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Differences in Lateral Core Muscles' Endurance Measurementsb Adolescents with And Without Flexible Flat-Feet

Mona T. Abd El Ghafar[1*], Khalid A. Olama[2], Marwa M. I. Ismaeel [2]
[1]Department of Physiotherapy, Zagazig Al-Ahrar Teaching Hospital, Zagazig, Egypt.
[2]Department of Physical Therapy for Pediatrics, Faculty of Physical Therapy, Cairo University, Egypt.
***Corresponding author:** Mona T. Abd El Ghafar, **Mobile:** (+20)01200332565, **E-mail:** ptmonamony@gmail.com

ABSTRACT

Background: Flexible flatfeet are a common deformity that affects youngsters and persists throughout their lives, and it is considered to be a contributing factor in many lower limb accidents and low back discomfort. Core muscles function as trunk stabilisers, and any disruption or weakening in these muscles puts a person at risk for low back discomfort and lower limb injury.

Objective: We aimed to compare the core muscles' endurance between adolescents with and without flexible flatfeet.

Patients and Methods: Thirty participants with bilateral flexible flatfeet (study group) were compared with thirty healthy participants (control group). Navicular drop test (NDT) was used to evaluate the medial longitudinal arch. Modified back extensors, modified flexion and lateral muscles' endurance tests were used to evaluate the endurance of the core muscles.

Results: There was no significant difference found in the trunk lateral muscles for left bridge (p = 0.38) and right bridge (p = 0.70) endurance time between both groups.

Conclusion: There is no significant difference in the endurance of the lateral core muscles between adolescents with and without flexible flatfeet at the selected age in the early adolescent stage.

Keywords: Core muscles, Endurance, Flexible flatfeet, Adolescents.

INTRODUCTION

The presence of a depressed medial longitudinal arch, with or without rear foot eversion, in youngsters is characterised as flexible flatfoot (also known as pes planus or planovalgus) [(1)]. It is one of the most common causes for seeking an orthopaedic opinion [(2)]. Flexible flatfoot is a common childhood deformity characterised by a collapsed medial arch, forefoot abduction, internal rotation, plantar flexion of the talus, and calcaneal eversion [(3)].

The core has been referred to as the lumbo pelvic-hip complex [(4)] and core training has highlighted benefits for athletes [(5)], general health [(6, 7)], and patients with low back pain [(8)]. Core measurement is frequently split into three categories: core endurance, core stability, and core strength [(9)]. The most critical core qualities for ensuring spine stability for force production and injury avoidance are core stability, strength, and endurance.

Core endurance is defined as the ability to maintain a position or perform multiple repetitions [(10)]. Core stability is described as "the stabilising system's ability to keep the intervertebral neutral zones within physiological limits" [(9)]. While, core strength refers to the ability as the ability of the musculature to produce force through contractile force and intra-abdominal pressure [(11)].

A later study discovered that those who performed poorly on the Biering-Sorenson muscular endurance test were three times more likely to suffer from low back pain (LBP) than those who performed better [(12)].

Flat feet result in more proximal lower limb dysfunctions, which impact lumbopelvic hip stability (core stability) and hence contribute to a variety of lower limb injuries affecting the lower back, hip, knee, lower leg, ankle, and foot [(13)].

The aim of the current study was to compare between lateral core muscles' endurance concerning adolescents with and without flexible flatfeet.

PATIENTS AND METHODS

Thirty adolescents were diagnosed by a physician as flexible flatfeet and thirty adolescents free from any type of deformities participated in this study. They were selected from the governmental Egyptian schools at Al-Sharqi Governorate according to inclusion criteria. Their ages ranged from 10 to 12 years.

They were assigned into two groups (A and B) with equality in number and gender distribution.

Group A included adolescents with flexible flatfeet. Group B included adolescents with normal feet. Participants of group (A), on visual assessment, had a normal medial longitudinal arch (MLA) in sitting and had a ten mm difference or more on the NDT for both feet, all participants on group (A) had flexible flatfeet according to Hubscher maneuver or Jack's test, which is used to differentiate between flexible and rigid flat feet.

Participants of group (B) had less than 10 mm difference on the NDT for both feet and followed the normal growth indices concerning weight and height.

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All participants were able to follow the verbal and visual commands and free from any medical disease.

Exclusion criteria included history of surgery, congenital deformity in lower extremities or trunk, injury to the lower extremities or back in the previous 6 months, neuromuscular damage of the spine and lower extremities and rigid flat-feet.

Ethical approval:

This study was approved by the Ethical Committee, Faculty of Physical Therapy, Cairo University (NO: P.T.REC/012/003166) on 24 March 2021. Informed written consents were obtained from parents of all children before recruitment in the study after explaining the objectives of the work. This work has been carried out in accordance with the Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans.

Materials:

Standard weight scale used to calculate the weight and height to calculate body mass index for each participant in both groups, index card, Marker, Plinth, Chair, Stopwatch and Wedge.

Procedures:

All participants had full explanation for the evaluation procedures. The examiner asked about age, gender, social level, and any other medical disease. A navicular drop test was used to assess the MLA as described by Brody [14]. The NDT was shown to have a high intra-and inter-tester reliability [15]. It has a moderate to good correlation with the x-rays [16]. ND of 10 mm or more was considered abnormal and a sign of reduced MLA while a drop of less than 10 mm was considered normal [17, 18].

The side bridge test was performed in the side-lying position on a treatment table. The participant's knees were extended with the top foot placed in front of the lower foot.

The participant supported his weight only on their lower elbow and feet while lifting their hips off the mat. The test was stopped when the side-lying position was lost or when the hips returned to the mat.

Statistical analysis

Descriptive statistics, including mean ± SD, were quantified for all variables. The study included one independent variable was the tested group (between-subject factor) with two levels: group (A) represent foot pronation group and group (B) represent normal group. The tested dependent variables were the right and left bridge core endurance.

The homogeneity of variance using Levene's test revealed that there was no significant difference with p values > 0.05, which reflect that the data were homogenous. The normality test of data using the Shapiro-Walk test was used, which reflect that the data was normally distributed. So, parametric analysis was performed. One way between subjects ANOVA was conducted to compare the mean values of these dependent variables between both groups. The alpha level was set at 0.05.

RESULTS

The Physical characteristics of all participants were shown for both groups A and B in table (1). There was no significant difference in all characteristics.

Table (1): Physical characteristics of all participants in both groups (A & B)

Items	Group A	Group B	Comparison		Sig.
	Mean ± SD	Mean ± SD	t-value	P-value	
Age (years)	10.88 ± 0.84	10.98 ± 0.85	-0.01	0.647	**NS**
Body weight (Kg)	40.17 ± 7.41	40.37 ± 7.43	0.01	0.917	**NS**
Height (cm)	147.47 ± 9.39	147.3 ± 9.3	0.03	0.945	**NS**
BMI (Kg/m^2)	17.98 ± 3.19	18.53 ± 1.34	0.02	0.388	**NS**
Sex distribution N (%)					
	Group A	**Group B**	**X^2**	**P-value**	**NS**
Boys	18 (60%)	18 (60%)	0.000	1.00	**NS**
Girls	12 (40%)	12 (40%)			

*SD: standard deviation, P: probability, S: significance, NS: non-significant

1. Left bridge core endurance

As presented in table (2), the mean values of left bridge core endurance in group "A" and group "B" were 60.17 ± 27.09 and 66.02 ± 25.03 respectively. The univariate tests of one-way ANOVA revealed that there were insignificant differences in the mean values of left bridge core endurance between both groups ($F_=0.461$, $P_=0.5$). In addition, multiple pairwise comparison tests (Post hoc tests) revealed that there was no significant difference between both groups (p = 0.389).

Table (2): Comparing left bridge core endurance between both groups

	Left bridge core endurance	
	Group A	**Group B**
Mean±SD	**60.17 ± 27.09**	**66.02 ± 25.03**
MD	**-5.85**	
Multiple pairwise comparison tests (Post hoc tests) for the left bridge core endurance between both groups		
Partial η2	**0.008**	
p-value	**0.389**	
Level of significance	**NS**	

X= Mean, ± SD= Standard deviation, MD = mean difference, p-Value=Probability level, NS: non-significant.

2. Right bridge core endurance

As presented in table (3), the mean values of right bridge core endurance in group "A" and group "B" were 63.02 ± 26.99 and 65.7 ± 27.28 respectively. The univariate tests of one way ANOVA revealed that there were insignificant differences in the mean values of right bridge core endurance between both groups ($F_=0.031$, $P_=0.86$). Additionally, multiple pairwise comparison tests (Post hoc tests) revealed that there was no significant difference between both groups (p=0.704).

Table (3): Descriptive statistics and one way ANOVA for the right bridge core endurance between both groups

	Right bridge core endurance	
	Group A	**Group B**
Mean ±SD	**63.02±26.99**	**65.7±27.28**
MD	**-2.68**	
Multiple pairwise comparison tests (Post hoc tests) for the right bridge core endurance between both groups		
p-value	**0.704**	
Level of significance	**NS**	

X= Mean, ± SD= Standard deviation, MD =Mean difference, p-Value=Probability level, NS: non-significant.

DISCUSSION

The purpose of this study was to investigate the difference in lateral core muscles' endurance between adolescents with and without flexible flat-feet.

There were several studies concerning measurements of core muscle endurance in late adolescents and adults but no studies concerning these important measures in children or early adolescents' age were done. So, the selected age of our study was from ten to twelve years to identify the effect of flexible flatfeet on lateral core muscle endurance at this age. Age selection in the current study comes in agreement with **Allen *et al.*** [19] who selected the age of their participants (mean age, 11.5 ± 2.5 years) in their study of the effect of a core conditioning intervention on tests of trunk muscular endurance in school-aged children as trunk and core muscular endurance was evaluated using 5 separate muscular fitness tests.

The most frequent form is flexible flatfoot, which has a normal medial longitudinal arch in non-weight-bearing but lowers significantly when weight is applied. Other structural defects and compensatory mechanisms might be linked to this deformity [20,21]. There is a statistically significant correlation between morphological variables of the foot and postural stability [22].

Navicular drop test has been used as a clinical method to assess foot mobility and pronation [23]**.** Using the NDT in the assessment of medial longitudinal arch as a valid and reliable method comes in agreement with **Zuil-Escobar *et al.*** [24] who stated that NDT appears to be a reproducible, valid, and simple test for evaluating medial longitudinal arch height.

Targeting the assessment of core muscle endurance in this study due to its vital role in stabilizing the axial trunk comes in agreement with **Allen *et al.*** [19] who stated that trunk musculature tends to be underdeveloped in the adult and pediatric populations because of a lack of sufficient targeting during functional daily physical activity. It also comes in agreement with **Hodges** [25] who mentioned that the sequence of muscle activation during whole-body movements was studied and it was found that some of the core stabilizers (i.e., transversus abdominis, multifidus, rectus abdominis, and oblique abdominals) were consistently activated before any limb movements. These findings support the theory that movement control and stability are developed in a core-to-extremity (proximal-distal) and a cephalo-caudal progression (head-to-toe).

The findings suggest that decreased postural stability may be one of the mechanisms underlying links between flatfoot and increased risk of lower limb injury. So, foot posture can be a potential confounding factor for the measurement of postural stability during transition tasks [26]. **Harreby *et al.*** [27] reported that 88% of children who experience LBP in childhood would experience LBP during adulthood. Core stability is the ability to control the position and motion of the trunk over the pelvis to allow optimal production, transfer, and control of force and motion to the terminal segment. Core stability is necessary to help maintain a good posture and give a stable base to allow the arms, legs, and head to move in a coordinated manner [28]**.** All participants in the study diagnosed with flexible flatfeet early and no one of them complained of low back pain previously and until the enrolment in the study. No significant difference was observed in the lateral core muscles between the study and control groups. This can be attributed to the two theories that explain the relationship between flatfoot and lumbopelvic impairments, which were mentioned by **Elataar *et al.*** [29] who stated that, although two theories could explain the relationship between flatfoot and lumbopelvic impairments, (a "ground up" approach and a "top-down" approach), the current study considers the ground up chain as our participants had flatfeet early in their life (known from the history) and they didn't report any back pain up till the time of the study.

There were no statistically significant differences in the ND between the right and left side for the same group or between both groups. Therefore, in flatfeet, it did not cause asymmetrical pronation at this age, which did not affect the pelvis. This in turn, did not differences in lateral muscle core endurance between the two groups despite its effect that was mentioned in previous studies on adults, which proves the effect of the age factor?

According to the current study, there was no significant difference between both groups in left lateral core endurance ($p = 0.5$) and right lateral core endurance ($p = 0.86$). So, in the early adolescent stage period, there is no effect of flatfeet on lateral core endurance.

It has been suggested that deficits in trunk extensor and flexor endurance and imbalances between trunk muscle groups may have short- and long-term negative consequences in low back health [30, 31]. This circumstance has led to the field-based assessment of trunk muscle endurance becoming common practice during childhood and adolescence [32]**.** The results of this study contradict with the results of **Telang and Dhumale** [33] who concluded that individuals with the flexible flatfoot will affect the proximal segment through the kinetic chain phenomenon of the body, affecting the core stability and individuals with flexible flatfoot to have reduced core stability in their study on adults. Furthermore, our findings come into agreement with **Duval *et al.*** [34] who described no significant relationship between flatfoot and lumbar lordosis. This is in line with our results in which the flatfoot did not affect the muscles acting on the sagittal plane.

The results of our study showed no significant difference in the endurance time of lateral core muscles, which contradicts with several studies done in adults and that may be attributed to the finding of **Saeterbakken *et al.*** [35] who stated that there were no significant correlations between the variables of core strength, core stability or core endurance, except for the endurance of lateral flexion, which correlated significantly with the core strength (extension and lateral flexion) and the core stability using the left leg. This shows the effect of age and development as a factor.

Several theories discussed the relation between biomechanical dysfunction of the lower limb and trunk to foot function, but limited studies had investigated the effects of foot abnormalities on the muscular performance of the trunk and hip in late adolescent stage and adults. Unfortunately, few studies concerned with studying the effect on children and early adolescents. It can be concluded that there was no significant difference in the endurance of the lateral core muscles between adolescents with flexible flatfeet compared to healthy subjects at the selected age.

Limitations of the current study included small sample size to generalize the data measured, one age group, and measuring only endurance as an indicator of the core stability.

CONCLUSION

From the obtained data of this study, the most notable conclusion is that there is no statistically significant difference in lateral core muscles’ endurance between adolescents with and without flexible flatfeet. Several research works are needed to measure different core stability indicators at different ages and to estimate the effectiveness of the rehabilitation programs for such cases.

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