Photogrammetric Variables Used by Physical Therapists to Detect Neck Pain and to Refer for Physiotherapeutic Intervention: A Cross-Sectional Study

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Abstract

Objective: The purpose of this study were as follows (1): to investigate photogrammetry variables that physiotherapists may detect by visually inspecting the static body posture that distinguishes young adults with or without neck pain, which may lead to referral to a physiotherapy intervention, and (2) to assess the reliability of postural assessment and clinical decision-making.

Methods: We conducted a cross-sectional, observational, balanced, controlled, single-blinded study. Fourteen physiotherapists aged 33 (6) years were recruited as raters for postural assessment of adults aged 28 (7) years with (n = 30) or without neck pain (n = 30). Photogrammetry was performed to quantify the static body posture alignments and angles. Visual inspection was performed to indicate the presence of postural misalignment and neck pain and to refer to physiotherapy intervention.

Results: Symptomatic participants showed low- to moderate-intensity neck pain, a high frequency of chronic neck pain, and low disability scores. Photogrammetry analysis revealed no statistically significant difference between groups. Classification of the participants according to the raters' visual inspection yielded sets of photogrammetry variables with significant differences, with a large variability among those sets. Intrarater and interrater reliability of photogrammetry varied from moderate to excellent (intraclass correlation coefficient$_{2,1}$ = [0.502; 0.995]; intraclass correlation coefficient$_{2,2}$ = [0.564; 0.996). Interrater reliability for visual inspection was no better than chance (κ_{Light} = -0.013 to 0.011; ı = -0.002).

Conclusion: Neither photogrammetry nor visual inspection distinguished the presence of neck pain in young adults. Using visual inspection, physiotherapists had unreliable clinical decision-making owing to high variability of photogrammetry variables used to distinguish postural misalignments, the presence of neck pain, and whether to refer young adults for physiotherapy intervention. (J Manipulative Physiol Ther 2019;42:254-266)

Key Indexing Terms: *Neck Pain; Physical Examination; Photogrammetry; Rehabilitation*

Introduction

Neck pain (NP) is among the most frequent health disorders, with prevalence in life ranging from 20% to 70% and with increasing incidence over recent years.[1-5] An increasing trend has been reported in global disability-adjusted life years with NP, with low back pain, increasing from the 12th leading cause in the 1990s to the eighth in 2005 and the fourth in 2015.[2] Strong evidence suggests female sex and previous history of NP are risk factors for new onset of NP.[2] Age, lifestyle, and workplace habits are also possible risk factors.[1,2,5] Body posture, including the set of joint angles defining static posture and its prolonged maintenance, were also among the risk factors for NP. Static body posture nonetheless remained a controversial risk factor for NP,[5-7] and was associated with head or neck posture and upper thoracic spine in middle-aged adults[8-10] but not in adolescents[11,12] or older adults.[13]

Postural assessment methods have been used in the physiotherapy setting, in which the patient's body is approached with major interest in assessing static postural alignments. The process of clinical decision-making includes establishing a patient's functional diagnosis—postural assessment included—and deciding whether to refer the patient for interventions.[14] Visual inspection is error-prone owing to the

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qualitative criteria that raters may apply when identifying the body's alignments[15] and has low reliability for identification of postural misalignments such as cervical lordosis.[16] Conversely, photogrammetry quantifies body alignments and angles[17] and is regarded as highly reliable in both within- and between-rater designs,[15,17,18] although it is a time-consuming process requiring dedicated technology and protocol for data collection.[17] As a corollary, visual inspection is widely performed in clinical settings, whereas photogrammetry apparently remains restricted to research settings. The reliability and validity are critical aspects of assessment methods,[19,20] and both have been investigated as related to postural assessment methods in NP.[15-18] However, the reliability of the decision-making process using visual inspection—regarding treatment, discharge, and change of the patient's procedure of interview after evaluation by visual inspection—remain uninvestigated.[21,22]

In light of the evidence, 2 interesting questions arise: What information do physiotherapists consider when using visual inspection or photogrammetry to detect NP in young adults? How does this information vary among physiotherapists? Therefore, we investigated what photogrammetry variables caused physiotherapists to detect, by visually inspection, the static body posture that distinguished young adults with or without NP and ultimately led to the clinical decision to refer for physiotherapy intervention. In addition, we investigated the reliability of the postural assessment by visual inspection and photogrammetry in this population. We hypothesized that physiotherapists detected postural features related to NP but with low reliability—and different raters identified different sets of photogrammetry variables—given the subjective criteria used for visual inspection.

Methods

Ethical Approval

The research ethics committee approved this study protocol (CAAE No. 50528515.7.0000.5235), following the National Health Council Resolution No. 466/2012. Participants and raters provided written informed consent before enrollment in this study. All data and computational routines for statistical analysis are available upon request to the authors.

Study Design and Reporting

This was a cross-sectional, observational, balanced, controlled, single-blinded study. All assessments were obtained independently. When assessing the participants by either visual inspection or photogrammetry, all raters were blinded to each other's postural assessments and all participants' clinical characteristics except for age and sex. In addition, raters who performed visual inspection were blinded to the study aims because this information was not disclosed until the data collection was completed, and which participant reported NP or the proportion of the sample reporting NP because it might have biased their assessment. Finally, the authors performed data collection regarding the demographic and clinical characteristics of the sample and thus were not enrolled in either postural assessment analyses. This study followed the Guidelines for Reporting Reliability and Agreement Studies.[20]

Sample sizes were estimated to detect zero to minimal[23] reliability ($\kappa = 0.205$, 95% CI = [0.01-0.40]) considering the dichotomous outcome of questions and the balanced proportions of participants. A minimal sample of 5 raters was required to assess a minimal sample of 29 participants per group.

Admission of Participants

Participants were consecutively invited from the academic community of the applicant institution for enrollment in this study (convenience sampling method). Inclusion criteria were age $\geq$18 years and no report of physical rehabilitation intervention or vigorous contact sports for the last 6 months. Participants who reported NP using the visual analog scale (VAS > 0) and answered positively to questions regarding pain chronicity (A6 and A7; see later section) were allocated to the symptomatic group (SG); the remaining participants were allocated to the asymptomatic group (AG).

Admission of Raters

Physiotherapists were consecutively recruited (convenience sampling method) from the applicant institution staff and were enrolled as raters to assess the body posture using either visual inspection or photogrammetry. They were asked to report on a 5-Likert item the intensity (strongly agree, agree, undecided, disagree, strongly disagree) and frequency (always, very often, sometimes, rarely, never) of usage of postural assessment by visual inspection in clinical decision-making when assessing patients with NP.

Clinical and Functional Assessments

Participants completed all assessments individually in a single session according to current guidelines[24] to check their adherence to the inclusion criteria. Body height (accuracy: 0.01 m) and body mass (accuracy: 0.1 kg) were measured using an analog stadiometer and scale, respectively (model 31, Filizola, São Paulo, Brazil); body mass index was calculated by the standard Quetelet index.

All participants reported their current pain intensity by marking a VAS, composed of a 100-mm ruler labeled with "no pain" and "very severe pain" at either extremity, with higher scores interpreted as higher pain intensities.[25] Neck pain severity was further assessed according to the 4-grade

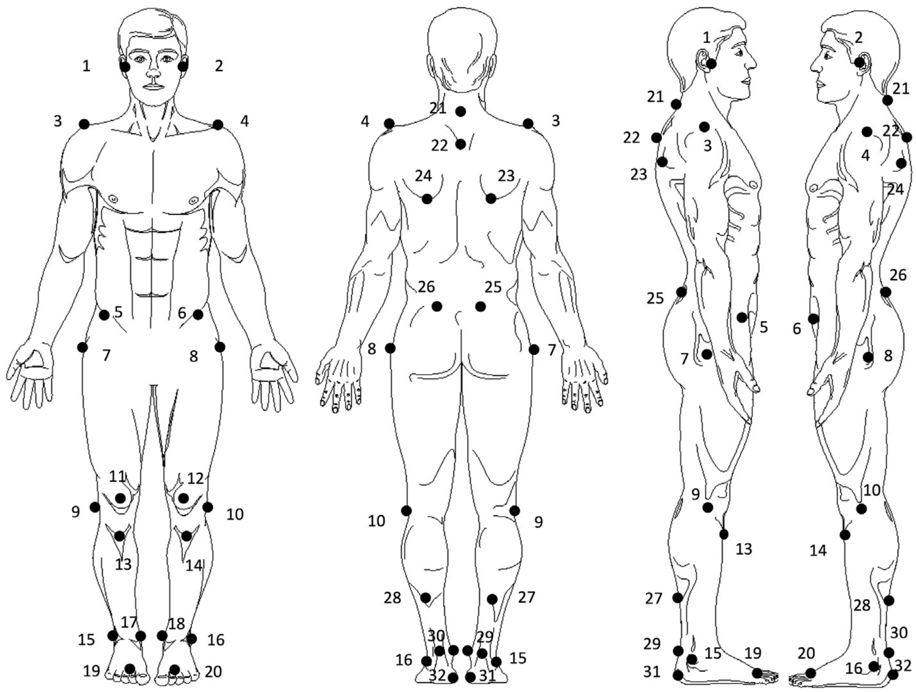

Fig 1. *Illustration showing the position of skin markers for quantitative assessment of posture (left body side = even numbers, except for markers in the central line): 1 and 2—tragus; 3 and 4—acromion; 5 and 6—anterosuperior iliac spine; 7 and 8—trochanter; 9 and 10—knee joint line; 11 and 12—patellar medial midpoint; 13 and 14—tibia tuberosity; 15 and 16—lateral malleolus; 17 and 18—medial malleolus; 19 and 20—midpoint between second and third metatarsus; 21—C7 spinous process; 22—T3 spinous process; 23 and 24—scapula lower angle; 25 and 26—posterosuperior iliac spine; 27 and 28—gastrocnemius muscle; 29 and 30—calcaneus tendon; 31 and 32—calcaneus.*

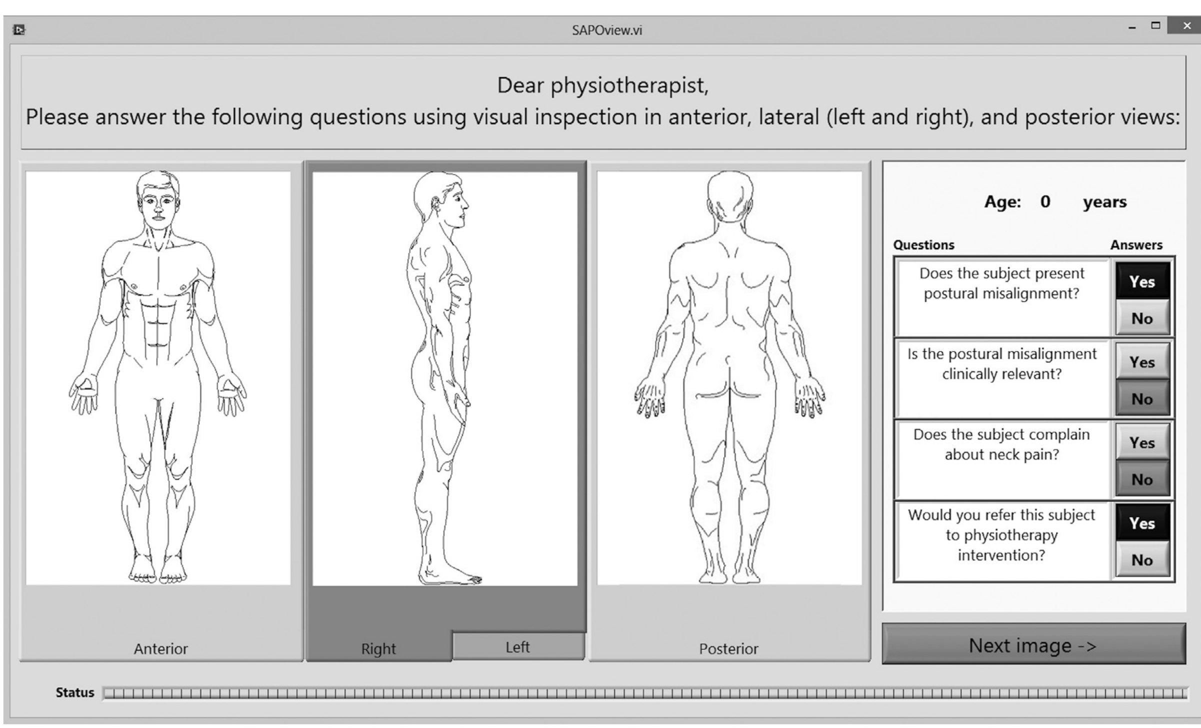

Fig 2. *Print screen of the custom-made software interface (SAPOview) for displaying a set of digital images (anterior, left-sided, right-sided, and posterior views) for postural assessment by visual inspection.*

Table 1. *Clinical and Functional Characteristics of the Study Participants*

Variables	Variables or Levels	Group		*P* Value
		Symptomatic	Asymptomatic	
Sample size, n (%)		30 (50)	30 (50)	NT
	Men (%)	3 (10)	7 (23)	.299 [a]
	Women (%)	27 (90)	23 (77)	.259 [a]
Age, y		29 (7)	27 (7)	.238 [b]
Anthropometry				
	Body mass, kg	63.2 (10.1)	64.8 (9.0)	.497 [b]
	Body height, m	1.61 (0.08)	1.64 (0.07)	.203 [b]
	Body mass index, kg/m^2	24.3 (3.2)	24.2 (2.8)	.904 [b]
VAS, mm		38 ± 20	NA	NT
SNQ				
	Chronic, n	28 (93%)	NA	NT
	Acute, n	2 (7%)	NA	NT
OMPSQ				
	Total, score	48 (11)	NA	NT
	High risk, n	14 (47%)	NA	NT
	Low risk, n	16 (53%)	NA	NT
NDI				
	Total, score	22 (8)	NA	NT
	No disability, n	1 (3%)	NA	NT
	Minimal disability, n	23 (77%)	NA	NT
	Moderate disability, n	6 (20%)	NA	NT
	Severe disability, n	0 (0%)	NA	NT
	Complete disability, n	0 (0%)	NA	NT

Data shown as the mean (SD) or n (%).
NA, not assessed; *NDI*, Neck Disability Index; *NT*, not tested; *OMPSQ*, Orebro Musculoskeletal Pain Screening Questionnaire; *SNQ*, Standardized Nordic Questionnaire; *VAS*, visual analog scale.
[a] Fisher exact test.
[b] Student *t* test (unequal variances, 2-tailed).

classification system recommended by the Neck Pain Task Force.[1]

Chronicity information of NP for the SG was obtained from the following questions adapted from other sources[26,27] as in previous studies[12]: "Has your neck been painful at any time in the previous month?" and "Has your neck pain ever lasted for more than 3 months? (A7)." Participants were classified with acute NP (yes to the first and no to the second question) or chronic NP (yes to both questions).

The risk for sick leave greater than 15 days and disability associated with psychosocial factors was identified for the SG using the Brazilian-Portuguese version[28] of the Orebro Musculoskeletal Pain Screening Questionnaire (OMPSQ).[29] Participants who obtained an OMPSQ score between 1 and

50 were classified as low risk and between 51 and 100 as high risk.

Regional functional capacity was assessed for the SG using the Brazilian-Portuguese version[30] of the Neck Disability Index (NDI) questionnaire.[31,32] Scoring was made from a percentage of maximum pain and functional disability and ranged from 0% (no disability) to 100% (complete disability).

Assessment of Body Posture by Photogrammetry

Participants underwent photogrammetry using postural assessment software (SAPO, Software de Avaliação Postural, São Paulo, SP, Brazil) under a standardized protocol.[17] First, all 32 anatomic landmarks required for photogrammetry assessment were identified with Styrofoam spheres (diameter 0.015 or 0.025 m according to the landmark) attached using double-sided adhesive tape (Fig 1). Second, each participant stepped onto a white paper (0.420 × 0.594 m) to outline a comfortable base of support, thus minimizing posture variations owing to repositioning on sequential images. Third, the participant was photographed to obtain an image for postural assessment in a given anatomic profile. Step three was repeated until a set of 4 images was obtained, corresponding to the anterior, posterior, right, and left profiles. Finally, the images were transferred to a microcomputer for storage, reproduction, and analysis. After collecting sets of images for the whole sample of participants, each rater identified in the computer screen all markers and the SAPO calculated and stored variables related to the body's alignments, angles, and lengths.

Assessment of Body Posture by Visual Inspection

Participants underwent visual inspection using custom-made software for image presentation and data collection developed in LabVIEW 2014 (National Instruments, Austin, Texas), namely, SAPOview (Fig 2). First, the SAPOview randomly chose without replacement 1 participant at a time to display the corresponding set of images on the computer screen. Second, the rater visually analyzed the set of images without time constraint. Third, the rater provided answers to questions related to the participant's photos in the SAPOview screen that were stored before the next set of images was presented. These 2 steps were repeated until completion of all participants. Finally, the answers to all participants from all raters were digitally stored as text files for subsequent analysis.

Clinical Decision-Making Based on Postural Assessment by Visual Inspection

Raters were requested to answer yes or no by checking the corresponding button on the computer screen to the following questions (1): "Does the subject present postural misalignment?" (2) "Is the postural misalignment clinically relevant?" (3) "Does the subject complain about neck pain?" and (4) "Would you refer this subject to physiotherapy intervention?" The dichotomous responses to each of those questions were used to dynamically classify the participants in 2 groups according the rater's answers to compare the photogrammetry variables.

Table 2. *Characteristics of Raters and Responses to Visual Inspection*

Variables	Levels	All Raters
Sample size (%)		12 (100)
	Men (%)	6 (50)
	Women (%)	6 (50)
Age, y		33 (6)
Time since undergraduate, y		6 (5)
Do you use postural assessment by visual inspection in clinical decision-making in adults with neck pain?		
	Strongly agree (%)	4 (33)
	Agree (%)	5 (42)
	Undecided (%)	1 (8)
	Disagree (%)	1 (8)
	Strongly disagree (%)	1 (8)
How often do you use postural assessment by visual inspection in clinical decision-making in adults with neck pain?		
	Always (%)	6 (50)
	Very often (%)	2 (17)
	Sometimes (%)	3 (25)
	Rarely (%)	1 (8)
	Never (%)	0 (0)

Data shown as the mean (standard deviation) or n (%).

Statistical Analysis

Statistical analysis was conducted with *R* Project software. Data from participants' clinical, functional, and SAPO assessments were typed into an electronic worksheet (Excel, Microsoft Corp, Redmond, Washington) and were imported into *R* environment without additional user manipulation. Raters' responses as exported from SAPOview were also imported. Four scripts were written in *R* Project for inferential statistics and plot generating. The significance level was set at $P < .05$ with Bonferroni adjustment to $P < .001$ where multiple comparisons were performed.

Descriptive analysis used mean (standard deviation), median (minimum; maximum), or absolute frequency (%) according to the variable type. Participants' between-group

Table 3. *Between-Group Comparison of Quantitative Postural Analysis in Adults With or Without Neck Pain*

Measure	Variable	Anatomic References	Group		P Value [a]
			Asymptomatic (n = 30)	Symptomatic (n = 30)	
Alignments, ° (anterior view)					
	Head horizontal alignment	1-2	0.9 (2.5)	1.4 (2.6)	.502
	Acromion horizontal alignment	3-4	-0.3 (2.4)	0.0 (2.1)	.681
	Anterior-superior iliac spine horizontal alignment	5-6	-0.2 (1.9)	-0.9 (1.4)	.092
	Tibia tuberosity horizontal alignment	13-14	0.4 (1.8)	0.2 (1.7)	.673
	Acromion-to-anterior–superior iliac crest	3-4 to 5-6	0.10 (3.00)	-0.88 (2.14)	.149
Right side					
	Lower extremity	7-9-15	-3.4 (2.7)	-2.5 (3.6)	.299
	Q-angle	5-13-11	16.0 (7.8)	15.1 (9.9)	.708
Left side					
	Lower extremity	8-10-16	-3.7 (2.6)	-3.3 (3.5)	.632
	Q-angle	6-14-12	19.5 (9.3)	19.8 (9.8)	.898
Lengths, 10^{-3} m (anterior view)					
	Lower limb length absolute symmetry	abs((5-17)-(6–18))	6.3 (3.8)	7.2 (5.1)	.453
Alignments, ° (posterior view)					
	Scapular-T3 horizontal absolute symmetry	abs((23-22)-(24-22))	14.4 (12.5)	12.5 (11.9)	.550
	Leg-to-rearfoot angle (right)	27-29-31	10.5 (5.1)	8.4 (6.1)	.158
	Leg-to-rearfoot angle (left)	28-30-32	12.9 (4.1)	9.9 (4.3)	.008
Alignments, ° (lateral view)					
Right side					
	Head horizontal alignment	1-21-HOR	50.0 (5.1)	50.0 (4.40)	.961
	Head vertical alignment	3-1-HOR	10.3 (8.1)	11.1 (10.5)	.759
	Trunk vertical alignment	3-7-VER	-1.5 (2.6)	-2.2 (2.4)	.262
	Pelvic horizontal alignment	3-7-15	-14.0 (3.9)	-12.6 (5.6)	.270
	Body vertical alignment	3-15-VER	1.9 (1.3)	2.1 (1.3)	.515
Left side					
	Head horizontal alignment	2-21-HOR	49.3 (7.3)	50.3 (4.5)	.524
	Head vertical alignment	4-2-VER	18.7 (9.5)	18.3 (9.1)	.858
	Trunk vertical alignment	4-8-VER	-2.9 (2.5)	-3.2 (2.4)	.719
	Pelvic horizontal alignment	4-8-16	-14.9 (5.1)	-14.2 (6.1)	.603

(continued on next page)

Table 3. (*continued*)

Measure	Variable	Anatomic References	Group		*P* Value [a]
			Asymptomatic (n = 30)	Symptomatic (n = 30)	
	Body vertical alignment	4-16-VER	1.8 (1.4)	2.4 (2.4)	.239
Joint angles, °(lateral view)					
Right side					
	Hip angle	5-25-HOR	-6.3 (4.2)	-7.8 (4.5)	.177
	Knee angle	7-9-15	-1.5 (4.0)	-1.2 (4.2)	.817
	Ankle angle	9-15-HOR	86.7 (2.6)	85.6 (3.2)	.178
Left side					
	Hip angle	6-26-HOR	-8.1 (4.1)	-10.1 (4.1)	.069
	Knee angle	8-10-16	-1.4 (3.8)	-2.6 (5.0)	.285
	Ankle angle	10-16-HOR	85.8 (3.1)	85.7 (3.2)	.951

Data shown as the mean (standard deviation).
HOR, horizontal reference line; *VER*, vertical reference line.
[a] Student *t* test (unequal variances; 2-tailed).

comparisons were performed with the original allocation criteria (SG vs AG) and the raters' classifications using the independent Student *t* test (equal variances not assumed, 2-tailed tests) or Fisher exact test as indicated. Standardized mean differences (SMDs) were calculated as effect size measures of between-group comparisons.[33]

Intrarater and interrater reliability of photogrammetry were assessed by the 2-way random-effects intraclass correlation coefficient (ICC) with single ($ICC_{2,1}$) and average ($ICC_{2,2}$) measurement types, alongside the confidence intervals. The ICC values were compared to 0.40 as a minimum reference value of reliability. The ICC values were accordingly interpreted as poor (<0.40), fair (0.40-0.59), good (0.60-0.74), or excellent (>0.75).[34]

Univariate and multivariate interrater reliability for visual inspection and decision-making were estimated using Light's kappa (κ_L) and Janson and Olsson's iota (ɩ), respectively, and were interpreted according to qualitative categories.[35] Confidence intervals were determined using the bias-corrected accelerated method from 1000 bootstrap samples.

Results

Characteristics of Participants

Sixty participants aged 28 (7) years were allocated to the SG (n = 30, 27 women) or AG (n = 30, 23 women) (Table 1). Significant differences were not observed between SG and AG regarding possible confounding variables (sex, body height, body mass, body mass index; *P* > .203). All participants of the SG were classified as grade I NP and reported pain intensity with a group-averaged VAS score equal to 38 (20) mm. The NDI categorized 28 (93%) participants as showing chronic NP. The OMPSQ total score was 48 (11) in SG, with 14 (47%) participants showing a high risk of developing chronic pain and disability associated with psychosocial factors. The NDI total score was 28 (2), with 23 (77%) and 6 (20%) participants of the SG showing minimal or moderate disability, respectively.

Characteristics of Raters

Twelve physiotherapists (6 women) aged 33 (6) years recruited as raters for this study reported an average time since graduation equal to 6 (5) years (Table 2). Nine raters (75%) reported either "strongly agree" or "agree" with use of postural assessment by visual inspection in clinical decision-making in adults with NP, whereas the remaining raters reported being "undecided" (n = 1, 8%), "disagree" (n = 1, 8%), or "strongly disagree" (n = 1, 8%). Eight raters (67%) reported either "always" or "very often" using postural assessment by visual inspection in clinical decision-making in adults with NP, whereas the remaining raters reported using "sometimes" (n = 3, 25%) or "rarely" (n = 1, 8%); no rater reported never using postural assessment.

Answers to question 1 exhibited a very low median frequency of yes category (3% [0; 73]), and thus this question was not used for further analysis. Conversely, questions 2

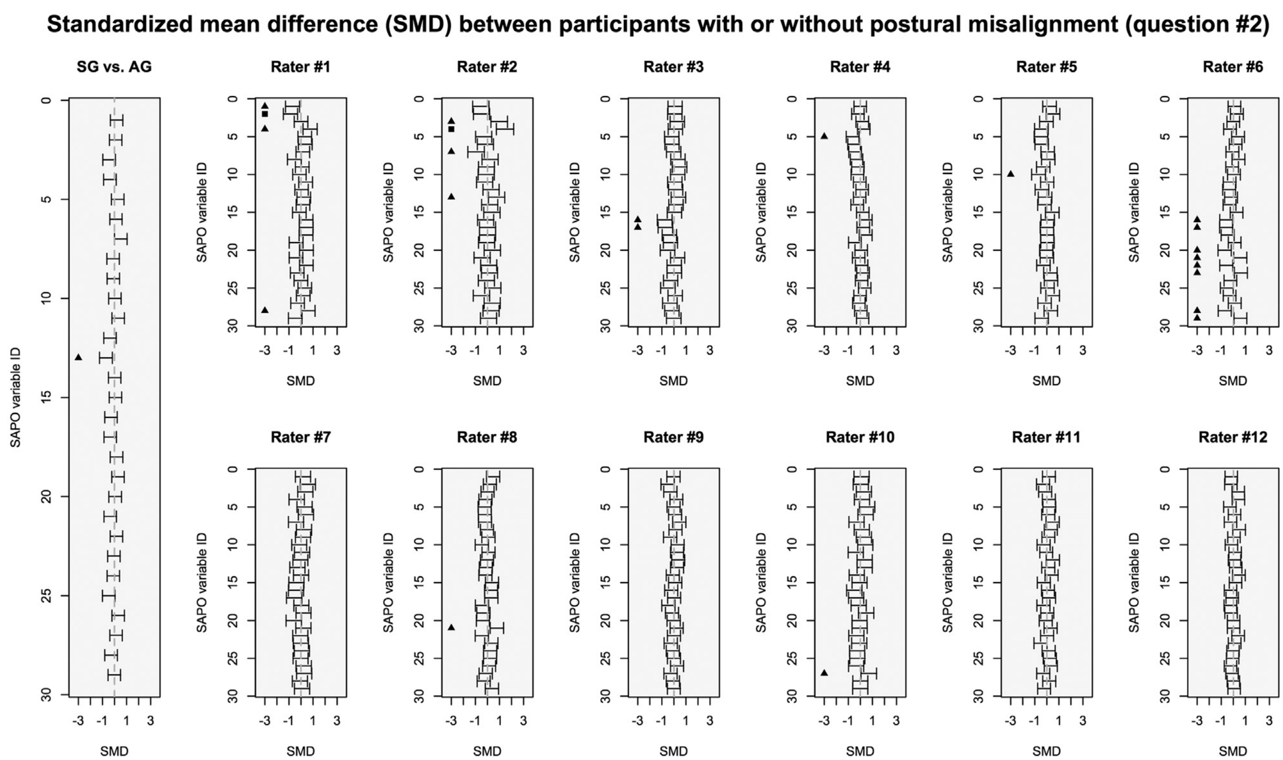

Fig 3. *Standardized mean difference (SMD) of quantitative variables for assessment of posture between participants with or without postural misalignment according to each rater's visual inspection (question 2). Statistical significance is displayed as ▲ P < .05 or ■ P < .001.* AG, *asymptomatic group;* SG, *symptomatic group.*

(49% [18; 78]), 3 (55% [22; 83]), and 4 (52% [5; 85]) showed a yes response in approximately 50% of all participants.

Between-Group Comparisons: SG vs AG and Raters' Classification

Between-group SG vs AG comparison showed no statistically significant differences for the calculated photogrammetry variables related to the body's alignments or angles ($P > .008$) (Table 3).

The SMD of the photogrammetry variables was calculated after classifying all participants according to the dichotomous responses of raters to questions 2 (Fig 3), 3 (Fig 4), and 4 (Fig 5). The SMD values calculated between groups (SG vs AG) are also shown for comparison. Figure 3 shows that 8 (67%) raters chose different sets of photogrammetry variables for distinguishing the participants as showing "relevant postural misalignment" or not, varying from 1 (raters 4, 5, 8, and 10) to 8 (rater 6) photogrammetry variables. Likewise, Figure 4 shows that 8 (67%) raters chose different sets of photogrammetry variables for distinguishing the participants as showing NP or not, varying from 1 (raters 4, 5, and 8) to 4 (rater 12) photogrammetry variables. Finally, Figure 5 shows that 8 (67%) raters chose different sets of photogrammetry variables for distinguishing the participants to refer to physiotherapy intervention or not, varying from 1 (raters 6, 7, and 8) to 6 (rater 5) photogrammetry variables.

Intrarater and Interrater Reliabilities of Photogrammetry Analysis

Intrarater reliability ($ICC_{2,1}$) ranged from 0.502 (0.287; 0.670) for the hip angle (right side) to 0.995 (0.992; 0.997) for the head vertical alignment (left side). Similarly, interrater reliability ($ICC_{2,2}$) for photogrammetry varied from 0.564 (0.363; 0.714) for the hip angle (right side) to 0.996 (0.993; 0.998) for the ankle angle (right side) (Table 4).

Interrater Reliability of Visual Inspection Analysis and Decision-Making

No univariate interrater agreement was observed to report that postural misalignment was relevant (κ_L = -0.013, 95% CI = [-0.029; 0.006]), to report the presence of NP (κ_L = 0.011, 95% CI = [-0.016; 0.051]) or to refer to physiotherapy intervention (κ_L = 0.002, 95% CI = [-0.018; 0.038]). Likewise, no multivariate interrater reliability visual inspection was observed (ι = -0.002, 95% CI = [-0.036; 0.014]). For all the above-cited analyses, the 95% CI included the null hypothesis and therefore no outcome was deemed statistically significant.

Discussion

To the best our knowledge, this is the first study to describe what photogrammetry variables physiotherapists detect by visual inspection of the static body posture to distinguish between young adults with or without NP and to refer them for

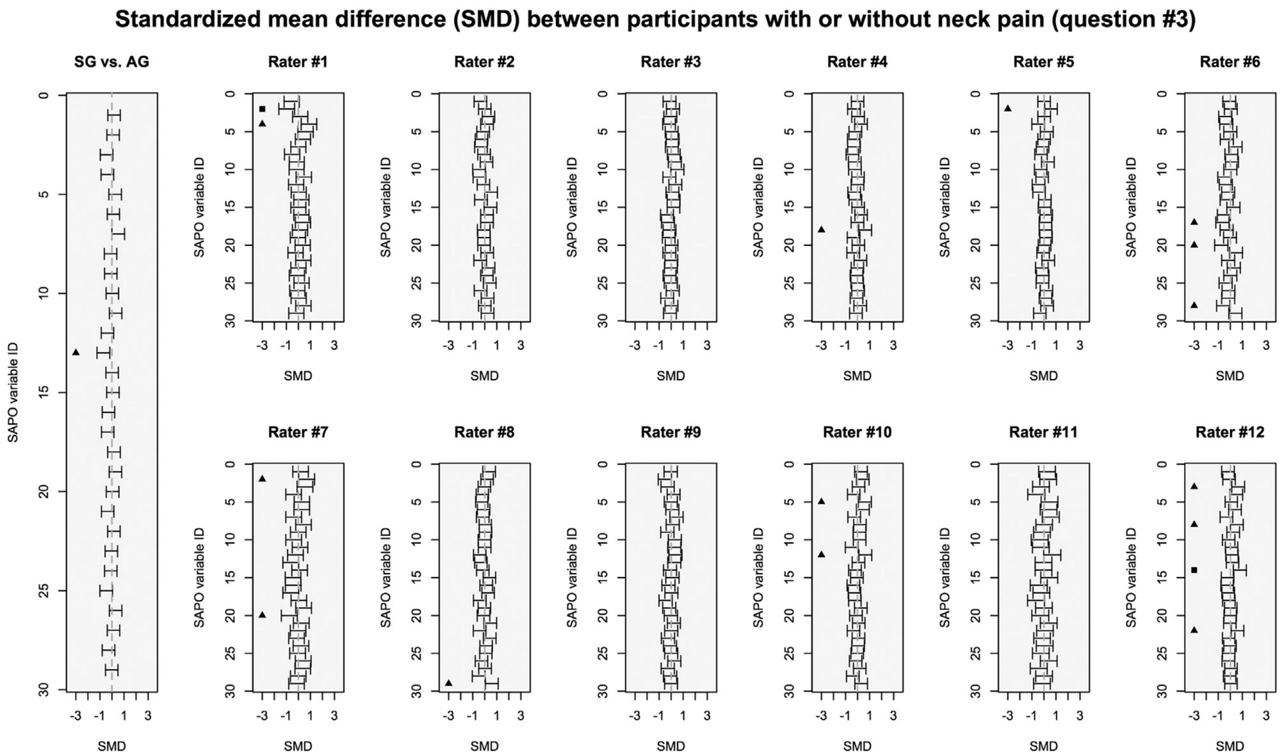

Fig 4. *Standardized mean difference (SMD) of quantitative variables for assessment of posture between participants with or without neck pain according to each rater's visual inspection (question 3). Statistical significance is displayed as ▲ $P < .05$ or ■$P < .001$.* AG*, asymptomatic group;* SG*, symptomatic group.*

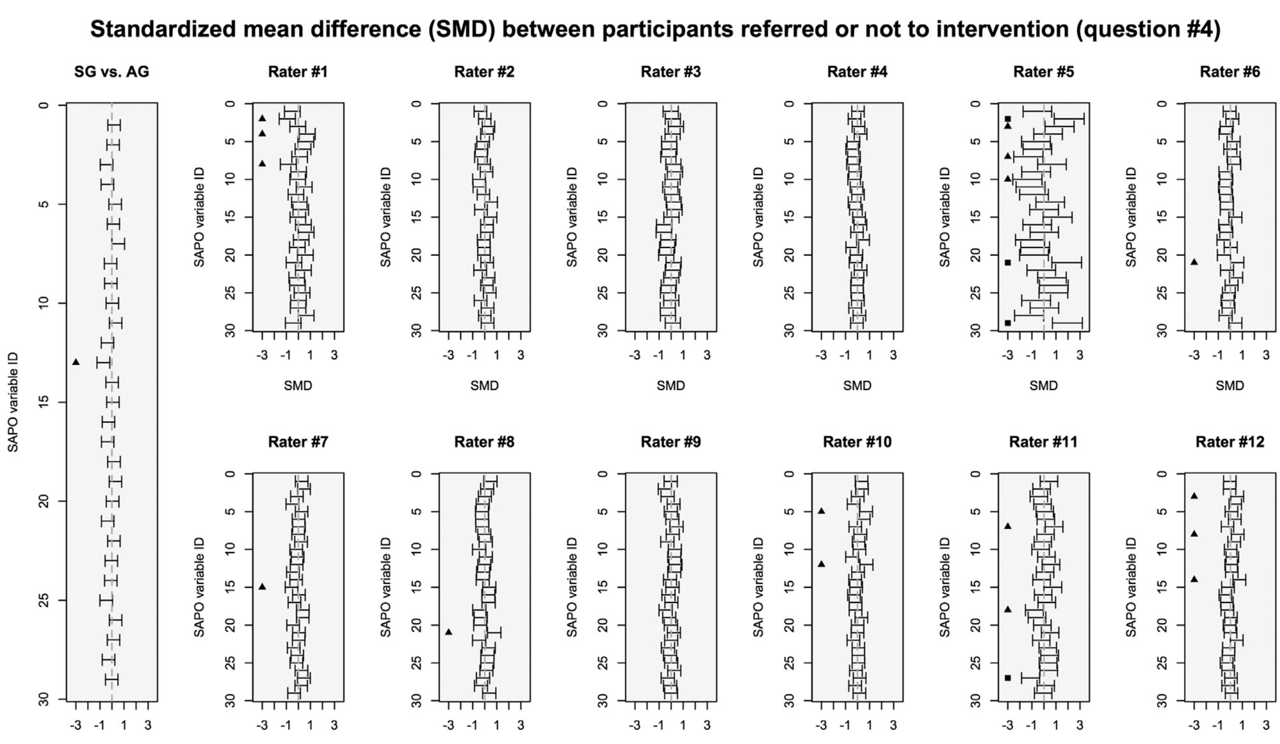

Fig 5. *Standardized mean difference (SMD) of quantitative variables for assessment of posture between participants with or without referral to intervention according to each rater's visual inspection (question 4). Statistical significance is displayed as ▲ $P < .05$ or ■$P < .001$.* AG*, asymptomatic group;* SG*, symptomatic group.*

Table 4. *Intrarater and Interrater Reliability for Quantitative Assessment of Posture Alignments*

Variable	Intrarater Reliability		Interrater Reliability		Standard error of mean	
	$ICC_{2,1}$ with 95% CI	*P* value *	$ICC_{2,2}$ with 95% CI	*P* value *	Rater #1	Rater #2
Alignments, degrees (Anterior view)						
Head horizontal alignment	0.865 (0.784; 0.917)	<.001	0.887 (0.818; 0.931)	<.001	0.326	0.324
Acromion horizontal alignment	0.984 (0.973; 0.990)	<.001	0.988 (0.979; 0.993)	<.001	0.288	0.282
Anterior-superior iliac spine horizontal alignment	0.948 (0.915; 0.969)	<.001	0.956 (0.928; 0.974)	<.001	0.223	0.231
Tibia tuberosity horizontal alignment	0.902 (0.841; 0.940)	<.001	0.915 (0.861; 0.948)	<.001	0.226	0.213
Acromion-to-anterior–superior iliac crest	0.971 (0.953; 0.983)	<.001	0.974 (0.958; 0.985)	<.001	0.340	0.345
Right side						
Lower extremity	0.961 (0.936; 0.977)	<.001	0.840 (0.746; 0.901)	<.001	0.415	0.446
Q-angle	0.925 (0.878; 0.955)	<.001	0.944 (0.908; 0.966)	<.001	1.139	1.144
Left side						
Lower extremity	0.961 (0.936; 0.977)	<.001	0.840 (0.746; 0.901)	<.001	0.415	0.446
Q-angle	0.960 (0.934; 0.976)	<.001	0.958 (0.930; 0.974)	<.001	1.223	1.216
Lengths, 10^{-3} m (Anterior view)						
Lower limb length absolute symmetry	0.946 (0.911; 0.967)	<.001	0.948 (0.914; 0.968)	<.001	1.040	1.112
Alignments, degrees (Posterior view)						
Scapular-T3 horizontal absolute symmetry	0.957 (0.928; 0.974)	<.001	0.941 (0.903; 0.964)	<.001	2.317	2.222
Leg-to-rearfoot angle (right)	0.899 (0.836; 0.938)	<.001	0.921 (0.871; 0.952)	<.001	0.734	0.785
Leg-to-rearfoot angle (left)	0.623 (0.439; 0.756)	.010	0.883 (0.812; 0.929)	<.001	0.573	0.643
Alignments, degrees (Lateral view)						
Right side						
Head horizontal alignment	0.974 (0.957; 0.984)	<.001	0.973 (0.955; 0.984)	<.001	0.606	0.633
Head vertical alignment	0.993 (0.989; 0.996)	<.001	0.994 (0.991; 0.997)	<.001	1.201	1.196
Trunk vertical alignment	0.995 (0.991; 0.997)	<.001	0.996 (0.993; 0.997)	<.001	.165	.164
Pelvic horizontal alignment	0.800 (0.686; 0.876)	<.001	0.797 (0.682; 0.874)	<.001	0.626	0.748
Body vertical alignment	0.981 (0.969; 0.989)	<.001	0.994 (0.990; 0.996)	<.001	0.328	0.327
Left side						
Head horizontal alignment	0.723 (0.576; 0.825)	<.001	0.708 (0.555; 0.815)	<.001	0.783	0.634
Head vertical alignment	0.995 (0.992; 0.997)	<.001	0.995 (0.992; 0.997)	<.001	1.193	1.175
Trunk vertical alignment	0.974 (0.957; 0.985)	<.001	0.893 (0.828; 0.935)	<.001	0.312	0.333

(continued on next page)

Table 4. (*continued*)

Variable	Intrarater Reliability		Interrater Reliability		Standard error of mean	
	$ICC_{2,1}$ with 95% CI	*P* value*	$ICC_{2,2}$ with 95% CI	*P* value*	Rater #1	Rater #2
Pelvic horizontal alignment	0.980 (0.966; 0.988)	<.001	0.977 (0.962; 0.986)	<.001	0.716	0.705
Body vertical alignment	0.691 (0.531; 0.803)	<.001	0.698 (0.541; 0.808)	<.001	0.252	.165
Joint angles, degrees (Lateral view)						
Right side						
Hip angle	0.502 (0.287; 0.670)	0.163	0.564 (0.363; 0.714)	.051	0.567	0.710
Knee angle	0.992 (0.986; 0.995)	<.001	0.994 (0.991; 0.997)	<.001	0.527	0.525
Ankle angle	0.993 (0.989; 0.996)	<.001	0.996 (0.993; 0.998)	<.001	0.379	0.382
Left side						
Hip angle	0.901 (0.840; 0.940)	<.001	0.898 (0.835; 0.938)	<.001	0.535	0.461
Knee angle	0.991 (0.985; 0.995)	<.001	0.993 (0.988; 0.996)	<.001	0.568	0.559
Ankle angle	0.991 (0.985; 0.995)	<.001	0.994 (0.990; 0.996)	<.001	0.404	0.398

* Statistically different from a reference value of ICC = 0.40. Bold formatting represents the extreme (minimum or maximum) values.

physiotherapy intervention. In addition, we investigated the reliability of postural assessment by visual inspection and photogrammetry in this population. Our hypothesis that physiotherapists could detect postural features related to NP but with a low reliability was not rejected.

Participants in both the SG and AG consisted of a homogeneous sample regarding age, body mass, and height, with a high proportion of women, similar to those reported in other studies.[4,6] The VAS was relatively low in the SG, suggesting that SG participants were among the 5% of the population that have NP during the lifespan, but of low intensity.[4] The NDI data showed that the SG are more likely to present minimal or moderate disability, corroborating another study, used to identify patients who seek intervention.[32] Similarly, OMPSQ data showed that the SG had a high risk of sick leave greater than 15 days and were more likely to present minimal or moderate disability.[28] Taken together, these data reinforced the clinical and disability burden of NP in young adults.

Our sample of physiotherapists presented clinical experience similar to those enrolled in previous studies in clinical reasoning and decision-making in physiotherapy.[36] There remains a lack of consensus as to what constitutes an expert in physiotherapy. Years of clinical experience has been considered a major criterion, although other factors such as postgraduate training may be considered.[36] Therefore, our findings should not be extrapolated to undergraduate physiotherapist students or those with more years of clinical experience. Also, we investigated clinical decision-making by physiotherapists and not the referral by other physical medicine and rehabilitation professionals. Whether physiotherapists and those health professionals agree on the decision to refer to physiotherapy intervention requires further investigation.

All but question 1 received a yes response rate of nearly 50%. This was an expected outcome because we enrolled symptomatic and asymptomatic participants in a balanced design.[37] Conversely, the reason why question 1 resulted in such a low rate of yes responses remains uncertain. It is possible that raters confounded or mixed questions 1 and 2, precluding using question 1 in further analyses.

We found no statistical evidence of differences between symptomatic and asymptomatic participants regarding the calculated photogrammetry variables, despite the expected[15-18] high intrarater and interrater reliability for the calculated variables. Those results are considered robust to the photogrammetry software SAPO because of its clinimetric characteristics[15,17,18] and its wide application in the research setting.[38] An interesting, unexpected result was that some physiotherapists could detect sets of few photogrammetry variables that were significantly different between participants when classified according to visual inspection, although with a large variability of those sets. These data strongly suggest that there was no information regarding static body posture that could be systematically assessed by raters and could lead to reproducible clinical reasoning regarding body posture—or likewise the presence or absence of NP or referral for intervention. These findings weaken the notion that posture and NP are associated,[8-10] although those observations were based on the assessment of upper body posture using quantitative and qualitative methods. Nevertheless, we widened the available data to whole-body posture and yet no valid assessment of NP was observed. Taken together, these data reinforced the notion that factors other than static body posture were major determinants for identification of NP in young adults.[11]

We found unreliable between-rater results for reporting the presence of relevant postural misalignment, NP, and referral to intervention. More interesting, almost every confidence interval included negative κvalues that are usually interpreted as worse-than-chance reliability.[35] These data corroborated a previous finding that experienced raters and undergraduate students displayed similar clinical reasoning processes in musculoskeletal physiotherapy.[36] Collectively, these data reinforced the subjectivity rater's criteria in assessing body posture by visual inspection alone[15] and strongly showed the need for a more reliable and valid method.

Perfectly symmetrical body posture was not observed in the general population even in upright standing.[39] There has been a debate concerning the role of quantitative assessment in decision-making. For instance, gait kinematic analysis changed the decision-making by an interdisciplinary team—including a physiotherapist—to refer for intervention in cerebral palsy patients.[40] Whether quantitative postural assessment in adults with NP can also contribute in the decision-making process warrants further investigation.

Limitations

It is possible that personal expertise (eg, specialization courses, the field of physiotherapy practice) may be another source of variability in our results. In addition, we did not train the raters for what would be considered postural misalignment, although training is known to inflate the interrater reliability and could artificially change the outcomes. Finally, our study did not include an assessment of daily and professional life activities of the participants for an additional investigation (eg, mediation) regarding the relationship between static body posture and NP. Nonetheless, the major strengths of this study include its novelty in the field and its simultaneous assessment of a large part of the decision-making process, including clinical, functional, and intervention referral. In addition, by following the guidelines[20] for reliability studies, we strengthened the overall quality of reporting, important for future systematic reviews on this topic.

Conclusions

Neither photogrammetry nor visual inspection distinguished the presence of NP in young adults. Using visual inspection, physiotherapists had unreliable clinical decision-making owing to a high variability of photogrammetry variables used to distinguish postural misalignments and the presence of NP and to refer in young adults for physiotherapy intervention.

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Contributorship Information

Concept development (provided idea for the research): E.C.N.V., N.A.M.M.-F., A.S.F.
Design (planned the methods to generate the results): E.C.N.V., N.A.M.M.-F., A.S.F.
Supervision (provided oversight, responsible for organization and implementation, writing of the manuscript): E.C.N.V., N.A.M.M.-F., A.S.F.
Data collection/processing (responsible for experiments, patient management, organization, or reporting data): E.C.N.V., N.A.M.M.-F., A.S.F.
Analysis/interpretation (responsible for statistical analysis, evaluation, and presentation of the results): E.C.N.V., N.A.M.M.-F., A.S.F.
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Writing (responsible for writing a substantive part of the manuscript): E.C.N.V., N.A.M.M.-F., A.S.F.
Critical review (revised manuscript for intellectual content, this does not relate to spelling and grammar checking): E.C.N.V., N.A.M.M.-F., A.S.F.

Practical Applications

- Photogrammetry was highly reliable but not valid for assessing NP in this study.
- Visual inspection was unreliable for assessing NP in this study.
- Physiotherapists in this study reported variate postural alignments related to NP.
- Physiotherapists in this study made unreliable clinical decisions based on visual inspection.

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