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A COMPREHENSIVE EXERCISE PROGRAM IMPROVES FOOT ALIGNMENT IN CHILDREN WITH FLEXIBLE FLAT FOOT

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Abstract

A flat foot is one of the most common skeletal disorders that affect the function of the foot.

The aim of this study was to compare the effect of two types of corrective exercise programs with a comprehensive and localized approach in correcting flat foot deformities in adolescents.

The statistical population consisted of adolescent male students in Mashhad. Using cluster sampling, 75 students aged 11 to 12 years, who had simultaneously flat feet, crossed knees, and internal rotation of the knee was purposefully selected. They were randomly divided into three experimental groups: local exercises (n=25), comprehensive (n=25), and control (n=25). The severity of flat feet was measured by the navicular bone loss test (pre-test). The experimental groups performed local and comprehensive correction programs for 6 weeks.

The results showed that local corrective exercises and comprehensive corrective exercises have a significant effect on correcting flat foot deformities. There was also a significant difference between the effect of local and comprehensive exercises in correcting flat foot deformities and the effect of comprehensive exercises was greater.

It is concluded that for the treatment of plantar fasciitis, both local corrective exercises and comprehensive corrective exercises can be used as effective training methods and comprehensive corrective exercises have an advantage over local corrective exercises.

Keywords: *flat-foot, corrective exercises, comprehensive corrective movements, local corrective movements.*

Introduction

One of the basic human needs for daily activities is having healthy upper and lower limbs. In comparison to other parts of the human body, the foot shows more structural changes [*Wong C et al., 2012*]. Some of the consequences of abnormalities in the foot arch are related to the functions of these arches, and since the functions of these arches include creating more movement in the foot, as well as absorbing and distributing the impact forces that enter the body from the foot, these arches do not allow all incoming forces to enter the body [*Peng Y et al., 2021*]. Having a natural foot arch allows for proper weight distribution on the feet and transferring it to the ground. Additionally, other benefits of having a natural foot arch include natural walking and running, and supporting the soft tissues of the foot in the presence of these arches. Given the high importance of the longitudinal arch, it is essential to take good care of it.

The internal arch of the foot and its function in

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human movement appears to have a significant impact on physical and motor readiness, as indicated by the difference in the size of the longitudinal inner arch [*Kim D et al., 2015; Huang Y et al., 2020*]. A flat foot is a condition in which the height of the inner arch of the foot has decreased or completely disappeared. The flatness of the foot can be flexible or rigid. Individuals with flat feet are prone to a variety of biomechanical dysfunctions in the foot and ankle, as well as abnormal gain [*Van Boerum D et al., 2003*]. Any pathological condition that flattens or exacerbates its curves seriously affects the ability to maintain the body on the ground and necessarily impairs running, walking, and maintaining posture [*Sagat P et al., 2023*]. Arches provide a place for nerves and blood vessels to pass through to facilitate blood flow and reduce fatigue. One of the reasons for this change in shape is the shortening of the thin and long muscle and the large anterior and posterior muscles. Weakness of the posterior tibial muscle is also a cause.

The main reason for this condition is the weakness of the intrinsic muscles, along with other important causes such as the complex of the tibialis anterior and posterior muscles, along with the thin and short muscles of the leg. Other causes include inheritance and diseases, occupation, overweight, inappropriate footwear, and lack of movement [*Bayattork M et al., 2020*]. Treatment for flat foot includes using regular shoes with supportive arches, common orthotic insoles, corrective exercises, physical therapy, and sometimes surgery. It should be noted that all children have naturally flat feet until the ages of 2-3, and the inner longitudinal arch of the foot forms before the age of 6 [*van der Tol P et al., 2003*].

If this natural arch does not form, problems such as walking difficulties and chronic pain in the spine and legs may occur, which can be preventable if flat feet are detected early in children [*Pauli R, 2019*]. It has been observed that the prevalence of flat feet in boys is higher than in girls [*Ezema C et al., 2014*]. Since lower limb abnormalities can contribute to balance disorders and can lead to difficulties in walking, running, jumping, and basic motor skills, the lack of alignment in the lower limbs puts additional pressure on the muscles, joints, and bones [*Kaminski T et al., 2002*]. Therefore, flat feet should not only be considered a static problem of the ankle and foot complex, but can also cause a change in the dynamic function of the entire lower limb.

Early detection and correction of foot abnormalities, such as flat feet, can prevent health problems that affect people's health [*Xu L et al., 2022*]. One of the most common, simplest, most cost-effective, and popular measures for measuring flat feet is the navicular drop test and the Staheli index [*Roth S et al., 2013*]. The purpose of exercises is to correct the function of the muscles related to the arch of the foot. As a result, correcting the function of these muscles improves the direction and number of forces and movements. The aim of this study was to compare the effect of two types of corrective exercise programs with a comprehensive and localized approach in correcting flat foot deformities in adolescents.

Material and methods

This article used a hybrid, experimental/observational approach. Teenage male pupils in Baghdad, Iraq, were tested for intelligence. A cluster sampling selected an area, and then a district within that region was selected.

From all the schools in Baghdad's 2nd ward, one all-male institution was chosen. Seventy-five male 11-to 12-year-olds were chosen for this study because of their flat feet, knee valgus, and internal knee rotation. They were randomly assigned to one of three groups: experimental (25 students), comprehensive (25 students), or control (25 students).

The pie chart (Fig. 1) visually represents the distribution of participants across three distinct groups: Local Exercise, Comprehensive, and Control. Each segment of the pie chart corresponds to one of these groups, with the size of the segment indicating the proportion of participants in that group relative to the total number of participants.

The degree of flat feet was first evaluated using a pre-test utilizing the Navicular Drop Test. Participants in both the experimental local and comprehensive programs engaged in remedial exercises for six weeks. The exercises performed by the local group targeted the flexor digitorum longus and tibialis posterior tendons to improve flexibility and develop the muscles on the inside and outside of the foot, particularly the internal rotator muscles. In the comprehensive group, exercises

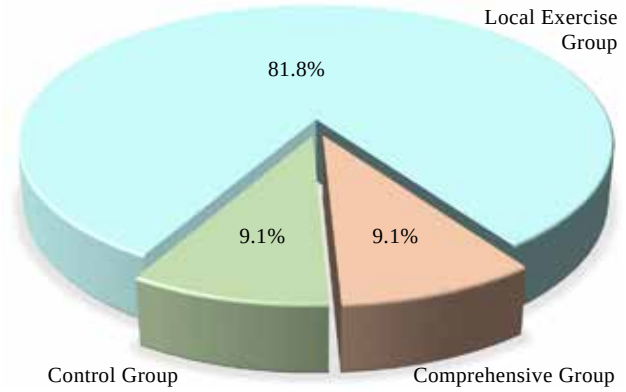

Figure 1. *Distribution of participants across groups*

focused on strengthening the adductors, short head of the biceps femoris, and iliotibial band, and stretching the medial and lateral hamstrings, eternal rotators of the thigh, and middle gluteus. During this time, the control group did not participate in remedial activities. The extent of flat feet was assessed after exercise by performing the Navicular Drop Test (post-test).

A flowchart above (Fig. 2) depicts the investigation's technique graphically. The procedure begins with participant selection and progresses to sampling, grouping, preliminary testing, and, eventually, interventions.

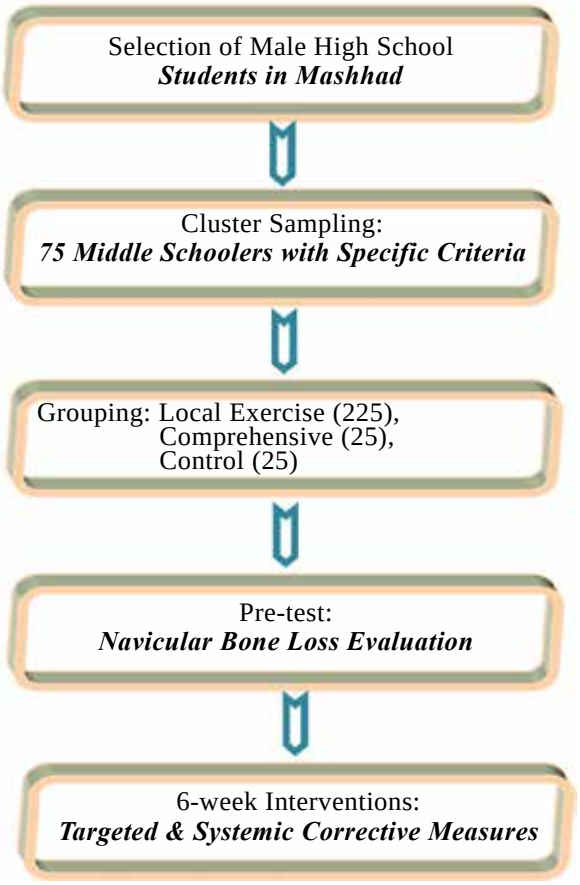

Figure 2. *Study design flowchart*

Table 1.

Mean and standard deviation of dependent variables in pretest and posttest in research groups

Group	Variable	Mean		Standard deviation	
		Pre-test	Post-test	Pre-test	Post-test
Localized group	Intrinsic and extrinsic foot muscles	54.55	56.73	13.9	14.5
	Adductor hallucis muscle	25	37.2	4.59	5.05
	Tibialis posterior tendon	36.6	45.6	2.59	2.46
	Achilles tendon	80.1	85.8	4.27	6.36
Comprehensive group	Medial and lateral gastrocnemius muscles	42.5	51.9	3.6	4.43
	External rotator muscles of the hip and thigh	50.60	61.74	1.08	2.98
	Hip adductor muscles	36.6	41.5	2.59	3.51
Control group	Intrinsic and extrinsic foot muscles	54.50	54.68	13.5	13.7
	Adductor hallucis muscle	24.8	25.1	4.32	4.42
	Tibialis posterior tendon	35.6	36.1	2.48	2.51
	Achilles tendon	88.8	89.8	4.50	4.61
	Medial and lateral gastrocnemius muscles	41.9	42.05	3.4	4.6
	External rotator muscles of the hip and thigh	51.45	55.81	1.10	2.05
	Hip adductor muscles	35.8	37.5	2.48	2.65
	Head of biceps femoris muscle	78	78.6	3.56	3.98

Adductor halluces muscle
Tibialis posterior tendon
Achilles tendon

Results

The pre-and post-test mean and standard deviation for a variety of muscle groups and tendon locations, including those of the sole, the tibialis posterior, the Achilles tendon, the middle and large adductors, the external rotators of the hip, the middle gluteal muscles, the adductors of the thigh, the biceps femoris (short head), the iliotibial band, and the control. All of the data in this research follows what the Kolmogorov-Smirnov test shows to be a normal distribution. Levene's test shows that the research groups had comparable variances across all dependent variables.

The results (Table 1) show that both targeted and systemic correction exercises are effective in reversing the deformity of the flat foot. As shown in table 2, the findings show that comprehensive exercises' impact is stronger than local workouts in treating the anomaly of the flat foot.

The bar chart showcases the difference in mean values of various muscles and tendons for the Localized group from the pre-test to the post-test (Fig. 3). The error bars represent the standard deviation, providing a measure of variability within the results.

This visualization demonstrates the change in mean values for the Comprehensive group. It provides insights into how the mean values of the muscles and tendons have shifted after the intervention, with the error bars highlighting the variability in these results (Fig. 4).

The graph presents the change in mean values for the Control group (Fig. 5). It highlights the minimal change observed, which is expected given that this group serves as a baseline for comparison. The error bars, once again, represent the standard deviation.

Table 2.

One-way ANOVA results for comparing post-test means of research variables among three local, comprehensive, and control groups

Variables	F-value	Significance level	Mean
Corrective exercises local	1.344	0.244	4.21
Corrective exercises comprehensive			4.35
Control			4.20

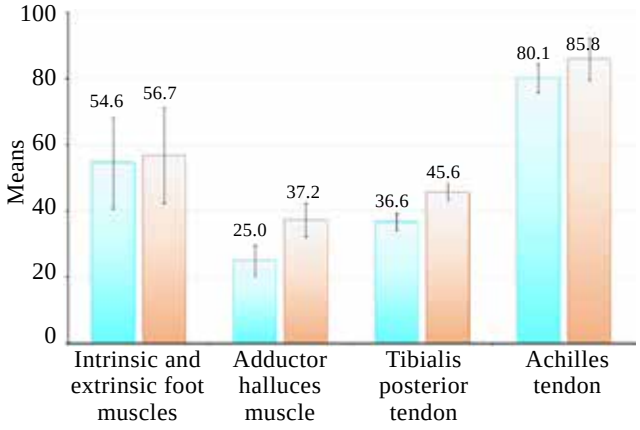

Figure 3. *Change in mean values from pre-test to post-test in localized group*

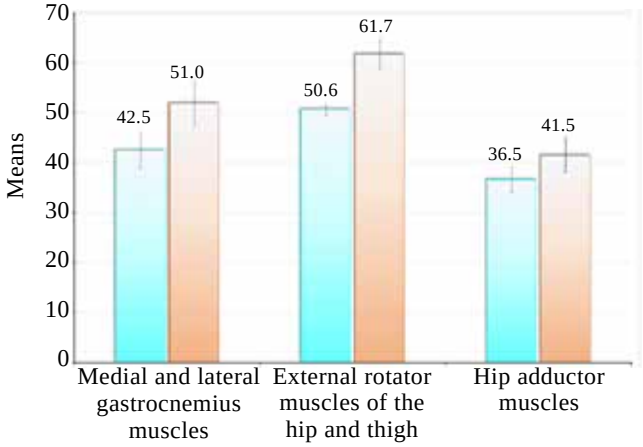

Figure 4. *Change in mean values from pre-test to post-test in comprehensive group*

Figure 6 represents the post-test mean values for the three different groups following the interventions. The group showing the most significant change, the Comprehensive group, is highlighted in gold. Annotations provide the F-value and significance level, offering a statistical perspective on the results (Table 2).

Discussion

Having a natural arch in the foot leads to proper weight distribution on the feet and transferring it to the ground. Another advantage of the natural foot arch is natural walking and running with its natural property. In addition, supporting the soft tissues of the sole of the foot occurs in the presence of these arches. Given the high importance of the longitudinal arch inside the foot and its function in human movement, it seems that the difference in the size of the longitudinal arch inside the

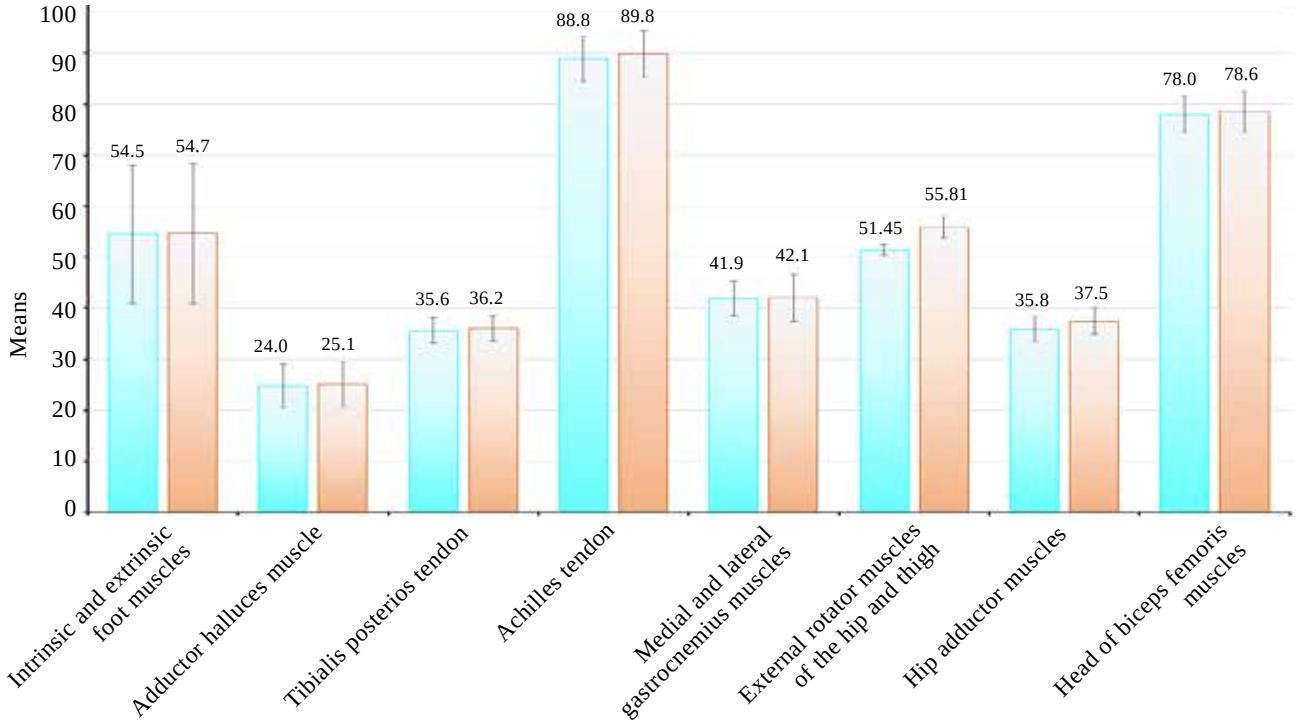

Figure 5. *Change in mean values from pre-test to post-test in control group*

foot may have an undeniable effect on physical and motor readiness. The aim of this study was to compare the effect of two types of corrective exercise programs with a comprehensive and localized approach in correcting abnormalities in the flat foot in adolescents. The experimental groups of local and comprehensive corrective program for six weeks performed local and comprehensive corrective exercises. The results indicated that local corrective exercises and comprehensive corrective exercises have a significant effect on the correction of flat foot deformity.

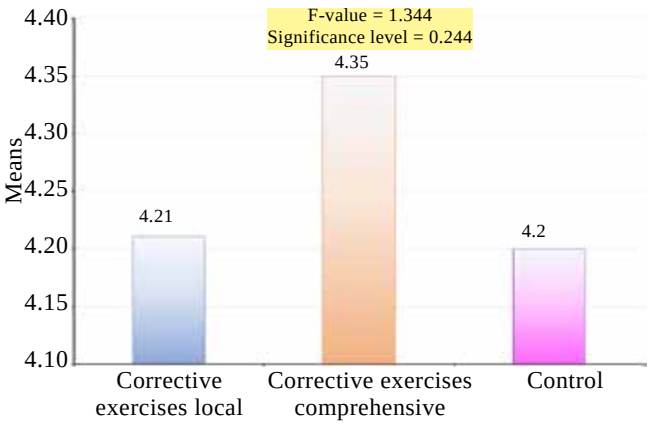

Figure 6. *ANOVA results for comparing post-test means among groups*

These findings were in line with other researches from around the world, which compared the effect of plyometric exercises with flatfoot corrective exercises on balance, foot posture, and functional mobility in 47 obese children aged from 7 to 11 years with a flexible flatfoot [*Allam H et al., 2021*]. In agreement with our findings, they also showed that plyometric exercises and foot correction exercises had a positive effect on foot posture, balance, and functional mobility in obese children with flatfeet. Concerning pre-intervention balance assessment, the results of the study revealed that obese children have deficient balance skills. This comes in agreement with [*Deforche B et al., 2009*], who mentioned that obese prepubertal males have decreased both static and dynamic balance and postural skills. Moreover, obese children have deficits in the torque of the ankle muscles needed for stability when they are subjected to any oscillations [*Corbeil P et al., 2001*]. Additionally, deficits in balance strategies in obese children preintervention had impaired functional mobility as represented by the TUG test score [*Deforche B et al., 2009*].

Also, we found that there is a significant difference between the effect of local and comprehensive exercises in correcting the deformity of flat

feet, and the effect of comprehensive exercises is greater. Concerning the effect of comprehensive exercises on foot posture, the results of the current study revealed that there was a significant improvement in the foot posture after comprehensive training. We can attribute this improvement to the improvement in plantar flexor strength and mechanical properties after comprehensive exercises. *Kubo et al*. [*Kubo K et al., 2007*] support this idea when they found a significant increase in plantar flexor muscle activity during the concentric phase of vertical jumps. Furthermore, the results obtained in [*Kyröläinen H et al., 2005*] denoted a significant improvement in both maximum voluntary contraction and muscular activity and strength of plantar flexors after comprehensive exercises. Moreover, study by [*Weist R et al., 2004*] confirmed the relation between the plantar flexors and the medial longitudinal arch when they concluded that fatigue of plantar flexors reduces its supination action and increases foot pronation. Additionally, in [*Fourchet F et al., 2015*] was found that decreased calf muscle activity due to fatigue was associated with an increase in the contact area under the medial longitudinal arch. Kamalakannan and Swetha came in agreement with our results when they concluded that robe skipping activities improved the foot arch and functional activities of the lower limb [*Kamalakannan M et al., 2020*]

Therefore, considering breakout rate of above deformity, problems and various consequences which can make for infected one, importance and necessity of prevention and curing flat foot, especially among students determined. Also, because in education environment, physical education teachers are ones who work with student's physical status, by coordination of parents and trainers, PE teachers can have the most roles in identifying and preventing of this deformity. It suggests that x ray method is used in screen phase, because in x ray method, existing angles between bones are clear, and for preventing of breakout of flat foot, factors like nutrition, decreased weight, use suitable shoes and correction of bad motor habits must be considered. In conclusion, based on the results of the present study, it can be concluded that both localized corrective exercise and comprehensive corrective exercise can be used as effective exercise methods for the treatment of flat foot. Comprehensive.

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