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Title
The coefficient of friction of wheelchair seats as a risk assessment for potential pressure ulcers

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Summary
Pressure ulcers in wheelchair users are caused by shear stress. We investigated the kinetic coefficient of friction (COF) of 5 wheelchair seats. The lowest COF measured (0.35-0.4) was still too high. We recommend a very low COF surface combined with a concave seat to reduce the ulcer risk.

Introduction/ basics
The prevalence of pressure ulcers in wheelchair users, depending on the cohort investigated, ranges from 17.6% [1] to 58% [2]. Pressure ulcers are localised damage to the skin caused by the combination of pressure and shear [3]. Shear stress reduces and disrupts the blood flow [4,5]. Consequently, recommendations for preventing pressure ulcers aim at avoiding shear forces by using fabrics with a low coefficient of friction (COF) [3,4]. However, a support surface that has a too low COF might pose a safety risk, leading to sliding off the surface [4,6]. The COF is the ratio of shear force to normal force (or pressure), at the point to impending slippage (static) or sliding (kinetic). If static friction builds up on the skin, the only passive relief is achieved by sliding friction when exceeding the point of impending slippage. The aim of this study is to investigate the kinetic COF of commercially available wheelchair seats to identify potential risks for pressure ulcers.

Material method; implementation/ process
We investigated 5 wheelchair cushions (Fig. 1): Melrose Seat (M); ROHO dry flotation cushion (R); JAY J2 (J); StimuLITE Honeycomb Cushion (S); and AFG air cushion (A). The cushions were tied to a Kistler force plate, and a wooden board was placed on top of the cushions. The board was covered with 3 different materials (smooth and slippery nylon fabric, and 2 different slip stoppers: magic stop and rug pad). We pulled the 3 different materials (together with the

board) against the 5 wheelchair cushions by placing two 10 kg barbell plates on the board. The friction and normal forces were recorded with the force plate, and the COF was calculated during the sliding process from the force ratio. The R and J cushions were tested against the 3 materials without their covers, and also tested against their own fabric covers.

Results

The COF of A, M and R cushions against the smooth nylon fabric ranged from 0.35 to 0.4; COF of S was 0.65, and of J 0.95-1.05 (Fig. 2). The COF of the rug pad against the 5 cushions was: 0.7 (S); 0.75 (A); 0.8 (M); 1-1.1 (R); 1.2 (J). The COF of the magic stop against the 5 cushions was: 1.05 (S); 1.1-1.15 (R); 1.15 (J); 1.15-1.2 (M); 1.2 (A).

The COF of J against the cover of J was 0.6-0.65. The COF of R against top and bottom covers of J was 0.4 and 0.65, respectively. Any higher-friction material placed above the top cover will not influence this COF of 0.4, as 0.4 is the point of least resistance in this scenario. Any lower-friction material placed above the top cover will shift the point of least resistance to the lower-friction material.

The COF of M and A cushions increased from 0.35-0.4 (smooth nylon fabric), over 0.75-0.8 (rug pad) to 1.15-1.2 (magic stop). In contrast to this, the COF of S was similar (0.65-0.7) against the fabric and the rug pad and then jumped to 1.05 against the magic stop. The COF of R jumped from 0.35-0.4 (fabric) to 1.05-1.15 (slip stoppers). The COF of J was worst, 1-1.2 against the fabric and the slip stoppers, owing to the sticky rubber surface of its fluid pads.

Discussion/ conclusion; conclusion for the practice

The COF depends on the interaction of two surfaces. Using slip stoppers during the testing process seems impractical, however logical when considering that J, R, and S were rubber based (without covers), and A and M cushions were fabric based. Rubber based surfaces act like slip stoppers. This is clearly seen by the fact, that the slip stopper 'rug pad' performed better against the rubbery S cushion (COF: 0.7) than the fabric-based A and M cushions (COF: 0.75-0.8). Thus, it suffices when only one surface is made of a rubbery slip stopper material to increase the COF drastically. The same effect is seen in the slip stopper 'magic stop' that yet again performed (slightly) better against S than against the remaining 4 cushions combined. From a safety risk perspective, it does make sense to design the cushion surface with a slip stopping effect. However, from a medical point of view, these seats pose a high risk of causing pressure ulcers. Even the lowest COF value of 0.35-0.4 (A, M, R against the fabric; and R against its top cover, thereby mitigating its slip stop effect) is still too high, as the shear force (per unit area) is 35-40% of the normal force (per unit area). We recommend addressing the COF issue by using cushion surfaces made of, or coated with, low friction fluoropolymers such as PTFE (Teflon) and suggest addressing the friction – safety risk trade-off by implementing ergonomically and anatomically shaped, concave cushions (Fig. 3) to prevent sliding off the seat.

References

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Image: Figure 1 Seats_95.jpg

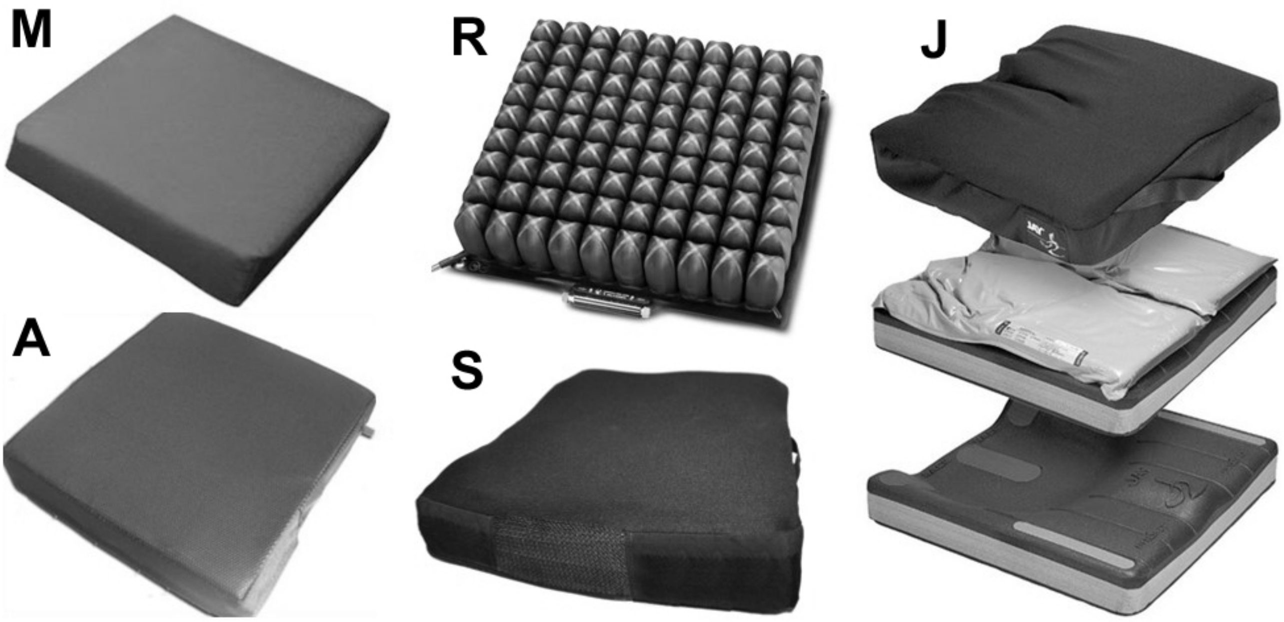

Image: Figure 2 COF_96.jpg

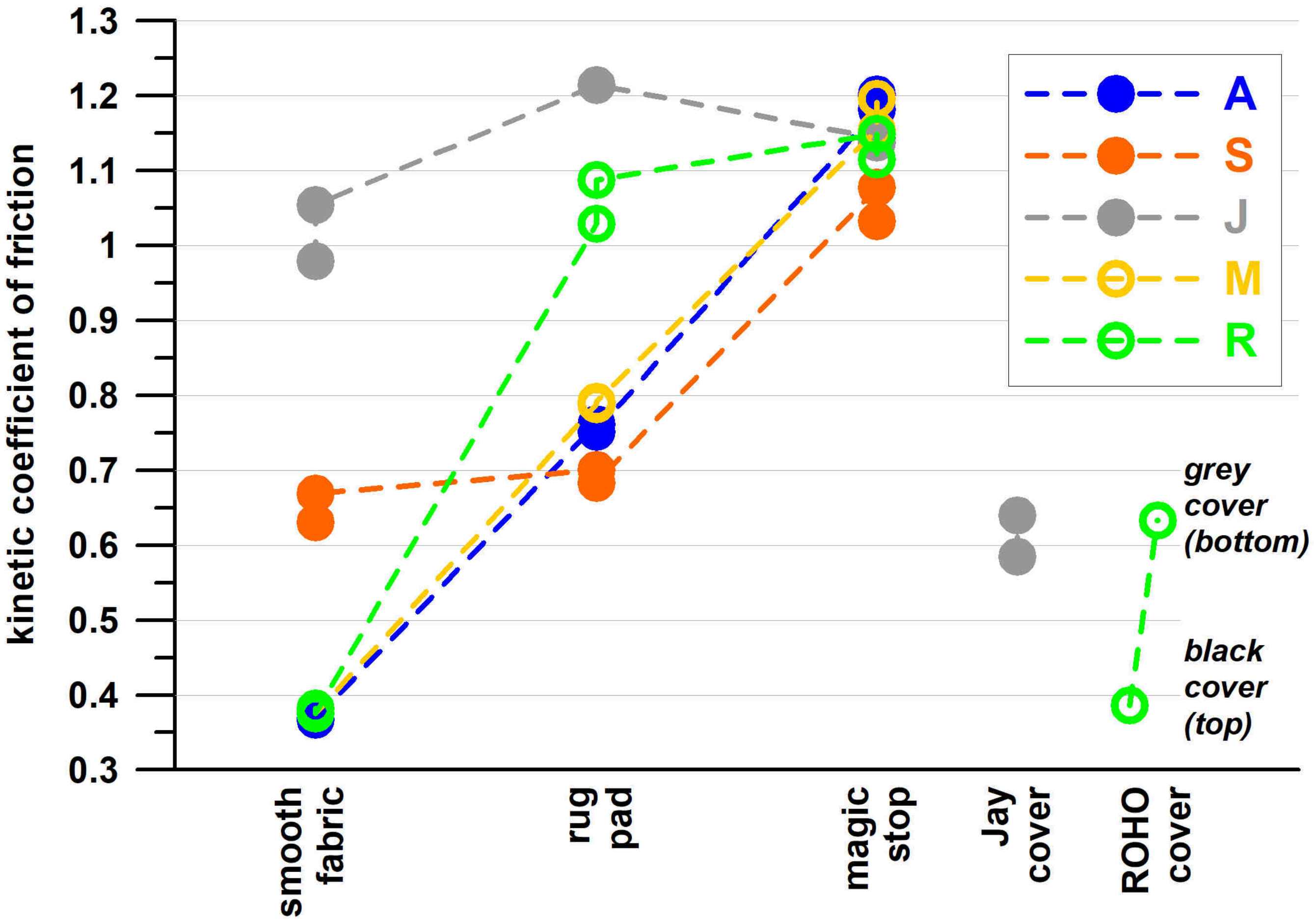

Image: Figure 3 FBD_97.jpg