Intra/Interrater Reliability of Measurements On Body Posture Photographs

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ABSTRACT: Intra/interrater's reliability of the coordinates of ten anatomical landmarks on a frontal and a dorsal body posture photograph of 18 subjects was tested. The measurements were conducted by two testers with an interval of seven days between each session. The repeated measurements of each examiner (intrarater) and the first and second measurement of both examiners (interrater) were assessed for reliability. Statistical testing was performed to confirm the data to fit a normal distribution according to Shapiro-Wilks ($\alpha = 0.05$). Intraclass correlation coefficients and Pearson Product-Moment correlation coefficients were used to assess reliability at the alpha level of 0.05. Pearson's correlation coefficients were between 0.72 and 1.0, Intraclass correlation coefficients (ICC) between 0.66 and 1.0. In further analysis of the results, repeated-measures paired T-tests were used to test for differences between repeated measures. After adjustment of the alpha level for the total number of comparisons, 10 of the paired T-tests were significant (2 intra; 8 inter). The results indicate that the measuring method provides reliable data and that two different test modes produce consistent measurements.

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A number of methods for assessing human orthostatic body posture have been developed.[1] Photographic evaluation of various aspects of body posture rarely occurs in the literature.[2]

Body posture is considered normal posture, when it can be maintained without difficulty; when the individual can hold the posture for a reasonable period of time without discomfort; and when the posture provides an esthetically acceptable appearance.[3] This judgement of the orthostatic body posture depends on a number of subjective criteria. Therefore, the above-mentioned formulation can hardly be used to assess posture or deviation of postural alignment. A more objective description of the erect body posture has been given by Kendall and McCreary.[1] The orthostatic body posture has been assessed, from a lateral and a dorsal view, towards a central plumbline and a background with horizontal and vertical lines for proper orientation. In normal postural alignment, the central plumbline of the lateral view should coincide with the following anatomical landmarks from the lateral aspect:

- slightly posterior to the apex of the coronal suture;
- through external auditory meatus;
- through odontoid process of axis, i.e., through the bodies of the cervical vertebrae;
- the acromial process;
- through bodies of the lumbar vertebrae;
- the greater trochanter;
- just anterior to the axis of the knee joint;
- slightly anterior to the lateral malleolus.

From a posterior inspection the central plumbline will merge from a point between the internal malleoli. Ideal posture characteristics formulated by Kendall:

- neither tilted nor rotated neutral position of the head;
- straight in drawing cervical spine;
- leveled shoulders, not elevated or depressed;
- neutral position of the shoulders, medial border essentially parallel and about 3 to 4 inches apart;
- straight thoracic and lumbar spine;
- leveled pelvis, both superior iliac spines in the same transverse plane;
- neutral hip joints, neither adducted nor abducted;
- straight lower extremities, neither bowed nor knock-kneed;
- parallel feet, sometimes toeing out slightly.

However, the above-mentioned criteria for evaluation of erect posture are subjective in nature as well.

A modification for evaluation of posture was reported in a recent study.[4] In addition to the Kendall/McCreary-method, posture was operationally defined from the lateral view, using a 6-point scale: normal = 0, mild = 1, mild+ = 2, moderate = 3, moderate+ = 4 and severe = 5. For the purpose of analysis, grades normal and mild were considered to be within normal limits and assigned grade 1. Mild+ and moderate were grouped as moderate and assigned grade 2, and moderate+ and severe were assigned grade 3. In grade 1 the center of the bony landmark is in line or up to one cm in front of the plumbline, in grade 2 the posterior border of the landmark is in line or one cm in front of the plumbline, and in grade 3 the posterior border of the landmark is more than one cm beyond the plumbline. Three experimental examiners and one experienced examiner/instructor observed these criteria: forward head, rounded shoulders, and kyphosis. Cohen's Kappa coefficients were used to determine intrarater reliability of the three experimental examiners at 0.82. Interrater reliability between the experienced examiner (the "gold" standard) and the three experimental examiners was established at Cohen's Kappa 0.61.

Another study[5] introduced a measuring method, which put the subjects on a platform used to quantify the location of the vertical projection of the subject's center of gravity in order to eliminate distortion, with respect to the vertical, due to postural sway. The examiners put markers on eight bony landmarks: temporomandibular joint, acromial process, superior iliac spines (both anterior and posterior), the greater trochanter, caput fibulae, the lateral malleolus and metatarsal V.

These well-defined and easy to palpate bony landmarks can be located with a marker and recorded on a photograph. A photograph was taken of the right side of 15 healthy subjects, 11 women and 4 men, with ages ranging from 21 to 52 years. After the photograph, subjects stepped off the scale. All markers were removed and the procedure was repeated. Intrarater reliability for each landmark ranged from Pearson's r = 0.67 to r = 0.87. Intraclass correlation coefficient for reliability was ICC = 0.80 for the least reliable measure, the posterior superior iliac spine (PSIS), and the most reliable measure was ICC = 0.93 for the lateral malleolus. Values of the reliability of the composite measures were r = 0.89 and ICC = 0.95. The data suggest that the technique described for quantifying orthostatic body posture is a reliable one.

Finally, a photographic method to record head posture was described.[6,7] Two mirrors were oriented at 45 degree angles to the frontal and to the horizontal plane.

The purpose of the study was to quantify postural differences between actual observation and the photographs. The results showed differences from one to two degrees. No information was provided on the reliability of the procedures. The purpose of this study was to test measurements of anatomical landmarks on body posture photography for intra-/interrater reliability. Research hypotheses included rejection of the null hypothesis of associative proof in favor of the alternative, and confirmation of the null hypothesis, stating the differences in the measurements to be equal to 0. The alpha level was set at 0.05.

Materials and Methods

A standardized photographic set-up for body posture photography was developed (**Figure 1**). A groundplate was located 0.5 meter in front of a background screen, on which square diagrams of ten centimeters each had been drawn. The camera was located four meters in front of the groundplate on a tripod, controlled on its horizontal position. The bony landmarks were palpated in accordance with anthropometric guidelines[8] and marked with a dark lipstick on the skin.

The pictures were taken with a 3.5/50 mm lens using black and white film. Four photographs of the orthostatic posture were taken, a frontal, a dorsal, and two lateral ones. The population consisted of all available sets of photographs. Due to guidelines for manuscripts, the lateral photographs are subject to a separate study. For this study the frontal and the dorsal photographs were used for evaluation of various postural aspects. A sample of 18 sets of photographs was selected from the available population to perform the reliability tests.

Procedure

The posture photographs had to be clear, without any visible distortion, and made with the standardized set-up

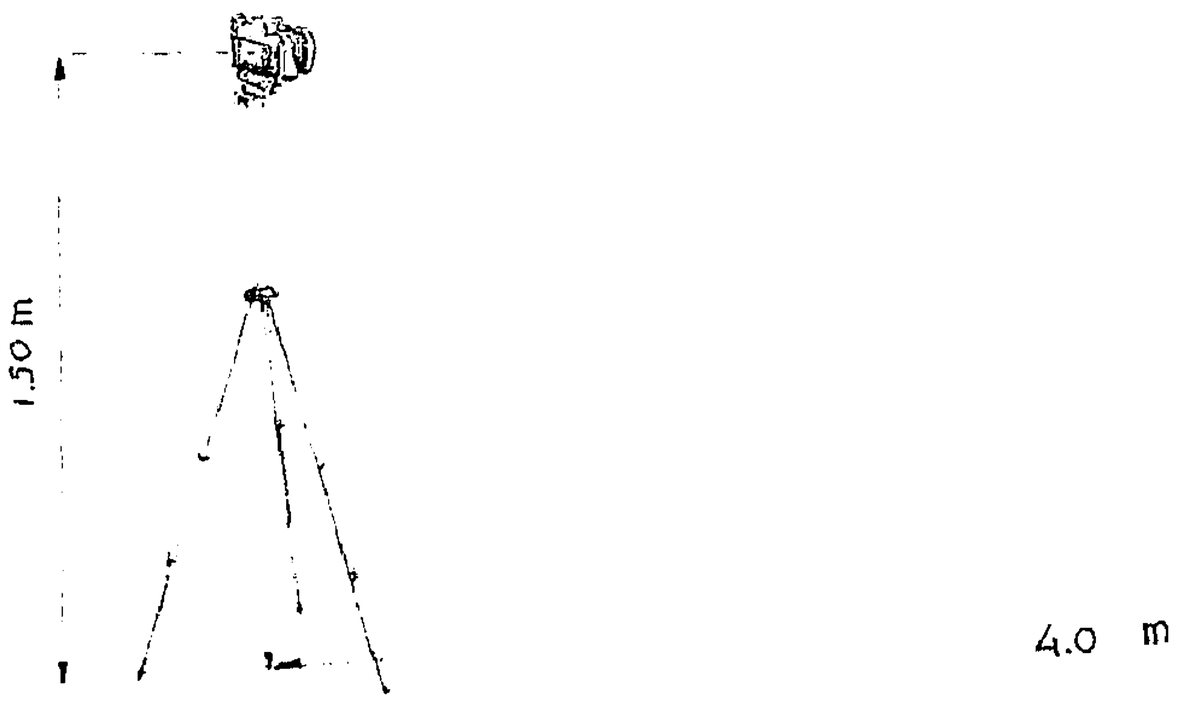

Figure 1
The photographic set-up.

described above. Frontal and dorsal takes were made in the same photographic session (**Figures 2A** and **2B**).

Statistical Analysis

The data sources of the anatomical landmarks were denominated as follows (**Table 1**, **Figures 2A** and **2B**): The values in respect to the central plumbline are nominated the x-coordinates, the values in respect to the groundplate are the y-coordinates. All values of the coordinates were measured with a millimeter ruler. Consequently, in each session 20 variables were measured on 18 sets of photographs.

Two examiners (A and C) performed repeated measurements of the variables on the basis of one week intervals. Measurements 1 and 2 of each examiner were assessed for intrarater reliability and nominated A1 and A2, C1 and C2. Measurement A1 and C1 as well as A2 and C2 were assessed for interrater reliability. Statistical testing was performed to confirm the data fit to a normal distribution according to Shapiro-Wilks[9, 10] at $\alpha = 0.05$. The Pearson Product-Moment correlation coefficient was used to quantify covariation, and the paired T-test was used to test for systematic differences.

Intraclass correlation coefficient ICC was used to assess the intra-/interrater reliability. The alpha level for Pearson's correlation coefficient was set at 0.001, the alpha level for the T-test at 0.05. Computations were performed with Statistix 4.0 by Analytical Software.

Table 1
Labeling the Data Sources

Right pupil	A
Left pupil	B
Right acromion (frontal)	CF
Left acromion (frontal)	DF
Right asis	G
Left asis	H
Right acromion (dorsal)	CB
Left acromion (dorsal)	DB
Left psis	N
Right psis	O

The values with respect to the central plumbline are nominated x-coordinates, the values with respect to the groundplate are the y-coordinates.

Results

Out of 36 posture photographs (18 frontal and 18 dorsal) 10 anatomical landmarks in x- and y-coordinates resulted in 20 variables, that were tested with Pearson's correlation coefficient. The values for covariation and reliability (r and ICC) are presented in **Tables 2** and **3**.

Pearson's correlation coefficient in **Tables 2** and **3** provides all values of the intrarater and the interrater tests to be statistically significant [$p\ (-0.708 < r > 0.708) = 0.999$].

Further analysis of the 20 variables with the paired T-test for systematic differences was performed. The values of the paired T-tests are presented in **Table 4**.

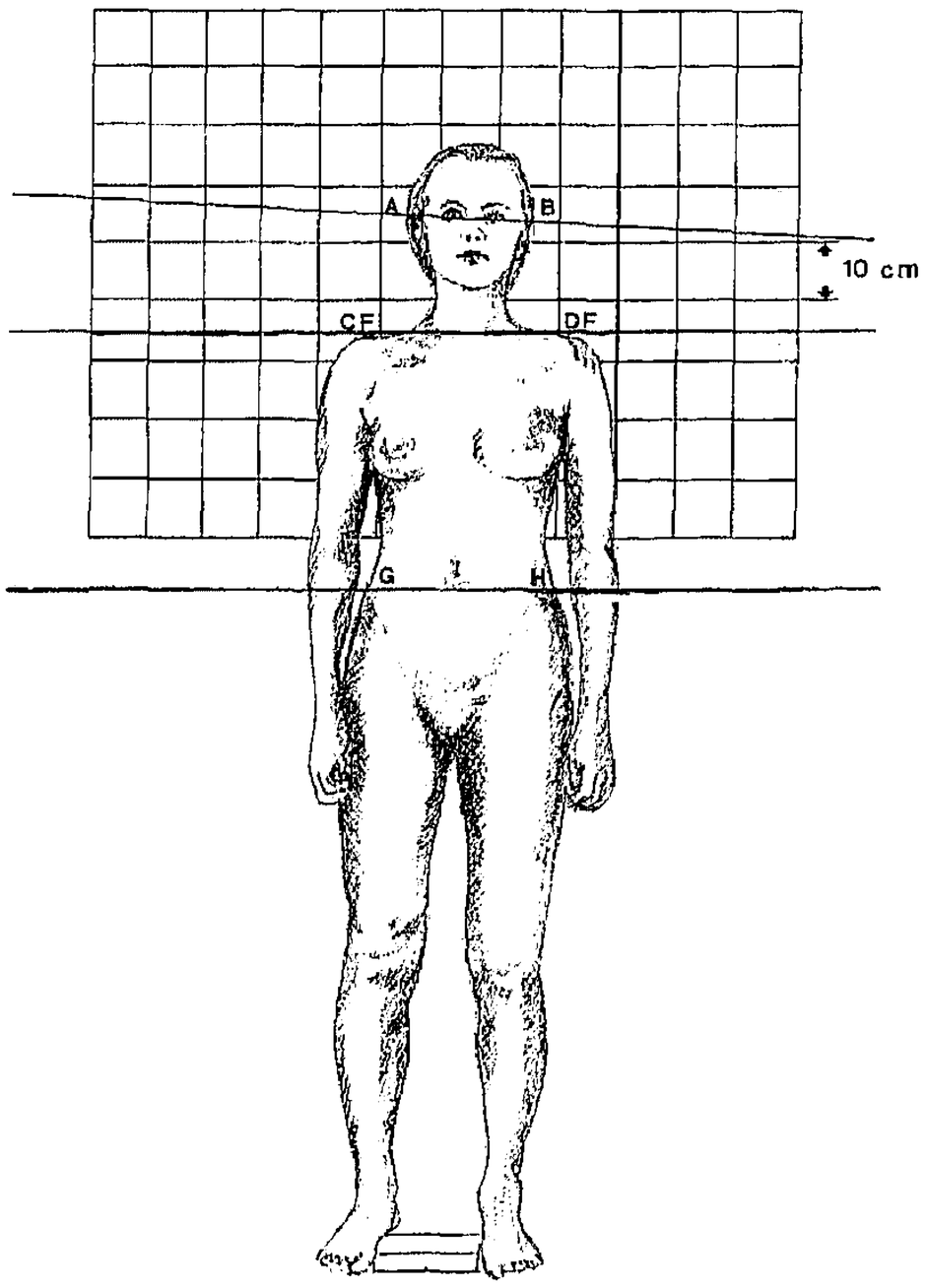

Figure 2A
Drawing of a body posture picture (frontal view).

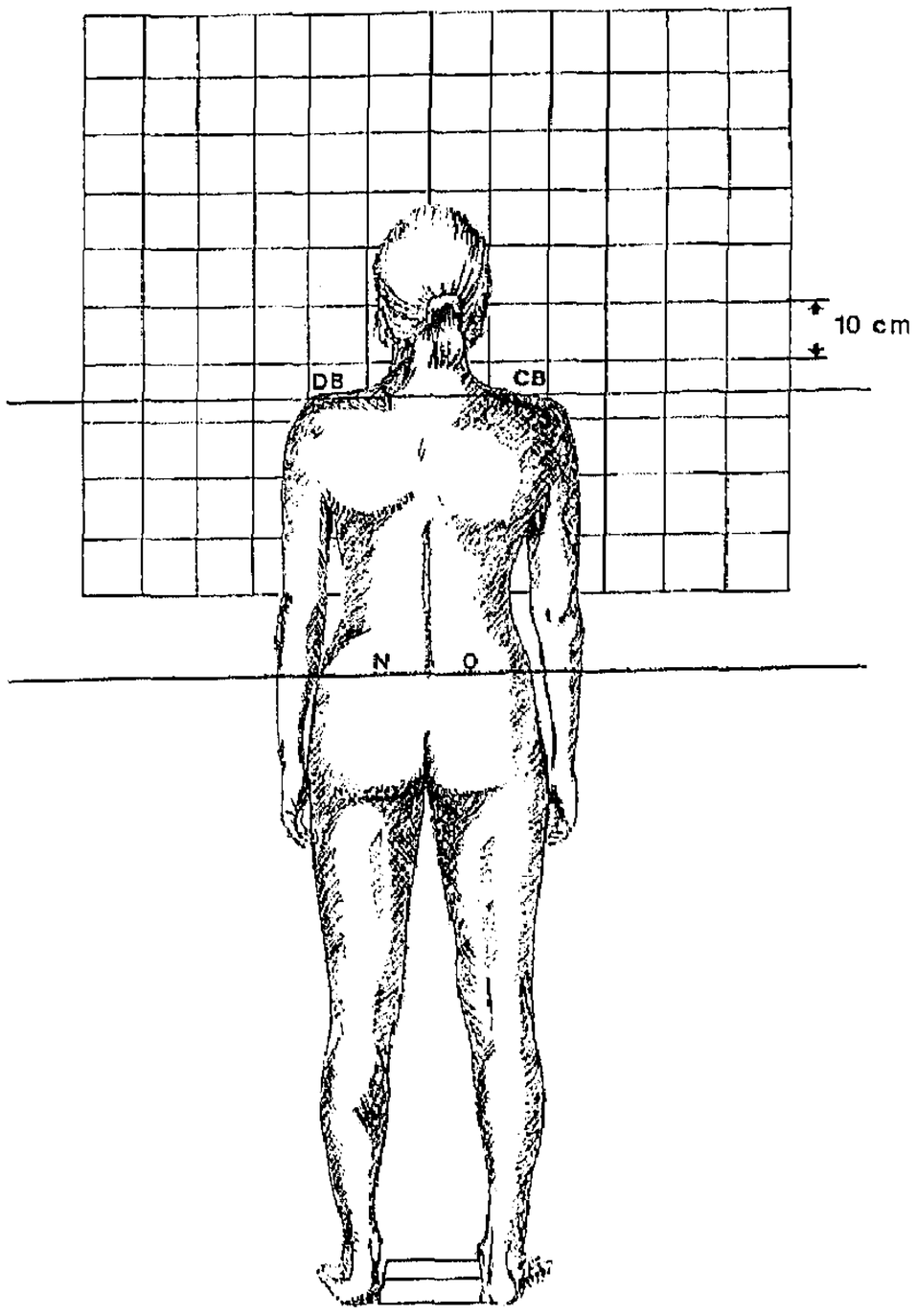

Figure 2B
Drawing of a body posture (dorsal view).

The repeated-measures T-test values of the intrarater analysis, made to assess reliability, resulted in two significant different comparisons: DFyAl - DFyA2 and DFyCl - DFyC2.

In the repeated-measures T-tests values of the interrater analysis for reliability, eight significant different comparisons were found: Ax Al - Ax Cl, Ax A2 - Ax C2, Bx Al - Bx Cl, DFy A2 - DFy C2, CBy A2 - CBy C2, DBy A2 - DBy C2, Oy Al - Oy Cl and Oy A2 - Oy C2.

All 10 values proved to be significant due to inaccuracy of measurement of both raters.

Out of 160 comparisons with Pearson's r and the paired T-test a total of 150 values are satisfactory. The Intraclass correlation coefficient for 80 values of the analysis was calculated.[11] The research hypothesis concerning associative proof was rejected.The research hypothesis to assess systematic differences was confirmed.

Discussion

This study was conceived due to the lack of data relative to this method of postural assessment available in the literature, because no one has done a study of intra-/interrater reliability. First of all, the criteria described by Cailliet,[3] are too subjective in nature to be used for postural assessment in a physical therapy research protocol. Evaluation of body posture, using well defined anatomical landmarks in their respective relation to a central plumbline, as was reported by Kendall and McCreary,[1] is subjective as well. A difference in interpretation can occur, when no exact distance is referred to by the use of the expression "slightly" or "just anterior." Even the reported 6-point scale by Griegel-Morris makes the impression to be accurate, however, the values are estimated, not measured. Nevertheless, intra-/interrater reliability assessment with Cohen's Kappa provides a fair to good result.

The results of this study give occasion to some remarks as well. For instance, in this study intra-/interrater reliability of the location of the markers on the subjects, as well as the photographic procedure are missing. Although well-defined anatomical landmarks[8] were selected, it appears to be necessary to question the effects of the technique used for palpation of the landmarks and the possible displacement of the skin when applying the lipstick markers. Nevertheless, after adjustment of the alpha level for the total number of comparisons made to assess

Table 2
Pearson Product-Moment Correlation Coefficients for Intra-/Interrater Reliability

	intra A	intra C	inter A1-C1	inter A2-C2
Ax:	0.9812	0.9955	0.9559	0.9728
Ay:	0.9964	0.9967	0.9975	0.9809
Bx:	0.9806	1.0000	0.9860	0.9850
By:	0.9962	0.9960	0.9977	0.9796
CFx:	0.8744	0.9960	0.9873	0.8638
CFy:	0.9994	0.9992	0.9986	0.9990
DFx:	0.7687	0.9755	0.9646	0.7466
DFy:	0.9993	0.9995	0.9981	0.9992
Gx:	0.9626	0.7523	0.9573	0.7271
Gy:	0.9989	0.9992	0.9964	0.9960
Hx:	0.9656	0.9710	0.9720	0.9739
Hy:	0.9986	0.9997	0.9965	0.9967
CBx:	0.9358	0.9789	0.9138	0.9640
CBy:	0.9983	0.9994	0.9978	0.9990
DBx:	0.8443	0.9881	0.9752	0.8833
DBy:	0.9985	0.9995	0.9981	0.9988
Nx:	0.9679	0.9956	0.9519	0.9890
Ny:	0.9985	0.9994	0.9971	0.9991
Ox:	0.9674	0.9979	0.9482	0.9829
Oy:	0.9992	0.9991	0.9976	0.9991

$\alpha = 0.001$
$r_{crititat} = 0.708$

Table 3
Intraclass Correlation Coefficients for Intra-/Interrater Reliability

	intra A	intra C	inter A1-C1	inter A2-C2
Ax:	0.9609	0.9948	0.9254	0.9619
Ay:	0.9948	0.9949	0.9960	0.9797
Bx:	0.9796	1.0000	0.9849	0.9789
By:	0.9950	0.9948	0.9960	0.9786
CFx:	0.8653	0.9959	0.9840	0.8524
CFy:	0.9993	0.9991	0.9985	0.9988
DFx:	0.6950	0.9709	0.9625	0.6600
DFy:	0.9980	0.9992	0.9980	0.9984
Gx:	0.9983	0.7324	0.9560	0.7148
Gy:	0.9988	0.9990	0.9961	0.9955
Hx:	0.9592	0.9701	0.9718	0.9659
Hy:	0.9985	0.9995	0.9962	0.9964
CBx:	0.9356	0.9758	0.9114	0.9614
CBy:	0.9982	0.9993	0.9976	0.9984
DBx:	0.8290	0.9871	0.9737	0.8565
DBy:	0.9977	0.9994	0.9977	0.9980
Nx:	0.9404	0.9950	0.9250	0.9878
Ny:	0.9980	0.9993	0.9969	0.9985
Ox:	0.9668	0.9976	0.9439	0.9798
Oy:	0.9991	0.9990	0.9968	0.9981

reliability, only ten values of Pearson's r and the paired T-test were not in line with previous expectations.

Analysis of the measures by the individual examiner revealed that examiner A twice made an incorrect measurement of the variable DFx. Examiner C made the same mistake for variable Gx once. The measured difference appeared to be 5 mm, apparently a mistake reading the ruler.

However, there are some restrictions in recording various aspects of body posture on photographs. First of all, the photograph is a reduced representation of the subject. Subsequently, the differences measured will be relatively smaller. Second, three dimensional relations of body posture will be projected on a flat surface. Projection of the three dimensional aspects of, for instance, the pelvis, rotated around a vertical axis, may produce a considerable distortion and suggest an oblique pelvic alignment. A dorsally rotated landmark will be visualized cranially in the convergent shaft of the camera. A posture photograph is a snapshot and does not represent differences caused by postural fatigue due to the subject's daily activities. Although body posture photography takes more time in patient education and production than the usual inspection in the daily routine physical therapy practice, the photographic procedure has some obvious advantages:

- the results of the photography seem more objective than the description of the anamnestic inspection in daily practice. A deviation of postural alignment seems easier detectable on a photograph. Accuracy of both Kendall's and Griegel-Morris' methods for evaluation of posture are affected by their estimated measures.
- the collected data of the various postural aspects of the subjects can be recorded in a computerized database, thus creating a method to evaluate "solid" data.
- it is a non-invasive procedure for the subjects that need to be screened with the method.
- standardization of the photographic procedure and the measurement procedure will provide repeatable and reliable data.

It is essential for the examiners to follow the exact procedure, both in taking the photographs as well as in the measurement procedure. Thorough instructions and a rehearsal for the examiners is recommended beforehand.

In view of the agreement in the number of observations and the few flaws in the intra-/interrater procedure, it can be concluded that the use of body posture photographs

Table 4
Repeated-measures T-test for Intra-/Interrater Reliability

	intra A	intra C	inter A1-C1	inter A2-C2
Ax:	-1.46	1.46	-3.59*	-2.70*
Ay:	-1.77	-1.61	-2.02	-0.83
Bx:	-1.84	0.00	-3.34*	-1.29
By:	-1.70	-1.50	1.96	-0.66
CFx:	-0.86	0.00	1.32	1.23
CFy:	1.84	-0.25	0.00	-1.59
DFx:	1.57	1.84	-1.46	-1.51
DFy:	2.20*	-3.00*	0.17	-3.50*
Gx:	0.00	1.29	-0.27	0.29
Gy:	-0.57	0.00	0.97	1.22
Hx:	-1.84	0.00	-0.32	-1.57
Hy:	0.57	-1.00	1.06	0.36
CBx:	0.27	1.46	0.24	1.10
CBy:	0.70	-1.43	-0.77	-3.29*
DBx:	-1.19	0.90	-0.40	1.45
DBy:	1.29	-1.29	-0.46	-3.07*
Nx:	-0.44	-1.46	-0.59	-1.37
Ny:	0.44	-0.81	1.10	0.52
Ox:	0.00	-1.00	-0.78	-1.76
Oy:	0.00	-0.32	-2.38*	-4.08*

$\alpha = 0.05$
$T_{critital} = 2.110 (n = 17)$
* = significant

as a measuring instrument for assessment of postural alignment is a reliable one.

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