CLOSE RANGE PHOTOGRAMMETRIC ANALYSIS OF THE HUMAN SPINE

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INTRODUCTION

Close-range photogrammetry (CRP) has been used extensively in medical applications, such as craniofacial mapping [1] and scoliosis screening [2] to obtain three-dimensional data. Advantages of this method over stadiometers and lasre scanning are that it is (i) non-contact and non-invasive, (ii) instantaneous imaging, (iii) highly accurate, and (iv) allows for dynamic analysis of structures.
This paper presents the development and application of a field-based CRP technique for studying diurnal variation in the geometry of young adult male spines.

METHODS

The system consisted of four Sony DSC-F828 still frame cameras mounted on a sturdy aluminium frame, synchronized using a LANC Shepherd remote control device, and a rigid photogrammetric control frame. The non-metric cameras were calibrated to determine the principal offset points (X_p,Y_p), the principal distance (PD), radial distortion parameters (K_1, K_2,K_3), the lens alignment (P_1,P_2) and in some instances, the dynamic fluctuation. This was achieved in the field using a detachable target board with known coordinates of control targets.

Image digitizing and data processing was performed using Australis® photogrammetric software. This provided the x,y,z coordinates of the object point and sensor calibration data were obtained using bundle adjustments. The average difference between true and measured 3D distances of the target board was 0.43 ± 0.01mm.

Thirty young male University students were recruited from halls of residence, and were excluded if they had current or recent history of low back pain. The exposed back was marked with fine-tipped permanent marker at superior spinous processes of T1, T3, T6, T9, L1, L3 and L5 and both posterior superior iliac spines (PSISs) following palpation by an experienced manipulative physiotherapist. Subjects stood behind and as close as possible to the reference grid and images taken during full exhalation. Images were taken 3 times during the day: first thing on rising (AM), mid-day (MD) and evening (PM). Subjects also completed and activity questionnaire.

RESULTS AND DISCUSSION

There was no significant diurnal variation in the length of the spine as represented by the vector from T1 to the midpoint between the two PSISs was 13.6mm or 0.74% of body height. Similarly, there were non-significant mean diurnal vector changes of 7.5mm in the thoracic spine and 5.0mm in the lumbar spine. This showed approximately 55% of the height loss occurred in the thoracic spine and 37% in the lumbar spine.

The thoracic, lumbar and thoracolumbar angles in the sagittal and frontal planes were derived from the 3D coordinates of the appropriate spinal landmarks.

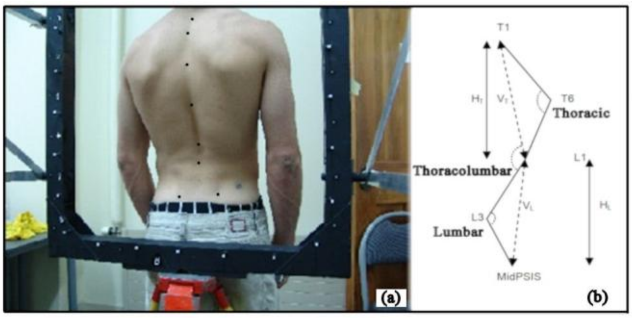

Figure 1: Angular measurements derived from spinal landmarks.

Thoracic kyphosis increased from AM to PM, with a mean change in the sagittal plane of 1.5deg and lumbar lordosis decreased slightly by 0.2 deg. Changes in the thoracolumbar spine (mean -0.3deg) were not consistent, although the majority (92%) of subjects demonstrated a lordotic change. All the spinal segments changed shape laterally only slightly during the day, and none of these changes were significant. There was an approximately equal distribution between left and right angulations of the thoracic (48% and 52%) and lumbar (54% and 46%) spine segments, but the thoracolumbar junction showed a greater tendency to angle to the right (62% vs 38%).

CONCLUSIONS

This technique showed that non-metric camera and off-the-shelf software can provide accurate 3D measurement of anthropometric landmarks and 3D mapping of the back surface contours. Results showed diurnal variation of the spine was consistent with published data derived using stadiometers. One of the suspected causes of loss of stature is the combination of viscoelastic deformation and fluid loss due to compressive loading. However, changes in intersegment angles suggests deformation in all three planes suggests could also contribute to this loss of stature.

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REFERENCES

1. Majid, ZB et al *Photogramm Rec.* **20:** 48-68, 2005.
2. Peterson, AE et al. Geomatica, **47:** 29-38, 1998.