

Comparison of postural balance between female and male adolescents

Comparação do equilíbrio postural entre adolescentes do sexo feminino e masculino

Comparación del equilibrio postural entre adolescentes del sexo femenino y masculino

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ABSTRACT | Adolescence phase comprises between 10 and 19 years old. This stage is characterized by a fast individual growth and development. However, these changes do not occur at the same rate for both genders, and can lead to differences in postural balance. The purpose of this study was to compare the postural balance between male and female adolescents. To this, 11 female and 19 male adolescents were assessed. The center of gravity height was obtained by a reaction board, and postural balance was evaluated with a force platform from Advanced Mechanical Technologies, Inc. model OR6-6. The variables analyzed were calculated from the center of pressure (COP): COP anteroposterior range of displacement (COPap), COP mediolateral range of displacement (COPml); and COP mean displacement velocity (COPvel). Female adolescents showed a significantly lower COPap ($p=0.011$) and COPml ($p=0.003$) ranges of displacement with open eyes when compared to male adolescents. With closed eyes, females had lower COPap ($p=0.001$), COPml ($p=0.001$) and COPvel ($p=0.004$). It suggests a lower postural sway for these female adolescents. It is believed that the results came from differences in anthropometric characteristics between genders. We conclude that female adolescents in this study had a better postural balance when compared to male adolescents.

Keywords | adolescent; postural balance; biomechanics.

RESUMO | A adolescência compreende a fase entre os 10 e 19 anos de idade, a qual se caracteriza por uma aceleração no crescimento e desenvolvimento dos indivíduos. No entanto, essas mudanças não ocorrem no mesmo ritmo para ambos os sexos, o que pode trazer diferenças no equilíbrio postural. Este estudo tem como objetivo comparar o equilíbrio postural entre adolescentes dos sexos masculino e feminino. O grupo de estudo foi composto por 11 adolescentes do

sexo feminino e 19 do sexo masculino. A análise da altura do centro de gravidade foi obtida com o uso de uma prancha de reação, e o equilíbrio postural por meio de uma plataforma de força *Advanced Mechanical Technologies, Inc.* modelo OR6-6. As variáveis avaliadas foram calculadas a partir do Centro de Pressão (COP): amplitude de deslocamento ântero-posterior do COP (COPap), amplitude de deslocamento médio-lateral do COP (COPml) e velocidade média de deslocamento do COP (COPvel). Os adolescentes do sexo feminino apresentaram amplitude de deslocamento do COPap ($p=0,011$) e COPml ($p=0,003$) significativamente menor na condição de olhos abertos que o sexo masculino, e na condição de olhos fechados nas três variáveis avaliadas, COPap ($p=0,001$), COPml ($p=0,001$) e COPvel $p=0,004$, sugerindo menor oscilação postural para as adolescentes deste estudo. Acredita-se que os resultados encontrados podem ser advindos das diferenças nas características antropométricas entre os sexos. Conclui-se que os adolescentes do sexo feminino apresentaram melhor equilíbrio postural quando comparados aos do sexo masculino.

Descritores | adolescente; equilíbrio postural; biomecânica.

RESUMEN | La adolescencia comprende la fase entre los 10 y 19 años de edad, la cual se caracteriza por una aceleración en el crecimiento y desarrollo de los individuos. Mientras tanto, esos cambios no ocurren en el mismo ritmo para ambos sexos, lo que puede traer diferencias en el equilibrio postural. Este estudio tiene como objetivo comparar el equilibrio postural entre adolescentes de los sexos masculino y femenino. El grupo de estudio fue compuesto por 11 adolescentes del sexo femenino y 19 del sexo masculino. El análisis de la altura del centro de gravedad fue obtenido con el uso de una plancha de reacción, y el equilibrio postural por medio de una plataforma de fuerza

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Advanced Mechanical Technologies, Inc. modelo OR6-6. Las variables evaluadas fueron calculadas a partir del Centro de Presión (COP): amplitud de desplazamiento antero-posterior del COP (COPap), amplitud de desplazamiento medio-lateral del COP (COPml) y velocidad media de desplazamiento del COP (COPvel). Los adolescentes del sexo femenino presentaron amplitud de desplazamiento del COPap ($p=0,011$) y COPml ($p=0,003$) significativamente menor en la condición de ojos abiertos que el sexo masculino, y en la condición de ojos

cerrados en las tres variables evaluadas, COPap ($p=0,001$), COPml ($p=0,001$) y COPvel $p=0,004$, sugiriendo menor oscilación postural para las adolescentes de este estudio. Se cree que los resultados encontrados pueden ser resultado de las diferencias en las características antropométricas entre los sexos. Se concluye que los adolescentes del sexo femenino presentaron mejor equilibrio postural cuando fueron comparados a los del sexo masculino.

Palabras clave | adolescente; equilibrio postural; biomecánica.

INTRODUCTION

According to the World Health Organization¹, adolescence is the period comprised between the ages of 10 and 19 years old, which is marked by accelerated growth and development of individuals. During childhood, preceding adolescence, the weight of boys and girls increases proportionally to height². At the early stage of transition to adolescence, lean body mass increases rapidly among boys due to the action of testosterone, with more bone and muscle growth, however, among girls it is possible to observe the increase of fat tissue, due to the action of estrogen².

In adolescence, the increment of female and male individuals does not keep the same rhythm, which can bring differences in postural balance among genders. Studies concerning postural balance with this population are still scarce in literature, since most scientific papers are conducted with adults, elderly and/or participants with pathologies³⁻⁶.

According to Horak and Macpherson⁷, balance is basic for all types of movements and is under the influence of visual, somatosensory and vestibular stimuli. It can be defined as the maintenance of a specific posture with minimum oscillation (static balance) or during the performance of a motor skill that tends to disturb body orientation (dynamic balance)⁸.

According to Smith et al.⁹, the level of stability of a body depends on four distinct factors: body weight, center of gravity height, size of the support base and location of the gravity line within this support base. The stability of the individual is inversely proportional to the center of gravity height, and directly proportional to the support base, and these variables are related with postural balance^{9,10}.

Postural balance can be assessed by means of the Center of Pressure (COP) dislocation, which, for Duarte and Freitas¹¹, is the point of ground reaction force over the support surface. Oliveira et al.¹² describe

that variables such as dislocation velocity and COP area are related with anthropometric data of individuals, especially height.

Due to possible differences between genders during adolescence as to the development of some anthropometric variables, which are directly related with postural balance, it is suggested that female and male adolescents present different postural control. So, this study aimed to compare postural balance between male and female adolescents.

METHODOLOGY

Study group

This is a cross-sectional, *ex post facto* study. The study group was comprised of 11 female adolescents (age: 15.45 ± 0.52 years old; height: 1.62 ± 0.05 m; mass: 58.07 ± 7.31 kg) and 19 male adolescents (age: 14.89 ± 0.80 years old; height: 1.71 ± 0.07 m, mass: 65.69 ± 10.88 kg).

The selection of individuals was made with verbal invitations to all of the students enrolled in the junior and sophomore years of high school, from an institution close to the Biomechanics Laboratory, where the collection was performed. One hundred and twenty people were invited to participate in the research. Out of these, only 60 people returned the informed consent form, and 20 fitted the exclusion criteria of the study, thus accounting for 30 students who were interested to voluntarily participate in the study.

Exclusion factors were: not being within the age range of 14 to 16 years old, not participating in physical education classes, regularly practicing any other sport modality outside school, being physically and/or mentally disabled, having hypertension or diabetes or spinal pain.

The study was developed in accordance with ethical aspects, according to the principles of Resolution 196/96, of the National Health Council, being approved by the Ethics Committee of *Universidade Federal de Santa Maria*, Protocol n. 0083.0.243.000-09.

Instruments

The analysis of the center of gravity (CG) height was obtained by a reaction board, consisting of a Kratos scale, 0.1 kg resolution and a wooden apparatus with two supports (one over the scale and another one on the ground), 1.80 m apart. The equation to calculate CG height is:

$$\frac{hCG \cdot (R2 - R1) \cdot d}{P_s}$$

In which:

CGh = CG height;

R2 = force measurement given by the scale with the person standing on the apparatus (kgf);

R1 = force measurement given by the scale without the person standing on the apparatus (kgf);

d = distance between supports (m);

P_s = individual's weight (kgf).

For the acquisition of data concerning postural balance, a force platform from Advanced Mechanical Technologies, inc. (AMTI), model OR6-6 was used (Figure 1).

Raw data were filtered with the 4th order low-pass filter, with 10 Hz cut-off frequency. The variables acquired by the force platform are related to COP, calculated by the following equations:

$$COP_x = (M_y - h \cdot F_x) / F_z$$

$$COP_y = (M_x - h \cdot F_y) / F_z$$

In which:

COP_x = coordinate of the center of pressure at the anteroposterior direction;

COP_y = coordinate of the center of pressure at the mediolateral direction;

M_x = moment around the anteroposterior axis;

M_y = moment around the mediolateral axis;

F_x = anteroposterior component of ground reaction force;

F_y = mediolateral component of ground reaction force;

F_z = vertical component of ground reaction force;



Figure 1. Force platform from *Advanced Mechanical Technologies, Inc.*

h = distance from the surface to the geometric center of the force platform.

The assessed variables were the COP anteroposterior range of displacement (COP_{ap}), COP mediolateral range of displacement (COP_{ml}) and COP mean displacement velocity (COP_{vel}).

Procedures for data collection

Collections took place in the Biomechanics Laboratory of *Universidade Federal de Santa Maria*. Individuals were welcomed by one of the people in charge of the research and were briefly enlightened as to the collection procedure. Afterwards, they were referred to another room, where all of the tests were performed, with barefoot participants. Measurements of height and body mass, CG height and postural balance were assessed. For the acquisition of CG height, the individual was told to stay in the dorsal decubitus position on top of the apparatus with stretched lower limbs, trunk and upper limbs and feet against the base of the apparatus. Afterwards, they were told to stay on top of the force platform in orthostatic position and with their feet apart, at the width of the hip. During the test, the individual should remain standing, with their heads faced forward under two conditions: open eyes (OE), staring at a target at a distance of approximately 2 m, and arms along the body; closed eyes (CE), with arms along the body. There were three attempts for each condition (OE and CE), accounting for six attempts for each individual, and their mean was used for statistical analyses. The position of the feet was marked in a millimeter paper, in order to consider the same position. The sample rate of the platform was 100 Hz, and acquisition time was 30 seconds.

Statistical analysis

Data were submitted to descriptive statistics. The normality in data distribution was verified by the Shapiro-Wilk test. Afterwards, the Mann-Whitney test was used to compare the variables of postural balance between the female and male groups. Significance level was 5%.

RESULTS

Female adolescents presented lower and significant COP anteroposterior and mediolateral range of displacement under the OE and CE conditions when compared to male adolescents. The COP displacement velocity was significantly lower for the female gender only with CE. Results are summarized in Tables 1 and 2.

DISCUSSION

This study aimed to compare postural balance between male and female adolescents. Results point to less and significant postural oscillation for the group of female adolescents under both conditions, and to lower COP mean displacement velocity with their eyes closed.

Colli¹³, when analyzing 6,765 adolescents aged from 10 to 19 years old, showed that sexual maturation generally begins 1 year earlier among female adolescents in relation to male adolescents. Siervogel et al.¹⁴ show that there are also differences between genders due to anthropometric changes and alterations in body composition during pubescence — a girl of any age usually has higher maturation level when compared to a boy at the same chronological age¹⁵.

During development, girls and boys with the same chronological age present very different characteristics for being in different stages of maturation¹⁶.

Certain anthropometric characteristics may interfere in postural balance, such as height and CG height. The boys in this study presented higher mean in the mentioned items than girls, thus suggesting that the higher and the more distant from the ground the CG of the individual, the more he oscillates, considering the model of simplification of the human body in inverted pendulum for balance studies, as described by other authors^{11,17,18}.

Table 1. Comparison between groups for anthropometric variables

Variables	Gender	Mean	Standard deviation	p-value
Height (m)	Female	1.62	0.05	0.001*
	Male	1.71	0.07	
CG (m)	Female	0.91	0.03	0.003*
	Male	0.97	0.05	
BMI (kg)	Female	22.05	2.12	0.722
	Male	22.40	3.19	

*Representing statistically significant differences.
CG: center of gravity height; BMI: body mass index

Table 2. Comparison between groups under the conditions of open eyes and closed eyes

Condition	Variables	Gender	Mean	Standard deviation	p-value
Open eyes	COPap (cm)	Female	1.93	0.69	0.011*
		Male	2.29	0.79	
	COPml (cm)	Female	1.15	0.46	0.003*
		Male	1.46	0.53	
	COPvel (cm/s)	Female	1.16	0.30	0.084
		Male	1.26	0.29	
COPap (cm)	Female	1.86	0.57	0.001*	
	Male	2.40	0.81		
Closed eyes	COPml (cm)	Female	1.15	0.54	0.001*
		Male	1.59	0.72	
	COPvel (cm/s)	Female	1.22	0.31	0.004*
		Male	1.43	0.38	

*Representing statistically significant differences
COPap: center of pressure anteroposterior range of displacement; COPml: center of pressure mediolateral range of displacement; COPvel: center of pressure mean displacement velocity (COPvel)

Lemos¹⁹ performed a study comparing the postural balance of children aged from four to ten years old with a group of adults, and verified that, with their eyes open, the group from nine to ten years old reached adult postural balance patterns. In this study, statistical differences were found in all of the postural balance variables in the adult group when comparing genders, both with their eyes open and closed. Such results corroborate with those of this study, because the assessed adolescents were aged between 14 and 16 years old, and had supposedly reached the adult postural balance pattern. So, the adolescents in this study, as well as the female participants in the research by Lemos¹⁹, presented better postural balance when compared to male individuals.

Narciso et al.²⁰ state that anthropometric and body segment variations lead to changes in CG placement, which will be lower among women, for presenting larger hips, and higher among men, due to the width of their shoulders. According to Weineck²¹, the length of the trunk of a woman is similar to 38% of her body, and this value gets to 36% for men, thus leading to lower CG displacement in women, around 0.08 cm lower than in men.

According to Rivas and Andries Jr.²² and Lemos et al.²³, the knee joint in relation to body height of female individuals is larger than male individuals, thus generating more instability in relation to body size and, consequently, better postural balance. These authors state that the mass distribution is different in female bodies due to morphological factors, thus lowering their CG in relation to male individuals with the same height, also decreasing postural oscillation values.

It is believed that the female adolescents in this study presented better postural balance than male individuals due to the different anthropometric characteristics. Another hypothesis would be the rhythm of maturation development, which usually occurs earlier for females. However, maturation level was not assessed, which is a major limitation for this study. As limitations we could also mention the small sample and the different number of individuals in each group.

The findings in this study lead to important clinical implications concerning postural balance for rehabilitation, because the deficit found in the balance of male adolescents may lead to changes in other motor skills, which depend on postural control, such as gait, and also make the process of musculoskeletal rehabilitation more difficult in case of possible lesions.

CONCLUSION

The female adolescents in this study presented better postural balance when compared to male adolescents.

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