Original Article

The effect of flexible flat-footedness on selected physical fitness factors in female students aged 14 to 17 years

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ABSTRACT

Nakhostin-Roohi, B., Hedayati, S. & Aghayari, A. (2013). The Effect of Flexible Flat-footedness on Selected Physical Fitness Factors in Female Students Aged 14 to 17 years. *J. Hum. Sport Exerc., 8*(3), pp.788-796. The purpose of this study was to evaluate influence of flexible foot flatness on several physical fitness factors that are necessary for sport performance. Fifty students were randomly selected from each group (Flatfoot and Normal group). Static balance (One Leg Test), Dynamic balance (Modified Bass Test), speed (45 Meter Dash Test) and agility (T Test) were selected as physical fitness factors. There were significant differences in agility and static balance records ($P<0.05$) but not significant differences in speed and dynamic balance records between groups ($P>0.05$). It seems foot as a last part of a close kinematic chain has very important role in dynamic and static position and affects physical fitness factors. However, owing to presence of a plenty of controversies suggests more works in this domain. **Key words**: FLEXIBLE FLATFOOT, STATIC BALANCE, DYNAMIC BALANCE, AGILITY.

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INTRODUCTION

A high percentage of young children present with flatfeet (Shih et al., 2012). Flat foot in children and adolescents, as a consequence of various factors such as hypo kinesis, obesity or hereditary factors, represents a current problem (Saša Milenković et al., 2011). Flexible flatfoot (FFF) is a condition in which the medial longitudinal arch of the foot collapses during weight bearing and restores after removal of body weight (Bordelon, 1983; Kuhn et al., 1999). In normal gait, the subtalar joint start to pronate after initial contact until the metatarsal head contacts the ground, where upon the subtalar joint starts to supinate and converts the foot into a rigid structure for propulsion in the late stance phase (Donatelli et al., 1988). In people with flexible flatfeet, the foot stays in a pronated position without turning to supination early enough during the late stance phase (Highlander et al., 2011), which is not efficient for completing the push-off during gait (Dennis et al., 1985; Donatelli et al., 1988; McCulloch et al., 1993). Considering the coupling movement between rearfoot inversion/eversion and tibial rotation (Nawoczenski et al., 1998; Pohl et al., 2006), an excessive or prolonged pronation of the foot is often linked to excessive or prolonged tibial rotation and larger valgus at the knee (Tiberio Z, 1987).

Motor tasks involving the lower legs activate a closed kinetic chain, with the foot being the terminal part of that chain. It is known that when a part of this chain is weak or damaged, it will affect other parts of the chain. This is a logical question how the different terminal segments of that kinetic chain (meaning low or high arch of the feet) influence the motor performance (Tudor et al., 2009). Therefore, if foot flatness is connected to the function of the lower leg, it may also affect the motor abilities originating from the activity of the leg muscles. On the premise that FFF should be related to children's physical fitness characteristics, we determined to evaluate influence of flexible foot flatness on several physical fitness factors that are necessary for sport performance.

METHOD AND MATERIALS

This study was conducted in the northwest of Iran, the city of Ardabil, the center of Ardabil province. Using cluster sampling technique, four high schools were randomly selected of 22 ones at the first stage. All eligible students on the basis of inclusion criteria participated in this study. Main items of inclusion criteria were:

- Age between 14-17
- BMI between 17-25
- Having no other disability and sickness except for flat-footedness
- Not to be athlete
- severe FF

68 flexible flatfoot students and 356 healthy ones were selected at second stage. In the last stage, 50 students were randomly selected from each group (Flatfoot and Normal Group). School principals and teachers consented to enroll prior to randomization. Before the testing, detailed explanations of the testing procedure and parental consent forms were sent to the parents, together with the questionnaire regarding their child's engagement in organized sports activities (apart from physical education lessons in school) and parents provided signed written informed consent for their children to participate in assessments.

The feet were grouped by the appearance of the longitudinal arch on weight bearing. The foot was graded as normal if the medial arch looked normal. If the arch was only slightly impressed but still visible, it was graded as mild FF but was still categorized as normal. Flexible FF meant that the longitudinal arch was not visible in stance (FFF). If the medial border of the foot was convex, with the head of the talus presenting on the plantar aspect of the foot immediately below and anterior to the medial malleolus, it was graded as severe FF (Barry and Scranton, 1983). The students with a severe FF excluded of our study.

Physical fitness Factors

Four tests were selected from the battery of tests usually used for testing participants:

Static balance test (One Leg Test):

The subject stood with closed eyes on 1 leg with the other leg abducted. The goal of the test was to stand in that position for maximum time. In our study, the test was done twice and the best score was recorded.

Dynamic balance test (Modified Bass Test):

Equipment required: adequate floor space, sticky tape for marking floor, measuring tape, and stopwatch.
Procedure: The course was marked out as illustrated in the diagram to the right. The subject began by standing stationary on the right foot on the starting point square. The subject then hoped to the first tape mark with the left foot and immediately held a static position for five seconds. After this time, he then hoped to the second tape mark with the right food and held a static position for another five seconds. This continued with alternate foot hopping and holding a static position for five seconds at each point until the course was completed. At each point, the sole of the foot must completely have covered each tape mark so that it could not be seen.

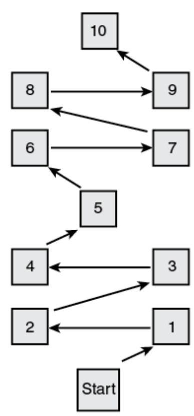

Figure 1. *Course for Modified Bass Test*

Scoring: The result was recorded as either a success or fail. A successful performance consisted of hopping to each tape mark without touching the floor with the heel or any other part of the body, and holding a static position on each tape mark for five seconds without exposing the tape mark (Figure 1). In our study, the test was done twice and the best result was recorded.

Speed Test (45 Meter Dash):

Equipment required: measuring tape or marked track, stopwatch or timing gates, cone markers, flat and clear surface of at least 50 meters.

Procedure: The test involved running a single maximum sprint over 45 meters, with the time recorded. First, a thorough warm up was given, including some practice starts and accelerations. Start from a stationary position, with one foot in front of the other. The front foot was on or behind the starting line. This starting position hold for 2 seconds prior to starting, and no rocking movements were allowed. The tester provided hints for maximizing speed (such as keeping low, driving hard with the arms and legs) and encouraged to continue running hard through the finish line.

Results: Two trials were allowed, and the best time was recorded to the nearest 2 decimal places. The timing started from the first movement and finished when the chest crossed the finish line.

Agility Test (T Test)

Equipment required: tape measure, marking cones, stopwatch, timing gates (optional)

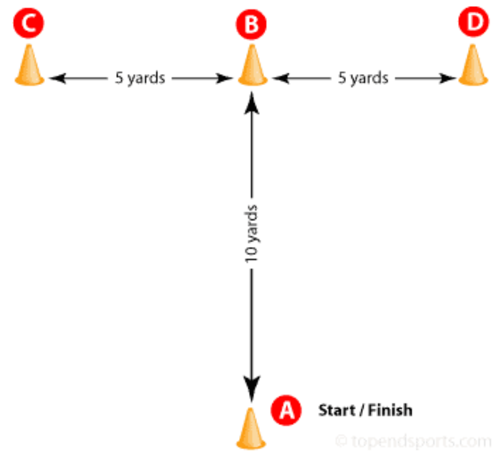

Figure 2. *Course for T test*

Procedure: Set out four cones as illustrated in the diagram above (5 yards = 4.57 m, 10 yards = 9.14 m). The subject started at cone A. On the command of the timer, the subject sprinted to cone B and touched the base of the cone with their right hand. They then turned left and shuffled sideways to cone C, and also touched its base, this time with their left hand. Then shuffled sideways to the right to cone D and touched the base with the right hand. Then, subjects shuffled back to cone B touching with the left hand, and ran backwards to cone A. The stopwatch was stopped as they passed cone A (Figure 2).

Scoring: The trial would not be counted if the subject crossed one foot in front of the other while shuffling, failed to touch the base of the cones, or failed to face forward throughout the test. The best time of three successful trials to the nearest 0.1 seconds was recorded.

Statistical Analysis

Means and standard deviations were calculated for each variable using descriptive statistics. The Kolmogorov-Smirnov normality test was used to determine whether data set was well modeled by a normal distribution or not. Independent t-test was carried out to assess differences in the dynamic balance, speed and agility records between groups. Owing to lack of normality in static balance records, we used U Man-Whitney instead of t-test. All statistical analyses were performed using SPSS (statistical package for social sciences, version 18.0). The significance level was set at $P<0.05$.

RESULTS

The characteristics of participants, including age, height, weight, and BMI are summarized in Table1. There were no significant differences between groups regarding to these characteristics ($P<0.05$).

Table 1. *The characteristics of participants*

	Age (year)	Height (cm)	Weight (kg)	BMI (km.m^{-2})
Normal Foot group (n=50)	15.66 ± 1.06	159.08 ± 4.93	54.02 ± 7.52	21.39 ± 3.15
Flat Foot group (n=50)	15.56 ± 1.05	160.64 ± 5.33	57.22 ± 8.06	22.23 ± 3.01

Values are mean ± SD

According to Figure3 and 4, there are significant differences in agility and static balance records between groups ($P<0.05$) but not significant differences in speed and dynamic balance records between groups (Figure5 and 6) ($P>0.05$).

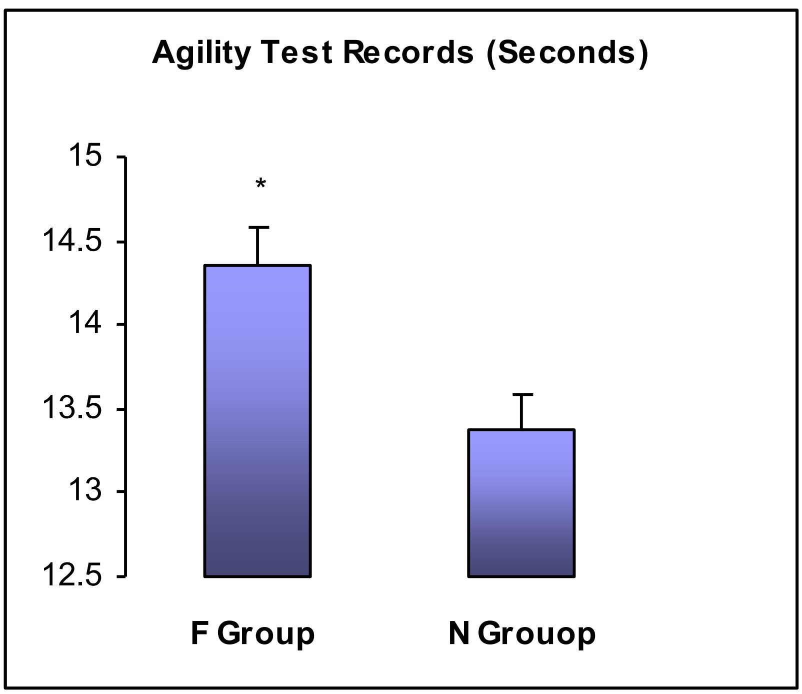

Figure 3. *Agility Records*

F group: Flexible flatfoot; N group: Normal group
* Significance of unpaired t- test

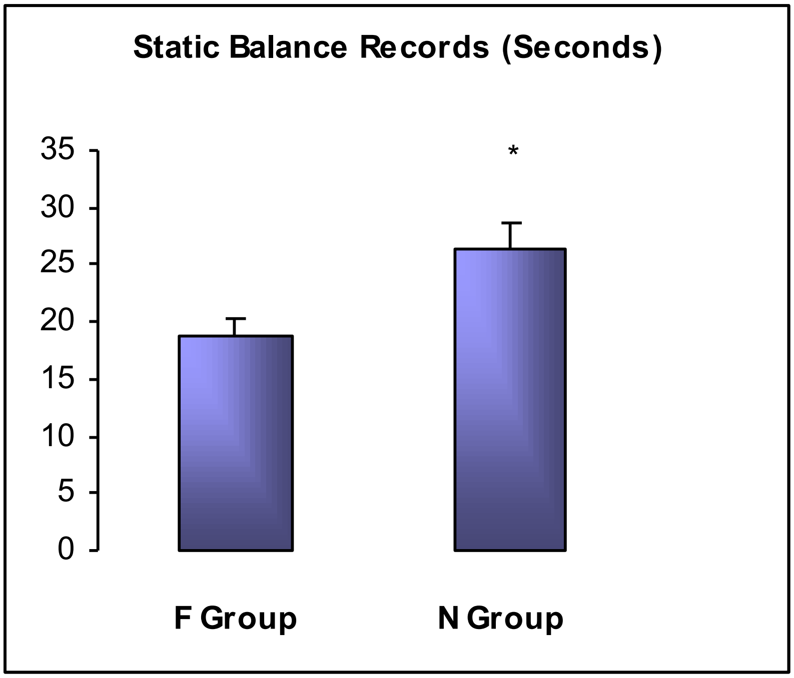

Figure 4. *Static Balance Records*

F group: Flexible flatfoot; N group: Normal group
* Significance of U Man-Whitney test

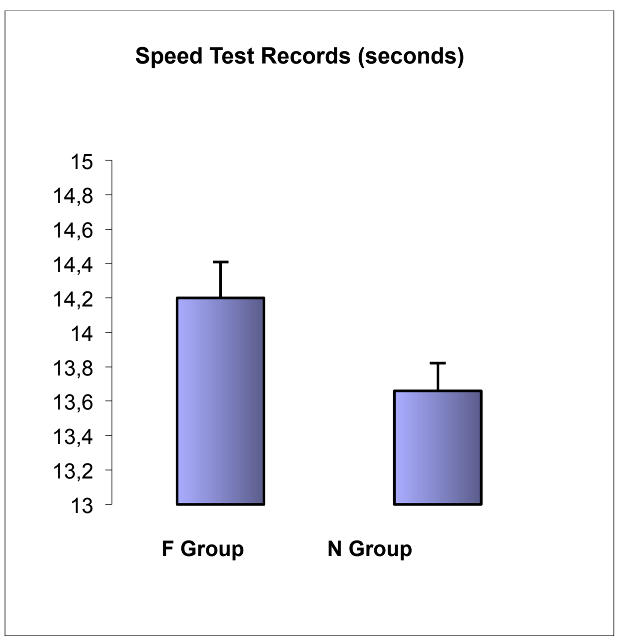

Figure 5. *Speed Records*

F group: Flexible flatfoot; N group: Normal group

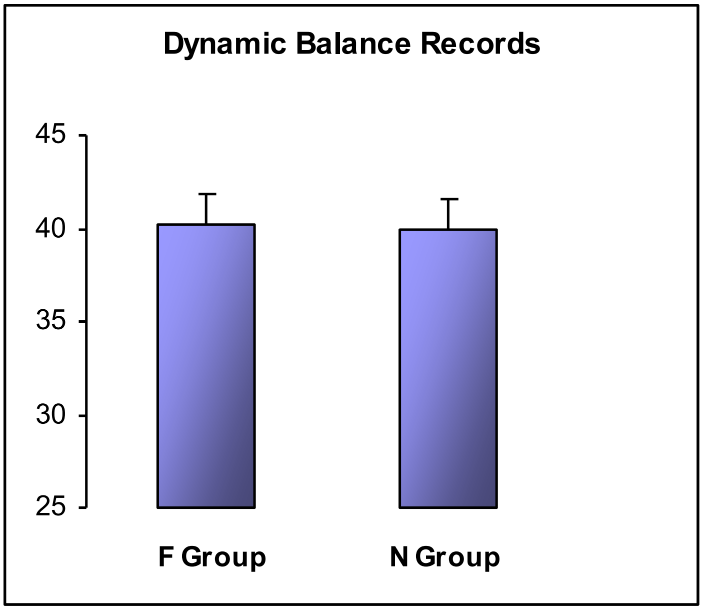

Figure 6. *Dynamic balance Records*

F group: Flexible flatfoot; N group: Normal group

DISCUSSION

The main finding of this study was significant differences in two of all four physical fitness factors among students 14 to 17 years who had flexible flat or normal feet. To our best knowledge, there are two relevant papers with absolutely disparate results related to our study. In one hand, Lin et al. (2001) claimed poorer performance in children with FFF. In the other hand, Tudor et al. (2009) strongly believed that Li et al. had stigmatized children with flat feet. The results of our study are nearer to first one. According to Li et al., the prevalence of FF correlates with general development, including joint laxity and poor physical performance and flat foot must be regarded not only as a problem of static alignment of the ankle and foot complex, but also as a dynamic functional abnormality of the lower extremity. Opposite to Li et al, Tudor indicated the selected motor skills were not affected by flat footedness. According to their results, measured athletic performance in all groups were similar and did not depend on foot morphology, as no significant influence of foot flatness and motor abilities was found.

All correlations were extremely low, not pointing to any possible relations between the arch index (corrected for the influence of age) and 17 motor test performances including speed, explosive power, reaction time, balance, and repetitive movements of the lower legs measured by standardized tests for testing of athletes usually used in our human performance laboratory. We strongly believe foot as a last part of a close kinematic chain has very important role in dynamic and static position. So, when a part of this chain debilitate or damage, it can affect other parts of the chain. So, it is logical if flat footedness influences static and dynamic characteristics of lower extremities. In current study, we observed significant differences in agility and static balance, as well as a trend of lower speed record in Flatfoot students. It seems in agreement with Li et al., flat footedness has damaged static and dynamic function of lower extremities.

Furthermore, we have some explanations for the difference between results of our study compared with Tudor et al. First, the age group of our study is disparate (14-17 in our study versus 11-15 in Tudor et al.). It is possible that effect of morphological pattern of foot has been exacerbated during growth. Second, Tudor et al. evaluated correlation between arch height and sport performance whereas we assessed differences between records of physical fitness records in two groups (Flexible flatfoot versus normal students). Third, our subjects were just female students.

Sex differences may be a main cause for differences. Forth, unlike Tudor, we just appraised flexible flatfoot versus normal one. Finally, worse records of flatfoot group might be related to psychological and pathological points. For example, some research indicates that greater intrinsic muscle activity is required to stabilize the transverse tarsal and subtalar joints in a flatfooted individual than in one with an average height arch, this might be expected to lead to foot fatigue and pain (Mosca, 2010). It is possible students with flatfoot anomalies owing to fear of injury or suffering from symptoms of damage to be less active and lose their motivation and self-confidence to do exercise.

CONCLUSIONS

In regard to presence of a plenty of controversies among our study and two relevant investigations, as well as many of un-replied questions, we suggest more works in this domain with large quantity of subjects and different variety of physical fitness tests for each factor, and close attention to methodological, psychological and pathological points.

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