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Original research article

JUMPING ABILITIES ARE NOT RELATED TO FOOT SHAPE

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Abstract. *Explosive strength is an important component of sport performance. During dynamic movements, a kinetic chain is responsible for providing take off power and stability, initiated distally at the feet. The purpose of this study was to compare the differences in explosive strength related to foot type (flat feet and normal feet) in three different age groups. The status of the longitudinal foot arch was measured with the computerized digitalized Pedikom System. Explosive strength of the legs was measured by the Kistler force plate expressed in the squat jump, countermovement jump and continuous jumps with straight legs.We hypothesized that foot type therefore may alter the efficiency of such a kinetic chain and subsequently affect explosive strength. We tested three different populations, 80 athletes (age 10±1), 60 adolescent athletes (age 15±1), and 164 students of the Faculty of Sport (age 20±1). All three age groups were divided into sub groups according to the measured status of longitudinal arch (Group A with presence of flat feet and Group B with normal feet). There were no differences in the explosive strength of the legs between the groups. These findings suggest that flat feet are not a disadvantage in performing sport activities, but can certainly cause other postural deformities.*

Key words: *explosive strength, longitudinal arch, foot type.*

INTRODUCTION

Strength is an important component of sporting performance, commonly defined as work performed in a unit of time. Explosive strength, a measure of the rapid production of strength, is determined by the ability of a muscle, or group of muscles to reach maximum force in the shortest possible time [21]. The identification of high levels of strength

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and explosive strength can be a useful tool for talent identification, strength diagnosis, development of sport specific profiles, and to record the effects of training [1, 28]. Explosive strength, particularly of the lower limbs, represents a major component of successful sport performance. [9, 12, 19, 20]. It is crucial to the successful performance of movements such as jumping, sprinting, sudden changes of direction and even throwing. These movements all require elastic explosive strength, predominantly provided by the quadriceps and hamstrings [10, 18, 27].

Flat feet are the process of the long arches dropping/collapsing and are a foot condition. The feet are a crucial component in these movements, providing support, and transferring forces to a surface, causing a resulting take off movement. Motor tasks involving the lower legs activate a closed kinetic chain, with the foot being the terminal part of that chain [22]. If the part of this chain is weak or damaged, it may therefore affect other parts of the chain, and consequential movement patterns. Similarly, if a joint is misaligned, then forces will not be transmitted in the intended direction, and the forces required for the movement will consequently be reduced. Symptoms of flat feet include a sore long arch, soreness of the feet, sore and tired legs, sore knees. In extreme cases it can also affect other areas of the body like the back and hips. Flat feet can lead to Plantar Fasciitis and pronation. The unbalanced condition can cause a sore back and sore joints and all the way up to the neck. Additionally, it can pull the joints out from the right alignment causing a rubbing/wearing process in the cartilage, which can in some cases lead to hip and knee replacements. Flat footedness, or a pes planus shaped foot, may result in over pronation, internal tibial rotation and a valgus knee, all of which may affect the efficiency of the kinetic chain [2].

For some reason, traditionally, flat-footedness is related to some kind of disability: 'children who have flexible flat foot are often noted to be slow in running or in performing athletic skills' or 'people with low-arch feet were often assumed to be inefficient in foot skills and to be predisposed to injuries of the lower extremities, which led to the exclusion of low-arch soldiers from regular service in some armed forces'.

The aim of this study was to determine if there is any association between the degree of the foot flatness and several motor skills that are necessary for sport performance. It is hypothesized that flat feet may be related to athletic performance, because foot flatness is related to the function of the lower leg and may therefore present a possible risk of sport injury.

MATERIALS AND METHODS

The sample included in the study consisted of three groups:

1. 80 athletes (age 10±1) from Academic Athletic Club *Novi Sad*, body height: 142.6 (6.2) cm, body mass: 31.5 (3.9) kg.
2. 60 athletes (age 15±1), body height: 177.5 (8.8) cm, body mass: 63.7 (6.6) kg: 20 athletes (jumpers and sprinters), 20 football players and 20 basketball players, all from the Sport Society *Vojvodina*, Novi Sad, Serbia.
3. 164 students of the Faculty of Sport and Physical Education (age 20±1), body height: 181.3 (6.4) cm, body mass: 74.7 (8.9) kg.

The participants were divided, into their groups, into two subgroups, based on foot status: a group without any deformity consisted of participants who had no deformity of

the longitudinal arch and those whose deformity belonged to the first level. The group with deformities consisted of participants who had the second and third level of deformity of the longitudinal arch, which was used in other studies as well [5, 16, 25]. Before the testing, detailed explanations of the testing procedure and parental consent forms were sent to the parents. For all the participants who were less than 18 years old, the parents gave written approval of performing the testing on their children, in accordance with ethical standards of the International Journal of Sports Medicine [7], and the participants were given detailed instruction about the procedure of testing in order to perform successful testing.

Testing procedures

All of the testing was performed in the sports-diagnostic center of the Faculty of Sport and Physical Education in Novi Sad. The participants underwent a testing procedure including measurements of

1. flat-footedness,
2. morphologic characteristics and
3. jumping abilities.

Strength assessment

Jumping performance was tested on a portable piezoelectric force platform Quattro Jump Kistler 9290AD (Kistler, Switzerland), connected to a portable computer where force data were recorded, according to the Quattro Jump Bosco Protocol [3]. All the participants warmed up for at least 15 minutes. All of the participants performed the squat jump (SJ), counter-movement jump (CMJ) and continuous jump with straight legs (CJs).

Description

The squat Jump (SJ) – single jump with knees bent at an angle of 90 degrees. Performance in the squat jump describes jumping ability and explosive (maximal) force production of the lower extremities. The SJ describes the ability to jump and the explosive (maximal) force of the feet, the ability of neuro-locomotive recruit, the quantity of fast fiber.

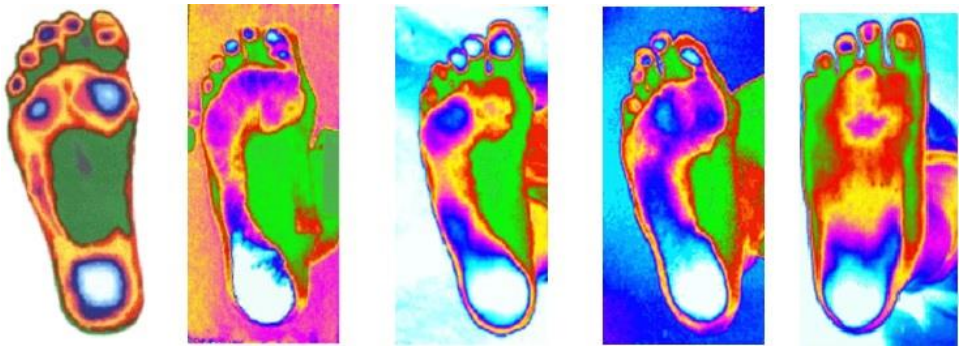
The Counter Movement Jump (CMJ) – the single jump starting with straight legs and performing a natural flexion before take-off. In the counter movement jump, during the breaking phase, elastic energy is stored in the muscles and tendons and then utilized in the following propulsion (concentric) phase. The CMJ presupposes doing a vertical jump which is identical to the Squat Jump test, but with a take-off from a standing position. A quick flexion is executed, followed by an extension and a vertical jump. The differences between the two tests correspond to the sport players' elastic aptitudes.

The Continuous Jump Straight Legs (CJs) – represents a series of 15 seconds of jumping with knees straight during the contact phase. The CJ evaluates the elastic energy of the plantar flexors.

Feet status assessment

The status of the foot arch was measured by using computerized digital podography of the Pedikom System type which consisted of special glass (standing surface), a digital video camera and a computer with special software which calculates the values by using modified methods designed by Russian authors [8]. There are four different degrees of flat feet (Fig. 2). Degree 0 – normal, 1 – slight, 2 – moderate, 3 – significant and 4 – extreme. From the group with no deformities, all the participants with degree zero and one were selected. The group with deformities consisted of participants with degrees two and three. Extreme flat feet were not present in any of the participants.

Basic central and dispersive statistics were calculated for all the variables. The differences in variables for the assessment of explosive strength between the groups with and without deformities were obtained by applying the Multivariate Analysis of Variance (MANOVA).



Normal foot arch Slight Moderate Significant Extreme

Fig. 1 Different degrees of flat feet.

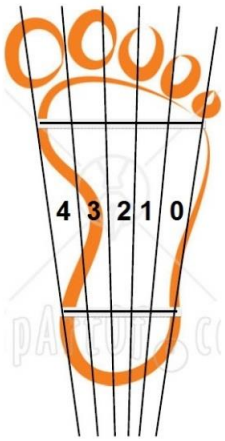


Fig. 2 Numerical evaluation of degrees of flat feet.

RESULTS

Table 1 Descriptive statistics of the whole research sample.

Athletes (N=80)		Sportsmen (N=60)		Students (N=164)	
Deformity	No Def.	Deformity	No Def.	Deformity	No Def.
21	54	15	45	43	121
SJ		SJ		SJ	
21.20 (3.87)	23.45 (3.54)	54.76 (13.09)	58.46 (10.74)	60.24 (8.91)	63.28 (7.60)
CMJ		CMJ		CMJ	
20.54 (5.65)	21.74 (4.60)	50.75 (15.34)	53.42 (9.30)	56.14 (7.14)	60.14 (5.74)
CJs		CJs		CJs	
18.74 (5.21)	19.95 (3.54)	36.99 (7.84)	40.16 (6.53)	32.74 (5.41)	35.79 (4.62)
MANOVA		MANOVA		MANOVA	
F= .957	P= .389	F= .847	P= .474	F= .901	P= .425

After measuring the feet status of the whole sample, it was determined that in the group of athletes 54 participants had no deformity of the longitudinal arch, while 21 of them did. In group of athletes, 15 of them had flat feet, while 45 had a normal foot arch. In the group of students, 43 reported having flat feet and 121 had no deformity. The deformity of the fourth level (extreme low foot arch) was not noticed in any group of participants.

The Multivariate Analysis of Variance was carried out on 3 variables of explosive leg strength: the Squat Jump (SJ), Counter Movement Jump (CMJ), Continuous Jumps Straight Legs (CJs) for all the age groups and the results and levels of significance, showed respectively, that there are no differences in jumping abilities between the groups with and without feet deformity.

DISCUSSION

We determined that the main findings of this study were that there were no differences in athletic performance among the age groups who had flat or normal feet. It may seem that the results of our study contribute even more to the overall controversy about the functionality of flat feet and the significance and clinical relevance of flat foot morphology, because our findings do not support the aforementioned popular thesis. It is very important to stress the fact that in our study the values of the arch index were corrected for the influence of age. As previously established, [13] arch height is strongly influenced by age even in coherent age groups, so the use of corrected arch index values in our study enabled a comparison of the groups strictly according to their motor skills. In addition, the correlation between obesity and arch height was established earlier, because obese children tend to have flatter feet [14]. As known [24, 26], obese children may have poorer performance, so that was one of the factors we had to keep in mind and that may have influenced the motor skills results in our study. It was also suggested [11] that there is a potential link between muscle strength and arch type of the foot. However, a distinct cause and effect dependence has yet to be established.

The first level of the lowered foot arch is a normal occurrence among athletes [6, 15]. By comparing the results of this and previous studies [17, 23], it has been confirmed that the first level of the lowered foot arch is a common occurrence for high quality sports

players who are faced with an early selection and specialization, as well as for recreation sports players whose activities are dominantly monotonous.

When it comes to flat feet and the performance of certain motor skills, most surveys confirm these results. The fact that there is no difference in performing explosive strength between the participants with and without deformities is also confirmed in the studies of Twomey et al. [24]. They prove that children with flat feet have the same, or, in some cases even better results, in other words they jump 15% higher than children with a normal foot arch. Tudor et al. [23] concluded that flat feet are not a disadvantage for good sports achievements.

Even though this research has not provided any statistically significant differences between the indicators of explosive strength and a foot arch status that does not mean that a foot is not an important link in solving motor tasks. It is a daily necessity, especially in sensitive phases of growing and development, to work on forming and strengthening an arch and the firmness of the whole foot. Prevention of foot and ankle joint injuries should be done simultaneously with forming an arch and strengthening muscles, tendons and ligaments, since flat feet cause a series of problems, starting with the knees, hips and spine, so it is necessary to pay special attention to them in diagnostics, prevention, as well as during the elimination of the existing deformity. As already stated by Wenger [26] it is not easy to solve the controversy about flat-footedness in only one study. Our findings merely contribute to the overall understanding of the functionality of flat feet and possibly related problems. According to our results, no disadvantages for sport performance originating from flat-footedness were confirmed in different age groups. Also, in this research we tested three different age groups and we get results about their current jumping abilities and the status of the longitudinal arch of the feet. Advantage of research of this type is that the equipment is portable and that it can be done in very limited conditions. Variations in foot posture from normal, such as pes planus (low-arched foot) or pes cavus (high-arched foot), are recognized as an intrinsic risk factor for developing lower extremity injury [4]. Also, flat feet can lead to disorders and painful states like Plantar Fasciitis and pronation, sore back and sore joints and even right up to the neck, over pronation, internal tibial rotation and a valgus knee.

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SPOSOBNOST SKAKANJA NIJE POZVEZANA SA TIPOM STOPALA

Eksplozivna snaga je važna komponenta sportskog uspeha. Tokom dinamičnih pokreta, kinetički lanac je odgovoran za snagu pri odrazu i stabilnost, za koju je potreban odraz sa obe noge. Cilj ovog istraživanja bio je da se porede razlike u eksplozivnoj snazi koje se tiču tipa stopala (normalni ili ravni tabani) na primeru tri različite starosne grupe. Status longitudinalnog luka tabana meren je Pedikom System aparatom. Eksplozivna snaga nogu merena je Kistler aparatom na primeru skoka iz čučnja, skoka u vis iz mirovanja i skakanja pravih nogu.Pretpostavka je bila da tip stopala može da utiče na efikasnost kinetičkog lanca pa samim tim i eksplozivnu snagu. Testirali smo različite grupe ispitanika, 80 sportista (starosti 10±1), 60 sportista omladinaca (starosti 15±1), i 164 studenata Fakulteta za sport (starosti 20±1). Sve tri starosne grupe podeljene su na pod-grupe na osnovu izmerenog status longitudinalnog svoda (Grupa A imala je ravne tabane a Grupa B normalne tabane). Nije utvrđena razlike u pogledu eksplozivne snage nogu između grupa. Ovi rezultati ukazuju na to da ravna stopala ne predstavljaju prepreku pri izvođenju sportskih aktivnosti, ali sigurno mogu dovesti do drugih posturalnih deformiteta.

Ključne reči: *eksplozivna snaga, longitudinalni svod, tip stopala*.