Original Articles

Postural Assessment of Lumbar Lordosis and Pelvic Alignment Angles in Adolescent Users and Nonusers of High-Heeled Shoes

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Abstract

Objective: The aims of this study were (1) to analyze the influence of wearing high-heeled shoes on lumbar lordosis and pelvic inclinations among adolescents aged between 13 and 20 years were users and nonusers of high-heeled shoes and (2) to correlate these postural angles with age.

Methods: Fifty adolescents from the nonuser group (NUG) of high-heeled shoes and 50 from the user group (UG) were evaluated. Postural assessments were obtained by photogrammetry under 2 conditions—barefoot and with high-heeled shoes—and analyzed using the evaluation postural software. The measured angles included lumbar lordosis and the horizontal alignment of the pelvis. Descriptive analyses were carried out, with a significance level of 5%.

Results: With high-heeled use, the NUG demonstrated rectification of the lumbar spine and pelvic retroversion, whereas the UG demonstrated hyperlordosis and pelvic anteversion. When barefoot, smaller lumbar lordosis angles for both groups were observed. However, the pelvic angles were lower for the UG group and higher for the NUG. The studied angles showed high reliabilities. Age was correlated with lumbar lordosis angles for the NUG in the barefoot condition and with pelvic alignments in both conditions for the UG.

Conclusion: For the subjects in this study, the use of high-heeled shoes is correlated with increased lumbar lordosis and pelvic anteversions. Lumbar lordosis angles are correlated with age for the NUG when barefoot. (J Manipulative Physiol Ther 2011;34:614-621)

Key Indexing Terms: *Low Back Pain; Lumbar Spine; Posture; Assessment*

Appropriate posture can be defined as the body position in which the center of gravity of each body segment is placed vertically above the lower segmentst.[1] This proper alignment allows the body to use ligament and bone structures to provide stability, instead of excessive muscular activity.[2] Thus, it provides a reduction of the tension in the supporting structures.

There are intrinsic and extrinsic factors that could influence the individuals' postures,[3] such as genetic, environmental, or physical conditions[4,5]; the use of school backpacks with excessive weights[6]; physical activity levels[7]; socioeconomic levels[8]; emotional factors[9-11]; and physiological changes caused by growth and development.[4,9,12] In addition, there are different postural responses to daily-task demands, according to their sex and individual skeletal maturation.[4,9,13]

During adolescence, several postural changes occur because of hormonal influences. These changes are important for the necessary adjustments in the structural

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posture[14] because the prepubertal and pubertal phases become crucial for the development of appropriate postures.[15] Among the contributing factors is the use of high-heeled shoes, which are becoming increasingly produced and frequently used in this population, which could lead to changes in postural patterns.

Studies have shown that postural measurements in the standing position could be clinically useful to detect musculoskeletal abnormalities in the early stages of the development of children and adolescents.[16-18] Opila et al[19] studied the displacements of the lines of gravity in barefoot and high-heeled conditions and observed that with high-heeled shoes, the lines deviated about 6 mm closer to the lateral malleoli. These deviations resulted in changes by compensations in various body segments, such as increased ankle plantarflexion and the posterior displacements of the trunk and pelvis. According to Bendix et al,[20] these changes occurred because of trunk displacements to reduce the anterior body tilt perceptions and the tendency to hyperextend the hip due to the posterior pelvic tilt. The pelvis is considered a key structure of body alignment, and any changes in its neutral position will cause compensatory movements in various regions, with the lumbar spine being one of the most affected segments.[20]

The aims of this study were to analyze the influences of wearing wedge high-heeled shoes on lumbar lordosis and pelvic inclination angles among adolescents aged between 13 and 20 years who were users and nonusers of high-heeled shoes and to correlate these angles with ages and the time of high-heel use.

Methods

Participants

One hundred female adolescents aged between 13 and 20 years[21] who were private-school students in Brazil were divided into 2 groups: the nonuser group (NUG) and user group (UG) of high-heeled shoes. The NUG is composed of 50 girls with a mean body mass of 51.2 kg/m^2, a mean height of 1.63 m, and a mean age of 16.7 years; whereas, the UG is composed of 50 girls with a mean body mass of 52.4 kg/m^2, a mean height of 1.62 m, and a mean age of 17.8 years. All subjects or their legal guardians signed the consent form to participate in this study. This study was approved by the Ethical Committee for Analysis of Research Projects of the Clinics Hospital of São Paulo University (protocol no. 236/06). The trial was registered with trial registration ACTRN12608000300370.

Participants were included if they were adolescents and users of high-heeled shoes at least 4 times a week for 4 consecutive hours and with at least 1 year of usage time[22]; were adolescent nonusers of high-heeled shoes; had a body mass index (BMI) below 85%[9]; and practiced only school physical activities with a maximum frequency of twice a week and/or less than 3 hours/week.[23] Adolescents with histories of congenital, traumatic, neuromusculoskeletal, or systemic diseases and limb length discrepancies greater than 1 cm were excluded.[23]

Fig 1. *High-heeled shoes used in this study. (Color version of figure is available online.)*

A questionnaire was given to standardize the types of high-heeled shoes used and to verify their frequencies of use. For this questionnaire, the participants were asked to indicate, by means of various photographs, which were the shoes most similar to those they most often used. Information was collected regarding the frequencies of weekly use, number of hours that the participants wore the shoes, and how long they used them. The types of footwear, which had 100% of frequency of use, were the wedge high-heeled shoes with a heel height of 10 cm and a platform height of 2 cm. The sizes ranged from 35 to 38 cm according to the Brazilian system (Fig 1).

Procedures

Photogrammetry was used to assess the lumbar lordosis and pelvic alignment angles. A SONY digital camera, H7, with 8.1 megapixels was positioned parallel to the ground on a tripod place at 1 m above the ground at a distance of 2.40 m so that the whole body of the adolescent could be photographed.[24] The camera was rotated and locked at 90° from a horizontal position to focus longitudinally on the adolescents' body. During the photogrammetric evaluations, the participants remained in the standing position next to a plumb line, with a distance of 15 cm from the wall. To ensure adequate positioning, rectangular-shaped ethyl vinyl acetate of 15 cm wide and 60 cm long was placed between the wall and the subjects.[24] Another same material of 7.5 cm (rectangular shaped) was placed between the participants' feet to keep them in a standard posture. Photographic records were obtained in a private room.

For the lumbar lordosis and pelvic alignment analyses, self-adhesive and polystyrene spherical markers (13 mm)

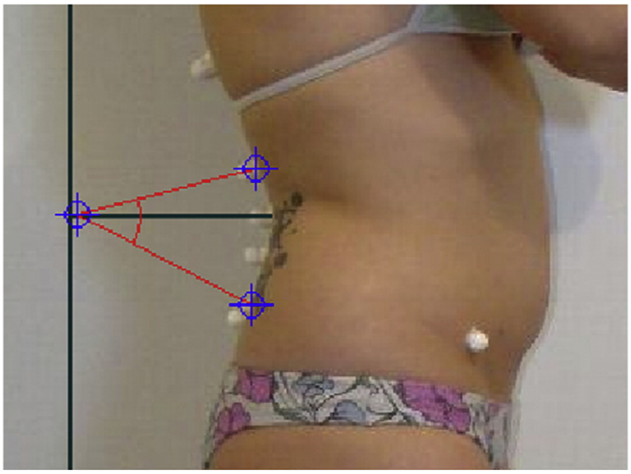

Fig 2. *Lumbar lordosis angle. (Color version of figure is available online.)*

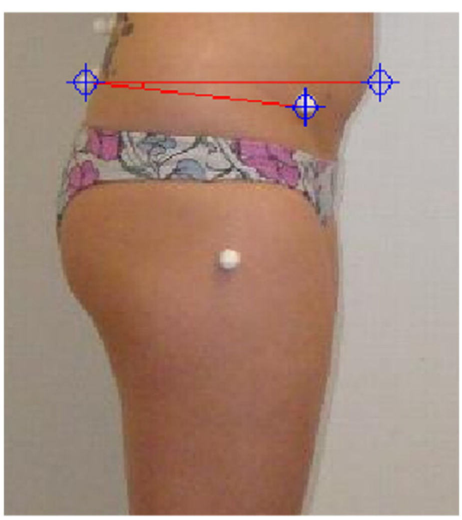

Fig 3. *Pelvis horizontal alignment. (Color version of figure is available online.)*

were placed on the following anatomical landmarks: anterior-superior and posterior-superior iliac spines, T12, L3, and L5 (Figs 2 and 3). First, the photographs were taken in the sagittal plane in a barefoot condition. Then the participants were asked to wear high-heeled shoes and remain with them for 1 hour, either standing or walking to allow possible postural adjustments, and the photographs were retaken. The photographs were analyzed using the Software for Avaliação Postural (postural analysis software) (São Paulo, Brazil). For the test-retest and interrater reliabilities, this procedure was repeated within a week by the first investigator and by 2 independent evaluators on the same day.[25]

Table 1 shows the variables that were considered for the lumbar lordosis and pelvic alignment analyses.

Table 1. *Description of the selected variables*

Variable	Interpretation	
Lumbar lordosis angle	The greater the angle, the greater the rectification[26]	The smaller the angle, the greater the hyperlordosis[26]
Pelvis horizontal alignment	The greater the angle, the greater the anteversion[26]	The smaller the angle, the greater retroversion[26]

Table 2. *Characterization of age, weight, height, and BMI between the GNU and GU*

	Group	Mean	Subjects	*P*
Age (y)	NUG	16.7 ± 2.74	50	.307
	UG	17.80 ± 2.42	50	
Weight (kg)	NUG	51.19 ± 8.43	50	.726
	UG	52.40 ± 6.33	50	
Height (m)	NUG	1.63 ± 0.07	50	.503
	UG	1.62 ± 0.06	50	
BMI (kg/m^2)	NUG	19.14 ± 2.49	50	.445
	UG	19.73 ± 1.52	50	

Statistical Analyses

Statistical analyses were carried out using Excel (Microsoft, Redmond, WA), Minitab (State College, PA), and Statistica software (Tulsa, OK). Wilcoxon tests were used to compare the barefoot and high-heeled conditions, whereas Mann-Whitney tests were used to compare the NUG and UG for both conditions. Intraclass correlation coefficients (ICCs) were used to assess the test-retest and interrater reliabilities. A simple linear regression equation was used, in which the dependent variables were the postural measures and the independent variable was the age of each group. For all analyses, a significance level of $\alpha = .05$ was considered.

Results

Subject characteristics (age, weight, height, and BMI) were compared to determine if there are significant differences between the two groups (Table 2).

Comparisons Between the Barefoot and High-Heeled Conditions

The results of the conditions for both groups are shown in Table 3. Statistically significant differences were found between the conditions for both groups. Decreases in lumbar lordosis and pelvic alignment angles were found for the NUG, whereas the UG demonstrated increases in lumbar lordosis and pelvic anteversion.

Comparisons Between the Groups in Both Barefoot and High-Heeled Conditions

Table 3 also shows the results of the comparison between the groups in the barefoot condition. Significant differences in the lumbar lordosis and pelvic

Table 3. *Descriptive data (means ± SD) and P values for the comparisons between the barefoot and high-heel conditions and comparisons between the NUG and the UG in both barefoot and high-heel conditions*

Variables (comparisons between conditions)	Condition	NUG (n = 50)	UG (n = 50)	*P* value (comparisons between conditions)		*P* value (comparisons between groups, NUG/UG)
				NUG	UG	
Lumbar lordosis angle (deg)	Barefoot	62 ± 4.3	40 ± 5.3	<.001 *	<.001 *	.001 *
	High-heeled	79 ± 3.2	38 ± 4.1			<.001 *
Pelvic horizontal alignment (deg)	Barefoot	−9.5 ± 6.7	−14.5 ± 4.4	<.001 *	<.001 *	.001 *
	High-heeled	2 ± 7.3	−16.6 ± 6.8			<.001*

* Statistically significant.

Table 4. *Reproducibility analyses of the barefoot and high-heeled conditions of the studied measures between the NUG and UG*

Variable	Condition	ICC		Classification	
		NUG	UG	NUG	UG
Lumbar lordosis angles	Barefoot	0.85	0.85	Very good	Very good
	High-heeled	0.87	0.87	Very good	Very good
Pelvic horizontal alignment	Barefoot	0.97	0.97	Excellent	Excellent
	High-heeled	0.98	0.98	Excellent	Excellent

Table 5. *Repeatability analyses of the barefoot and high-heel conditions of the studied measures between the NUG and the UG*

Variable	Condition	ICC		Classification	
		NUG	UG	NUG	UG
Lumbar lordosis angles	Barefoot	0.86	0.86	Very good	Very good
	High-heeled	0.85	0.86	Very good	Very good
Pelvic horizontal alignment	Barefoot	0.98	0.92	Excellent	Excellent
	High-heeled	0.97	1.00	Excellent	Excellent

alignment angles were observed between the groups. The UG had lower lumbar lordosis angles and greater pelvic anteversions.

In the high-heeled condition, significant differences between the groups were also found (Table 3). The lumbar lordosis angles in the UG increased even more compared with the NUG, whose participants showed rectification of their lumbar lordosis when using high-heeled shoes. For pelvic alignment, the UG increased their anteversion, whereas the NUG showed retroversion.

Reliability

According to Wahlund, Listín and Dworkin,[27] the ICC values of postural variables were classified as follows: less than 0.70, not acceptable; 0.71 < ICCs < 0.79, acceptable; 0.80 < ICCs < 0.89, very good; and greater than 0.90, excellent (Tables 4 and 5). Regarding the test-retest and interrater reliability, for both conditions, the ICCs ranged from very good to excellent for the studied angles.

Linear Regression Analyses

In simple linear regression analyses, a mathematical equation was used to predict the values of the dependent variable (denoted by Y) based on the independent variable (denoted by X): $Y = a + b * X$. Variable a, termed the *Y intercept*, refers to the expected level of Y when $X = 0$. Variable b, or the regression coefficient for X, represents the increased or decreased variation in Y values for each variation of 1 unit of X (Tables 6-8). Relationships between the independent variables of age and the lumbar lordosis angles were observed only for the NUG in the barefoot condition. In the UG, significant relationships in the pelvic alignments were found in both conditions. It was also observed only in the UG that the variables related to the time of high-heel use were related to increases or decreases of the angles.

Discussion

The aims of this study were to analyze the influences of wearing wedge high-heeled shoes on the lumbar lordosis and pelvic alignment angles among adolescents aged between 13 and 20 years who were users or nonusers of high-heeled shoes and to investigate the associations between postural angles, ages, and time of high-heel use.

It was difficult to compare the present results with those in the literature because most of these studies involving

Table 6. *Linear regression analyses between age and the assessed postures in the NUG*

Variable	Condition	Estimate	SE	*t*	*P*	Equation
Lumbar lordosis angles	Barefoot	−9.59	3.54	−2.70	.009 *	Lumbar lordosis angles = − 9.587 − 0.0532*age
Pelvic alignment	Barefoot	−4.875	6.61	−0.73	.46	Pelvic alignement = − 4.875 − 0.2786*age
Lumbar lordosis angles	With heels	−4.255	3.69	−1.15	.254	Lumbar lordosis angles = − 4.255 − 0.0794*age
Pelvic alignment	With heels	13.69	7.02	1.95	.056	Pelvic alignment =13.699 − 0.6932*age

* Statistically significant.

Table 7. *Linear regression analyses between age and the assessed postures in the UG*

Variable	Conditions	Estimate	SE	*t*	*P*	Equation
Lumbar lordosis angles	Barefoot	−3.446	5.32	−0.64	.520	Lumbar lordosis angles = *v* − 3.447 − 0.3606*age
Pelvic alignment	Barefoot	−16.02	4.29	−3.72	.005 *	Pelvic alignment = − 16.02 + 0.08419*age
Lumbar lordosis angles	With heels	−0.502	4.83	−0.10	.917	Lumbar lordosis angle = − 0.5030 − 0.3495*age
Pelvic alignment	With heels	−21.99	6.53	−3.36	.001 *	Pelvic alignment = − 22.00 + 0.31310*age

* Statistically significant.

Table 8. *Linear regression analyses between the time of high-heel use and the evaluated postural angles in both the NUG and UG*

Variable	Group	Estimate	SE	*t*	*P*	Equation
Lumbar lordosis angles	NUG	0.376	0.330	1.14	.269	Lumbar lordosis angle = − 0.376 + 0.1624*time of use
Pelvic alignment		−0.245	0.629	−0.39	.679	Pelvic alignment = − 0.245 + 0.0562*time of use
Lumbar lordosis angles	UG	−0.5264	0.126	−4.16	.001 *	Lumbar lordosis angle = − 0.526 + 0.265*time of use
Pelvic alignment		−1.724	0.274	−6.28	.002 *	Pelvic alignment = − 0.5264 + 0.4516*time of use

* Statistically significant.

high-heeled shoes were performed on women already in adulthood and not during their growth phase. In addition, qualitative postural studies were found more frequently compared with quantitative ones.[16,28]

Lumbar lordosis angles were found to be significantly different between the groups and conditions. Although in barefoot condition, both groups demonstrated lumbar hyperlordosis postures, with an average of 62° ± 4.3° for the NUG and 40° ± 5.3° for the UG, the UG showed higher levels of hyperlordosis. However, when asked to wear high-heeled shoes, the NUG reversed their lumbar spine posture and acquired a lordosis rectification, with an average of 79° ± 3.2°; whereas the UG only increased their hyperlordosis to an average of 38° ± 4.1°.

Controversy regarding the influence of high-heeled shoes on the lumbar spine and pelvic postures exists in the literature. Opila et al,[19] Bendix et al,[20] and Franklin et al[29] reported decreases in the lumbar lordosis angle with increasing heel heights in the static posture. According to these authors, body adaptations such as rectification of lumbar lordosis caused by the use of high-heeled shoes are due to pelvic retroversions, which prevent any possibility of lumbar hyperlordosis. However, De Lateur et al,[30] Snow and Williams,[22] and Lee et al[31] found nonsignificant decreases in lumbar lordosis. These diverging results could be explained in most studies by the methodological differences used in the present study, such as the studied population, photogrammetric methods, and the lack of standardization of the footwear.

The conclusions of these previous studies corroborate the present findings on lumbar lordosis rectification shown by the NUG. It is possible that this rectification had occurred in these adolescents because of postural compensations seeking postural equilibrium, because high-heeled shoes moved the center of gravity anteriorly and caused postural imbalance. To regain balance, these adolescents probably adopted compensatory strategies and assumed postures of lumbar rectification. However, the UG showed different results because the participants increased their lumbar lordosis. This fact might have occurred because this group had already chronically used this type of footwear, and its influence over time led to adaptations of the lumbar spine to hyperlordosis. This finding is corroborated by Nasser et al,[32] Kulthanan et al,[33] and Snow et al,[34] who also found increases in lumbar lordosis associated with high-heeled shoes.

Lumbar spine posture is directly related to pelvic postures, and therefore, the literature describes the changes in lumbar lordosis in conjunction with changes in the pelvic segments. Thus, it was observed that both groups had pelvic anteversions accompanied by lumbar hyperlordosis in the barefoot condition. However, the UG demonstrated more accentuated pelvic anteversion angles. While maintaining the use of high-heeled shoes, the NUG adopted compensatory patterns with a reversal condition of the pelvic posture, which was placed in retroversion. It is believed that this occurred because high-heeled shoes moved the center of gravity anteriorly, and therefore, there was a need to regain balance; hence, they ended up tilting their pelvis posteriorly, just as what happened with lumbar rectification. These data corroborated those reported by Manfio et al[35] and Franklin et al.[29]

These authors concluded that high-heeled shoes would reduce pelvic anteversion, and the barefoot condition would increase this angle.[35] It is important to note that they investigated the acute effects of these types of shoes, as was the case with the NUG in the present study. However, the UG had different results, in which there were observed increases in the anteversion angles with the use of high-heeled shoes. This may have happened because these participants were already users of this type of footwear; they kept an adaptive posture of anteversion by having their center of gravity already displaced because of the prolonged use of high heels. These findings were also found by Nasser et al,[32] Kulthanan et al,[33] and Snow et al.[34]

In the present study, very good to excellent coefficients were found for both reproducibility and repeatability tests in both groups for the studied angles, which is different from the results reported by Iunes et al,[24] who found low reliability coefficients. Furthermore, Iunes et al[24] described that the method's repeatability was subject to errors, with only few angles having excellent reliability. However, this was not observed in this study, which showed that this was a reliable quantitative method for postural assessment.

In this study, the relationships of the investigated angles with the independent variables of age and the time of high-heel use were also examined. By applying linear regression analyses, it was found that the lumbar lordosis angles were only associated with age in the barefoot condition, which was also observed by Pagnussat and Paganotto.[36] However, these authors found these relationships with a younger population aged between 6 and 8 years and 11 and 13 years. These relationships were not observed in the high-heeled condition. This may suggest that when adolescents are wearing high heels, the pressures from wearing these shoes might determine the lumbar lordosis positioning and not the time of high-heel use and age.

This idea was strengthened by the observations of these relationships in the UG because in this group, there were no relationships observed between age and both the barefoot and high-heeled conditions, which suggested that lumbar lordosis was not related to age, even when the subjects were barefoot. This might have occurred because these subjects were high-heel users and had, as a determinant factor for the lumbar lordosis, the shoes and not because of their age. Being frequent users, even when they were not wearing high heels, was still a factor that determined the degree of lumbar lordosis of these adolescents.

When analyzing the relationships between the pelvic horizontal alignments and age, for the NUG, there were no relationships observed between both the barefoot and the high-heeled conditions. Similarly, Pagnussat and Paganotto[36] found no relationships between pelvic positioning and aging in children. However, as previously described, it is worthy to note that pelvic positioning is related to lumbar lordosis because pelvic movements are closely related to the biomechanics of the lumbar spine. Nevertheless, for the UG, there were significant relationships found between age and both the barefoot and the high-heeled conditions. These findings suggested that among the adolescents in the UG, the age factor may be related to pelvic inclination and probably to the time of high-heel use. Lapierre[37] considered that balance seeks stability and should initially be organized according to the stability of the pelvis over the hips. Any inclinations of the pelvis would involve simultaneous movements of the lumbar spine and the hip joints. If the lumbar paraspinal muscles predominate over the retroversor muscles, the pelvis will move toward anteversion, aided by the hip flexor muscles.

When analyzing the relationships between these angles and the time of high-heel use, it was observed that as the time of use increased, the hyperlordosis also increased, as well as the pelvic anteversion angles. These findings may explain the clinical reports of the UG regarding lumbar spine fatigue and low-back pain and, consequently, pain of the hips and legs, as a result of using high-heeled shoes for many years.[29,38]

Limitations

Photogrammetry presents some limitations such as the assessment of posture at a single instant and plane. It should be noted that most user and nonuser adolescents studied were owners of high-heeled shoes over some period of weeks, although these girls have a time of use of less than 1 year. Another important factor to be considered is the variability of measurement errors of variables.

Another limitation was the transversal nature of the study's design. The measurement of the postural assessment was obtained only once during the progression of age. Postural evaluation requires serial assessments and needs to be performed in a longitudinal design. It is important to emphasize the importance of correct methodological guidelines to ensure that photographic records are with quality, reliable, and replicable, as well as additional studies seeking new viable forms of practice clinic assessment and those that validate and verify the reliability of the methods.

Conclusions

Prolonged use of high-heeled shoes, that is, chronic use of this footwear since adolescence, correlated with an increase in lumbar lordosis and pelvic anteversion. Age was correlated with lumbar lordosis when a high-heeled condition was not present. Thus, increases or decreases in age, on average, are associated with increases or decreases in the estimated lumbar lordosis values for the NUG in the barefoot condition, although pelvic angles showed positive relationships with age for the UG in both conditions. This study also revealed that with the increasing time of use of high-heeled shoes, both hyperlordosis and pelvic anteversion tended to increase.

Practical Applications

- For the group studied, prolonged use of high heels, or chronic use of worn footwear since adolescence, showed an increase in lumbar lordosis and pelvic anteversion.
- In this group of subjects, age was correlated with the lumbar lordosis when high-heeled shoes were not often used.

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References

1. Watson AWS, MacDonncha C. A reliable technique for the assessment of posture: assessment criteria for aspects of posture. J Sports Med Phys Fitness 2000;40:260-70.
2. Grimmer K, Dansie B, Milanese S, Pirunsan U, Trott P. Adolescent standing postural response to backpack loads: a randomised experimental study. Biomed Central Musculoskel Disord 2002;3:10.
3. Chansirinukor W, Wilson D, Grimmer K, Dansie B. Effects of backpacks on students: measurement of cervical and shoulder posture. Aust J Physiother 2001;47:110-6.
4. Grimmer KA, Williams MT, Gill TK. The associations between adolescent head-on-neck posture, backpack weight, and anthropometric features. Spine 1999;24:2262-7.
5. Mackenzie WG, Sampath JS, Kruse RW, Sheir-Neiss GJ. Backpacks in children. Clin Orthop 2003;1:78-84.
6. Heuscher Z, Gilkey DP, Peel JL, Kennedy CA. The association of self-reported backpack use and backpack weight with low back pain among college students. J Manipulative Physiol Ther 2010;33:432-7.
7. Chow RK, Harrison JE. Relationship of kyphosis to physical fitness and bone mass on post-menopausal women. Am J Phys Med 1987;66:219-27.
8. Sheir-Neiss GI, Kruse RW, Rahman T, Jacobson LP, Pelli JA. The association of backpack use and backpack pain in adolescents. Spine 2003;28:922-30.
9. Asher C. Variações de postura na criança. São Paulo: Editora Manole; 1976.
10. Balague F, Skovron ML, Nordin M, et al. Low back pain in school children: a study familial and psychological factors. Spine 1995;20:1265-70.
11. Niemi S, Levoska S, Kemila J, Rekola K, Keinanen-Kiukaanniemi S. Neck and shoulder symptoms and leisure time activities in high school students. J Orthop Sports Phys Ther 1996;24:25-9.
12. Widhe T. Spine: posture, mobility and pain. A longitudinal study from childhood to adolescence. Eur Spine J 2001;10:118-23.
13. Perret C, Poiraudeau S, Fermanian J, Lefèvre Colau MM, Mayoux Benhamou MA, Revel M. Validity, reliability, and responsiveness of the fingertip-to-floor test. Arch Phys Med Rehabil 2001;82:1566-70.
14. Magee DJ. Orthopedic physical assessment. (3rd ed.). Philadelphia, PA: Saunders Company; 1997.
15. Barbosa L, Braga ES, Frederico BR, Madeira JS. Prevalência de lombalgia em acadêmicos de fisioterapia no ambulatório de um hospital universitário. Revista Fisiot Brasil 2002;3:372-3.
16. Penha PJ, João SMA, Casarotto RA, Amino CJ, Penteado DC. Postural assessment of girls between 7 and 10 years of age. Clinics 2005;60:9-16.
17. Penha PJ, Casarotto RA, Sacco ICN, Marques AP, João SMA. Qualitative postural analysis among boys and girls of seven to ten years of age. Revista Brasileira de Fisioterapia 2008;12:386-91.
18. Penha PJ, Baldini M, João SMA. Spinal postural alignment variance according to sex and age in 7- and 8-year-old children. J Manipulative Physiol Ther 2009;32:154-9.
19. Opila KA, Stephen SW, Schiowitz S, Chen J. Postural alignment in barefoot and high-heeled stance. Spine 1988;13:542-7.
20. Bendix T, Sorenson SS, Klausen K. Lumbar curve, trunk muscles and line of gravity with different heel heights. Spine 1984;9:223-7.
21. Vitalle MSS, Tomioka CY, Juliano Y, Amancio OMS. Índice de massa corporal, desenvolvimento puberal e sua relação com a menarca. Rev Assoc Med Bras 2003;49:429-33.
22. Snow RE, Williams KR. High heeled shoes: their effects on center of mass position, posture, three-dimensional kinematics, rearfoot motion and ground reaction forces. Arch Phys Med Rehabil 1994;75:568-76.
23. Dahl MT. Limb length discrepancy. Pediatr Clin North Am 1996;43:849-65.
24. Iunes DH, Castro FA, Salgado HS, Moura IC, Oliveira AS, Bevilaqua-Grossi D. Confiabilidade intra e interexaminadores e repetibilidade da Avaliação postural pela fotogrametria. Rev Bras Fisioter 2005;9:327-34.
25. Pausic J, Pedisic Z, Dizdar DJ. The reliability of a photographic method for assessing standing posture of elementary school student. Manipulative Physiol Ther 2010;33:425-31.
26. Iunes DH. Análise da confiabilidade inter e intra-examinador na avaliação postural pela fotogrametria computadorizada [dissertação]. Ribeirão Preto, SP: Universidade de São Paulo; 2004.
27. Wahlund K, List T, Dworkin SF. Temporomandibular disorders in children and adolescents: reliability of a questionnaire, clinical examination, and diagnosis. J Orofac Pain 1998;12:42-51.
28. Martelli RC, Traebert J. Estudo descritivo das alterações posturais de coluna vertebral em escolares de 10 a 16 anos de idade. Rev Bras Epidemiol 2004;9:87-93.
29. Franklin ME, Chenier TC, Brauninger L, Cook H, Harris S. Effect of positive heel inclination on posture. J Orthop Sports Phys Ther 1995;21:94-9.

30. De Lateur BJ, Giaconi RM, Questad BA, Ko M, Lehmann JF. Footwear and posture: Compensatory strategies for heel height. Am J Phys Med Rehabil 1991;70:246-54.
31. Lee CM, Jeong EH, Freivalds A. Biomechanical effects wearing high heeled shoes. Int J Ind Ergon 2001;28: 321-6.
32. Nasser JP, Mello SIL, Avila AOV. Análise do impulso em calçados femininos em diferentes alturas de salto. Annals of XII Congresso Brasileiro de Biomecânica, Campinas, São Paulo, Brazil, May 28-30, 1997.
33. Kulthanan T, Techakampuch S, Bed ND. A study of footprints in athletes and non-athletic people. J Med Assoc Thai 2004; 87:788-93.
34. Snow RE, Willians KR, Holmes Junior GB. The effects of wearing high heeled shoes on pedal pressure in women. Foot Ankle 1993;13:85-92.
35. Manfio EF, Vilarde NP, Abrunhosa VM, Souza LV, Fernandez BM, Pereira RM. Alterações na marcha descalça e com sapato de salto alto. Anais do X Congresso Brasileiro de Biomecânica 2003;1:87-9.
36. Pagnussat AS, Paganotto KM. Caracterização da curvatura lombar em escolares na fase do desenvolvimento estrutural. Fisioter Mov 2008;21:39-46.
37. Lapierre A. A reeducação física. Editora Manole; 1982.
38. Cowley EE, Chevalier TL, Chockalingam N. The effect of heel height on gait and posture. A review of the literature. J Am Podiatr Med Assoc 2009;6:512-8.