PHOTOGRAMMETRIC MEASUREMENT OF THE HUMAN BACK SHAPE AND ITS RELATION TO THE SPINE

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1. ABSTRACT:

The surface of human back shape and its relation to the geometric behavior of the spine under occupational-medical aspects is not exactly investigated until now.
We examined a group of 30 helicopter pilots because they have to work under special environment conditions. We answered the following questions:

1.) It is possible to discribe human back shapes by photogrammetric measurements.
2.) It is possible to verify different postures (sitting and standing) by defined parameters and it is useful for the clinical diagnosis.

The examination was carried out in cooperation between the two institutes (Photogrammetry / Biomechanics) within an 4-years-lasting research project.

2. KEY WORDS: back shape, medical purpose

3. METHODS:

30 pilots were examined carefully by an orthopaedic which included a special examination of the spine.
22 probands were measured photogrammetrically. Out of this group we considered 13 pilots.
The photogrammetric equipment consists of the following components:

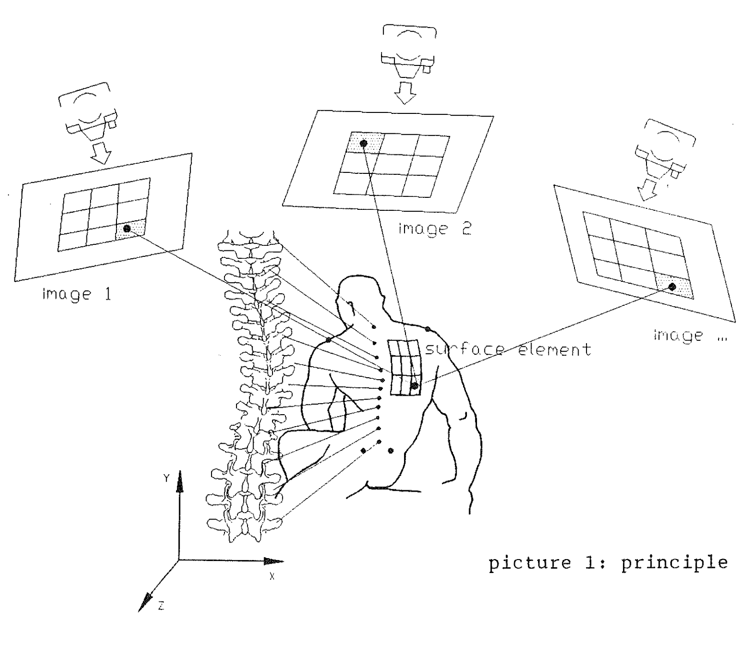
* Rolleiflex 6006 Mid-format cameras with a 121 points Réseau
* spots
* slide projektor with a grid-slide (3 cm x 3 cm meshes in object space)

The grid slide was projected onto the patient back and then the cameras were released simultanously with 1/15 -1/30 sec and f-8 - f-11. We used a 100 ASA Agfapan film.

The patients were required to take their normal standing and sitting postures in front of a 3-dimensional calibration field on the wall which allows also a simultanous calibration of the cameras. Additional we marked anatomical landmarks with reflecting targets:

* 2-4 scapulae points
* 11-17 points of the spine
* 2 pelvis points

To analyse our photogrammetric examinations we took pictures from 3 cameras. First we enlarged the negatives to 18 cm x 24 cm format positives. We manually digitized the points of the calibration field, the points of the spine, the pelvis, the scapulae and points of the human back shape. Because it is difficult to digitize the normally insuffizient structured skin we took the cross points of the projected grid.
The digitizing took place picture by picture with the Rollei MR 2 system. To calculate the object-coordinates we used the CAP bundle adjustment programm.
To get a satisfying visualisation of the calculated objectcoordinates we presented a digital altitude model as a grid model with HIFI. Finally we transferred the coordinates to CAEDS and produced a shaded model.
In addition we used AUTOCAD to derive clinical parameters with geometrical aspects as rotations, axis proportions and transverse section.



picture 1: principle

4. THE COLLECTIV

All pilots were consulted about back pain during or after flight exposure. Out of 30 pilots 16 told us that they had no pain at all, 14 pilots answered in the affirmative. Out of this group we chose 13 persons, 7 without back pain called collectiv I and 6 with pain (collectiv II). All the pilots without pain had an average flight exposure of 1575 hours, the chosen 7 pilots had an average flight exposure of 1513 hours. The pilots with pain had an average flight time of 2607 hours, the chosen group flew on an average of 2660 hours.
The group of the pilots with spinal pain was older than the other group. On the day we took the orthopaedic and photogrammetric examination there was no flight exposure for all pilots and the surrounding conditions during our examination were the same for all pilots. None of them had an acute disease of the locomotion system or a common illness.

5. RESULTS

5.1 Results of the clinical examination

In the clinical orthopaedic examination of the 30 pilots we couldn't find a statistic relevant result. The lumbar and thoracal back pain was mostly based on local segmental functional disorders. This we could find as well in the rest of the population too. Only the accumulation of malfunction of the caudal thoracal spine made the pilots stand out but it is not possible to make an exact statistical statement because up to now there is no other group with which we can compare it.

5.2 Results of the photogrammetric measurement

The results of our photogrammetric analysis were 3-dimensional objectcoordinates with standard deviations of 0,7 mm in x and z and 1,7 mm in y (receiving direction). A priori we expected an accuracy of some mm which is influenced through exterior factors (skinmovement, reproducebility). The results we received were well-suited for our medical purpose.
The following parameters of examination were used to judge the different postures:

A) The axis between the dorsal edge of the right and the left acromion and the tactile spinae posterior superior. These points were marked with retrotargets and show the rotation of the pelvis-acromion-axis along the vertical body axis.

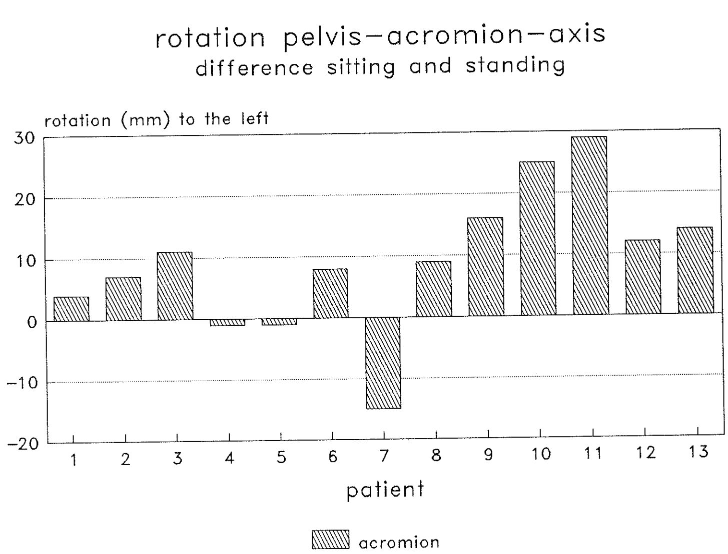
B) We defined transverse sections in the spacial shape profile 10 cm, 25 cm and 35 cm above the connection of the spinae iliaca posterior.
These sections are useful to size the body rotation along the vertical body axis in different heights of the trunk.

C) The tactile line of the spine was also marked with reflecting targets to represent the spacial geometry (kypho-lordosis) including the vertical.

The examinations were carried out in normal standing and sitting postures, the patients sat down on a backless stool.

With our analyses we emphasized the variation of the rotation of the trunk in the horizontal plane in transition from sitting to standing.
The connection line of the pelvis points was defined generally horizontal to enable a comparison of the trunk rotation and inclination.

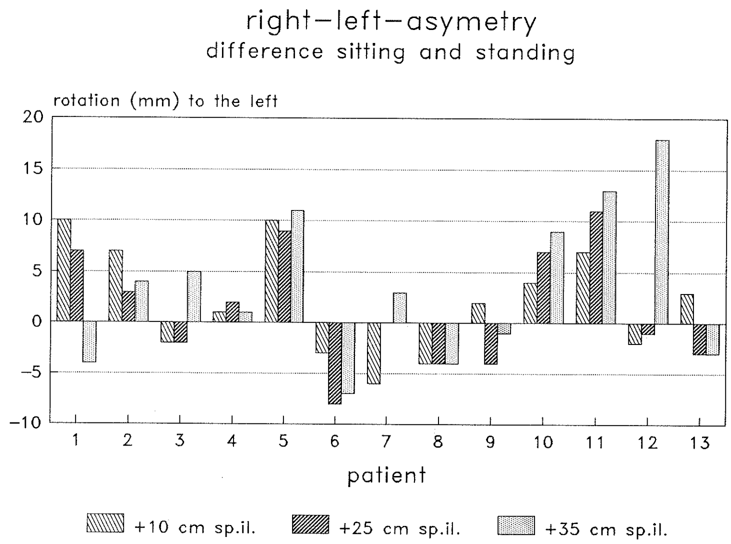
to A) In both sitting and standing postures we found a light leftrotation of the upper part of the body at 8 probands in relation to the pelvis axis (right acromion is rotated forward):
0 - 36 mm standing ; 0 - 48 mm sitting
5 patients showed a light right rotation of the acromion connected axis:
0 - 21 mm standing ; 0 - 12 mm sitting
Those deviations may be influenced by an insuffizient positioning of the retrotargets. Differences between the standing and sitting results were calculated to show the effective movements in space. We found out clearly that most of our patients had an increase of leftrotation in transition from standing to sitting posture (0 - 29 mm).
This effect corresponds with the occupational posture.



picture 2: differences between sitting and standing positions rotation of the pelvis-acromion-axis

to B) The transverse sections were laid 10 cm, 25 cm and 35 cm above the spinae iliaca posterior and the transverse sections were reflected along the midline. A comparison between the left and the right side shows the rotation of the body. These results may be influenced by muscular asymetries. Therefor it is necessary to calculate the differences between both positions. As a result we receive indications of an increase of body rotation in left or right direction.

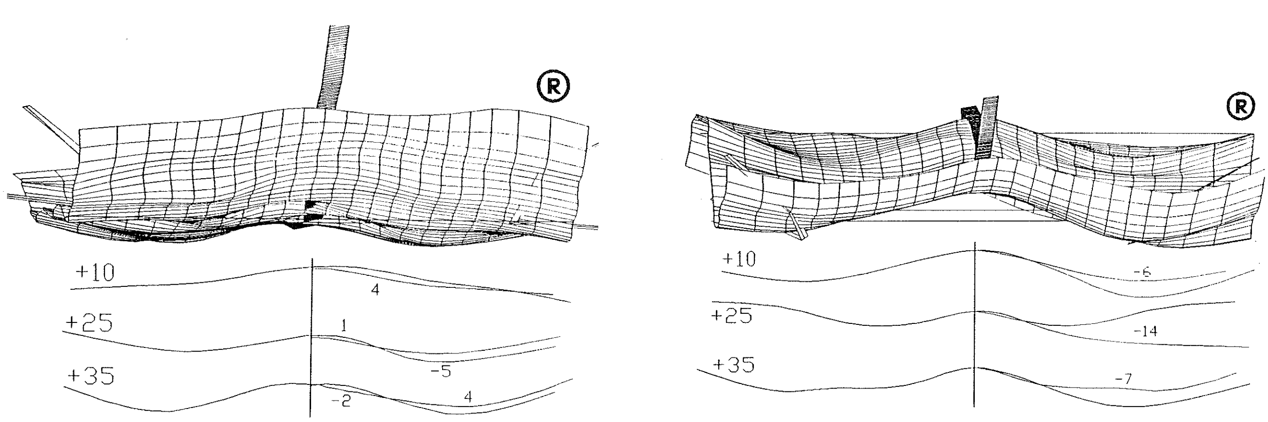
5 probands rotated in left direction (0-12 mm; max 18 mm), 2 pilots were rotated to the right direction. The other probands (n=6) vary in the direction of rotation in different trunk segments. The maximums of rotation were always found in left rotation (0-18 mm). The rotation in right direction varies between 0-8 mm. Another tendency of our investigations is the increase of the rotation in connection with the increase of height of the taken section. The rotations 35 cm above the spinae iliaca posterior are more obvious.



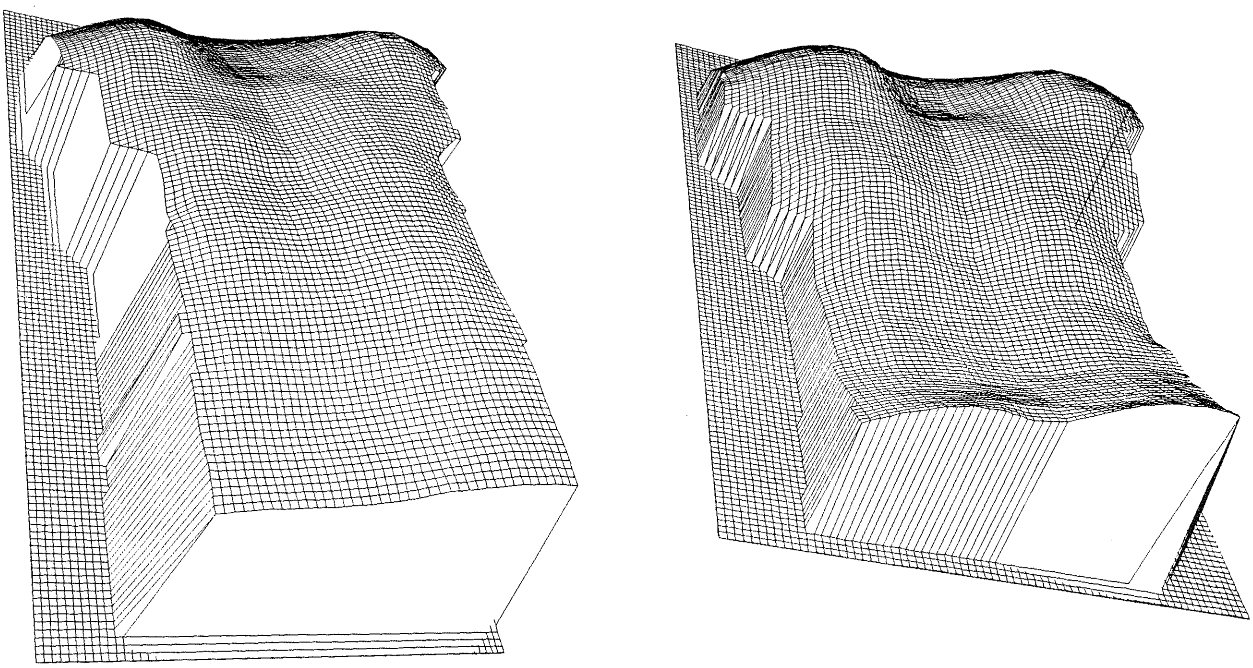
picture 3: differences between sitting and standing positions right-left asymetry

to C) Comparing the clinical results of pilot no. 5 and no. 11 with the results of the photogrammetric measurement and the analyses of the derivated representations the following statements can be made:
Patient no. 5 is clinical normal except for a light hanging of his right shoulder. Transverse sections in standing posture show the physiological kypho-lordosis. The pilot was rotated forward in left direction (rotation to the right). In transition to the sitting posture we found a significant decrease of right rotation. +10 cm above the pelvis axis the sulcus medianus dorsi is more flat than in the standing position.

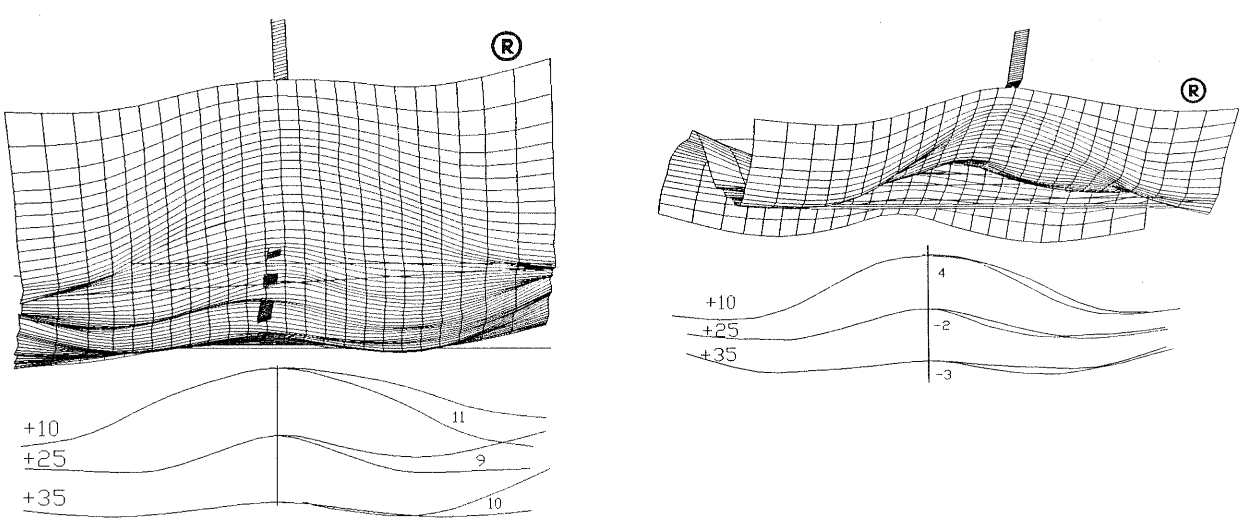
The clinical diagnosis of patient no. 11 is more extensive: He suffers from a light scoliosis (chest right bending, loins left bending), a flat thoracal kyphosis and his left pelvis and shoulder are standing deeper. We equalized this irregularity in the transverse sections-representations so that we found a significant overhang on the right side. In the standing positions there was no striking assymetry between the left and the right side, in transition to the sitting position we found a definite rotation to the left. The flat of the chest kyphosis is documented in transvers section +35 cm above the pelvis axis.



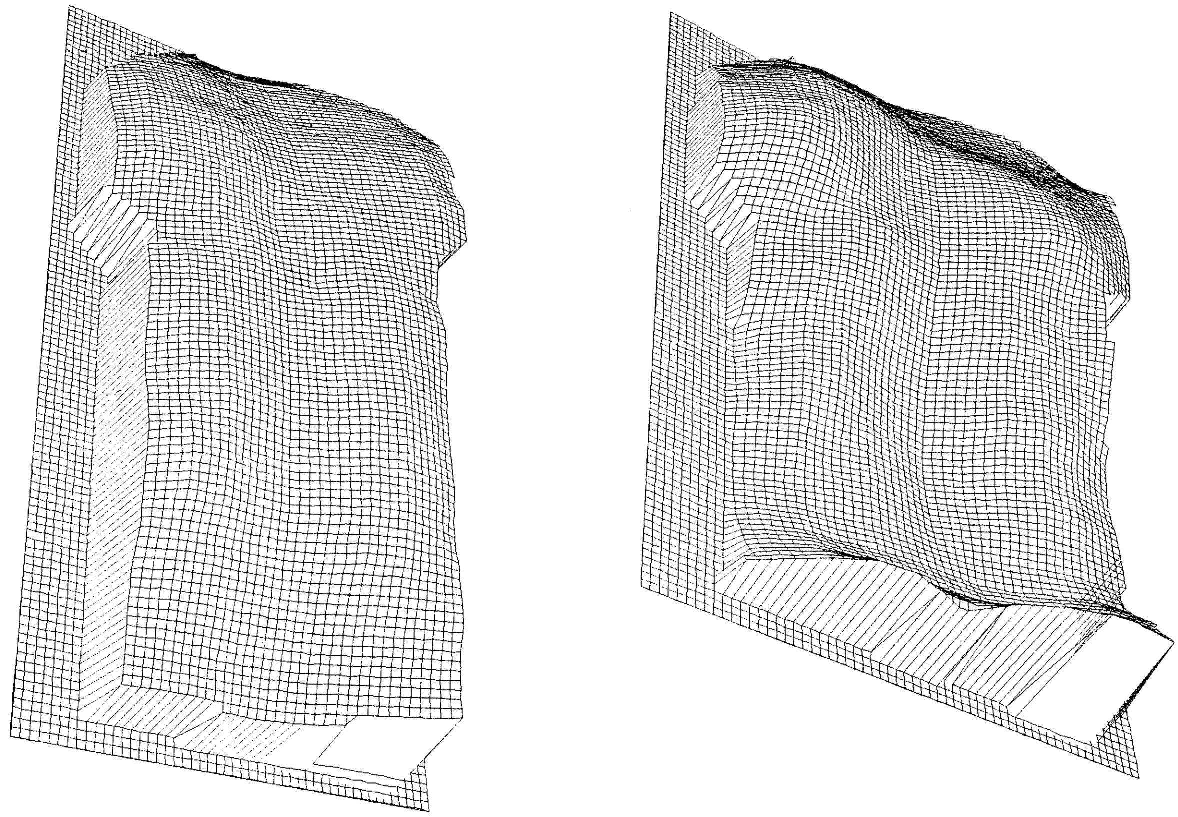
picture 4: sitting and standing position (results of AUTOCAD) transverse sections pilot no.5



picture 5: sitting and standing position (results of HIFI)
pilot no.5



picture 6: sitting and standing position (results of AUTOCAD)
transverse sections pilot no.11



picture 7: sitting and standing position (results of HIFI)
pilot no.11

6. Conclusions

The investigated parameters of rotation of the upper trunk against the pelvis axis and its variations between the sitting and standing position lead to the following conclusions:
The specific geometry of the sitting posture while working in a helicopter leads to a static-motoric pattern in ordinary life.

With the help of photogrammetric surface measurement of the human back shape we were enabled to provide objective criterions for the clinical diagnosis, contrary to the orthopaedic examinations which give no specific results.

The accuracy of the photogrammetric results allows derivations of important geometric parameters (rotation, inclination, transverse sections). In addition graphic representations support the clinical judgement and make the analysis easier.

In future these possibilities should be used more often.

7. LITERATURE:

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