ORIGINAL ARTICLE

Influence of different types of seat cushions on the static sitting posture in individuals with spinal cord injury

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Study design: Cross-sectional study.

Objectives: To evaluate the efficacy of the Postural Assessment Software PAS/SAPO in the posture analysis of individuals with spinal cord injury (SCI) during sitting position and to analyze if the use of different types of seat cushions—gel and foam, with no cushion—can interfere in the individual's posture during sitting position.

Setting: Centre of Rehabilitation at the University Hospital (FMRP—USP), Ribeirão Preto, Brazil.

Methods: Eight individuals, four paraplegics and four tetraplegics with SCI and 20 healthy individuals participated in the study. Photos were taken of individuals in the sitting position using foam, gel cushions and with no cushion. They were analyzed using the PAS/SAPO. The alignment of the anterior–superior iliac spine (ASIS) and the posterior pelvic tilt were evaluated from the angle formed between the ASIS and the greater trochanter of the femur.

Results: The group of healthy individuals presented the best postural alignment when compared with the group with SCI, both for the ASIS alignment ($P < 0.05$) and for the degree of posterior pelvic tilt ($P < 0.05$). No significant differences were found in the variables analyzed when the seat cushions were compared.

Conclusion: The different types of cushions did not alter the sitting posture; however, individuals with SCI showed worse postural alignment than the healthy individuals. PAS/SAPO was demonstrated to be useful for postural assessment.

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Keywords: posture; PAS/SAPO; cushions

INTRODUCTION

An injury in the spinal cord can cause major functional deficits and result in significant deficiencies and disabilities.¹ Owing to the use of the non-postural muscles to compensate for the functional loss of the erector spine muscle² and the differences in the location of the center of gravity, the posture of individuals with spinal cord injury (SCI) usually changes.^{3,4} Individuals with SCI have difficulty in maintaining a sitting position with back straight or in varying this position,⁵ and usually postural disorders such as lateral deviation of the pelvis and/or spinal cord and reduced lumbar lordosis, or the presence of the kyphosis lumbar and posterior pelvic rotation, are observed.^{5,6}

The wheelchair cushions were developed for pressure management mainly in the ischial tuberosity. There are many cushion materials, such as water, gel, foam, convoluted (egg-crate), viscoelastic^{7,8} and the contoured cushion, which is shaped to fit the individual's body. The materials have many characteristics and can be used for improving stability, positioning, comfort and prevention of ulcers.⁹ Takara *et al.*¹⁰ did not observe the influence of gel and foam cushions on balance during the seated position in individuals with paraplegia. However, it is not known if these types of cushion can accentuate the misalignment posture occurs due to the muscular deficit observed in subjects with SCI.

Spinal cord-injured subjects, due to the functional loss of the erector spine muscle, have difficulty in maintaining an appropriate

sitting position and, consequently, it impairs their posture. However, in the lower injury levels, the posture impairment is not a concern of most health professionals and the indication of the cushion type is based on the prevention of ulcers. Therefore, based on the fact that the SCI subjects have a tendency to have posture problems and most prescribed cushion types in many rehabilitation centers in Brazil are not the contoured type, it is relevant to study the impact of these cushions on the posture alignment of SCI subjects.

Studies that have evaluated the seated posture have used imprecise methods of analysis, such as photo printing with manual measurements of posture⁵ or expensive equipments, which are not used in clinical practice, such as tridimensional-movement analysis or radiological evaluations.^{11,12}

The computerized photogrammetry has been used for quantitative postural evaluation, which provides an accurate value for the analysis. The postural assessment software PAS/SAPO was developed based on the information provided by many research centers in Brazil. This software is considered to be reliable in the upright posture assessment, besides it is accessible and inexpensive. However, there is no evidence of its use in the seated position assessment. We hypothesize that the PAS/SAPO would be effective in identifying differences in the postural alignment between individuals with SCIs and able-bodied subjects, and to evaluate if the type of cushion would change the posture of individuals with SCI.

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The objectives of the study were to evaluate the efficacy of PAS/SAPO in the posture analysis of individuals with SCI during sitting position and to analyze if the use of different types of seat cushions—gel and foam, with no cushion—can interfere in the individual's posture during sitting position.¹³

MATERIALS AND METHODS

Subjects

This study involved male and female with SCI (SCI group: $n=8$; mean ages = 32.33 ± 12.67 years; mean weight = 73.33 ± 9.33 kg; mean height = 1.71 ± 0.09 meters), individuals with paraplegia ($n=4$) or quadriplegia ($n=4$) with at least 12 months of injury (mean time of injury = 5.96 ± 4.04 years) and healthy individuals (control group: $n=20$; mean age = 21.63 years (± 7.37); mean weight = 66.63 kg (± 26.37); mean height = 168 cm (± 0.17)) for comparison purposes. The inclusion criteria were presence of traumatic SCI for at least 12 months and the use of wheelchair for daily activities. The exclusion criteria were presence of a history of cranial-encephalic trauma associated with spinal cord and amputation.

Table 1 Number of patients of the spinal injury group with the respective level according to the American Spinal Injury Association Impairment Scale

Number of patients	Level
2	C4 A
1	C4 C
1	C6 D
1	T3 A
1	T7 B
1	T11 A
1	T12 B

Table 1 shows the impaired segments and disability levels classified by the American Spinal Injury Association Impairment Scale of individuals who were subjected to the postural assessment.

Ethical commitments

This study was approved by the Ethics Committee of the School of Medicine of Ribeirão Preto (process no. HCRP 4051/2009). All volunteers signed a free and informed consent statement.

Local

The evaluations were carried out at the Rehabilitation Center of the Clinical Hospital at School of Medicine, Ribeirão Preto, Brazil. All evaluations were conducted by the same examiner.

Data assessment

Initially, the assessment of the SCI group, anamnesis and neurological examination were carried out in accordance with the American Spinal Injury Association protocol jointly with the postural assessment by photogrammetry. The measures provided by PAS/SAPO are generated in the form of distances and angles considering a plane of movement, in a two-dimensional analysis, related to a previously defined and calibrated scale.¹³

In postural assessment, each individual had his/her photographs taken in a sitting position, in frontal-, right-side and left-side views. Each view was photographed once in three types of seats: wheelchair—seat of the wheelchair itself (without additional cushion); gel—gel cushion (viscous gel, 40×45 cm², 10 cm thick); and foam—foam cushion (egg crate seat pad, 45×45 cm², thickness = 10 cm and density = 28 g dm^{-3}).

The selection for the types of seat cushions used in this study was based on the types most commonly used by patients assisted at the Rehabilitation Center Physiotherapy Unit of the Clinical Hospital at School of Medicine.

Figure 1 Frontal view in the wheelchair seat for the analysis of alignment between the right and left anterior superior iliac spine. (a) Individual from the spinal cord injury group; (b) individual from the control group.

A wheelchair (Baxmann Jaguaribe Ágil Reclinável, São Paulo, Brazil) with footrest, without headrest and the arms removed was used. It has a backrest with a 110° inclination and was chosen because many individuals with SCI, mainly those with poor trunk control, use this wheelchair inclination.⁶ However, this backrest inclination increases the pressure on the ischium,¹⁴ sacrum and can cause ulcers.⁶ Therefore, to evaluate the influence of types of cushion on posture alignment in this backrest position seems relevant to evaluate the more appropriate cushion to indicate in this case. The wheelchair was positioned at a distance of 15 cm from the wall. The wall was covered with black non-reflective fabric.

A digital camera (Sony-Cyber Shot 7.2 Megapixels, Sony, Tokyo, Japan) was positioned on a tripod at a height of 90 cm and at a horizontal distance of 3 m from the wheelchair.^{13,15}

All individuals were photographed using markers consisting of polystyrene spheres in the following anatomical points: greater right trochanter, greater left trochanter, right and left anterior–superior iliac spine (ASIS), right and left acromion, angle of the sternum, mentum and tragus.^{13,15}

Data analyses

The photos were analyzed through PAS/SAPO.^{13,15,16} The alignment was evaluated between the ASIS (frontal plane) (Figure 1) and the angle formed between the ASIS and the greater trochanter (GT) of the corresponding side (sagittal plane) (Figure 2).

In the frontal view, it was possible to analyze, through the PAS/SAPO software, the alignment between the ASIS, where the value 0 was considered as the ideal alignment. Positive or negative variations are considered as changes of alignment; the greater the variations, the more the distance from 0.¹³ The positive or negative values, which represent, when the right ASIS is superior to the left, or when the left ASIS is superior to the right, respectively, were placed in the form of a module to consider its difference from 0.

In right and left lateral views, it was possible to analyze, by using the function ‘measurement of free angles’ from the PAS/SAPO software program, the angle formed between the ASIS and the GT of the Femur, similarly to what was done by Yi *et al*.¹⁶ For reason of adjustment, the value of the 180° difference minus the angle obtained was used in the right-side view, so that this angle could be evaluated in the same way as the angles in the left side were obtained. This angle indicates

the amount of pelvic inclination; the lower the value of the angle (in degrees), the greater the posterior pelvic tilt presented by the individual.

Statistical analysis

Three analyses of two-factor analysis of variance were carried out, including the particular group and the types of seat cushion. The dependent variables were: in the first analysis, the ASIS alignment; in the second analysis, the angle between the right ASIS and the right GT; and in the third analysis, the angle formed between the left ASIS and the left GT. Significant difference for values of $P < 0.05$ was set. Software SPSS 16.0 (SPSS, Chicago, IL, USA) was used.

RESULTS

Figure 3 shows the average values of ASIS alignment in different types of cushion. In both groups, when the seat cushions were compared, there was no difference between them: wheelchair and gel, gel and foam, and foam and wheelchair ($P < 0.05$). Despite this, the control group presented values closer to 0, when compared with the SCI group in three types of seats ($P < 0.05$), that is, they exhibited better alignment.

Figure 4 shows the average values of the angle formed between the ASIS and the GT, right and left sides in different types of seat cushions. In both groups, no differences were found between the cushions ($P > 0.05$); however, the control group showed higher values compared with SCI in three types of cushion ($P < 0.05$), which indicates that the control group presents lower posterior pelvic inclination in relation to the SCI group.

DISCUSSION

Postural changes are common in individuals with SCI.^{3,4} In addition, this population frequently uses cushions in their wheelchairs to prevent ulcers and to increase comfort. When choosing the appropriate cushion, some aspects should be regarded as: comfort, prevention of ulcers and postural stability generated by these types of seats.

For postural management, the contoured cushion type is recommended however, in Brazil, many subjects use the traditional cushion for pressure management—even those individuals with high levels of SCI, who could benefit from some sort of contouring. However, there

Figure 2 Left-side view for the analysis of alignment between the right and left anterior–superior iliac spine. (a) Individual from the spinal cord injury group; (b) individual from the control group using the foam cushion.

are no studies that evaluate the influence of soft surface on the static sitting posture of these individuals.

The photographic records, along with the computerized programs, have been widely used as a tool to record accurate postural assessments.¹⁷ In the previous study, the PAS/SAPO software presented high and significant correlation with the Corel Draw software for the measurement of angles, despite presenting low correlation with the results obtained by goniometry.¹⁵ The PAS/SAPO software is considered to be an accurate instrument for measuring corporal angles and distances, in addition to presenting good inter- and intra-rater reliabilities.¹³

Through the analysis of the ASIS alignment, it was observed that the cushions studied did not affect the sitting posture of individuals with and without SCI however, some differences were observed among individuals with SCI when compared with the healthy ones, which suggest the efficacy of the PAS/SAPO software in identifying posture differences between groups. The greater ASIS misalignment is probably the cause or consequence of a misalignment of the trunk, which

favors more evident postures with lateral inclination of the trunk. These results can be compared with those obtained by Alm *et al.*,⁵ which indicate that most individuals with SCI did not have their lumbar spine centered in the wheelchair.

Likewise, when the angles obtained between the superior iliac spine and the GT of the femur were compared, the cushions did not exert any influence on the anterior–posterior pelvic inclination of individuals with or without SCI.

A more stable seated posture was found with the use of chairs with reclining seat and back, in which the individual rests his trunk against the backrest and moves the pelvis forward, shifting the center of mass backward.^{5,18} However, this posture increases the pressure on the ischium and sacrum, and can cause ulcers.^{6,14} In the present study, it was observed that individuals with SCI have a pelvic tilt in the sitting position, greater than individuals without such injury. An interesting fact observed is that the different cushions evaluated did not interfere with pelvic inclination, which suggests that the choice among these types of cushions does not have influence on the alignment between the ASIS, nor an effective action in the correct positioning of the sacrum. It is important, as a previous study¹⁴ already demonstrated that the 110° backrest inclination increases the pressure on the ischium and none of the types of cushions evaluated in the present study improved the pelvis tilt.

Although the studied cushions did not alter the sitting posture, it is known that some wheelchair components can be used for postural management, such as contoured cushions, reclined backrest, seat belt, headrest, armrest, footrest, shoulder harness and chest trap.¹⁸ Such wheelchair components have an influence on the postural alignment, pressure management, comfort and ability to perform the reach task and self-propel, besides its role in the prevention of muscular and joint disorders.¹⁹

Individuals without SCI, as expected, present lesser postural deviations in relation to lateral inclination of the pelvis and the pelvic tilt, which demonstrates the relationship between SCI and the deficit in postural alignment.

The cushion types evaluated in the present study seems not to influence the sitting posture with a 110° backrest inclination and they should not be considered as postural management in individuals with SCI. The results show that the indication of the cushion type must consider not only the pressure and comfort aspects, but also the posture deficit. It is relevant, as most individuals with SCI in Brazil use gel or foam cushion, without concern about the postural alignment and the appropriate management for this aspect.

Figure 3 Alignment of anterior–superior iliac spine. ^a $P < 0.05$, spinal cord injury versus control.

Figure 4 Angle between ASIS and GT of the femur. (a) Right side; (b) left side. ^a $P < 0.05$, spinal cord injury versus control.

Additionally, PAS/SAPO was demonstrated to be useful for postural assessment, as it was capable of detecting differences between subjects with and without SCI. The results demonstrate that the PAS/SAPO, a simple, rapid and inexpensive software, can be used as an additional tool in order to provide a posture evaluation, which can help in the treatment management of these individuals.

The limitations of the study are related to: small sample number, which prevented a separate assessment of individuals with paraplegia and quadriplegia, the lack of analysis of lateral deviations of the spinal cord and the deviation of adduction and internal rotation of the thighs due to the inability of the PAS/SAPO software to evaluate the posture in three dimensions. The study was limited to the analysis of only two types of cushions; however, there are other options that can also be used by individuals with SCI, such as air, viscoelastic and contoured cushions, which may have a different influence on the sitting posture of these individuals. Also, only a wheelchair with reclined backrest was investigated in the present study.

Additional studies should be carried out to better clarify the influence of these and other cushion types and other wheelchair backrest angles on the sitting posture of individuals with SCI, considering the postural and pressure managements, besides the functional range of motions.

CONCLUSION

Among the cushions evaluated, no difference was found in postural alignment when the use of foam, gel cushions and without cushion was compared in individuals with SCI and healthy ones. On the other hand, it was verified that individuals with SCI have greater misalignment of the torso and greater posterior pelvic inclination than the healthy individuals, which suggest the efficacy of PAS/SAPO software in the evaluation of posture.

DATA ARCHIVING

There were no data to deposit.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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1. Lim PAC, Tow AM. Recovery and regeneration after spinal cord injury: a review and summary of recent literature. *Ann Acad Med Singapore* 2007; **36**: 49–57.
2. Potten YJM, Seelen HAM, Drukker J, Reulen JPH, Drost MR. Postural muscle responses in the spinal cord injured persons during forward reaching. *Ergonomics* 2009; **42**: 1200–1215.
3. Shumway-Cook A, Woollacott MH. *Motor Control—Theory and Practical Applications*, 2nd edn. Manole: São Paulo, 2003.
4. Aissaoui R, Boucher C, Bourbonnais D, Lacoste M, Dansereau J. Effect of seat cushion on dynamic stability in sitting during a reaching task in wheelchair users with paraplegia. *Arch Phys Med Rehabil* 2001; **82**: 274–281.
5. Alm M, Gutierrez E, Hultling C, Saraste H. Clinical evaluation of seating in persons with complete thoracic spinal cord injury. *Spinal Cord* 2003; **41**: 563–571.
6. Samuelsson K, Larsson H, Thyberg M, Tropp H. Back pain and spinal deformity—common among wheelchair users with spinal cord injuries. *Scand J Occup Ther* 1996; **3**: 28–32.
7. Bergen AF. Orthotics, prosthetics and the prescriptive wheelchair. In: O'Sullivan SB, Schmitz JT (eds). *Physical Rehabilitation: Assessment and Treatment*, 2nd edn., Manole: São Paulo, 2003.
8. Koo TKK, Mak AFT, Lee YL. Posture effect on seating interface biomechanics: comparison between two seating cushions. *Arch Phys Med Rehabil* 1996; **77**: 40–47.
9. Gil-Agudo A, De la Peña-González A, Del Ama-Espinosa A, Pérez-Rizo E, Díaz-Domínguez E, Sánchez-Ramos A. Comparative study of pressure distribution at the user-cushion interface with different cushions in a population with spinal cord injury. 2009; **24**: 558–563.
10. Takara K, Gaspar MIFAS, Metring NL, Mateus-Vasconcelos ECL, Cliquet A, Abreu DCC. Evaluation of the influence of different types of seats on postural control in individuals with paraplegia. *Spinal Cord* 2010; **48**: 825–827.
11. Murans G, Gutierrez-Farewik EM, Saraste H. Kinematic and kinetic analysis of static sitting of patients with neuropathic spine deformity. *Gait Posture* 2011; **34**: 533–538.
12. Berthoinaud E, Hilmi R, Labelle H, Dimnet J. Spino-pelvic postural changes between the standing and sitting human position: proposal of a method for its systematic analysis. *Comput Med Imaging Graph* 2011; **35**: 451–459.
13. Ferreira EAG, Duarte M, Maldonado EP, Burke TN, Marques AP. Postural assessment software (PAS/SAPO): validation and reliability. *Clinics* 2010; **65**: 675–681.
14. Jan YK, Jones MA, Rabadi MH, Foreman RD, Thiessen A. Effect of wheelchair tilt-in-space and recline angles on skin perfusion over the ischial tuberosity in people with spinal cord injury. *Arch Phys Med Rehabil* 2010; **91**: 1758–1764.
15. Sacco ICN, Aalibert S, Queiroz BWC, Pripas D, Kieling I, Kimura AA *et al*. Confiabilidade da fotogrametria em relação a goniometria para avaliação postural de membros inferiores. *Rev Bras Fisioterapia* 2007; **11**: 411–417.
16. Liu CY, Jardim JR, Pignatari SS, Inoue DP. The relationship between excursion of the diaphragm and curvatures of the spinal column in mouth breathing children. *J Pediatr* 2008; **84**: 171–177.
17. Watson AWS. Procedure for the production of high quality photographs suitable for the recording and evaluation of posture. *Rev Fisioterapia Univ São Paulo* 1998; **5**: 20–26.
18. Potten YJM, Seelen HAM, Drukker J, Reulen JPH. Chair configuration and balance control in persons with spinal cord injury. *Arch Phys Med Rehabil* 2000; **81**: 401–408.
19. Cherubini M, Melchiorri G. Descriptive study about congruence in wheelchair prescription. *Eur J Phys Rehabil Med* 2011; **47**: 1–6.