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Systematic review

DOES PES PLANUS PRECONDITION DIMINISH EXPLOSIVE LEG STRENGTH: A PILOT STUDY

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Abstract. *The urban environment in combination with modern living conditions has curtailed the inherent human need for movement, as a consequence of the lack of conditions conducive to essential physical activity. One result of this is the ever-increasing incidence of deformities and postural disorders, especially in children. The aim of this pilot study was to ascertain whether children with flat feet have diminished explosive leg strength. The participant sample comprised 55 students aged 14 years ± 6 months, divided into three subsamples: students with a normal foot (NF) (n=30), students with a collapsed arch (CA) (n=15), and students with a completely collapsed arch (CCA) (n=10). The variables for assessing the participants' morphological status: body weight (BW), thigh circumference (TC), circumference of the lower leg (CLL) and foot length (FL). This study used two tests to assess explosive leg strength via the vertical jump, namely the squat jump (SJ) and the counter movement jump (CMJ). The variable for determining the foot's postural status was obtained based on an assessment of the degree of arch collapse (ADAC). To determine the degree of deformity and arch collapse, the Chizhin plantography method was used. This study found no statistically significant differences pertaining to indicators of explosive leg strength in relation to the position of the arch between the subsamples of children with flat foot disorder and those without such a postural deformity. One suggestion for future research on this topic is to use a participant sample of a larger size. At the initial measuring, there should be no differences in the values of morphological characteristic between the subsamples, to avoid an effect on motor ability manifestation.*

Key words: *explosive strength, young children, influence, pes planus*

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INTRODUCTION

The urban environment in combination with contemporary living conditions has curtailed the inherent human need for movement, as a consequence of a lack of conditions conducive to essential physical activity. The human body, however, is not always able to put up a sufficient defense against the adverse effects of hypokinesia (Heimer, 2013).

One result of this life style is the ever-increasing incidence of deformities and postural disorders, especially in children. The incidence of flat feet is considerable in the preschool (Romanov et al., 2014; Stanišić et al., 2014) and junior school populations (Kendić et al., 2007; Đokić & Stojanović, 2010; Puzović et al., 2010; Ilić & Đurić, 2014; Daniel et al., 2015). It is one of the most frequent forms of postural deformity reported by out-patient health facilities (Vukasinovic et al., 2009), as well as in the general population (Lešić et al., 2013). It was also found in athletes of the same age group (Đurić et al., 2013; Janković et al., 2014), as well as in the adult population (Krsmanović et al., 2010; Đurđević et al., 2010). Its possible causes include both a sedentary lifestyle and obesity, as well as inadequate footwear (Hodžić, 2008).

A physical deformity can have a permanent effect on the child, not only in terms of physical appearance, but also in terms of a characteristic physical condition (Mihajlović et al., 2010). Prevention is therefore a primary task for the expert trying to influence this phenomenon, followed by correction (Milenkovic, 2001; Golubiček & Vuković-Topčić, 2007; Stanišić et al., 2014).

The occurrence of flat feet can lead to various clinical symptoms (Jovičić et al., 2007), such as: pain in the foot and lower leg due to the stretching of muscles and tendons in the feet, lower back pain as a consequence of compensating for the imbalance in the static-dynamic relationships in the foot, chronically cold feet due to impaired function of vasodilators, varicose veins in the lower leg due to muscle weakness, faster lower extremity fatigue, etc.

Less severe forms of pes planus can be ameliorated by means of physical treatment (Evans & Rome, 2011), while the more severe forms may require surgery.. All of the above symptoms can have an adverse effect and may limit the physical or motor activity both in children and in adults (Živković et al., 2014).

Due to the humans' upright posture, it is the feet that bear the bulk of the body's weight. The foot, however, is not always able to sustain the stress it is placed under, which can in turn lead to various deformities. The role of the foot in the statics and dynamics of the whole body is crucial. Its static role consists of receiving the entire weight of the body and distributing it onto basic support points. Its dynamic role is evident during running and jumping. The foot lifts the body off the contact surface, cushions the impact on reestablished contact with the surface, and enables further movement (Rakovac et al., 2013). A physical deformity such as pes planus can affect motor manifestation, and especially explosive leg strength.

It is therefore the aim of this pilot study to ascertain whether children with flat feet have diminished explosive leg strength.

METHODOLOGY

The participant sample comprised 55 students aged 14 years ± 6 months, divided into three subsamples: students with a normal foot (NF) (n=30), students with a collapsed arch (CA) (n=15), and students with a completely collapsed arch (CCA) (n=10).

The variables for assessing the participants' morphological status: body weight (BW), thigh circumference (TC), circumference of the lower leg (CLL) and foot length (FL).

This study used two tests to assess leg explosiveness via the vertical jump, namely the squat jump (SJ) and the counter movement jump (CMJ).

The variable for determining the foot's postural status was obtained based on an assessment of the degree of arch collapse (ADAC). To determine the degree of deformity and arch collapse, the Chizhin plantography method was used.

Jumping performance was tested on a portable force platform, Kistler Quattro Jump 9290AD (Kistler, Switzerland), connected to a portable computer where force data were recorded, according to the Quattro Jump Bosco Protocol (Bosco et al., 1983). All of the participants warmed up for at least 15 minutes beforehand. All of the participants performed the squat jump (SJ) and counter-movement jump (CMJ).

The Squat Jump (SJ) – a single jump with the knees bent at an angle of 900. The performance in SJ 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, as well as the quantity of fast fiber.

The Counter Movement Jump (CMJ) – a single jump starting with straight legs, with 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 SJ, but with a take-off from a standing position. Quick flexion is executed, followed by an extension and a vertical jump.

Vertical jump height in both tests was measured in relation to flight time according to the following formula:

$$H\ (SJ) = T_F^2 x\ g/8\ ,\ \text{i.e.,}\ H\ (CMJ) = T_F^2\ x\ \ g/8,$$

where H (SJ) – vertical jump height in SJ, H (CMJ) – vertical jump height in CMJ, T_F – flight time, g – gravitational acceleration.

Plantography and the Chizhin method

Felt or gauze is placed in a plastic container measuring 50x30x5cm and soaked in a solution of ink and water. Two pieces of paper are placed in front of the container, to make prints for the left and right foot, respectively. Once a print of the foot is obtained, a tangent is marked on the medial side of the foot linking the most prominent points, AB. Next a line is drawn linking the top of the print of the second toe, and the middle of the print left by the heel, CD. The CD line is then divided into two equal parts using the line EF, perpendicular to the line CD. Along the EF line marks are made, as follows: 'a' – on the lateral side of the foot, 'b' – on the medial side of the foot, and 'e' – the intersection of AB.

The lines AB and BE are measured in centimeters, and entered into the equation which yields the index of arch collapse: I = AB/BE. Thus, the arch is normal if I= 0-1.0; collapsed if I=1.0–2.0; completely collapsed if I= 2.0–3.0.

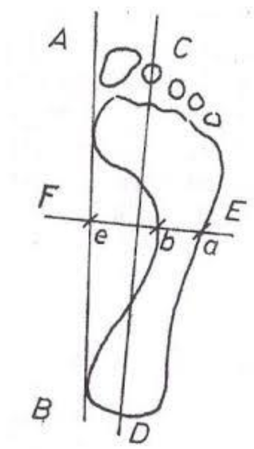

Fig. 1 The Chizhin method for establishing flat foot

Statistical data analysis

Firstly, the descriptive statistical parameters for the tested variables were determined: arithmetic means and standard deviation (SD). The Student's t-test for small dependent samples was used in order to analyze the difference between the two groups of subsamples (NF vs CA; NF vs CCA; CA vs CCA).

RESULTS

Table 1 Between-group Student's t-test results.

Variable	Total		NF		CA		CCA		NF vs CA		NF vs CCA		CA vs CCA	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	t-value	p	t-value	P	t-value	P
BW	54,33	14,94	50,23	12,84	63,85	18,18	52,34	9,03	-2,91	0,01	0,48	0,63	-1,85	0,08
TC	48,98	6,67	46,85	5,75	53,72	7,45	48,26	4,59	-3,42	0,00	0,70	0,49	-2,06	0,05
CLL	33,54	4,07	32,35	3,58	36,17	4,74	33,18	2,56	-3,03	0,00	0,67	0,50	-1,82	0,08
FL	24,31	1,69	24,08	1,82	24,65	1,72	24,47	1,23	-1,01	0,32	0,62	0,54	-0,29	0,77
HSJ	0,18	0,05	0,19	0,05	0,17	0,05	0,18	0,04	1,20	0,24	-0,97	0,34	0,11	0,91
HCMJ	0,19	0,05	0,19	0,05	0,19	0,05	0,19	0,04	0,21	0,83	-0,04	0,97	0,13	0,90

Comparing NF vs CA, there were statistical differences between the participants across all morphological variables, namely: BW, TC, and CLL, except FL. There were differences, albeit not statistically significant ones, in the motor variables H(SJ) and H(CMJ), for NF vs CA. Furthermore, the groups NF and CCA can be said to differ in all morphological and motor variables, albeit not statistically significantly. Comparing CA and CCA, statistically significant differences were found in only one morphological variable, namely TC. There were also differences in the remaining morphological and in all the motor variables; these, however, were not statistically significant.

DISCUSSION

This study found no statistically significant differences pertaining to indicators of explosive leg strength in relation to the position of the arch between the subsamples of children with flat foot disorder and those without such a postural deformity. In this study, a collapsed arch was not found to present a hindrance to motor ability, as exemplified by explosive leg strength. This is in accordance with other studies which found no relation between flat-foot and motor manifestation (Jovičić, 2007; Petrović et al., 2013). This does not mean, however, that the foot is not a significant factor in the solving of motor tasks.

The correct formation and strengthening of the arch, and the firmness of the foot as a whole, require everyday practice, especially during the sensitive stages of growth and development (Mihajlović et al., 2012). Simultaneously with arch formation, by way of muscle, tendon and ligament strengthening, foot and ankle injuries are prevented, and, since pes planus can cause various issues, from the knees, through the hips and the back (Nakhaee et al., 2008) Lees, Lake, Klenerman, 2005), its timely diagnosis and prevention should be given prominence, as should a decisive correction of any detected deformity.

Other studies also found no statistically significant differences in how motor abilities are manifested in participants with and without foot deformity (Perić, 2008; Tudor et al., 2009). Based on a sample of 54 participants aged 9-12 (27 subjects each in the control and experimental groups). Based on the obtained results, we conclude that there is no significant difference in vertical jump height between the students with this foot deformity and those without it.

One drawback of this study, which makes its conclusions difficult to generalize from, is the fact that the participant sample was taken from a population of seventh grade elementary school students, and was not homogeneous in terms of morphological characteristics. Statistically significant differences between the groups were present in terms of morphological characteristics, further limiting the possibility of drawing any conclusions based on the analysis of inter-group explosive leg strength results.

Differences are discernible between the subsamples that comprise this sample. These differences stem from the fact that the body's growth and development is not complete at this age, so any further effects of this postural deformity on vertical jump height cannot be predicted with certainty based on the obtained results.

On the other hand, this fact also presents an opportunity both for following the participants longitudinally, and for future studies which might be of use in the selection process in those sports where the emphasis is on explosiveness in general, and explosive leg strength in particular.

A drawback of the study is the fact that the authors did not survey the participants about wearing orthotic insoles or supports. Insoles can be a significant factor in jump efficiency (Arastoo et al., 2014); therefore, our suggestion for future studies is for authors to prevent any bias due to use of insoles, that is, to test participants when they are not wearing these corrective supports.

CONCLUSION

One suggestion for future research on this topic is to use a participant sample of a larger size, as well as to cover a larger territory. At the initial measuring, there should be no differences in morphological characteristic values between the subsamples, to avoid an effect on motor ability manifestation. Furthermore, we recommend using a battery of tests including a greater number of tests of explosive leg strength. The high incidence of foot deformity (as well as other physical and postural disorders) in children and adolescents should be accepted by sports coaches as a reality and a fact, given that these age groups comprise the selection pool of future athletes.

The authors finally propose using contemporary, sensitive methods for foot deformity assessment, accompanied by movable equipment appropriate for fieldwork.

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DA LI SU RAVNA STOPALA PREDUSLOV SLABIJE EKSPLOZIVNOSTI NOGU – PILOT STUDIJA

Urbana sredina i savremeni životni uslovi života uskratili su čoveku iskonsku potrebu za kretanjem zbog nedestatka adekvatnih uslova u kojima bi se odvijala potrebna fizička aktivnost. Kao rezultat ovakvog načina života uočava se sve veća pojava deformiteta i posturalnih poremećaja, naročito kod dece. Zbog toga je cilj ovog pilot istraživanja da se utvrdi da li deca sa ravnim stopalima imaju slabiju eksplozivnu snagu nogu. Uzorak ispitanika je činilo 55 učenika starosti 14 godina ±6 meseci, podeljenih u tri subuzorka: učenici sa normalnimstopalom (NS) (n=30), učenici sa spuštenim stopalom (SS) (n=15) i i učenici sa jako spuštenim stopalom (JSS) (n=10). Varijable za procenu morfološkog statusa ispitanika su bile sledeće: težina tela (TT), obim butine (OB), obim potkolenice (OP) i dužina stopala (DS). U ovom istraživanju su upotrebljena dva merna instrumenta za procenu eksplozivne snage nogu uz pomoć vertikalnog skoka i to: skok iz čučnja – squat jump (SJ) iskok suprotan kretanju - counter movement jump (CMJ). Varijala za procenu posturalnog statusa stopala dobijena je na osnovu procene spuštenosti svoda stopala (PRAS). Za utvrđivanje stepen deformiteta i ocenu spuštenosti stopala, korišćena je metoda plntografije – Čižinova metoda. U ovom istraživanju nisu utvrđene statistički značajne razlike upokazateljima eksplozivne snage nogu u odnosu na stanje svoda stopala kod ispitivanih subuzoraka dece koji imaju poremećaj u vidu ravnog stopala i onih bez tog poremećaja. Za dalja istraživanja je neophodno sakupiti veći uzorak ispitanika. Između svakog subuzorka ispitanika, inicijalno ne bi smelo biti razlika u vrednostima morfoloških karakteristika, da ne bi imale uticaj na manifestaciju motoričkih sposobnosti.

Ključne reči: *eksplozivna snaga, mlada deca, uticaj, spužteno stopalo*