Wheelchair tilt in space and recline functions: influence on seat interface pressure and ischial blood flow in an aged population

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Summary
Sitting interface pressure and ischial blood flow parameters were examined in 20 healthy elderly subjects whilst seated in a tilt-in-space and recline wheelchair (Rea Dahlia 45, Invacare®). Five different seat tilt angles (5°, 15°, 25°, 35°, 45°) were assessed in combination with three different backrest recline angles (5°, 15°, 30°).

Aims & Objectives
To examine if tilt-in-space and recline functions of a wheelchair decrease sitting interface pressure.
To examine if tilt-in-space and recline functions of a wheelchair increase ischial blood flow.
To understand the relationship between tilt-in-space and recline and both blood flow and interface pressure in physiologically healthy elderly subjects.

Background
7 males and 13 females with an average age of 79 years, participated in this study. Subjects had to be at least 60 years old and were excluded if they were wheelchair users, suffered from acute musculoskeletal injury, cognitive impairment, blood pressure disorders or peripheral arterial disease. Participants were recruited in collaboration with two nursing homes, and ethical approval was granted with all participants providing written informed consent. The (Invacare®) Rea Dahlia 45 wheelchair with Flo-shape seat cushion and Flex3 backrest was selected due to its passive tilt-in-space design. Depending on the height and weight of the subject, a small or large model Dahlia was used.

The wheelchair was fitted with two spirit levels to measure tilt and recline angles, and was adjusted for each subject. Attention was paid to the hamstring muscles to prevent pelvic movement, and pelvic position was monitored throughout. Neck pillows were used for additional comfort as needed. Five tilt angles (5°, 15°, 25°, 35°, 45°T) were combined with three backrest recline angles (5°, 15°, 30°R). To avoid excessive sitting periods, the 15°T/15°R and 35°T/15°R combinations were excluded. To minimise pelvic movement and sliding the tilt angle was always adjusted prior to recline angle. The order of the twelve different conditions (tilt & recline) was randomised. Prior to every test position, subjects were placed into the upright reference posture.

Sitting interface pressure was recorded using a pressure sensor mat (Novel Pliance™). The Oxygen to See (O2C) system was used to record blood flow parameters. The system combines a laser Doppler flowmeter with a tissue spectrometer that allows the capture of blood flow (BF), blood flow velocity (BFV), and relative amounts of haemoglobin (rHb) in arbitrary units (AU).

Prior to each measurement, the left ischial tuberosity was palpated while subjects lay on their right side with their hips and knees flexed to 90°, the O2C system was then attached to the skin. The pressure mat was fixed over the seat cushion, and taped to prevent sliding. Once seated, subjects' feet were taped to the foot support to prevent lower limb movement. Both blood circulation and pressure parameters were recorded at a frequency of 1 Hz.

To avoid peaks in pressure due to the O2C system, only pressure values on the right half of the body were considered. BF and rHb values were filtered at 0.1 Hz using a 5th order low pass Butterworth filter (27). The last 20 seconds of each (150 second) measurement period were used to calculate mean sitting pressure (33) (only pressure values greater than 0 kPa were considered) and the average of all blood parameters. Data processing was performed using MATLAB (MathWorks®).

A repeated linear mixed model was used to analyse the influence of the test positions on the mean sitting pressure and blood parameters. Subjects were random factors and the covariance type "compound symmetry" for repeated measures was used. A Bonferroni post-hoc test was performed to compare the different test positions individually. The significance level was set at $p<0.05$. All statistical analyses were performed using the IBM SPSS-Software

Discussion

Pressure ulcers (PUs) remain a major challenge for healthcare services globally. Wheelchair users are constrained to prolonged periods of sitting, putting them at increased risk of PU development, thus necessitating effective prevention strategies that enable a reduction of mechanical load at the ischial tuberosities. This study has demonstrated that tilt-in-space and recline wheelchair functions are able to effectively reduce sitting interface pressure and increase ischial blood flow.

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