In vivo shoulder joint loads at wheelchair propulsion on different surfaces

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INTRODUCTION:
People depending on a wheelchair are often affected by overuse syndromes and pain in the shoulder [1]. However, the acting contact loads in the shoulder joint have only been estimated by mathematical models so far with approx. 50% Bodyweight (%BW) for level ground wheelchair propulsion [2]. Additionally the influence of different floor conditions is unknown. To obtain a first impression about the range of load magnitudes, shoulder joint contact forces and moments were measured with instrumented implants in 2 patients during wheelchair propulsion on different surfaces. The results can be used to improve mathematical models using the measured data as a gold standard.

METHODS:
To measure the loads in the glenohumeral joint, a BIOMET Biomodular shoulder hemi-prosthesis was equipped with 6 strain gages, a 9-channel telemetry, and a coil for inductive power supply [3]. Two patients (S2R, 83 kg, 63yrs; S3L, 72 kg, 71yrs) with these implants and preserved glenoid performed wheelchair propulsion on smooth indoor surface, street paving, cobblestones and dry lawn (approx.10cm height). The patients rode along a 10 m track at a self chosen speed. Maximum resultant forces and moments were averaged over at least 10 strokes from several trials. The initial and braking strokes were excluded from data processing. Data from patient S3L with the implant on the left side were mirrored to the right side.

Measurements were performed after complete recovery from shoulder surgery 18 (S2R) and 16 (S3L) month postoperatively with approval of the ethics committee and informed consent of the patients. All data are measured in the ISB coordinate system.

RESULTS:
As expected, highest resultant forces and moments were reached on the lawn surface (Fig.1). But no clear trend was found for the other three surfaces. On lawn the highest force occurred at the pushing phase (Fig.2, left index C). This force peak was very pronounced for the very competitive patient S2R, who also reached a higher speed than S3L. For the other floor conditions and the female patient S3L the hand lift off in the most forward position (A) and/or the shoulder extension before grabbing the wheel (B) caused the same or even higher forces. The contact moments in S3L were approx. three times higher than in S2R on all floors (Fig. 1, bottom).

DISCUSSION:
This study showed that the shoulder joint force increases clearly when riding a wheelchair on lawn compared to other floors with lower rolling resistance. Some observations like the lower forces on pavement than on indoor floor can not be explained without further investigation. The muscle strength of the patient seems to be decisive for the joint force especially for the force peak during the pushing phase. At low resistance and in weaker patients, the backward motion of the arm can lead to the same or higher forces than the actual pushing movement. The strongly differing contact moments between patients on all surfaces lead to the assumption that individual friction parameters in the humeral-glenoid joint are more important for the contact moments than the surface or rolling resistance. Measurements with more patients on a treadmill at defined velocities and inclinations are planned for the future.

REFERENCES:

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