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ORIGINAL RESEARCH

Influence of the malleolar marker position on postural parameters in the sagittal plane

Influência da posição do marcador maleolar sobre os parâmetros posturais no plano sagital

Influencia de la posición del marcador maleolar en los parámetros posturales del plano sagital

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ABSTRACT | Photogrammetry is a postural evaluation method that provides information based on the reference of anatomical markers. In the sagittal plane, one of the main evaluations is related to the plumb line; however, the literature shows divergences regarding the placement of the malleolar reference marker. Some argue that it must be placed exactly on the center of the lateral malleolus, while others defend placing it slightly in front of the lateral malleolus. This study aimed to identify whether the modification of the position of the malleolar marker affects the results of the procedure. This is a cross-sectional analytical observational study, with comparative intrasubject design. Forty-four healthy subjects (25 women and 19 men; 27±6 years old; 170±11 cm; 71±15 kg) were evaluated using protocol and software DIPA© for investigation of the variables (plumb line test and pelvic version) in the sagittal plane, with the malleolar marker in two positions: (1) in the center of the lateral malleolus and (2) in front of the lateral malleolus. The analysis was carried out according to descriptive (frequency distribution, mean and standard deviation) and inferential (Shapiro-Wilk test, dependent Student's t-test, and Wilcoxon test, α=0.05) statistical methods. For both variables, the malleolar marker position presented statistically significant difference ($p<0.05$) only on the scalar value, not significantly affecting the posture classification. The results suggest that the vertical reference point for photogrammetry, based on the malleolar marker, can be chosen by the evaluator.

Keywords | Photogrammetry/methods; Posture; Men; Women.

RESUMO | Fotogrametria é um método de avaliação postural que fornece informações baseadas no referencial de marcadores anatômicos. No plano sagital, uma das principais avaliações está relacionada ao fio de prumo, apresentando divergências a respeito da colocação do marcador de referência maleolar na bibliografia. Alguns defendem que seja feita exatamente sobre o centro do maléolo lateral, enquanto outros defendem a colocação um pouco à frente do maléolo lateral. O objetivo deste estudo foi identificar se a modificação da posição do marcador maleolar influencia os resultados do procedimento. Trata-se de um estudo observacional analítico transversal, com delineamento comparativo intrassujeitos. Foram avaliados 44 indivíduos saudáveis (25 mulheres e 19 homens; 27±6 anos; 170±11cm; 71±15Kg) utilizando o protocolo e software DIPA© para investigação das variáveis (teste do fio de prumo e pulsão da pelve) no plano sagital, com o marcador maleolar em duas posições: (1) no centro do maléolo lateral e (2) à frente do maléolo lateral. A análise realizada segundo os métodos estatístico, descritivo (distribuição de frequências, média e desvio padrão) e inferencial (testes de Shapiro Wilk, t de Student dependente e Wilcoxon, α=0,05). Para ambas as variáveis, a posição do marcador maleolar exerceu influência estatisticamente significativa ($p<0,05$) apenas no valor escalar, não afetando significativamente ($p>0,05$) a classificação postural. Os resultados sugerem que o ponto de referência vertical

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para a fotogrametria, baseado no marcador maleolar pode ser de escolha do avaliador.
Descritores | Fotogrametria/Métodos; Postura, Homens; Mulheres.

RESUMEN | La fotogrametría es un método de evaluación postural que proporciona información basada en los referenciales de los marcadores anatómicos. En el plano sagital, una de las principales evaluaciones se relaciona con la plomada, y demuestra divergencias en cuanto a la colocación del marcador de referencia maleolar en la bibliografía. Algunos autores argumentan que se lo hace exactamente en el centro del maléolo lateral, mientras que otros lo defienden colocando un poco delante del maléolo lateral. El estudio propone identificar si la modificación de la posición del marcador maleolar influye en los resultados del procedimiento. Se trata de un estudio observacional analítico transversal, de concepción comparativa intraindividual. Se evaluaron a 44 individuos sanos (25 mujeres y 19 hombres; 27±6 años; 170±11 cm, 71±15 kg) por medio del protocolo y el software DIPA© para analizar las variables (prueba de la plomada y pulsión de la pelvis) en el plano sagital, con el marcador maleolar en dos posiciones: (1) en el centro del maléolo lateral y (2) delante del maléolo lateral. Se realizó el análisis conforme los métodos estadístico, descriptivo (distribución de frecuencias, media y desviación estándar) y estadística inferencial (prueba de Shapiro-Wilk, prueba t de Student dependiente y de Wilcoxon, α=0,05). En ambas variables, la posición del marcador maleolar tuvo una influencia estadísticamente significativa ($p<0,05$) en el valor escalar, pero no afectó significativamente ($p>0,05$) a la clasificación postural. Los resultados revelaron que el punto de referencia vertical a la fotogrametría desde el marcador maleolar puede ser elegido por el evaluador.
Palabras clave | Fotogrametría/Métodos; Postura, Hombres; Mujeres.

INTRODUCTION

Photogrammetry is a postural assessment tool that provides quantitative data on individual posture[1,2]. The use of the tool follows a protocol of use that foresees the organization of the room, marking of anatomical reference points, standardization of the positioning of the volunteer to be photographed, and standardization of the equipment for capturing and processing images[3,4]. Sagittal plane analysis is conventionally carried out in the right profile, where the reflective markers are fixed at certain anatomical points[5]. The marking of anatomical references, as well as prior knowledge on their palpation, is essential to ensure quality in the evaluation[6].

Still in the sagittal plane, the main evaluation established in the literature and commonly used in clinical practice is the plumb line test. However, there is divergence between the authors regarding the placement of the reference marker in the malleolar region. Peninou[7] defends the placement exactly over the center of the lateral malleolus, while Kendall et al.[8] defend placing it slightly in front of the lateral malleolus.

The methodological divergence between the authors raises doubts about the possibilities of results based on the different procedures, at the time of implementation of the evaluation. When the result obtained by postural evaluation by photogrammetry is used to determine the posture diagnosis and, therefore, the treatment planning[6,9], the tool use methodology must ensure the reliability of the findings[10,11].

Based on the two possibilities of evaluation protocol, we created the hypothesis that the arbitrary choice of the marker's position in the malleolar region may interfere in the final evaluation report, affecting the postural classification. In this context, this study aimed to identify whether the modification of the position of the malleolar marker affects the results of the postural evaluation by photogrammetry in the sagittal plane.

METHODOLOGY

Sample selection

The study population consisted of volunteers from undergraduate and graduate courses from Universidade Federal do Rio Grande do Sul (UFRGS), aged between 18 and 50 years old. The sample was intentional, composed by healthy adults of both sexes, with an average age of 27±6 years, height of 170±11 cm, and body mass of 71±15 kg. Sample calculation was performed in Gpower® version 3.1.9.2 (Kiel University, Germany), based on t-tests, one-tailed one-sample

Wilcoxon test, predicting a normal distribution, with 0.5 effect size, 0.05 probabilistic error, and 0.90 power. The estimated "n" was 38 individuals. Expecting losses, 44 individuals were evaluated.

Eligibility criteria were: individual presenting thoracic mass imbalance compared to the pelvis and without any type of pain at the time of the evaluation; joint hyperlaxity; neurological sequel; use of prosthetics; history of spinal or lower limb surgery. Individuals who agreed to participate, after signing the informed consent form, and who did not present thoracic imbalance compared to the pelvis (sacrum) were excluded from the research. The procedures used in this study were approved by the Research Ethics Committee of UFRGS – CAAE: 47 61251 5.1.0000.5347.

Study location

The research was conducted in the department of Postural and Functional Evaluation of the Laboratório de Pesquisa do Exercício (Lapex), in the Escola de Educação Física Fisioterapia e Dança (Esefid) of UFRGS. All evaluation procedures were carried out individually by the same evaluator, in one day. Initially, the purpose of the research and evaluation procedures were explained, and all subjects signed the informed consent form.

Procedures and materials used

The identification of the thoracic mass imbalance compared to the pelvis (defined as thoracic balance) was initially done by a visual analysis, with vertical reference aid, from the region S2 to T6[12]. The other information for eligibility of the sample were performed by interview. For the evaluations, the individuals wore bathing suits, were barefoot and with their hair up.

The room was air conditioned (between 24°C and 26°C) and prepared for the evaluation by photogrammetry. The plumb line was fixed to the ceiling, 1.05 m away from the wall. It had two reflective markers with 1.5 cm diameter and distance of 1.00 m between them. The images were obtained by photographic record, by a 14.1 megapixel Sony Cyber-Shot digital camera, coupled to a 0.95 m high tripod, 2.80 m horizontally away from the individual[11].

Palpation of the anatomical points of interest (tragus, acromion, posterior superior iliac spine, anterior superior iliac spine, greater trochanter of the femur, tuberosity of the femur lateral condyle and of the lateral malleolus) in the right sagittal plane (Figure 1A) was carried out by an experienced physical therapist. The points were marked with white spherical styrofoam markers, with diameter of 1 cm in the tragus and 1.5 cm in the other points of interest, as determined by DIPA© protocol. Two images were obtained in sequential moments, only modifying the position of the malleolar reference marker: (1) in the center of the lateral malleolus (Figure 2A) and (2) in front of the lateral malleolus (Figure 2B). These images were used for comparison by the statistical procedures proposed in this study.

The images were scanned in the postural evaluation software DIPA©, in which the marking was standardized in the geometric center of the marker. The software provided a report with quantitative information and classification on the posture of the individuals. From the information contained in the sagittal plane report, the following variables were used in this study: pelvic version and plumb line test.

In DIPA©, the plumb line test[12] is determined by the distance between the plumb line and the vertical line formed by the union of the points of tragus, acromion, greater trochanter of the femur, tuberosity of the femur lateral condyle and of the lateral malleolus (Figure 1B)[7,12]. The results provided by the software (Figure 1B) show that positive values are those in front of the plumb line and negative values are those behind. The result of this test can be: neutral posture, anterior body imbalance (when values are in front of the plumb line), and posterior body imbalance (when values are behind the plumb line)[12].

Pelvic version is determined by the horizontal distance from the greater trochanter of the right femur to a vertical line that begins in the lateral malleolus, and the distance from the greater trochanter of the right femur to a vertical line that begins in the right acromion (Figure 1C)[12,13]. The pelvis is classified as: neutral (when the greater trochanter of the femur is aligned with malleolus and acromion), anteversion (when the greater trochanter of the femur is in front of malleolus and acromion), and retroversion (when the greater trochanter of the femur is behind malleolus and acromion).

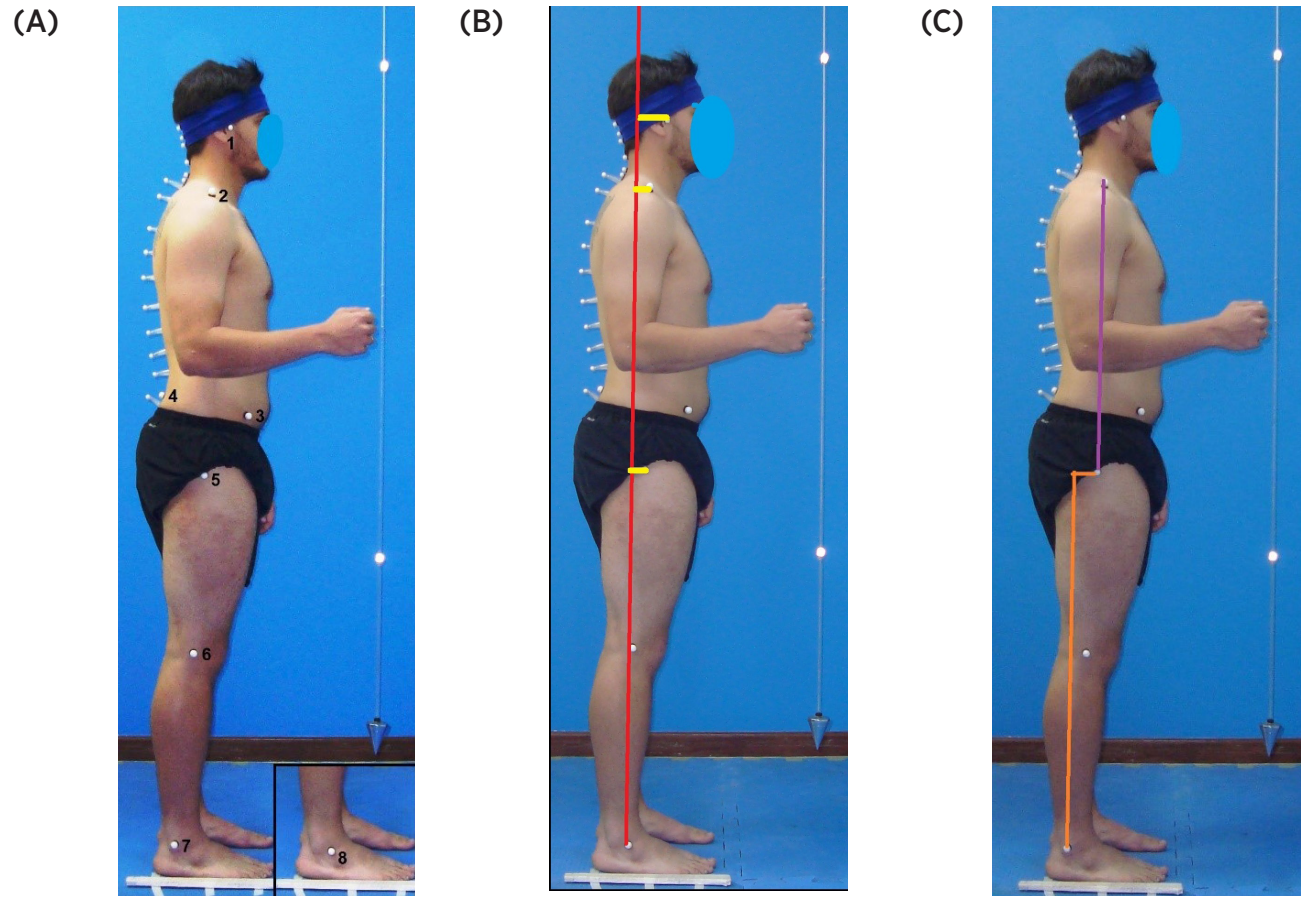

Figure 1. (A) anatomical points in the right sagittal plane: 1-Tragus, 2-acromion, 3-anterior superior iliac spine, 4-posterior superior iliac spine, 5-greater trochanter of the femur, 6-tuberosity of the lateral condyle of the femur, 7-center of the lateral malleolus, 8-in front of the lateral malleolus. (B) Plumb line test: distance from the reference points (horizontal yellow line) to the plumb line (vertical red line). Results provided by DIPA© with the malleolar marker in the center of the lateral malleolus. (C) Pelvis version: results provided by DIPA© with the malleolar marker in the center of the lateral malleolus.

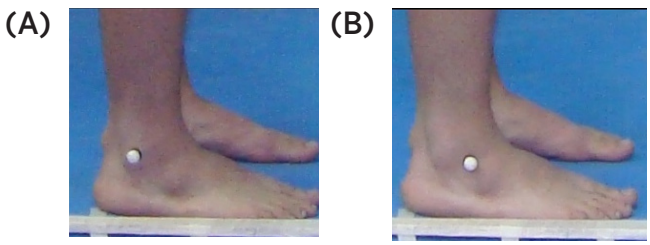

Figure 2. (A) Reference marker in the center of the lateral malleolus; (B) Reference marker in front of the lateral malleolus.

Statistical analysis

SPSS (version 20.0) was used for statistical analysis. The variables were analyzed by descriptive (frequency distribution, mean and standard deviation) and inferential statistics. The Shapiro-Wilk test was conducted to evaluate the normality of the quantitative variables (scalar data). The data with normal distribution were analyzed using Student's t-test for dependent samples. Data that did not show a normal distribution and categorical data were analyzed using Wilcoxon test (α<0.05). All statistical procedures were performed according to the recommendations of Field (2009)[14].

RESULTS

Forty-four subjects, 57% women (n=25) and 43% men (n=19), were evaluated. For both variables– plumb line test and pelvic version –, the modification of the position of the malleolar marker had statistically significant effect only in the scalar value (p<0.05) (Table 1), and there was no statistical difference in the categorical variables for the classification of pelvic version and plumb line test (p>0.05) (Table 2).

Table 1 – Comparison of scalar values between the two malleolar marker positions.

	Variables	Reference marker	Mean±standard deviation (cm)	P
Plumb line test (cm)	Tragus distance	In the malleolus	7.8±2.9	<0.001[1]
		In front of the malleolus	4.8±3.4	
	Acromion distance	In the malleolus	4.7±2.9	<0.001[2]
		In front of the malleolus	1.8±3.3	
	Trochanter distance	In the malleolus	5.2±2.2	<0.001[1]
		In front of the malleolus	2.3±2.2	
	Condyle distance	In the malleolus	2.9±1.9	<0.001[1]
		In front of the malleolus	0.1±1.9	
Pelvis version (cm)	Trochanter-acromion distance	In the malleolus	0.4±2.5	0.414[1]
		In front of the malleolus	0.5±2.5	
	Trochanter-malleolus distance	In the malleolus	5.1±2.3	<0.001[1]
		In front of the malleolus	2.3±2.2	

Note: Dependent sample t-test[1]; Wilcoxon test[2].

Table 2 – Comparison of categorical variables between the two malleolar marker positions.

Variables	Reference marker	Classification (n)			P
Plumb line test		Posterior	Neutral	Anterior	
	In the malleolus	0	0	44	0.063
	In front of the malleolus	3	1	40	
Pelvic version		Retroversion	Neutral	Anteversion	
	In the malleolus	0	32	12	1.000
	In front of the malleolus	0	32	12	

Note: Wilcoxon test.

DISCUSSION

In our study, we sought to identify whether the modification of the position of the malleolar region marker affects the postural evaluation results obtained by photogrammetry, in the sagittal plane. Based on the two possibilities of evaluation (marker in the lateral malleolus or in front of the malleolus), our hypothesis that the arbitrary choice of the position of the malleolar marker could interfere with the final evaluation report and reflect on posture classification was refuted.

Our results indicated that the arbitrary choice of placing the reference marker in the malleolar region, whether in the lateral malleolus or slightly in front of it, does not interfere in the classification of body posture, obtained by processing with software DIPA©.

Often, the postural evaluation by photogrammetry uses as anatomical reference of the malleolar region the point exactly on the center of the lateral malleolus, by its easy location and palpation[15,16]. We can highlight two disadvantages in using the marker in alternate location. The first is related to the palpation of the bony anatomical references, which is prone to errors[10,17]. The bias on palpation may significantly affect the results, thus, placing the marker exactly on the lateral malleolus would help palpation, decreasing bias.

The second concerns the lack of standardization in the nomenclature of the placement region, hindering its location. As proposed by Kendall[8], the placement of the marker on the malleolar region must be located slightly in front of it. This lack of precise anatomical description, in our view, increases the risk of error. The anatomical region in question still receives distinguished names, such as or calcaneocuboid joint[18] or anterior fossa of the lateral malleolus[19,20], which also hampers its precise location.

In this regard, minimizing errors in photogrammetry evaluations is of utmost importance to ensure quality both in the execution of the evaluation and in the interpretation of results. As a result, the consistency of the

result generated is directly proportional to the credibility of the tool to support clinical decision-making.

To our knowledge, only three studies used other anatomical references in the malleolar region, different from the lateral malleolus itself: Noll et al.[19], Da Rosa et al.[20] – both having described the use of the marker on the external malleolus anterior fossa, aiming to evaluate the knee posture and body posture in school children – and Batistão et al.[21], who used the plumb line slightly in front of the lateral malleolus when performing the qualitative visual postural evaluation proposed by Kendall et al.[8], also in school children.

Despite the homogeneity of the sample in our study, modifying the position of the malleolar reference marker placed on the center of the lateral malleolus to a position in front of it only changed the posture classification in four subjects, in the plumb line test, without statistically significant difference. In the pelvic version analysis, no subject has undergone change in the posture classification.

Significant differences were found in the comparison of the values of scalar variables when the position of the malleolar anatomical referential was modified. This result was expected, but the categorical variables (postural classification) showed no significant difference.

The comparison with other studies becomes difficult because of the particularity of the various evaluation software, differences in quantitative measurement, and diversity of mathematical routines, in which many use angles as unit of measurement[1,22].

We can also point out some limitations found in our research. We highlight the fact that all individuals in the sample had the same pattern of thoracic imbalance (i.e., an imbalance of thoracic mass compared to the pelvis). Despite the homogeneity regarding the anterior thoracic imbalance not having interfered with postural classification, we question whether different results would have been found in a heterogeneous sample.

CONCLUSION

Although the change of position of the malleolar reference marker affects the scalar values of the analyzed variables, the interpretation of the result of the evaluation has not been changed. That is, the analysis of the categorical variables of information from the body of the individual compared to the plumb line (neutral posture, anterior, or posterior to the wire) and the pelvis (neutral position, with anteversion, or retroversion) remained unchanged. These results suggest that the vertical reference point for photogrammetry, based on the malleolar reference marker, can be chosen by the evaluator, be it in the center of the lateral malleolus or in front of it.

However, we highlight that, as there was no significant difference in the postural classification with the modification of the anatomical referential investigated, we suggest the use of the marker in the center of the lateral malleolus by its easy palpation, minimizing errors in location and, as a result, decreasing bias in the performance of the evaluation and analysis of results.

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