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# Comparing the Effects of Simultaneous Eight-Week Stretching / Strengthening Trainings with Core Stability Exercises on the Flat Foot Deformity of 9- to13- Year -Old Female Students

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**Background**: This study aimed to compare the effects of simultaneous eight-week stretching and strengthening trainings and exercises with core stability exercises on the flat foot deformity of female students with the age ranges from 9 to 13 years.

**Methods and Materials**: In the present Quasi-experimental study on 130 female students, 60 girls with flat feet and the age ranges from 9 to 13,were selected randomly and divided into two experimental groups (n = 20 in each group) and one control group (n = 20). The samples were selected using Navi loss, and then Staheliarch index was evaluated. The experimental groups received the treatment(one group received stretching and strengthening exercises and the other group received core stability exercises for 45 minutes, three times a week) for 8 weeks, but the control group received no treatment and was engaged in daily routine activities. The data were analyzed through analysis of independent samples t-test at the significance level of $P \leq .05$.

**Results**: Post-test of arch corrective exercises revealed a significant difference among the three groups so that the subjects of both the experimental groups, compared to the control group, had a significant decrease in the angle of the back nut side while the difference between the two experimental groups was not statistically significant ($P < .001$). Also, in the second experimental group, exercises influence on the arch more than that of the first experimental group ($P < .001$).

**Conclusions**: It seems that the eight-week correction training program with emphasis on compound exercises (core stability) as a non-invasive method had a good effect in the treatment of the female students suffering from flat foot deformity with the age ranges from 9 to 13 years.

**Keywords**: Flatfoot, Corrective exercises, Core stability exercises, Navi loss.

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## Introduction

Musculoskeletal disorders especially in the lower extremities are among the factors affecting children performance on assessment programs. Musculoskeletal disorders could be influential on the human body biomechanics, particularly running, walking, and generally human movement biomechanics (Daneshmandi, Alizadeh & Gharekhanloo, 2004; Twomey et al., 2010).Skeletal-muscular disorders are unfavorable conditions caused by the effects of environmental factors, poor movement, inappropriate functioning of the muscles and joints; however, it is possible to correct and improve them via the elimination of the related causes(Daneshmandi, Alizadeh &Gharekhanloo, 2004).Because of the specific foot anatomic structure and its positioning in the lowest extremities of the movement chain with relatively small supporting surface bearing the whole weight of the body and balancing it, it seems logical that the tiniest biomechanical variations in the supporting surface of the body could affect the body posture control(Powers, 2010) .Accordingly, one of the abnormal changes in the human body anatomy is the flat sole (pesplanus) in the lower limbs. In many studies, the prevalence rate of flat sole has been reported to be relatively higher in the children compared with the rest of the population. For example, in a study, the prevalence rate of such a syndrome was reported to be 44% in three- to six-year-old children(Pfeiffer et al., 2006). In another study, the prevalence rate of flat sole was reported to be 70% in three- to four-year-old children which was lowered to 40% in five- to eight-year-old children(Daneshmandiet al., 2011).Also, in another study conducted in Isfahan, the prevalence rate of sole longitudinal arch collapse was 23.5% in 7- to 14-year-old children, it was also reported that sole arch collapse in one foot was larger (14.1%) than the arch collapse in both feet (9.5%). In this study, the prevalence rate was reported to be 24.2% and 23% in boys and girls, respectively (Kordi,& Ghalamghash,2014). The reduction in the foot interior longitudinal arch height is called flat sole (pesplanus) resulting from muscular weaknesses and factors such as ligamentous laxity, tibial torsion malformation, the presence of accessory navicular bone, congenital vertical talus, and the tarsal bony bridge; however, nowadays, a combination of such factors is realized as responsible for flat sole(Magee, 2014).Flat foot is a deformity which is prevalently accompanied with the anterior supination and dorsal pronation of the foot (Sadeghi& Azadinia, 2011).Flexible flat sole can be as a result of ligamentous laxity, and of course, it looks normal up to 4-6 years of age. The factors contributing to the flat sole include overweight, hospitalization, long-term physical sedentariness, aging, jobs requiring to be carried out on foot for long hours, as well as, other factors such as genetic, weak and short calf and sole muscles, wearing inconvenient shoes for long hours, extensive fracture (Letafatkar et al., 2012). Existed proposed theory indicates the body chain performance,the individuals whose feet arches are not normal in size may be faced with different pat home chanical and physiological symptoms and signs (Alter, 2004). They may complain about the problems in inward torsion of their feet such as knee, pelvic girdle, and back pain(Graham et al., 2012).The symptoms stemming from intensive stretching or long walks on the toes in order to compensate the foot fallen arches, usually per se cause in secondary problems such as pain and discomfort while walking, foot deformation, severe pain in the sole region of the foot, foot ulcers, hammertoes, and backaches(Meehan & Brage, 2003; Burns & Crosbie, 2005). Twomey et al. (2010), in their extensive research on 9- to12-year-old children, expressed that flat feet should be considered not only as a disadvantage in individual in not being able to get close to the sport fields but also as an advantage in carrying out some physical activities. For instance, they showed that children with the flat feet can better succeed in vertical jumps(Twomey et al., 2010). In another study, it was reported that the individuals with normal feet sole had higher rate of muscular stamina in high speed sports in comparison to the individuals with flat feet (Cubukcu et al., 2005).During the recent years, the central region of the body and the exercises related to the strengthening and reinforcing of the central area of the body have attracted to a great extend the attentions ofmanyresearchers. So the exercises related to the back-pelvic-thigh region of the body and other muscles in its periphery are considered as the exercises necessary for the strengthening of the central area of the body. As the anatomic position of the body gravity center is situated in this region, and human movements are originated from this point, so the stability in this area is of a great importance (Hodges & Richardson, 1997). The central area of the body can be considered as a muscular belt situated in the central part of the movement chain, which acts as a stabilizing unit firming the spinal column and the upper extremities. Also, asa central initiator for the entire array of the limbs' movements, the central area of the body is considered as a propelling unit exerting the driving force required for the various body organs(Tse, 2009).This region's power and endurance allow the whole system to optimally distribute, deliver, and transfer the driving force of the body by mechanically stabilizing the spinal column(Hill & Leiszler, 2011).The exercises related to the central area of the body increase the power, endurance, and neural control of the region so that the control of the interior spinal column limbs, internal abnormal pressure, and upper extremities muscular movement can be improved; they can also affect body ability for preserving balance in various dynamic movements (McCaskey, 2011). The central stability exercises include strength trainings of the central body area, contributing to the movement and higher levels of stability in this area. Performing such exercises results instability of the central part of the body, which is required for better movements of the lower extremities(Kibler,Press & Sciascia, 2006) .Since there are abundant researches performed regarding exercises and trainings for central body area in various age groups, a thorough research on the foot arch is missing; therefore, the present study aimed to study the effects of simultaneous stretching and strengthening exercises and also combinational training exercises on the defections and disorders of the flat feet in 9- to13-year-old female students.

## Methods

### Study methodology

The present study was a semi-experimental research, and the study population was consisted of 130 female students diagnosed with flat feet disorders with the age ranges from 9 to 13 years. They were studying during the school years of 2015 to 2016 in the schools of Khalil Abad County. To undertake the study, firstly, a legal permission was acquired from the ministry of education, the branch of Khalil Abad County, and then coordination was made with the center for applying corrective movements in this center. Because there were three girls' primary schools in Khalil Abad County during the aforementioned academic years, the study participants were selected from the female students in all of the three girl's primary schools after the preliminary screening tests were conducted. In the present study, 60 female students with flat feet disorders were selected, who were stochastically assigned to three 20-individual groups (the first experimental group trained with the simultaneous stretching and strength exercises, the second experimental group trained with the stretching and strength exercises accompanied with exercises related to central stability training, and the third group was a control cohort). The participants' selection was qualitatively performed by making use of the Pedoscope apparatus, and the foot arch rate was measured via the use of Staheli index for which a high level of reliability and stability has been reported(Thomas,Nelson & Silverman, 2015).Inclusion criteria for the students to be included in the study were: being in one of the age ranges from 9 to 13 years, being female, providing an informed consent, and being in generally a good health status. Data were collected through interview performed by the health assistant of the school(s) and investigating the medical files of the students in the school(s). No participant was found with a prior history of lower extremities surgery or lesion; or a previous history of broken bone in the calf, foot, and ankle regions; severe orthopedic problems(Miller, Basu &Hutchinson, 2008);and a prior history of medical pads. To determine the weight and height of the testees, the analog scales and wall stadio meter were used, respectively, and to insert their ages into the questionnaires, their educational files were used. To diagnose the flexible flat feet, the individuals were asked one time to stand in an erect position bearing the whole weight of the body and the other time to stand on the tip of their toes. If in the weight bearing state, there was no observable interior feet arch but observable while standing on the tip of the toes, then the individual was diagnosed with the flexible flat feet (Chang et al., 2012).The navicular collapse test was used to determine the feet inward torsion. The testees were asked to sit on a chair with her thigh and knee forming a 90degree angle in a flexion state, her sole on the ground, and the subtalar joint in a neutral position (no bearing of the body weight). The tester touched and marked the testees' navicular bone protruding part and measured the distance from the bump to the ground by a ruler. Then the testees were asked to stand in an upright position and to open their legs quite the same distance as their shoulder width and to support the body weight equally by both of the feet (weight bearing). The distance between the navicular bone and the ground was measured twice (Photo 1). The difference between these two positions in millimeter was recorded as the navicular collapse rate. The measurements with respect to the left and right feet were repeated thrice, and the mean values of these three were recorded as the navicular bone collapse (Brody, 1982; Hertel, Dorfman &Braham, 2004; Cote et al., 2005) .

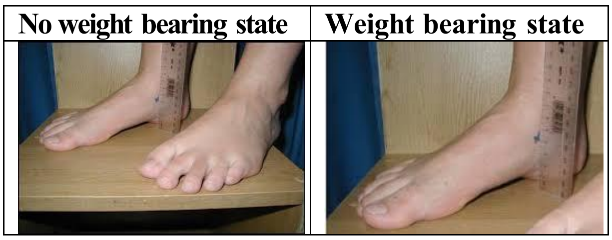


**Figure 1.Navicular bone collapse measurement**

Afterwards to measure Staheli index, the testees were asked to cover their feet with Talc powder and to stand with no sliding in their feet on the inflexible surface and then to pick up their feet off the inflexible surface. Finally, according to the foot arch index calculation method based on Staheli process (Figure 2), firstly, the distance between the narrowest section of the arch, and in the next stage, the distance between the broadest section of the foot sole to the nearest one in millimeter was measured three times consecutively and separately by making use of a transparent ruler, and the values were averaged and recorded, then the size of the narrowest section of the arch (A) was divided by the broadest section of the foot sole (B) based on the formula proposed by Staheli (AI=A/B)(Chang et al., 2010).

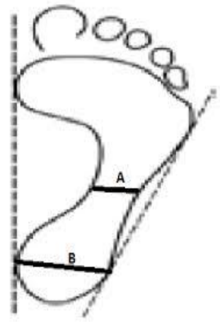


**Figure 2.Staheli method-based foot arch index measurement**

**Training Protocol**

No training program was assigned to the control cohort during this study, but the first experimental group received a training program including the exercises related to the Achilles tendon stretching and strengthening, exercises effective on the interior longitudinal foot arch, and the second experimental group was trained with the exercises related to the muscles Achilles tendon stretching and strengthening, exercises effective on the interior longitudinal foot arch and also with activities for central body area stability. It is worth mentioning that at the beginning of every training session, the testees were asked to perform warm-up activities for five minutes, and then they followed the corrective training exercises. The aforesaid exercises took about 25 minutes during the first sessions, and they gradually were increased to 45 minutes during the final sessions. The experimental groups performed the exercises for 8 weeks, three times a week, in the form of three turns with 20 repetitions. The testees prepared themselves for implementing the main exercises through conducting several simple moves, and then they were divided into two cohorts. Each group was assigned with separate exercises. In Group 1, the objective of the first and second week of the training was to focus on the stretching of the Achilles tendon; the long, short, and lateral fibular muscles; the lateral exterior ligaments such as sole fibula and the talocalcaneal ligament which is usually shorter in this kind of deformity in comparison to the normal individuals. The objective pursued by the exercises from the Week three and four was to strengthen the plantar muscles, internal rotators that are the anterior and posterior tibia, gastrocnemius, soleus, and long flexors of the toes. During the Week five to eight of the training program, a combination of the stretching and strengthening movements were carried out. As for the second group, they were assigned to the same exercises performed by the first group, and additionally, they were asked to perform the exercises related to the central body stability along with the stretching and strengthening exercises. The central stability-related exercises were carried out in three levels: Level one was included static contraction exercises which were conducted in a stable status of the body, Level two incorporated static contraction exercises in an environment lacking stability, and Level three involved dynamic movements in an unstable environment which were carried out by making use of Swiss ball.

**Results**

In Table 1, the participants' demographic characteristics are shown. The demographic characteristics of the three groups were compared via taking advantage of independent t-test. Due to the fact that there were no significant differences between the groups, they were considered as demographically congruent.

**Table 1: Testees' demographic characteristics**

| Variable | First experimental group (mean + standard deviation) | Second experimental group (mean + standard deviation) | Third experimental group (mean + standard deviation) |
|---|---|---|---|
| Age (in years) | 11.2 ± 0.8 | 11.18 ± 0.8 | 11.5 ± 0.9 |
| Height (in cm) | 142.9 ± 5 | 143.4 ± 5 | 142.4 ± 5 |
| Weight (in kg) | 38.1 ± 3.4 | 36.7 ± 3.4 | 37.9 ± 2.5 |

**Table 2: The groups Staheli indices in the pretest and posttest and the results of the paired t-test and independent t-test**

| Variable | Test turn | First experimental group | Second experimental group | Control group | Intra-group effects | Interactive effects | Intergroup effects |
|---|---|---|---|---|---|---|---|
| Flat foot | Right foot | 0.53 ± 0.09 | 1.04 ± 0.08 | 1 ± 0.10 | *P*=.001 | *P*=.001 | *P*=.80 |
| | | 0.52 ± 0.11 | 0.91 ± 0.04 | 0.95 ± 0.11 | *F*=35.32 | *F*=33.30 | *F*=0.30 |
| | Left foot | 0.54 ± 0.10 | 0.95 ± 0.13 | 0.89 ± 0.16 | *P*=.001 | *P*=.001 | *P*=.27 |
| | | 0.54 ± 0.13 | 0.87 ± 0.05 | 0.88 ± 0.11 | *F*= 22.21 | *F*= 22.93 | *F*=1.32 |

In the column demonstrating the intra-group effects of the flat foot groups illustrated in Table 2, when comparing the groups mean scores on the pretests and posttests, a significant difference could be observed (right foot, *P*=.001,*F*=35.32; left foot=.001,*F*=22.21). Also, the intra-group variations interaction (variation line gradient) was also significant (right foot, *P*=.001, *F*=33.30; left foot, *P*=.001, *F*=22.93), and it can be statistically stated that the two groups were in an interactive relationship with one another. In other words, when the scores variations of each of the two groups are taken into consideration separately, the significance level increases, and the internal variations patterns of the groups can be considered as significantly different. The column pertaining to the intergroup effects illustrated in Table 2 indicates that the intergroup differences of the flat foot groups was not statistically significant during the two turns of the tests for both the right and left feet (*P*=.80, *F*=0.30;*P*=.27, *F*=1.32, respectively).

## Discussion

The objective of the current study was to survey the effect of simultaneous stretching and strengthening exercises and also a combination of the two exercises on the flat foot deformity in the 9- to13-year-old female students. According to the obtained results, it was confirmed that the simultaneous stretching and strengthening and also a combination of the two exercises were effective on the plantar arch, and additionally, it was shown that the combined exercises were more effective on the correction of the foot arch. To determine the flat foot disorder, the authors made use of footprints (Staheli's plantar arch) index.Although there are discrepancies between the researchers as to which parameters should be given more importance and significance in adopting an appropriate footprint method, but a majority of the researchers have introduced interior longitudinal arch measurement as the main parameter for the determination of the flat foot. As far as the authors know, there was no research undertaken concerning the effects of simultaneous stretching and strengthening and also combinatory exercises on the plantar arch. There is only one study conducted on the effect of the corrective moves in restoring the normal situation of the plantar arch in children, in which the author stated that the corrective training was significantly effective on preserving balance in the children with flat foot (Payandeh et al., 2014) .These results are challenging in different studies(Logue, 2007). They investigated the effects of a 6-week training period on the flat foot deformity improvement, and finally, they concluded that there was no significant difference in the improvement of the flat foot defection between before and after training. Such a discrepancy in the results can be due to the differences in the study sample volume, age groups, mean scores, and the exercises and training choices. The results of the current study showed that there was a significant difference between the control group and the experimental groups in their posttest results regarding the navicular collapse index, and that the effects of the trainings were more prominent in the second group. Muscles play a significant role in preserving the interior longitudinal plantar arch, and the flexible flat foot deformity is often as a result of the weakness in the intrinsic and extrinsic muscles of the feet (Headlee et al., 2008).The most important and effective muscles in preserving the interior longitudinal plantar arch are the ones located in the beneath of the arch, among which we can point to the toes' flexor muscles, particularly the long flexor halluc is long us muscle of the big toe because it is the longest deep calf muscle, and also to the muscles in the dorsal and anterior regions of the tibia. Triceps surae muscle, which is comprised of the collection of the gastrocnemius and soleus and plantar muscles, passes through the ankle joint and travels from over the subtalar joint,and because of its location within the movement axis of the joint,it causes an inward rotation and supination in the joint (Letafatkar et al., 2012).The dorsal tibia is responsible for the plantar flexion and ankle inversion, a factor contributing to the preservation of the interior and traverse plantar arch(Shier, Butler & Lewis, 1996).Flat foot deformity is usually accompanied with the subtalar joint pronation.The inverter and supinator muscles play a critical role in preserving the interior longitudinal plantar arch(Sahrmann, 2010).

The central area of the body can be considered as a muscular belt within the central movement chain of the body, and it is also enumerated as a stabilizing unit fixing the spinal column and the upper body as a whole. As an initiator of the entire array of the body organs moves, it is regarded as the main driving force of the body(McCaskey, 2011). The muscular strength and endurance of this region of the body allows the whole system to optimally distribute, deliver, and transfer the driving force of the body by mechanically stabilizing the spinal column(Hill & Leiszler, 2011).Exercises and trainings related to the central area of the body increase the power, endurance, and neural control of the region so that the control of the spinal column interior section, the abdominal internal pressure, and the upper extremities muscular movement can be improved. These exercises are also effective on preserving body balance when performing various dynamic moves(McCaskey, 2011).In case of weakness in the central area of the body, all of the above cases are disordered, and the lower extremities become prone to lesions and injuries (Aggarwal et al., 2010).Because the central area of the body is the final point and the locus of connection and the place for receiving power from the entire movement chain while performing the entire array of the dynamic moves, the central body stabilization could maximize the performance of the lower and upper extremities of the movement chains. Also, it has been reported that when the central body stabilization training is undertaken in long-term as a supplement to training programs, it causes the body to learn how to correctly make use of the middle and external muscular layers. There is a presupposition that it activates the main muscles, leading to a considerable increase in preserving a given posture and finally an improvement in the body status(Akuthota et al., 2008; Kaji et al., 2010).In a study conducted in 2008 it was shown that the muscular activity was in a higher level while exercising with a Swiss ball than exercising on a fixed surface (Duncan, 2009) .Due to the unlimited number of the researches in this regard and based on the studies performed by the authors of the current research, there was no such a research on the effects of simultaneous stretching and strengthening exercises and combinatory exercises, as well, on the flat foot syndrome. The results of the present study indicated that the stretching and strengthening exercises and trainings for improving the central body stabilization can be effective on improving the flat foot deformity, and the exercises selected in the present study were found to have promising results in reinforcing the muscles effective on the plantar arch, and they were also found to have great influence on the tendons stretching and plantar fibula muscles because it is clear that the substantial causes of the flat foot deformity in children are the weakness in the plantar arch holding muscles and also the imbalance between the plantar rotating muscles in- and outward.

The limitations which can be recounted for the present study were consisted of the low number of the study sample volume, evaluating the tests from just one gender, lack of the researchers' control on the activities performed by the tests out of the training program time, especially sport activities. The present study was conducted in eight weeks, thus it is suggested that the future researches to be carried out on longer periods so that the results could be compared with the results obtained herein. Moreover, it is suggested that due to the high prevalence rate of the flat feet, there is a need for further researches to be performed on the individuals with such a deformity in both genders and encompassing various age groups.

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**Authors ' contribution**
SMM: Conducted whole study and had full access to all of the data for analysis. Also she was involved in drafting the article
RKH: Assessed the patients and confirmed their eligibility for the study. He took responsibility for conducting the study and the integrity of the data and the accuracy of the data collection.
NR.FRZ: Participated in conducting the study. All authors approved the final version of the manuscript.

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