and assessing the angles pre and post the intervention played a role in the possible marginal inaccuracy of the results. In addition, the different technicians that was involved in the study could affect the final result of the de-torsion straps or the insole and thus their effect on the in-toeing gait and falls.

5. CONCLUSIONS

Femoral anteversion is the most common cause of idiopathic in-toeing gait, both the de-torsion straps and the insole, are effective in reducing falls in children with an in-toeing gait. The medial wedge insole is favorable over the de-torsion straps owning to the fact that it was effective in reducing falls and more acceptable by children due to it was worn longer. We recommend larger sample studies over an extended period of follow up. The use of a camera assisted computerized gait analysis lab with sensors to accurately measure the angles with and without an orthosis. The used of a more objective method to assess the falls before and after an orthosis. The use of a computerized devise to mold the insole to get the best results and reduce the effect of a different orthotists skills.

Ethical Approval:

All ethical issues were approved by the author. Data collection and patients enrollment were in accordance with Declaration of Helsinki of World Medical Association , 2013 for the ethical principles of researches involving human. Signed informed consent was obtained from each participant and data were kept confidentially.

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