

ORIGINAL PAPER (ARTIGO ORIGINAL)

# PREPUBESCENTS AND PUBESCENTS OVERWEIGHT POSTURAL CHARACTERIZATION

## CARACTERIZAÇÃO POSTURAL DE PRÉ-PÚBERES E PÚBERES COM EXCESSO DE PESO

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### ABSTRACT

ROSELL, A. A.; FREGONESI, C. E. T. P.; CAMARGO, M. R.; MANTOVANI, A. M.; PURGA, M. O.; FREITAS JUNIOR, I. F.; FERREIRA, D. M. A.; FARIA, C. R. F. Prepubescent and pubescent overweight postural characterization. *Brazilian Journal of Biomotricity*, v. 4, n. 2, p. 104-114, 2010. The study aimed to characterize and quantify biomechanical responses of obesity in pre-adolescents and adolescents. Thirty-five overweight individuals aged between 10-15 years, both genders, were evaluated. The whole procedure was based on the Software of Postural Assessment - SAPo protocol. The descriptive statistical analysis was used. The most evident postural alterations were: calcaneus valgus, hyper-extension and knee valgus, pelvic anteroversion and head protraction. The projection of the gravity center was forwarded in 30.17% of the subjects. Obesity could be related to postural imbalance in overweight at this population. The displacement of the gravity center could lead to compensatory postures to redistribute the body weight.

**Key words:** Adaptation, physiological; Adolescents; Evaluation; Child; Obesity; Posture; Photogrammetry; Overweight.

### RESUMO

ROSELL, A. A.; FREGONESI, C. E. T. P.; CAMARGO, M. R.; MANTOVANI, A. M.; PURGA, M. O.; FREITAS JUNIOR, I. F.; FERREIRA, D. M. A.; FARIA, C. R. F. Prepubescent and pubescent overweight postural characterization. *Brazilian Journal of Biomotricity*, v. 4, n. 2, p. 104-114, 2010. O objetivo do estudo foi caracterizar e quantificar respostas biomecânicas de adaptação à obesidade em crianças e adolescentes. Foram avaliados 35 indivíduos com sobrepeso, com idade entre 10 e 15 anos, de ambos os



gêneros. Todo o procedimento foi baseado no protocolo do *Software* de Avaliação Postural - SAPo. Na análise dos resultados, foi utilizada a estatística descritiva, através de separação em quartis, média e desvio padrão. O índice de massa corporal médio indicou sobrepeso. As alterações posturais mais evidentes foram: calcâneos valgus, hiperextensão e valgismo de joelhos, anteroversão pélvica e protração de cabeça. A projeção do centro de gravidade encontrou-se anteriorizada em 30,17% dos participantes. A obesidade pode estar relacionada com desequilíbrios posturais de crianças e adolescentes com sobrepeso. O deslocamento do centro de gravidade pode levar à adoção de posturas compensatórias buscando redistribuir o peso corporal.

**Palavras-chave:** Adaptação Fisiológica, Adolescentes, Avaliação, Criança, Fotogrametria, Obesidade, Postura, Sobrepeso.

## INTRODUCTION

The man, being the only biped among other animals, has certain privileges, however with a considerable number of particularities. The formation of the erect posture was only possible due to modifications that arouse on the vertebral spine, with the fundamental role of the anti-gravitational muscles for the balance between head, trunk, pelvis and the whole body on a new gravitational center (LOVEJOY et al., 2005; PONTZER et al., 2009)

Posture is the body's position to perform a specific activity or assume a characteristic attitude with the objective to support the own body (KISNER, COLBY et al., 2007; KENDALL et al., 2005). If the adopted posture causes muscular imbalance and this is a persistent fact, there could be postural deviations, culminating in pain and possible osteoarticular deformities.

Therefore, it is important to identify such deviations, which, in the majority of the cases, appear during the individual's growth period. From seven to fifteen years' old the skeletal system suffers great modifications in the search of a balance which is compatible with the new body's proportions. In this age range, the posture adapts to the activities practiced throughout the day, facilitating both poor bone formation and its correct postural correction (KISNER, COLBY et al., 2007; KENDALL et al., 2005; GREENE, NAUGHTON, 2006). This way, good postural habits are important to avoid abnormal overload on the growing bones and adaptation alterations on muscles and other soft tissues (GELDHOL et al., 2006; STEELE et al., 2006).

There are various internal and external factors which could influence the individual's posture, among them, obesity. When this factor occurs in childhood or adolescence, postural dysfunctions tend to be more aggressive, increasing the need to perform earlier postural evaluations for diagnosis and treatment, with the aim to avoid progression of this damage in adult life (JEFFRIES et al., 2007; DETSCH et al., 2007; CONLNÉ et al., 2008; DE SÁ PINTO et al., 2006).

Presently, there are 1.6 billion overweight and 400 million obese individuals in the world. Among the children and adolescent population (six to 19 years old) the prevalence of overweight and obesity is around 35% (WHO, 2009; LOW et al., 2009). Some disturbs, characteristic of obese adults, such as hypertension, resistance to insulin, dyslipidemia and poor endothelial function, are, nowadays, also common in obese children and adolescent (REILLY et al., 2003). If these disturbs are already well correlated in the literature, on the other hand, there is much to discuss about the impact of young obesity on the skeletal-muscle system (WEARING et al., 2006). Recently, the photogrammetry associated to specific computer software, has been used to perform postural evaluation, since this is a method whose easiness and accessibility allow its reproduction in a clinical-scientific environment (LARSEN et al., 2008; IUNES et al., 2005; BRAZ et al., 2008). This way, the objective of the present study was to characterize the biomechanical postural

responses of adaptation to child-adolescent overweight and obesity through photogrammetry.

## MATERIAL AND METHODS

### Research Subjects

Thirty-five overweight and obese subjects, on the age range between 10 and 15 years old, from both genders, were sent from the university extension project of obesity-related studies “*Super Action Program*” from the São Paulo State University, Presidente Prudente, São Paulo, Brazil. The subjects which had a history of other diseases culminating in postural deviation would be excluded from the study, however there were no sample loss.

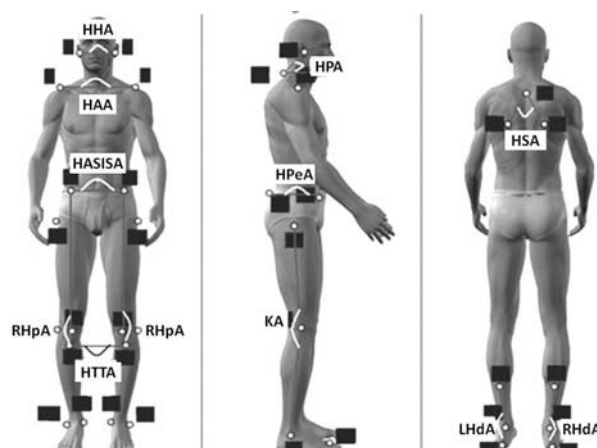
The participants, as well as their legal responsible, signed the Free and Clear Consent Form of the research approved by the Ethics in Research Committee of the School of Sciences and Technology of the São Paulo State University (protocol number 205/2007).

### Procedures

The study was performed at the Laboratory of Physical Therapy Clinical Studies (LECFisio) of the same university. Initially, data referring to age, weight and height of the individuals was registered, and the body mass index (BMI) was calculated. The criteria of the World Health Organization for classification of body mass were used (WHO, 2009).

The postural evaluation of the participants was performed through the Postural Evaluation Software (SAPo), which analyses the angles formed by points manually informed through digital images. However, this software offers a protocol of pre-established anatomic points (Figure 1), which is automatically processed when used, generating, besides the angles formed between these points, the symmetry of the body segments and the plantar projection of the gravity center of the individual. This software is appropriate scientific grounds, full and free internet access (BRAZ et al., 2008; SAPo, 2009; FERREIRA, 2005).

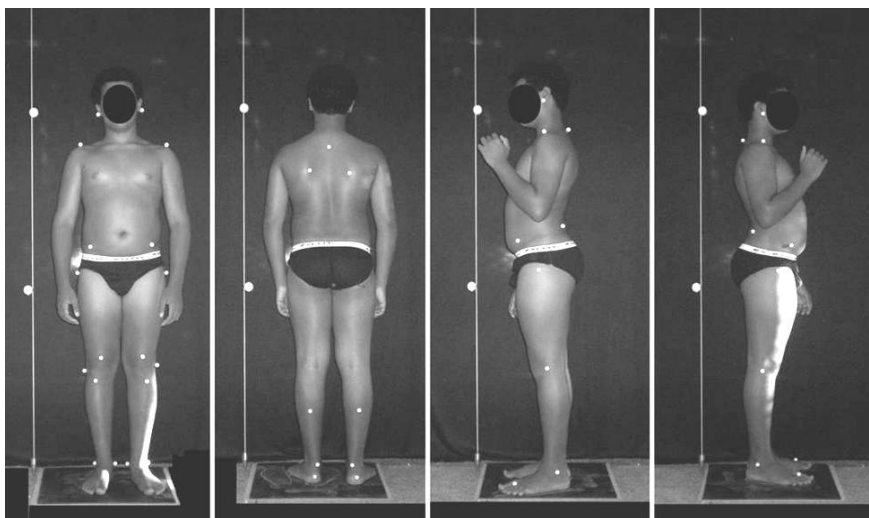
The participants were told to wear bathing suits and rubber caps (when necessary), to facilitate the visualization of the points to be marked. Small Styrofoam balls were used as markers, being fixed with adhesive tape at the anatomic points in such a way to allow its visualization on the digitalized images.



**Figure 1** - Points pre-determined by the protocol SAPo. Angles analyzed by the software. HHA (horizontal head alignment) – angle formed between a line drawn on two drafts of the earlobe and a ground horizontal parallel line; HAA (horizontal achromous alignment) – angle formed between a line drawn on two achromous and a ground horizontal parallel line; HSA (horizontal scapulas

alignment) – symmetry of scapulas in relation to the third toracic vertebrae; HASISA (horizontal antero-superior iliac spines alignment) – angle formed between a line drawn on both antero-superior iliac spines and a ground horizontal parallel line; HTTA (horizontal tibial tuberos alignment) – angle formed between line drawn on tibial tuberos and a ground horizontal parallel line; RHpA and LHpA (right and left hips angles) – angle formed between two vertical lines, the first one drawn on the antero-superior iliac spine and the patella's center, and the other drawn on the patella's center and the tibial tuberos. HPA left and right (head protraction angle) – angle formed between a line drawn on the glabellas to the seventh cervical vertebrae and a ground horizontal parallel line; HPeA left and right (horizontal pelvic alignment) – angle formed between the line drawn on the two antero and postero-superior iliac spines and a ground horizontal parallel line; KA left and right (knee alignment) – angle formed between the greater trochanter of the femur, articular line of the knee and lateral malleolus; RHdA (right hindfoot angle) and LHdA (left hindfoot angle) – external angle obtained between two lines, the first one on a median point of the malleolus and the median point of the leg, and the other on the median point of the malleolus and the calcaneus.

Following that, the individuals were asked to remain in orthostatic position, parallel to a vertical thread fixed on the ceiling, in such a way that this thread and the individual were on the same level ground, perpendicular to the camera axis. In order to allow the future calibration of the software, were also placed, on the vertical thread, Styrofoam balls at a distance of 0.40m between them (Figure 2).



**Figure 2** - Sample of a picture obtained for analysis. Anterior, posterior and lateral views for pictures. In left: the plumline. In the ground: the black rubber mat.

On the process of image capturing, a digital camera was positioned on a tripod, at a height corresponding to 50% of the stature and at a distance of 3 meters from the individual. Four images were made: anterior, posterior, lateral, left and right views.

Ensuring the same support basis, a black rubber mat was used, on which the individual was freely positioned, in anterior view, for the first photography take. At this moment, the feet were outlined with white chalk aiming at directing their position on the subsequent takes. This way, the mat was rotated 90° from the initial position for each new image. The individual was asked to always position his / her feet on the drawing made on the mat. The positioning of the mat was standardized inside a frame of 0.50 x 0.50m, marked on the floor with adhesive tape.

Afterwards, the calibration of the images obtained was made, aimed at adjusting the vertical direction of the picture and transforming the distances on the image, from pixels to real distances from the object (measured in meters). Following that, the Styrofoam markers were identified and delimited. The digitalized pictures were processed and, from then on, the results were obtained from a report generated through the own software.

### Data Analysis

For the analysis of the results obtained, the descriptive statistical data analysis was used, through the calculus of the mean, standard deviation and separation in quartiles.

## RESULTS

On the analysis of the images digitalized by the software SAPo, angulations with negative values (-) indicate deviations to the left (L) on the frontal plane (anterior and posterior) and deviation posterior on the sagittal plane; angulations with positive values (+) indicate deviations to the right (R) on the frontal plane (anterior and posterior) and anterior deviation on the sagittal plane.

In anterior view, the horizontal head alignment (HHA), the horizontal achromous alignment (HAA), horizontal antero-superior iliac spines alignment (HASISA), horizontal tibial tuberoses alignment (HTTA), right and left hip angles (RHpA and LHpA), were evaluated. The means and standard deviations relative to these variables are shown on Table 1.

In posterior view, the horizontal scapulas alignment (HSA), the right hindfoot angles (RHdA) and the left hindfoot angle (LHdA). The results of the means and the standard deviations of these variables are shown on Table 1 (HSA) and on Table 2 (RHdA and LHdA).

On the lateral views R and L, the head protraction angle (HPA), the horizontal pelvic alignment (HPEA) and the knee alignment (KA) were evaluated. The most relevant results of the means and standard deviations of these variables are shown on Table 2.

**Table 1** - Mean and standard deviation of the results regarding HHA; HAA; HAS; HASISA; HTTA – Frontal Plane, Anterior View; RHpA and LHpA – Frontal Plane, Posterior View; for female and male groups. (n=35). (-): Clockwise (+): anti-clockwise deviation. Values in degrees (°).

Variables/Gender	HHA	HAA	HSA	HASISA	HTTA	RHpA	LHpA
<b>FG</b>	-0.02 (4.10)	-0.75 (1.62)	6.59 (19.17)	0.42 (1.62)	1.14 (2.09)	18.86 (5.06)	18.29 (4.85)
<b>MG</b>	1.28 (3.70)	0.66 (1.89)	5.77 (11.22)	-0.20 (1.72)	-0.20 (1.36)	13.94 (7.65)	13.21 (8.00)
<b>TOTAL</b>	0.57 (3.92)	-0.10 (1.86)	6.22 (15.82)	0.13 (1.67)	0.52 (1.90)	16.61 (6.75)	15.97 (6.88)

HHA – horizontal head alignment; HAA – horizontal achromous alignment; HSA –horizontal scapulas alignment; HASISA – horizontal antero-superior iliac spines alignment; HTTA – horizontal tibial tuberos alignment; RHpA and LHpA – right and left hips angles. MG: male group and FG: female group.

**Table 2** - Mean and standard deviation of the results regarding HPA (L); HPA (R); HPeA (L); HPeA (R); KA (L); KA(R) – Sagittal Plane, (L) and (R) Lateral View; RHdA and LHdA – Frontal Plane, Posterior View; for female and male groups. (n=35). (-): Clockwise (+): anti-clockwise deviation. Values in degrees (°).

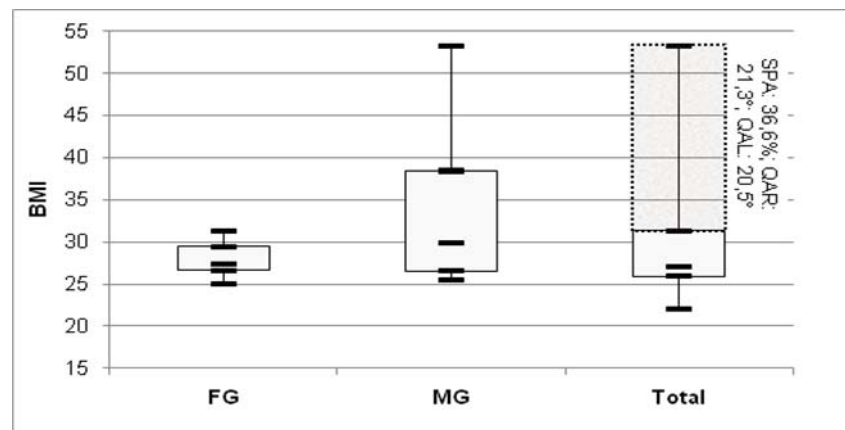
Variables/Gender	HPA(L)	HPA(R)	HPeA(L)	HPeA(R)	KA(L)	KA(R)	RHdA	LHdA
<b>FG</b>	41.71 (6.26)	43.50 (8.52)	-12.81 (4.98)	-12.59 (4.92)	-5.80 (4.32)	-6.22 (4.44)	18.45 (6.47)	17.93 (5.41)
<b>MG</b>	40.51 (5.04)	39.31 (6.40)	-14.18 (5.73)	-11.48 (5.07)	-6.32 (6.00)	-3.32 (4.52)	8.93 (11.05)	14.28 (10.40)
<b>TOTAL</b>	41.16 (5.68)	41.59 (7.81)	-13.43 (5.30)	-12.08 (4.94)	-6.04 (5.08)	-4.89 (4.64)	14.15 (9.98)	16.26 (8.16)

HPA left and right – head protraction angle; HPeA left and right – horizontal pelvic alignment; KA left and right – knee alignment; RHdA and LHdA – right and left hindfoot angle. MG: male group and FG: female group.

Regarding the plantar projection of the gravity center (GC), it was possible to observe a frontal plane asymmetry (FPA), with a discreet mean deviation to the left, being in  $-4.73 \pm 14.40\%$  for the FG and in  $-1.03 \pm 12.23\%$  for the MG (total mean of  $-3.04 \pm 13.39\%$ ). The plantar projection of the GC for sagittal plane asymmetry (SPA) shows an anterior mean deviation, being in  $27.55 \pm 8.60\%$  for the FG and in  $33.29 \pm 9.23\%$  for the MG (total mean of  $30.17 \pm 9.23\%$ ). The results found are described in percentages due to the SAPo base for calculation. The value 0.0% is the axis drawn on two lines, one horizontal, contained on the frontal plane on the two malleolus (X axis) and the other drawn vertically contained on the sagittal plane at the center of the sustentation basis (Y axis).

## DISCUSSION

On the sample evaluated, there was a predominance of the female gender (54.30%), with the mean BMI indicating overweight. The profile of the sampling group with its respective distribution in quartiles can be seen in Figure 3. Due to the fact that the human body is completely interconnected, the development of biotypes with adaptations derived from gender, age and body composition could lead to musculoskeletal imbalance, which interfere in the whole postural pattern. Therefore, a non-compensated muscular imbalance is always associated to others (AXELSON, 2004). Structural disorders related to overweight cause a direct impact on the alignment of the pelvis and the inferior members, being that imbalance on superior members are compensations at a distance. For this reason, more importance will be given to information regarding pelvis and inferior members (CONLNÉ et al., 2008; DE SÁ PINTO et al., 2006).



**Figure 3** - Characterization of the BMI of the sample in quartiles for female and male groups. *HSA*: horizontal scapulas alignment; *RHpA* and *LHpA*: right and left hips angles. *MG*: male group and *FG*: female group.

Angular deviations on inferior members attempt to compensate alterations on the pelvis caused by anterior displacement of the GC. As a consequence, there could be a medial rotation of the hips and accentuation of knee and ankle valgus, favoring a pelvic anteroversion (BRUSCHINI, NERY, 1995; TAYLOR et al., 2006). Besides that, the GC forward, due to overweight, causes mechanical overloads and alterations on the locomotor system, since it redistributes the body weight and increases instability (CONLNÉ et al., 2008; MCGRAW et al., 2000; KESSUKI et al., 2007), interfering on posture.

In the present study, the evaluation of the GC of the overweight brought results that corroborate with those found in the literature. On the SPA, which indicates the deviation on the antero-posterior position on lateral view, the GC projection was 30.17% forwarded, on the totality of the group (27.5% on the FG and 33.29% on the MG). When relating this variable to the BMI, such tendency to anterior projection becomes more evident, since the quartile 3 (BMI above 31.3 kg/m<sup>2</sup>) showed anterior deviations superior to 36.6% (Figure 3).

Some studies evidence that obesity can lead to imbalance of the feet articulation. Small alterations on its structure or alignment with the ankle articulation can influence postural control strategies, as well as the alignment of the other inferior members and body articulation (CICCA et al., 2007; CONLNÉ et al., 2008). The feet represent the base for a good structure and are an essential support for the human biped position. In the presence of deformities or asymmetries in this region, compensations will necessarily occur and the postural system will end up responding with adaptations (MICKLE et al., 2006).

Cicca et al. (2007), in a postural study with children ranging from seven to 10 years old, observed a significant difference between the values of the angles on the ankles of cases ( $7.97^{\circ} \pm 3.99^{\circ}$ ) and controls ( $6.06^{\circ} \pm 5.91^{\circ}$ ). In the present study, in posterior view, the values of RHdA and LHdA were, respectively,  $14.15^{\circ} \pm 9.98^{\circ}$  and  $16.26^{\circ} \pm 8.16^{\circ}$  (Table 2), in accordance with the valgus described in the literature (TAYLOR et al., 2006; MICKLE et al., 2006). Possibly, the large difference of the values found is justified by the difference in profile of the sample on both studies.

Podal alterations, as well as alterations on hips cause postural influences on knees, due to its location on the half third of the inferior members. Besides that, all the bone structures and soft tissues in this region make the knee a common target for misalignments. Gushue et al. (2005) found a greater variability at the extensor moment of the knee during the march in overweight children than in controls, possibly caused by the lack of capacity of the musculature to control the adequate positioning of the knee during the support phase.

In the present study, despite the analysis was realized in static posture, the general angular mean of the knee also suggested hyperextension of  $6.04^{\circ} \pm 5.08^{\circ}$  on the L view of  $4.89^{\circ} \pm 4.64^{\circ}$  on the R view (Table 2). When BMI was considered, such tendency is accentuated: subjects with BMI above  $31.3 \text{ kg/m}^2$  present values above  $8.09^{\circ}$  in both views, representing approximately 40% of the subjects on lateral L and 26% on R.

Besides the abovementioned parameter, the HpA deserves investigation in postural analyses. Various authors who correlate adaptations of the knee with obesity report the presence of valgism (REILLY et al., 2003; WEARING et al., 2006; CICCIA et al., 2007). In the present study, the means of RHpA and LHpA were, respectively,  $16.61^{\circ}$  and  $15.97^{\circ}$  (Table 1), confirming such tendency. It could still be verified that the bigger the overload, the higher the incidence of valgus: the quartile 3 (BMI superior to  $31.3 \text{ kg/m}^2$ ) showed values of RHpA and LHpA superior to  $20.5^{\circ}$  (Figure 3).

Finally, certain compensations at a distance should be considered. In posterior view the HSA that describes the position of the scapulas in relation to adduction (-) and abduction (+), had a general mean value of  $+6.22^{\circ} \pm 15.82^{\circ}$ . On the FG, the superior means to the MG ( $0.82^{\circ}$ ), and the means of FG and MG were, respectively,  $+6.59^{\circ} \pm 19.17^{\circ}$  and  $+5.77^{\circ} \pm 11.22^{\circ}$  (Table 1). The result of the HSA found, indicating abduction of the scapulas, could be associated to the protruded shoulder. Perhaps, this fact has relation with various changes typical from this age range such as anxiety and stress (EHRMANN FELDMAN et al., 2002), which, associated to overweight lead to the selection of an arched posture of the superior trunk (GREENE, NAUGHTON, 2006; GELDHOL et al., 2006; STEELE et al., 2006; JEFFRIES et al., 2007; WATSON et al., 2002).

The HAA also demonstrated a difference between the genders: the mean of the FG indicated the R achromous more elevated than the L ( $-0.78^{\circ}$ ) and the mean of the MG suggested the L achromous more elevated ( $+0.66^{\circ}$ ). The HASISA presented large amplitude of data, with variations between the elevation to the R and to the L. The FG, on average, had a slight inclination to the R ( $+0.0042\text{m}$ ), and, in relation to the MG, the mean of the HASISA suggested an inclination to the L ( $-0.0020\text{m}$ ) (Table 1).

The HSA and HAA results demonstrated contrary to the findings of HASISA. The fact that the alignment of the scapular waist is asymmetric could have been influenced by the laterality, being the dominant shoulder the most elevated (CONLNÉ et al., 2008). However, the misalignment scapular x pelvic waist could have occurred in response to a contra-lateral imbalance, since the studied population is in a period of acceleration of their development. In this phase, it is common to observe posture disorders among the axial skeleton structures, which, associated to life and eating habits (GREENE, NAUGHTON, 2006; GELDHOL et al., 2006; STEELE et al., 2006; WATSON et al., 2002), added to overweight, possibly culminate on the fixation of a pathological postural pattern.

Kussuki et al. (2007), suggest that the increase on cervical lordosis for repositioning of the head and recovery of the corporal balance occurs with adaptation. Therefore, excess body weight, besides the possibility of having association with a misalignment between the pelvic and scapular waists, incurs in protrusion of the abdomen, which displaces the GC, increasing lumbar lordosis and thoracic kyphosis. In the present study, cervical hyperlordosis was present on both groups, being the mean HPA of the FG, to the R ( $43.50^{\circ} \pm 8.52^{\circ}$ ) and to the L ( $41.71^{\circ} \pm 6.26^{\circ}$ ), and, on the MG, to the R ( $39.31^{\circ} \pm 6.40^{\circ}$ ) and to the L ( $40.51^{\circ} \pm 5.04^{\circ}$ ) (Table 2).

In conclusion, the study presented data on postural alterations caused by overweight in pre-pubertal and pubertal subjects, which suggest that mechanical overload on locomotor system interferes on the postural pattern of this population. The modifications on the

distribution of corporal mass could be related to the anterior displacement of the GC, leading the body to seek new adjustments on the posture, in order to adapt and better distribute the body weight. Despite the fact that a statistical test was not applied, due to the absence of a control group, the results of the evaluations identified a postural model similar to the few found in the scientific literature, and it could differ between genders.

Future studies with larger samples should be performed in order to combine the findings of this study with a preventive and educational work for the treatment of overweight, since the progression of obesity leads to a process of modification of the body scheme, causing harm to the postural system which could persist during the whole adult life.

## PRACTICAL APPLICATIONS

The childhood obesity prevalence has increased dramatically in recent years. Monitoring and intervention programs focused on this population should be encouraged, because the weight excess causes many health hazards.

The findings of this study demonstrate clinical relevance, since they describe a peculiar posture pattern among children and adolescents with overweight. This pattern may be able to consolidate and become irreversible in adulthood. Other studies should be performed to investigate the posture in children and adolescents without obesity and to quantify the postural deviations of this population to supplement the present findings.

Despite this limitation, the study results lead to think about the need for early intervention to these children and adolescents losing body weight. Perhaps, techniques proprioception and postural reeducation should be encouraged to reduce the overhead joints. However, if no physical activity programs, psychological and nutritional counseling for weight loss, itself, little success will be achieved as the physical therapy treatment.

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