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Original Article

Impact of various foot arches on dynamic balance and speed performance in collegiate short distance runners: A cross-sectional comparative study

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ABSTRACT

Objective: To compare the impact of foot arches on dynamic balance and speed performance.
Materials and methods: 30 collegiate male short distance runners were divided into three groups based on foot arches, high, neutral and low. Balance and speed performance were estimated based on scores of star excursion balance test (SEBT), 40 yard dash test and vertical jump test (VJT).
Results: Significant improved scores ($p < 0.001$) were noted in SEBT, 40 yard dash test and VJT.
Conclusion: Short distance runners with high arch foot have improved dynamic balance and speed when compared to low and neutral arch foot.

1. Introduction

Newton's Law of Reaction says that, every action has an equal and opposite reaction. The force for the run is provided through the upward and forward ground reaction force in response to the downward, backward drive of the foot. Small vertical component of force has greater horizontal or driving component. In the most efficient run, vertical movements of the centre of gravity are reduced to a minimum. There should be no bounce in running.

In an efficient run, the foot should strike the ground as close as possible to the line of gravity. If the foot should strike ahead of the line of gravity, the reaction force to this forward and downward thrust will be a backward and upward force, acting to delay forward motion.[1] The more completely the horizontal force is directed straight backward, the greater its contribution to the forward motion of the body. Lateral motions are inefficient and detract from forward propulsion. But In Short Distance Running consist the series of ballistic strides in which the body is repeatedly launched forward as a projectile. These forces greatly absorbed by the arches of foot.[2]

The arches of the foot are maintained by a combination for bony structure, aponeuroses, ligaments and tendons.[3] In some individuals these arches will not develops either in one foot or both. There is a strong relationship between the type of arch and injury risk. Moreover, it has been reported that individuals with flat feet feel fatigue in their feet more readily. In a strong foot, muscle activity is involved for balance, adjusting the foot when encountering uneven surfaces, during locomotion. The foot posture can vary among healthy individuals, as well as runners.[4] The foot is classified into three following category depending on arch height. They are pes planus (PP), normal, and pes cavus (PC) foot types. The PP also known as flat foot, here the excessive pronation, due to this ankle fail to stabilize the body, which decrease the ability to absorb shock properly but speed of running is not affected.[5]

In PC the arch is higher than normal and causes clawing of the toes. There are lateral variation and rotation of the hallux, together with hypertrophy of the medial part of metatarsal head and an overlying bursa which together form a prominent biunion on the medial side. Lateral variation of the hallux may lead to overcrowding and occasionally overriding of the lateral toes results in uneven distribution of force causes shock traveling up the legs.[5]

Since running is a linear motion of the entire body, dynamic balance, horizontal component of the momentum is much more important for speed performance than the vertical component. After preparing for ground contact, the emphasis is moved to a vertical pushing motion for maximal velocity sprinting.[6] Although sprinting is a combination of pushing and pulling, the emphasis on vertical pushes will ensure that the athlete actively accelerates the thigh down towards the ground during the flight phase and will increase leg stiffness once ground contact time is made. This in turn will reduce ground contact time, recovery mechanics and increase stride frequency and length.[4,7]

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Table 1
Demographic characteristics among short distance runners with various arches recruited.

Demographic characteristic	Group A (Low arch foot)	Group B (Neutral arch foot)	Group C (High arch foot)	P-value
Age (Years)	22.1 ± 3.9	22.9 ± 3.1	22.8 ± 3.3	0.8
Height (cm)	166.5 ± 3.7	168.1 ± 4.1	170.5 ± 8.1	0.7
Weight (kg)	64.5 ± 6.1	66.9 ± 7.2	67.5 ± 3.2	0.5
BMI (kg/m2)	22.2 ± 2.8	21.9 ± 3.6	23.6 ± 1.5	0.9

Abbreviations: cm—centimeter; kg—kilogram; BMI—Body mass index.

However the relationship between types of foot arches and balance components among healthy sprinters has not at established and thus it becomes the need for present study.

2. Materials and methods

2.1. Recruitment and allocation

The study protocol was approved by the university research and ethics committee (ACS/2016/25) and the study was done strictly in accordance with the guidelines of Helsinki declaration, revised 2013. A total of 30 collegiate male short distance runners (CMSDR) were recruited by the simple random sampling (lottery method) to participate in this cross-sectional comparative study. They were recruited based on navicular drop test and talocalcaneal angle measurement which classified the foot under three category, pronated foot, normal foot and supinated foot. After the demographics, recruited subjects were divided into three groups based on their foot arches, group A (low arch foot/pronated foot), group B (neutral arch foot/normal foot) and group C (high arch foot/supinated foot). Signed informed consent was obtained from all the recruited collegiate short distance runners

The recruited subjects in comfortable dress performed vertical jump test, 40 yard dash test and star excursion balance test on consecutive days. Before beginning the session, the subjects followed standardized warm-up protocol for 8 min, which includes 5 min of static stretching (lower limb group muscle) and 3 min of jogging.

2.2. Measurement of vertical jump test (VJT)

In this procedure the subjects standing height was determined by having the subject stand with the side of his dominant hand next to the wall, and heels together on the floor. With chalked finger- tips the subject reaches upward as high as possible and marks the wall. The subjects then assumes a position next to the wall with both feet on the floor. From this position the subject gather himself in a semi-squat position and jumps, making a chalk mark on the wall at the peak of the jump. Subjects were not allowed to hop, go off of one foot, or walk into the jump. The height jumped is measured distance between the standing reach height and the jumping height. Measurements were recorded in centimeters. Each subject received 3 trails jumps in succession, with approximately 15 to 30 s recovery between jumps and the best of the 3 jumps was used to calculate the subject score.[8,9]

2.3. Measurement of 40 yard dash

40 yard dash test consists of a five yard running start to the starting line. The reason for a running start was to eliminate the skill factor of different subjects in starting performance. The subject began on whistle sound, five yards from the starting line and ended at 40 yard line consist of an end thread. Timing was measured manually using stopwatch which has operated in a 0.001 s mode. Each subject was given 3 trails of the 40 yard sprint, with rest recovery in between. The fastest of the three scores was used to report sprinting speed.[10,11]

2.4. Measurement of star excursion balance test (SEBT)

SEBT is used to analysis the dynamic balance of the subject. The test was explained to each subject verbally, allowing the subject to ask any questions regarding the test. The test was performed with the subject maintaining a single-leg stance while reaching with the contra lateral leg i.e. the reach leg. The aim is to reach as far along the 8 directions as possible to touch the furthest point on the line as lightly as possible so as to avoid using the reach leg for support. The subject then returned to the centre of the grid on both feet whilst maintaining balance. Each subject performed 3 circuits of the SEBT. Each circuit consisted of 3 reaches (trials) in each of the 8 directions. Subjects were given a 5 s rest between each reach.[12,13]

All the three sessions were performed in following order, VJP, 40 yard dash test and SEBT with 24-h rest between the sessions. They were compared and analysed.

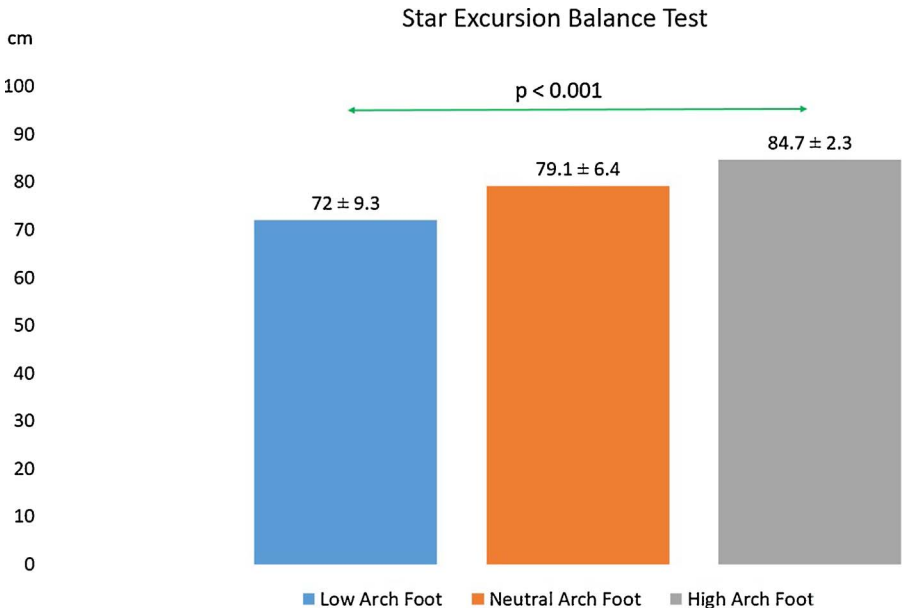

Fig. 1. Mean star excursion balance test (SEBT) score among low arch, neutral arch and high arch foot in short distance runners.