PELVIC SUBCUTANEOUS ADIPOSE TISSUE THICKNESS AND OUTER SHAPE CHANGE WITH POSITION FOR NUMERICAL MODELING

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Introduction

The distribution of soft tissue around the anterior superior iliac spine (ASIS) is hypothesized as critical factor for seatbelt occupant interaction [1]. State-of-the-art Finite Element (FE) Human Body Model (HBM) subcutaneous adipose tissue (SAT) thickness values mostly are based upon supine medical imaging. So far, an increase in SAT thickness above the ASIS from supine to a sitting posture has been observed in a single individual [2]. To improve FE HBM geometry for seating positions more robust SAT thickness transfer data for different sitting postures is needed [3]. This study characterizes SAT thickness above the ASIS in four different body positions through sonography to narrow the gap in current FE HBM morphology.

Methods

Ethical approval was obtained from the Medical Faculty Ethics Committee of the University of Munich LMU. The study included ten healthy 50th percentile male volunteers aged 27.5 years (median) (range 22-31) (body height: 180cm (175-186); body weight: 80.5kg (73.0-86.5); BMI: 24.9 (22.8-25.9). The SAT thickness was measured non-invasively between the ASIS and the skin surface using a linear handheld 9.0 MHz sonographic probe (Logiq P9, General Electric, USA) by the same operator. Four body positions were tested: supine, resting (seat angle 5°, backrest angle 45°), driving (seat angle 5°, backrest angle 15°) and upright standing. For each, three measurements were taken with as little pressure as possible, shortly before losing body contact with the probe. For the supine position, a second measurement series was taken pressing the probe onto the ASIS. Median values per position and volunteer are utilized. Pairwise non-parametric tests for dependent samples with Bonferroni adjustment are applied to detect differences between postures. In addition, 3D surface objects of all subjects in every posture were reconstructed from high-resolution images using 92 cameras simultaneously (Vectra WB360, Canfield Scientific Inc., USA) (Figure 1).

Results

In Figure 1, median values per volunteer and position are presented. Median SAT thickness for ten volunteers each in supine, resting, driving and standing posture in [cm] was 0.56, 0.90, 1.09 and 0.89, respectively. In nine out of ten subjects, ASIS SAT thickness increased with increasing seatback angle. The individual SAT minimum was always found in supine posture. The median transfer factor for SAT thickness above the ASIS from supine to resting posture is 1.54 (range 1.02 - 1.87) and from supine to driving posture 1.81 (range 1.41 - 2.22). The within-subject difference in SAT thickness between with and without pressure for the supine posture was 0.35±0.14 cm. Significant differences between positions was found for driving vs supine ($p=0.000$) and resting vs supine ($p=0.019$).

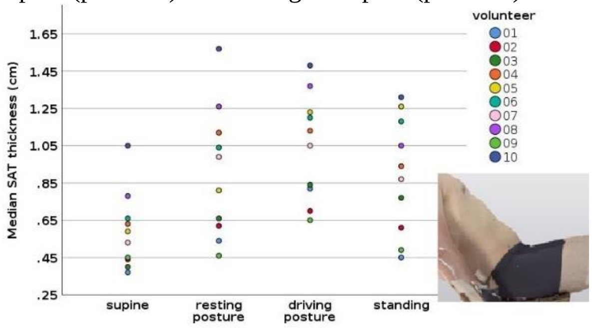

Figure 1 Median SAT thickness (cm) above the ASIS in four body postures (n=10) and a 3D-object of a resting volunteer

Discussion

For the first time, ASIS SAT thickness values for two sitting postures, supine and standing posture are presented. When seated, the more vertical the upper body is positioned, the more SAT thickness tended to increase at ASIS level. As SAT thickness was smallest in supine posture, it might be underestimated in current FE HBM. A transfer factor of 6 from supine to sitting measured based on one post mortem subject in [2] cannot be confirmed within the present cohort. Various factors, e.g. imaging modality, posture, age and post mortem processes, may contribute to this deviation. Combined SAT thickness data and reconstructed 3D-objects may inform design modifications for existing and future FE HBM, ensuring a more biofidelic soft tissue representation in a key region for belt engagement.

References

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