Original Research

Comparison of Lower Extremities Physical Performance on Male Young Adult Athletes with Normal Foot and Flatfoot

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Abstract

Background: 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 disturbed, it will affect other parts of the chain, including the effect on the motor performance of lower extremities.
Aims: To see the difference of physical performance on athlete age 14 – 17 years with flatfoot and normal foot on strength, balance and agility factors.
Methods: Male athletes age 14 – 17 years enrolled in Sport Senior High School at Sidoarjo who underwent athletes screening at Sport Clinic of dr. Soetomo General Hospital and fulfill the inclusion criteria. The subject were 29 boys, the normal foot were 22 boys and the flatfoot were 7 boys. Subjects were examined for Clarke's angle and Chippaux-Smirak index to diagnose flatfoot and did Single-leg Hop for Distance, One Leg Test, Star Excursion Balance Test, and Hexagon Hop Test.
Result: The statistical analysis showed no difference of lower extremities' physical performance in strength using Single-leg Hop for Distance ($p>0.05$), balance using One Leg Test and Star Excursion Balance Test ($p>0.05$), and agility using Hexagon Hop Test ($p>0.05$) on male athletes age 14-17 years with normal foot and flatfoot.
Conclusion: There are no difference of lower extremities' physical performance in strength, balance and agility on male athlete age 14-17 years with normal foot and flatfoot.

Keywords: *flatfoot, physical performance, strength, balance, agility*

Introduction

Flexible flatfoot is a condition in which the medial longitudinal arch of the foot collapses during weight bearing and restores after removal of body weight.[1] Prevalence of flexible flatfoot in children, 2 to 6 years of age, has been reported at between 21% and 57%, and the percentage decreased to 13.4% and 27.6% in primary school children.[1] At the age of 12-14, the foot acquires a form similar to that of an adult, and the final formation of the bones is complete by around the 18 year.[2] At least 20% of adults have flatfeet, most of which are flexible.[3]

Flatfoot cause several complications such as foot pain, knee pain, back pain and postural disturbance. These pain rarely occur on babies and children, but the main cause of pain on runners and increase the risk of sport injury. Flatfoot claimed to be occurred at 60-90% of all the lower extremities' injury which said to be an overuse condition.[3,4]

The etiology of flatfoot are congenital disturbances such as ligament laxity and accessory navicular, acute trauma such as rupture of ligament or tendon that support the medial longitudinal arch, muscle imbalance (weakness of *Tibialis posterior* as foot invertor) and other conditions that add weight on medial side while weight bearing, such as obesity and genu valgum.[5,6] The state of the feet of sportsmen depends significantly on the type of effort and the weight of the load carried, which differs in different disciplines, and depends on the type of surface on which training and competition are conducted.[2]

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. In people with flexible flatfeet, the foot stays in a pronated position without turning to supination early enough during the late stance phase, which is not efficient for completing the push-off during gait. A certain amount of pronation is required for normal running activity, but too much pronation may hamper the running performance.[5,7] An excessive or prolonged pronation of the foot is often linked to excessive or prolonged tibia rotation and larger valgus at the knee.[5,8]

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, including the effect on the motor performance of lower extremities.[8]

Physical performance is commonly measured as the outcome (product) of standardized motor tasks requiring speed, agility, balance, flexibility, explosive strength, local muscular endurance, and static muscular strength. Isometric strength increases linearly with age during childhood and the transition into adolescence in both sexes. Thereafter, the differences become increasingly larger so that at the age of 16 years and later only a few girls perform at the same level as the average boy. In contrast, girls are more flexible than boys at virtually all ages. The aerobic capacity of boys increase during childhood to adolescent, but girls only reach the peak of aerobic capacity at 13-14 years old. The aerobic power also related to body size.[9]

Nakhostin-Roohi et al. (2013) 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.

Sharma et al. (2016) did a study to determine the effects of flat foot on running ability (short distance, middle distance, long distance) of an athlete. The normal foot performs better in 100 meter sprint and 12 minutes run test.

Number of researches about the influence of flatfoot on physical performance of adolescent athletes is still limited. Adolescent athletes are on the growth and maturation state, which influence the flatfoot condition and physical performance. Good physical performance are required to be able to bring good result in competition. This phenomenon should encourage researchers to do research about difference of physical performance on athlete age 14 – 17 years with flatfoot and normal foot. There are several physical performance factors that are necessary for sport performance, in this research, we evaluate strength, balance and agility.

Material and Methods

Design

This is a cross-sectional study. Participants were divided into 2 groups, the flatfoot group and normal foot group.

Participants

The research samples were twenty nine male athlete age 14 – 17 years (n=29) from Sport Senior High School at Sidoarjo who underwent athletes screening at Sport Clinic of Dr. Soetomo General Hospital and fulfill the inclusion criteria. Subjects then divided into two groups, the flatfoot group and normal foot group. The inclusion criteria were male athletes age 14 – 17 years and willing to enroll in the research. The exclusion criteria were if the subject participating on the branch of sports done without weight bearing position (swimming, diving), having history of injury or surgery on lower extremities within the last 6 months, and having other musculoskeletal injury that could endanger or hamper subject in doing the physical performance. The subjects who met the inclusion criteria received informed consent and underwent examination of body height, body weight, and body mass index, also Clarke's angle and Chippaux-Smirak index to diagnose flatfoot. Subjects then told to warm up before doing physical performance test, strength test was Single-leg Hop for distance, static balance test was One Leg Test, dynamic balance test was Star Excursion Balance Test, and agility test was Hexagon Hop Test.

Procedures

Clarke's angle and the Chippaux-Smirak index was a procedure of diagnosing flatfoot using footprint. Clarke's angle is obtained by calculating the angle of a first medial tangential line that connects the medial edges of the first metatarsal head and the heel, and the second line that connects the first metatarsal head and the acme of the medial longitudinal arch concavity. The Chippaux-Smirak index is defined as the ratio of the length of line B, a line parallel to A at the narrowest point on the foot arch, to the length of line A, the maximum width at the metatarsals (B/A × 100, %).[10] Single-leg Hop for Distance was done by jumping forward using one leg as far as possible, afterward we counted the limb symmetry index, (Mean Involved / Mean Uninvolved) x 100%.[11–13] One Leg Test was done by standing 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 afterward we counted the limb symmetry index.[14]

Star Excursion Balance Test consists of a grid formed by three lines made with tape extending out at 90° arcs from each of the posterior line and each of the posterior line form 135° arcs from the anterior line. Patients were asked to stand in the center of the grid with one leg and reach with the contralateral leg along each direction lines. We then counted the Normalized reach distance, reach distance divided by limb length, multiplied by 100 and Composite Normalized Reach Distance, the sum of 3 Normalized Reach Distance divided by 3 limb length, multiplied by 100.[15]

In Hexagon Hop Test, subject stands in the middle of the hexagon, on the command, subject jumps with both feet outside and inside each side of the hexagon. Subject complete three circuit.[16]

Statistical Analysis

We performed descriptive data analysis. The data distribution normality test was One-Sample Kolmogorov-Smirnov Test concluded that the data distributed normally, afterward we did the independent samples test.

Result

The subjects were 29 boys, there were 22 normal foot boys (75,9%) and 7 flatfoot boys (24,1%). The characteristics of participants, including age and BMI are summarized in Table 1. The side of foot involved on the flatfoot group is summarized in Table 2. Branch of sports variety summarized in Table 3.

Table 1. The characteristics of participants

Variabel		**Normal foot (%)**	**Flatfoot (%)**	**Total (%)**
Age (year)				
	14	1 (4,5)	1 (14,3)	2 (6,9)
	15	15 (68,2)	5 (71,4)	20 (69,0)
	16	6 (27,3)	1 (14,3)	7 (24,1)
Total		22 (100)	7 (100)	29 (100)
IMT				
	Low	3 (13,6)	3 (42,9)	6 (20,7)
	Normal	18 (81,8)	3 (42,9)	21 (72,4)
	Obese	1 (4,5)	1 (14,3)	2 (6,9)
Total		22 (100)	7 (100)	29 (100)

Table 2. The characteristics of flatfoot group

Side of flatfoot	**Sum (%)**
Right foot	2 (28,6)
Left foot	1 (14,3)
Both sides	4 (57,1)
Total	7 (100)

Table 3. The characteristics of branch of sports

Branch of sports	**Sum (%)**
Sepak takraw	6 (20,69)
Athletic	5 (17,24)
Wrestling	3 (10,34)
Judo	3 (10,34)
Fencing	2 (6,90)
Pencak Silat	2 (6,90)
Roller skating	2 (6,90)
Table tennis	2 (6,90)
Beach volley	2 (6,90)
Karate	1 (3,45)
Climbing	1 (3,45)
Total	29 (100)

According to Table 4, there were no significant differences in strength using Single Leg Hop for Distance, and Limb Symmetry Index between groups, $p>0,05$. The static balance using One Leg Test and the Limb Symmetry Index showed no significant differences between groups, $p>0,05$. (Table 5). The dynamic balance using Star Excursion Balance Test shows no significant differences between groups, $p>0,05$ (Table 6).

Table 4. The difference of physical performance in strength using Single Leg Hop for Distance between normal foot and flatfoot

Variable		**Normal foot**		**Flatfoot**		**p**
		N	**mean±SD**	**N**	**mean±SD**	
Single Leg Hop for Distance (cm)	Right	23	173,83 ± 25,31	6	170,50 ± 20,31	0,769
	Left	24	171,88±22,58	5	171,401±19,09	0,965
Limb Symmetry Index		22	1,001±0,01	7	0,96±0,06	0,166

Table 5. The difference of physical performance in static balance using One Leg Test between normal foot and flatfoot

Variable		**Normal foot**		**Flatfot**		**P**
		N	**mean±SD**	**N**	**mean±SD**	
One Leg Test (seconds)	Kanan	23	189,39±272,31	6	125,00±134,77	0,583
	Kiri	24	169,88±211,88	5	138,40±152,05	0,756
Limb Symmetry Index		22	90,05±78,68	7	81,29±50,35	0,785

Table 6. The difference of physical performance in dynamic balance using Star Excursion Balance Test between normal foot and flatfoot on analyzing each side of feet

Variable		Normal foot		**Flatfoot**		**P**
		N	**mean±SD**	**N**	**mean±SD**	
Normalized Reach Distance Anterior	Right	23	96,81 ± 8,90	6	98,07 ± 3,9	0,738
	Left	24	97,19 ± 9,18	5	99,30 ± 4,721	0,625
Normalized Reach Distance Posteromedial	Right	23	93,26 ± 14,08	6	92,47 ± 3,13	0,894
	Left	24	90,09 ± 11,60	5	89,77 ± 3,07	0,952
Normalized Reach Distance Posterolateral	Right	23	98,23 ± 14,10	6	101,68 ± 2,87	0,561
	Left	24	98,29 ± 12,77	5	97,16 ± 4,79	0,849
Composite Normalized Reach Distance	Right	23	108,20 ± 14,97	6	107,57 ± 4,87	0,921
	Left	24	106,87 ± 13,96	5	106,17 ± 6,20	0,914

The Star Excursion Balance test below described the physical performance of both feet. These result showed no significant differences between groups, p>0.05 (Table 7).

The physical performance in agility using Hexagon Hop Test showed no significant difference between groups, p>0.05 (Table 8).

Table 7 . The difference of physical performance in dynamic balance using Star Excursion Balance Test between normal foot and flatfoot on analyzing both feet

Variable	**Normal foot (n=22) mean±SD**	**Flatfoot (n=7) mean±SD**	**P**
Mean Reach Distance Anterior (cm)	86,59±7,18	89,00±4,69	0,415
Mean Reach Distance Posteromedial (cm)	82,73±10,80	80,14±7,73	0,564
Mean Reach Distance Posterolateral (cm)	88,82±11,80	88,14±5,55	0,886
Mean Normalized Reach Distance Anterior (cm)	96,63±8,78	100,57±3,82	0,264
Mean Normalized Reach Distance Posteromedial	92,32±12,02	90,57±8,22	0,724
Mean Normalized Reach Distance Posterolateral	99,05±12,91	99,71±6,16	0,897
Mean Composite Reach Distance	257,91±26,55	257,00±16,65	0,933
Mean Composite Normalized Reach Distance	107,61±14,67	109,66±8,05	0,729

Table 8 The difference of physical performance in agility using Hexagon Hop Test between normal foot and flatfoot

Variable	**Normal foot**		**Flatfoot**		**p**
	N	**mean±SD**	**N**	**mean±SD**	
Hexagon Hop Test (seconds)	22	28,03±6,15	7	29,89±11,53	0,581

Discussion

In this research, the single leg hop for distance and its Limb symmetry Index showed no significant differences between groups. This results match with the study done by Mozafaripour, et.al (2014), which couldn't find the significant difference of lower extremities' physical performance among flatfoot and normal foot soccer players. The authors hypothesized that there were no significant difference on physical performance of both groups because both groups were well trained athletes, with good physical condition.[17]

Chaab and Mahdavinejad (2014) were doing quasi-experimental research to evaluate the effectiveness of a pedaling exercise program on boys age 12-16 years with *pes planus* abnormality. They were divided into two groups, experimental and control groups. After 8 weeks of exercise program, there were increase of strength and muscle endurance on the plantar flexor muscles of the ankle, and general endurance on the experimental group.

Our research didn't measure endurance, but the increase of plantar flexor muscles of the ankle after doing exercise on the study by Chaab and Mahdavinejad (2014) could explain the not significant result on both groups, which they were trained athletes. This could also explain the existence of neuromuscular adaptation on flatfoot.

About the physical performance in balance, both static and dynamic balance showed no significant difference in both groups. This result matches with the study by Tudor, et.al (2009) which evaluate the relationship of physical performance on children age 11-15 years with normal foot and flatfoot.[18] However, this result doesn't match the study by Nakhostin-Roohi, et.al (2013) which evaluate physical performance on girls age 14-17 years with normal foot and flatfoot. The examination of physical performance in static balance by Nakhostin-Roohi, et.al using One Leg Test, similar to this research, while the dynamic balance test used was Modified Bass Test. The research by Nakhostin-Roohi, et.al used different gender of the subject, which were female and non-athletes. The number of the samples also different, 50 subject for each groups.[8]

Boys have muscle strength and aerobic capacity better than girls. While girls have better flexibility.[9] These facts cause gender influence on the result. As mentioned before, athletes have a better physical condition, in strength and neuromuscular adaptation on flatfoot. This fact causes difference result on our research and the research by Nakhostin-Roohi, et.al.

The neuromuscular adaptation matches with the research by Pozzi, et.al (2015) about neuromuscular control on dynamic balance using Star Excursion Balance Test of three groups, control group, coper group (with a history of ankle sprain but didn't develop into chronic ankle instability), and CAI group (Chronic Ankle Instability). The results found were increases in muscle activation of *peroneus longus* and *tibialis anterior* on coper group. Pozzi, et. al estimated this result as a compensation strategy to increase the dynamic joint stability. This compensation strategy could also occur on flatfoot.[19]

The examination of lower extremities' physical performance in agility using Hexagon Hop Test showed no significant difference in both groups. This result matches the research by Musavi, et.al (2012) about the relationship of longitudinal medial arc height with endurance of cardio respiration and agility on boys age 12-14 year. Musavi, et.al (2012) found relationship between longitudinal medial arc height and endurance of cardio respiration, but no relationship between longitudinal medial arc height and agility. This research doesn't match with the study by Nakhostin-Roohi, et.al (2013) where the agility on flatfoot group were better significantly than the flatfoot group. As been mentioned before, the subjects in Nakhostin-Roohi, et.al (2013) study were female, non-athletes and with larger number of the subject. There was also a different examination method; Nakhostin-Roohi used T Test to examine agility, while our research used Hexagon Hop Test.

The intra class reliability of T Test and Hexagon Hop Test on 3-trial showed good reliability coefficient (R), 0,98 on T Test and 0,95 on Hexagon Hop Test. T Test able to evaluate speed, strength and agility of the lower extremities. Pauole, et.al (2000) found that T Test is better in evaluating speed of lower extremities rather than evaluating strength and agility of lower extremities.[20]

Authors have opinion that this research have already use a good agility test in the form of Hexagon Hop Test, which can better describe the agility on athletes than T test.

Limitation of the study were the amount of the subject which were only in a limited number, the variety of the branch of sports, and the endurance component that was not being evaluated in this research. Therefore, further studies are required with larger amount of participants and specific branch of sport, also with examining component of endurance.

Conclusion

There are no difference of lower extremities' physical performance in strength, balance and agility on male athletes age 14-17 year-old with normal foot and flatfoot.

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