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Professional paper

RELATIONSHIP BETWEEN SKELETAL DEFORMITIES AND MOTOR COORDINATION IN ELEMENTARY SCHOOL STUDENTS

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Abstract

Postural control plays an important role in child development. Spinal deformity is a complex and dynamic change that occurs in the sagittal or coronal planes. The structure and function of the foot are crucial to the control of postural stability. The objective of the study was to examine the relationship between spinal and foot deformities and motor coordination in children attending elementary school. This study included a sample of 105 children, 59 males (56.2%) and 46 females (43.8%), aged 13 and 14 years. We performed physical examination to determine if there are some deformities of the spine and the feet. We also performed three tests for motor coordination: Balance test, Coordination test and Precision test. Results from these tests were displayed as low, medium and high degree of balance. For statistical data analysis we used Fisher's exact test with level of significance $p<0.05$. Scoliosis was determined in 63.8% of the children. Foot deformities were present in 76.2%. Pes valgus was present in most of the cases of foot deformity. Majority of children with scoliosis and feet deformities had high degree of balance while standing on one leg. There was statistically significant difference only between the presence of scoliosis and degree of balance on the right leg ($p=0.004$). There is no relationship between spinal and feet deformities and degree of motor balance in children.

Keywords: scoliosis, foot deformity, motor coordination, balance

1. Introduction

Spinal deformity is a complex and dynamic change that occurs in the sagittal or coronal planes. There are two types of spinal deformity: coronal plane deformity – scoliosis and sagittal plane deformity – kyphosis (Hyun, 2018). Scoliosis is a deformity in which there is a lateral curvature greater than 10 degrees. The primary deformity is lateral flexion plus rotation of the involved vertebrae around a vertical axis (Taft & Francis, 2003). The measurement in diagnosing scoliosis is traditionally done using the Cobb method and gives the Cobb angle (Cheng, et al., 2015). In approximately 20% of cases, scoliosis is secondary to another pathological process. The remaining 80% are cases of idiopathic scoliosis. Idiopathic scoliosis may develop at any time during childhood and adolescence (Negrini, et al., 2018). Scoliosis has a spectrum of severity, ranging from mild curves with little progression throughout a patient's lifetime to rapidly progressing and potentially debilitating curves (McCarthy & Kelly, 2020)

The structure and function of the foot are crucial to the control of postural stability. From a biomechanical point of view, this part of the locomotor system is the area of contact between the body and the ground. The ankle joint is responsible for the most essential reactions involving corrective balance control, especially in the sagittal plane (Puszczalowska-Lizis, et al., 2017). Postural control can be defined as achieving a desired body position (e.g. upright standing) and maintaining this position in any static or dynamic situation (Verbecque, et al., 2014). Postural control plays an important role in child development, as it is a necessity to achieve both new postures in early life and more complex motor skills (Verbecque, Vereeck, & Hallemans, 2016). The development of standing balance is nonlinear and that it is accelerated beginning at a certain age. The ability to maintain the one-leg standing position with eyes open will dramatically improve in children

within the period from late preschool age to early school age, and the improvement will slow down during late school age (Morioka, et al., 2012).

Congenital foot deformity is classified into two major groups, namely, varus and valgus. The group of congenital varus foot deformities consists of idiopathic congenital clubfoot, congenital clubfoot with arthrogryposis multiplex congenita and congenital metatarsus adductus without equinus deformity. The group of congenital valgus foot deformities consists of benign congenital talipes calcaneo-valgus and congenital vertical talus with or without arthrogryposis multiplex congenital (Machida, Inaba & Nakamura, 2017).

The aim of the study was to examine the relationship between spinal and foot deformities and motor coordination in children attending elementary school.

2. Methods

This study included a sample of 105 children, 59 males (56.2%) and 46 females (43.8%), aged 13 and 14 years. The children are students attending the following schools: ES "Hasan Prishtina" in Skopje, ES "Todor Angelevski" in Bitola and ES "Vancho Prke" in Shtip.

We performed physical examination to determine if there are some deformities of the spine and the feet. Examination for scoliosis consists of an inspection of the symmetry of the head, the height of the shoulders and scapulas, and the Lorentz triangle (symmetry between one and the other lateral side of the torso, i.e. symmetry of the angle between the upper arm and the forearm with the torso). Examination of feet consists of an inspection of the convexity of the Achilles tendon and a visual inspection of the descending arch of the foot.

We also performed three tests for motor coordination: Balance test (Test on balance pillow), Coordination test and Precision test. Results from these tests were displayed as the ability of the child to stay on one leg in duration of ≤ 5 seconds (low degree of balance), 6-10 seconds (medium degree of balance) and 11-15 seconds (high degree of balance). For statistical data analysis we used Fisher's exact test with level of significance $p<0.05$.

3. Results

We displayed the relationship between normal spine, scoliosis and three degrees of motor balance on the right leg (Table 1). Most of the children in subgroup with low degree of balance had scoliosis. A statistical analysis shows that there is statistically significant difference between the presence of deformity and degree of balance (p=0.004).

Table 1. Relationship between scoliosis and motor balance on the right leg.

Presence of deformity	≤ 5 seconds		6-10 seconds		11-15 seconds		Total	
	No	%	No	%	No	%	No	%
Normal spine	1	1.0	3	2.9	34	32.4	38	36.2
Scoliosis	10	9.5	17	16.2	40	38.1	67	63.8
Total	11	10.5	20	19.0	74	70.5	105	100

Fisher's exact test (p=0.004)

The relationship between normal spine, scoliosis and three degrees of motor balance on the left leg was displayed in Table 2. Majority of the children with scoliosis had high degree of balance. A statistical analysis shows that there is no statistically significant difference between the presence of spinal deformity and degree of balance (p=0.052).

Table 2. Relationship between scoliosis and motor balance on the left leg.

Presence of deformity	≤ 5 seconds		6-10 seconds		11-15 seconds		Total	
	No	%	No	%	No	%	No	%
Normal spine	3	2.9	3	2.9	32	30.5	38	36.2
Scoliosis	11	10.5	15	14.3	41	39.0	67	63.8
Total	14	13.3	18	17.1	73	69.5	105	100

Fisher's exact test (p=0.052)

There were two types of foot deformities in the sample. In Figure 1 we displayed foot status in all children. Pes valgus was present in most of the cases of foot deformity. In 23.8% we determined normal feet.

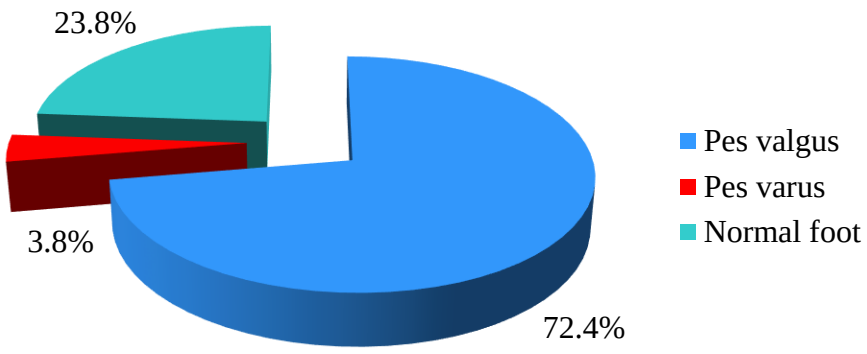

Figure 1. Types of foot deformities in children

We displayed the relationship between normal foot, foot deformity and three degrees of motor balance on the right leg (Table 3). Majority of the children had high degree of balance while standing on the right leg. A statistical analysis with Fisher's exact test shows that there is no statistically significant difference between the presence of foot deformity and degree of balance (p=0.26).

Table 3. Relationship between foot deformity and motor balance on the right leg.

Presence of deformity	≤ 5 seconds		6-10 seconds		11-15 seconds		Total	
	No	%	No	%	No	%	No	%
Normal foot	2	1.9	2	1.9	21	20	25	23.8
Pes valgus	9	8.6	17	16.2	50	47.6	76	72.4
Pes varus	1	1	1	1	2	1.9	4	3.8
Total	12	11.4	20	19.0	73	69.5	105	100

Fisher's exact test (p=0.26)

The relationship between normal foot, foot deformity and three degrees of motor balance on the left leg was displayed in Table 4. Majority of the children also had high degree of balance while standing on the left leg.

Table 4. Relationship between foot deformity and motor balance on the left leg.

Presence of deformity	≤ 5 seconds		6-10 seconds		11-15 seconds		Total	
	No	%	No	%	No	%	No	%
Normal foot	2	1.9	6	5.7	17	16.2	25	23.8
Pes valgus	12	11.4	13	12.4	51	48.6	76	72.4
Pes varus	1	1	1	1	2	1.9	4	3.8
Total	15	14.3	20	19.0	70	66.7	105	100

Fisher's exact test (p=0.56)

A statistical analysis shows that there is no statistically significant difference between the presence of foot deformity and degree of balance (p=0.56).

4. Discussion and conclusions

We examined the relationship between spinal and foot deformities and motor coordination in children attending elementary school. During physical examination we determined scoliosis in 63.8% of the children. We do not found great impact of scoliosis to ability of children to stay on one leg during motor coordination testing.

It has been indicated that severe deformation of the body morphology resulting from scoliosis could negatively influence the sensorimotor control of posture and decrease the postural balance capabilities (Wiernicka, et al., 2019). According to Nault, et al. (2002) standing imbalance was related to body posture parameters measured in the frontal and horizontal planes only. It appeared that factors other than body posture parameters were related to standing imbalance in adolescent idiopathic scoliosis. A larger sway area of the center of mass than of the center of pressure was attributed to a greater neuromuscular demand to maintain standing balance. These findings support the concept of a primary or secondary dysfunction in the postural regulation system of scoliotic subjects.

In our study pes valgus was present in most of the cases of foot deformity. Feet deformities had small influence on ability of children to stay on one leg during balance testing. The ankle joint complex is comprised of the lower leg and the foot and forms the kinetic linkage allowing the lower limb to interact with the ground, a key requirement for gait and other activities of daily living (Brockett & Chapman, 2016). Human bipedal stance is inherently unstable. Small deviations from a perfect upright body position result in a gravity-induced torque acting on the body, causing it to accelerate further away from the upright position. Corrective torque must be generated to counter the destabilizing torque due to gravity (Peterka & Loughlin, 2004). According to Szczepanowska-Wolowiec, Sztandera, Kotela and Zak (2019) there is a statistically significant correlation between morphological variables of the foot and postural stability. When assessing the key variables of the foot and their interrelationship with postural stability, the Clarke's angle, Wejsflog index, hallux valgus angle, and foot width, should be granted due prominence in the girls. In boys, the following variables were established as predictive in assessing postural stability: Clarke's angle, Wejsflog index, and foot width.

Majority of children with scoliosis and feet deformities had high degree of balance while standing on one leg. There is no relationship between spinal and feet deformities and degree of motor balance in children.

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