Evaluation of mechanical loads acting on blood vessels in the soft tissues of the shoulder while carrying a backpack

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Background: Shoulder strain is a major limiting factor associated with load carriage. Despite the advances in backpack designs, there are still reports of shoulder discomfort and loss of sensorimotor functions of soldiers' hands. The current study is aimed at i) characterizing the loads imposed on the shoulder, the subclavian artery (SCA) and its surrounding tissues, by a heavy backpack, and ii) to suggest a better shoulder strap, which will alleviate the pressure on the shoulder's tissues.

Methods: MRI scans are utilized for building 3D subject-specific finite element (FE) models of the shoulder and measuring tissue deformations. Skin pressure measurements while carrying a 25kg backpack experiments are used as boundary conditions for the modeling, and validation of the models is achieved by comparing tissue deformations to those obtained using MRI.

Results: MRI and skin pressure data revealed significant compression of the soft tissues of the shoulder, with substantial deformations in the area of the SCA. The maximal pressure values exerted by a 25 kg load were extensive and reached ~90 kPa. The 3D FE computational model was developed and validated successfully against the tissue deformations calculated from the MR images. The model simulations further revealed substantial strains in the soft tissues surrounding the SCA.

Discussion: Large deformations and pressure hotspots are likely to result in soft tissue damage in the shoulders or damage to shoulder nerves that may project pain or numbness to the hands if loads are excessive and sustained for long time exposures.

The study was presented at the following scientific meetings:

- The Shoresh bi-annual Military Medicine meeting of the US Army and IDF. Held October, 24-29, 2010, Kfar Hamaccabia, Israel. (Oral presentation, see copy of proceeding abstract below)
- ISMBE 2011 conference held February, 22, 2011, Afeka College, Israel. (Poster).

Finite Element Modeling To Assist With Backpack Design

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Results: Preliminary MRI and skin pressure data revealed significant compression of the soft tissues of the shoulder, with substantial deformations in the area of the SCA. The maximal pressure values exerted by a 25 kg load were extensive and reached ~90 kPa.

Discussion: Large deformations and pressure hotspots obtained in preliminary studies are likely to result in tissue damage if sustained for long time exposures.

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