THE ACUTE EFFECT OF DYNAMIC TAPING ON PLANTAR DISTRIBUTION IN CHILDREN WITH FLAT FOOT

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Abstract. *Flat foot may alter plantar pressure distribution of the foot by collapsing medial longitudinal arch. Increased plantar pressure in some areas as first metatarsal (MTP) joint, mid-foot area and soles may cause pain in individuals with flat foot. Previous studies suggested that supporting the medial longitudinal arch by taping may be beneficial. However, best to our knowledge, no study investigated the effects of the Dynamic Taping (DT) application on plantar pressure distribution in children with flat foot. Twenty-two children (median age: 13 years) with asymptomatic flat foot were divided into two groups as DT group (n=11, males: 9) and control group (n=11, males: 5). Participants in both groups underwent an evaluation performed with RSScan pressure platform at baseline, and plantar pressures related to first MTP join, mid-foot, and soles were recorded. DT was applied as one strip of double layer starting from the big toe, with the first MTP joint in flexion, through the medial longitudinal arch finishing on the posterior 1/3 of the calf. No taping was applied in the control group. Both groups were reassessed after 45 minutes. At baseline, the groups were similar regarding physical characteristics ($p>0.05$). The plantar pressures in the assessed regions decreased ($p<0.05$) following the DT. No differences were detected in the control group ($p>0.05$). According to our results, increased plantar pressure may be redistributed by applying DT in children with flat foot.*

Keywords*: Dynamic Taping, flat foot, plantar pressure*

Introduction

As the most distal part of the human body, the foot is defined as a three-dimensional kinematic segment, which has important functional roles especially during walking cycle, in case of normally developed children, for adolescents and for adults (Stebbins et al, 2006, Page et al, 2010). The morphology of the foot can be classified based on the height of the medial longitudinal arch (MLA). The importance of this structure is based on statistical information which attests the fact that the development of this arch represents the first step in the evolution of human bipedal gait (Day & Napier, 1964). MLA consists of first metatarsal, medial cuneiform, navicular, calcaneus, and talus bones, and is considered as the most important support of the foot (Pallant, 2013). The first goal of the MLA is to lift the body weight during stance with the help of plantarflexors that have enough mechanical force to make this process happen. Another role of the MLA is to provide the foot the ability to absorb the shocks delivered by the upright striding (Ker et al, 1987). Plantar pressure distribution which is associated to height of the MLA is an important clinical variable to ensure the optimal foot loading. Being considered a variable structure, MLA can modify its height, thus modifying plantar pressure distribution, muscular activity, force absorption, gait and stability (Goffar et al, 2013). In addition, the alignment of lower extremity can suffer modifications in relation with lower MLA such as subtalar pronation, internal rotation of the tibia, genu recurvatum with knee laxity (Shultz et al, 2012). However, in existence of flat foot, the MLA flattens, and this leads to re-distribution of foot loading. The importance of flat foot diagnosis, evaluation and treatment is a common topic of debate.

Pfeiffer et al., (2006), define the flat foot as a complex deformity with unmoderated talus plantar flexion, a subtalar eversion while weight bearing and the positioning of the calcaneus in relation to the hind foot in valgus, external rotation and dorsiflexion, which represent the basis for changes in the medial longitudinal arch. This posture is better seen in standing position, but it can also be noticed while sitting and during gait.

Rigid flat foot and flexible flat foot represent the two types of the flat foot. This classification is based on the height change of the MLA during weight-bearing: if the MLA height changes with weight bearing, it is considered as flexible flat foot; and if the MLA does not change with weight bearing, then it is accepted as rigid flat foot. While the rigid flat foot is seen in 1% of the population, flexible flat foot affects 0,6–77,9% of children (Harris et al., 2004, Roth et al., 2013, Kothari et al., 2015, Evans, 2008). The variation of prevalence can be associated with the variation of the definition of flat foot and the diagnosis offered to patients suffering from this disease, followed by inconsistent measurements and evaluations of the foot.

While Rodriguez and Volpe (2010), consider that the existence of flat foot is a normality in the developing of healthy children, beginning from the age of 1-3 years and reaching the 7-8 years, Uden et al., (2017) contradict their theory of normality in the description of this type of child's foot posture, questioning the form of measurement in order to provide the diagnosis. They consider that the age of the child at which the development of the plantar arch materializes should be taken into account. Their claims were based on previous studies (Leung et al., 2005) which found that the length of the leg, considered as a benchmark in the evolution of the plantar arch, can increase from the age of 4 to 13 years, in the case of girls and from 4 to 14 years, in the case of the boys.

Most children have signs of physiological flat feet, the vast majority being flexible and asymptomatic, so they tend to be easily overlooked. The normal development of childhood feet helps understanding the importance of flat foot in the evoluation of childrens body posture development. It is also requaired to take into consideration the fact that boys arches develop much slower then girl arches, that makes the number of flat feet amongst boys to increase in the early evaluation of children.

Villarroya et al., (2008), refers that flat foot is common and normal in the first ten years of life which is the period of time for MLA development. Nearly 45% of children among 3-6 years may present flat feet however this rate decreases as the MLA matures (Villarroya et al., 2008). Flat foot can also be influenced by being overweight.

Flat foot diagnosis should consider biomechanical, clinical and radiological parameters. Clinical parameters often depend on constants such as age of the child and symptom-cause relationship. Because the diagnosis of flat foot takes in consideration many factors it is often perceived confusing, therefore misleading the treatment approach.

For an objective decision regarding treatment approach, there should be an objective and validated evaluation. Although some studies discuss the evaluation of anatomical considerations of flat foot through the help of radiographs, especially for the placement of foot bones in the weight bearing position that could only be made with the help of radiographs (Bresnahan & Juanto 2020), others give information of less invasive approach through the help of medical equipment that uses pressure and force plates to determine the contact area of middle section of plantar footprint (Rome et al., 2010). Bresnahan and Juanto (2020) also discuss the issue regarding subjective clinical observation in case of standard parameters such as arch height, heel eversion and foot anatomical considerations.

According to Bencke et al., (2012), other less invasive methods of evaluation that can also give the possibility of proper diagnosis reference to the height of medial longitudinal arch (MLA) which involves several assessment methods that can achieve a clear classification of the foot and plantar pressure distribution. Taking in consideration the fact that the evaluating MLA techniques are multiple, one single method of evaluation has not been approved, leaving the appropriate assessment method for the therapist to choose, depending on the particularities of each patient.

Debatably, most studies take in consideration the fact that this kind of pathology may also cause several other disturbances in body such as poor balance, asymmetry, abnormal gait, pain and motor dysfunctions (Rome et al., 2010). It is believed that along with this change in foot posture kinetic chain reactions can occur, such as changes in knee posture, hips and spine.

The literature highlights the top treatment options for flat foot includes orthotics (MacKenzie et al., 2012) and surgical procedures (Winfeld & Winfeld, 2019) both focus on improvement of MLA , correction of bone alignment and normalization of plantar pressure distribution. Several other methods such as serial casting, weight reduction, activity modification, joint manipulations, and strengthening exercises are also suggested to address the flat foot (Halabchi et al., 2013, Harris et al., 2004, Rome et al., 2010).

The management of the pediatric flat foot takes into account the degree of disorder, the type of disorder (physiological or pathological), the age of the child, the symptoms and the main cause. Most studies take in consideration the fact that this kind of pathology can cause several other disturbances in body posture such as poor balance, asymmetry, abnormal gait, pain and motor dysfunctions, which encourage management (Rome et al., 2010). Additionally, it is believed that this symptomatology may alter adult life if not treated (Dunn et al., 2004). There was also the idea of self-repair for the asymptomatic cases with flat foot that was based on the study of Morley (1957). This idea emphasized many controversial discussions that concluded with the lack of necessary data to make the assumption real.

For positive outcome we must take into account the characteristics of the pathology while mastering three principles: straightening, stabilization and preservation of the joints. The primary goal of treatment is to maintain a proper alignment of the foot, with a stable foot accompanied by a proper range of motion (Bresnahan & Juanto, 2020).

The benefits of supportive taping were also discussed for flat foot (Luque-Suarez et al., 2014, McNeill&Pedersen, 2016). The mechanism relies on supporting the collapsed MLA, by applying the band on it, thus creating a vector force that shortening the plantar area. Dynamic taping uses a strong and elastic resistance that stretches in four directions, allowing a force of recoil that amplifies the support and assists the motion of tissue, muscle and joint without limiting range of motion during movement (McNeill&Pedersen, 2016).

The aim of DT application used in flat foot pathology, as mentioned by Kendrick, (2013) is to reduce the load on the MLA, increase force closure and improve stability and proprioception (Kendrick, 2013). According to Velasco-Roldan et al., (2018), no more than

15 minutes are necessary for immediate effects in case of tape application, especially for pain management, but taking in consideration the fact that the muscle needs more than 30 minutes to react properly to input.

However, best to our knowledge, no previous study determined the effect of dynamic taping (DT) application on pediatric flat foot.

The aim of our study is evaluate the effects of dynamic taping (DT), by plantar pressure distribution measurement, at children with flat foot, after 45 minute DT application. The main role of this application is to change and maintenance of plantar pressure, as well as navicular support.

Material and Method:

The study was conducted in a private practice clinic from Craiova/Romania, in October 2019. A total of 22 children, average age 13 years (min/max: 12/13 years), who were diagnosed with asymptomatic flat foot were included.

The inclusion criteria were having bilateral flat foot. The exclusion criteria were foot pain, obesity, and any other neurological/musculoskeletal disorders. Informed consents were obtained from children and their families.

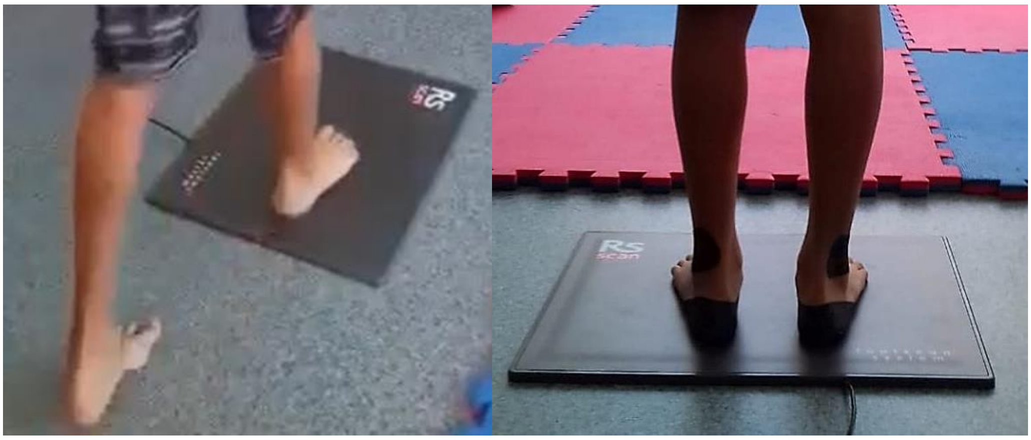
Children were allocated in two groups, as the Dynamic taping group (DT, n=11) and the control group (CT, n=11), which participate to common program for foot flat.

Evaluation

RSScan pressure platform was used to evaluate the plantar pressure of the first toe, first metatarsophalangeal (MTP) joint, mid-foot and heel contact areas (Figure 1A, B).

The platform recorded plantar distribution related to, big toe, first MTP joint, first metatars, midfoot and heel contact areas for right and left sides. The evaluation of plantar pressure distribution was performed at baseline and after 45 minutes for both groups.

. The evaluation was performed barefoot. Data were recorded during dynamic (walking) and static (standing) positions.



A B

Figure 1. RSScan pressure platform: a) Dynamic position; b) Static position with DT

Intervention

The 5-cm wide dynamic tape was used for the applications. The MLA support technique was employed as described by Ryan Kendrick (McNeill & Pedersen, 2016).

Children lay in prone in a relaxed position, with their foot and ankle outside the worktable. The foot was placed in plantar flexion, adduction and inversion, with the first toe in flexion. The application area was cleaned and shaved, if necessary, prior to the taping. DT was applied as an 'I' strip of double layer starting from the plantar surface of the first toe (proximal phalanx), with zero tension on the anchor. The tape stretched until moderate resistance was applied towards the medial heel, through the cutaneous projection of MLA in an oblique manner so that navicular tubercle was included. Then the tape wrapped around the calcaneus posteriorly and was finished on the 1/3 posterior of the calf, with zero tension on the finishing anchor. The direction of stretch was longitudinal and transverse with high tension (without making the tape curve on the side, but enough so that it will feel tight) on tape while crossing the navicular tubercle and are presented in anterior and lateral view (Figure 2A,B, Figure 3A,B).Control group has not any specific taping intervention, during 45minutes.

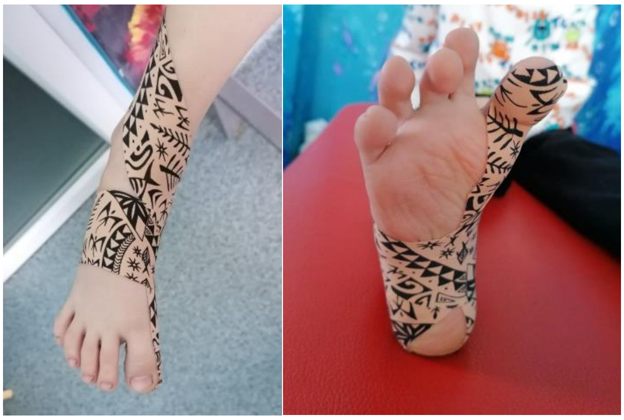


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Figure 2. DT application for flat foot: a) Anterior view; b) Plantar view

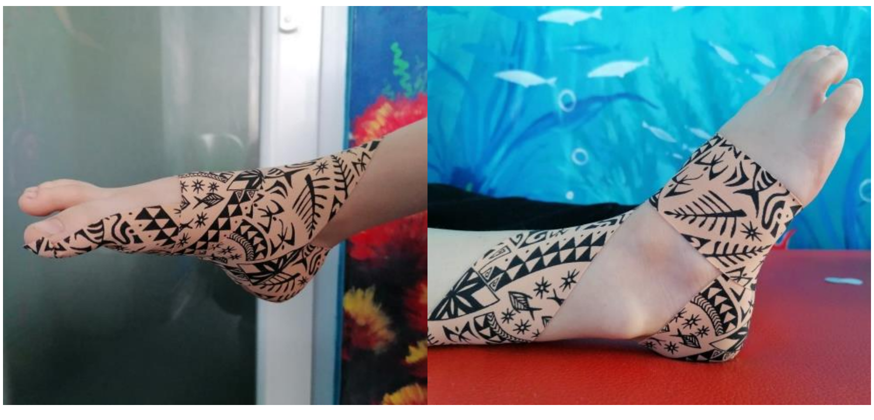

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Figure 3. DT application for flat foot: a) Medial view; b) Lateral view

Statistical analyses

The statistical analyses were performed by using SPSS version 15. The normal distribution of data was assessed with Shapiro-Wilk test. Non-parametric tests were found preferable due to the heterogeneous distribution of the data. Descriptive statistics were presented as medians and interquartile ranges 25/75 (IQR 25/75). Mann–Whitney U test was employed for between group comparisons and Wilcoxon Signed Rank test was used for in-group comparisons. Effect sizes were calculated using Rank-biserial correlation which is a recommended effect size measure for the Wilcoxon signed-rank test for paired samples (Tomczak & Tomczak, 2014). It quantifies the degree of association between the paired observations and provides a standardized measure of the effect's magnitude, enabling easier interpretation and comparison of results across studies. The r value varies from 0 to close to 1. The interpretation values for r commonly in published literature and on the internet are: 0.10 - < 0.3 (small effect), 0.30 - < 0.5 (moderate effect) and >= 0.5 (large effect). Although their interpretation varies depending on the scientific field. *P* value less than 0.05 was accepted as statistically significant.

Results

When sample parameters were compared at baseline, no significant differences were found in Age, Height, Weight, or BMI (p>0.05, Table 1). 81% of DT group, and 45% of control group were male (p>0.05). Regarding plantar pressure variables there were no significant differences, between groups, except for pressure on right foot 1st metatarsal and medial part of heel (p<0.05, Table 2). Effect size regarding difference between both groups, we observe a large effect only for 1st metatarsal and medial part heel, right side (r>0.5, Table 2).

When comparing plantar pressure in DT group before and after tape application, almost all plantar pressure variables were lower after the application of taping, with statistically significant difference (p<0.05), for both side, but not statistically significant difference, for right foot 1st metatarsal and medial part of heel (p>0.05, Table 3). According to the calculated effect size, is a large effect (r>0.5, Table 3). In the control group, is not a statistically significant differences (p>0.05,Table 4), except right foot 1st metatarsal which has the significant statistically difference (p<0.05,Table 4). Regarding the effect size for control group statistically analysis demonstrates a large effect (r>0.5, Table 4)., but less then DT group.

Table 1. *Comparison of groups at baseline regarding physical characteristics*

Parameter	**DT group (n=11)** **Median (IQR 25/75)**	**Control group (n=11)** **Median (IQR 25/75)**	***p***
Age [years]	13 (13/13)	13 (13/13)	1.000
Height [cm]	160 (155/165)	158 (153/163)	0.489
Wight [kg]	53 (42/56)	52 (48/59)	0.411
BMI [kg/m^2]	19.5 (18.9/20.9)	21.5 (20/23.1)	0.101

Table 2. *Comparison of groups at baseline regarding plantar pressure*

Parameter	DT group (n=11) Median (IQR 25/75)	Control group (n=11) Median (IQR 25/75)	P	*r*
Right Side				
Big Toe [cm²]	13.1 (10.9/14.2)	11.6 (9.9/14.6)	0.621	-
Metatarsal 1 [cm²]	12 (11.2/14.8)	9.8 (8.2/10.7)	**0.044***	0.511
Midfoot [cm²]	36.8 (34.9/42.4)	29.6 (26/36.5)	0.115	-
Medial heel [cm²]	16.5 (14.8/20)	14.6 (11/16.3)	**0.048***	0.421
Left Side				
Big Toe [cm²]	15 (13.5/15.9)	13.9 (12/16.6)	0.742	-
Metatarsal 1 [cm²]	11.2 (7.8/12.8)	8.2 (6.5/9.7)	0.076	-
Midfoot [cm²]	40.9 (34.6/45.6)	33 (29.6/35.8)	0.076	-
Medial heel [cm²]	16.5 (14.3/19.1)	12.8 (9.5/15)	0.056	-

Legend: * - statistically significant

Table 3. *The effect of Dynamic Taping application on plantar pressures-DT group*

Parameter	Before Median (IQR 25/75)	After Median (IQR 25/75)	*p*	*r*
Right Side				
Big Toe [cm²]	13.1 (10.9/14.2)	11.2 (9.7/13.4)	**0.023***	0.684
Metatarsal 1 [cm²]	12 (11.2/14.8)	10.1 (8.6/11.8)	0.062	-
Midfoot [cm²]	36.8 (34.9/42.4)	31.1 (28.5/39.2)	**0.003***	0.885
Medial heel [cm²]	16.5 (14.8/20)	16.5 (14.5/18.4)	0.050	-
Left Side				
Big Toe [cm²]	15 (13.5/15.9)	13.1 (12.4/14.2)	**0.003***	0.886
Metatarsal 1 [cm²]	11.2 (7.8/12.8)	7.1 (5.8/9.1)	**0.007***	0.818
Midfoot [cm²]	40.9 (34.6/45.6)	33 (28.9/40.8)	**0.003***	0.885
Medial heel [cm²]	16.5 (14.3/19.1)	15.8 (13/17.4)	**0.005***	0.873

Legend: * - statistically significant

Table 4. *The effect of no taping on plantar pressures-control group*

Parameter	Before Median (IQR 25/75)	After Median (IQR 25/75)	p	*r*
Right Side				
Big Toe [cm²]	11.6 (9.9/14.6)	11.6 (9.9/14.6)	0.157	
Metatarsal 1 [cm²]	9.8 (8.2/10.7)	9.6 (8.2/10.4)	**0.027***	0.636
Midfoot [cm²]	29.6 (26/36.5)	29.2 (25.9/36.5)	0.180	
Medial heel [cm²]	14.6 (11/16.3)	14.6 (11/16.3)	0.414	
Left Side				

Big Toe [cm^2]	13.9 (12/16.6)	13.5 (12/16.5)	0.109
Metatarsal 1 [cm^2]	8.2 (6.5/9.7)	8.2 (6.5/9.7)	0.066
Midfoot [cm^2]	33 (29.6/35.8)	33 (29.6/35.8)	0.102
Medial heel [cm^2]	12.8 (9.5/15)	12.8 (9.5/15)	0.066

Legend: * - statistically significant

Discussions

The present study was designed to determine the effect of DT on plantar pressure in children with flat foot. According to our results, applying DT may help to normalize increased plantar pressures in first toe, mid-foot, and heel contact areas in children with flat foot.

According to the results, most of the plantar pressure variables did not show significant differences at baseline, except for the pressure exerted on the first metatarsal and medial part of heel on the right foot. These differences are probably due to randomizing a small sample of participants.

As expected, the DT group showed a significant decrease in most plantar pressure variables after the Dynamic Taping application. For the registered pressure in the 1st metatarsal and medial part of heel of the right foot before and after the tape application, there could be several reasons why there was no significant difference observed and one possibility is that the tape application was not effective in reducing the pressure in those specific areas. Another possibility is that the sample size was not large enough to detect a significant difference, or there could be variability in the participants' foot structures or walking patterns that influenced the outcomes. It is also possible that the tape application had an unintended effect on other parts of the foot, leading to compensatory changes in plantar pressure distribution. Further research may be necessary to explore these possibilities and better understand the observed results.

Interestingly, the Control group displayed a significant difference only in the pressure on the 1st metatarsal of the right foot, while no significant differences were observed in other plantar pressure variables. This difference is probably a spurious finding due to randomization problems as noted above.

Literature confirms the fact that for us to develop a better treatment approach for flat foot there is a necessary consistent approach for flat foot description and assessment method (Evans& Rome, 2011). While systematic review by Evans& Rome, (2011) et al. investigated sixteen different evaluation techniques regarding flat foot and concluded that footprint-based measures were the most conclusive ones (Evans& Rome, 2011). Similarly, a study by Pauk et al., (2014) reported that plantar pressure distribution evaluation essential in emphasizing the deficiency of foot loading in children with flat foot. Moreover, Vorlickova and Korvas, (2014) find that plantar pressure analysis can make a difference in the improvement of flat foot management by offering exact information of the effects of the treatment. Thus, we preferred a plantar pressure evaluation method in the present study.

Many non-invasive methods of treatment were recommended related to flat foot deformity for children, such as foot/ankle orthoses, stretching exercises, specific shoes, strengthening exercises (Bresnahan & Juanto, 2020). Although the study of MacKenzie et al., (2012) identify the positive role of foot orthoses on flat foot management, there is still no strong evidence to show the benefits of a long-term use of foot orthoses on the foot morphology (Choi et al., 2019). In addition, foot orthoses can be considered hard to wear and heavy. Therefore, solutions using lighter materials such as taping may be more preferable.

To the best of our knowledge, this is the first study investigated the effect of DT on plantar pressure in children with flat foot. However, DT application was found beneficial on other parameters in flat foot previously.

Lim&-Park, (2020) have investigated the effect of DT application on dynamic balance in adult subjects with flat foot and concluded that DT may be useful to improve dynamic balance (Lim &-Park, 2020).

A statistical difference was found in study conducted by Ercan et al., (2021) which showed the improvement of navicular drop distance which had increased after DT applications for adolescent volleyball players. Also, this study concluded the practical use of DT as an easy-to- apply treatment for flat foot regarding MLA support.

DT represented an suitable alternative in the management of flat foot because its effects are more likely to ensure stability of MLA due to the idea that this tape works as a bungee cord, while applied it will create a force of recoil that will bounce back the falling segment in need. This theory has been in agreement with previous research in which it presumed that it will reduce navicular drop and control the drop of the medial longitudinal arch (McNeill& Pedersen, 2016), an assumption that we considered beneficial for our study.

The limitations of the study were convincing the parents to allow the use of this technique on their children, which led to a small number of participants.

Conclusions

The results of the present study implicated that DT application may be beneficial for normalizing plantar pressures in children with flat foot. However, these effects are limited to acute use of the tape and correspond immediate needs. The effect of combining DT into a structured exercise program on a longer period may reveal the real value of DT application on flat foot related problems in children.

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