IMPACT OF TILT-IN-SPACE ANGLE ON PRESSURE REDUCTION FOR INDIVIDUALS WITH SPINAL CORD INJURY

Ed Giesbrecht[1], Karen Ethans[1], Douglas Staley[2]
[1]University of Manitoba, [2]St. Boniface General Hospital

INTRODUCTION

Individuals with spinal cord injury (SCI) are at particularly high risk for developing pressure ulcers (1). Impaired sensation can impede the ability to recognize the discomfort that precipitates tissue damage due to hypoxia and signals the need to adjust posture for pressure relief. The loss of motor function and postural control can also impact the capacity for individuals with SCI to perform pressure-redistributing maneuvers such as repositioning, leaning and 'push-ups'. One strategy commonly used to redistribute pressure from the buttocks is a tilt-in-space (TIS) wheelchair. A TIS wheelchair rotates the seat and backrest as a unit within the frame of the wheelchair, in essence tipping the user into a more recumbent position. In an upright position, gravity pushes the buttocks directly against the wheelchair seat. As the TIS wheelchair tilts backward, this force is reduced and pressure is redistributed to other surface areas, most notably the backrest.

Tilting the wheelchair may have other benefits, such as improving postural control and stability, improving digestion, and even improving the biomechanics of wheelchair propulsion (2-4). However, there are also potential negative implications for its use. TIS wheelchairs are typically larger and heavier, which may limit accessibility particularly when positioned in large tilt angles, and may be more costly than a conventional wheelchair (5). Because of these factors, TIS wheelchairs on the market provide varying capacities for tilt angle and those with larger tilt angle range are often more costly.

Given the multiple benefits and limitations of the TIS wheelchair design, clinicians may prescribe them for a number of reasons. The most frequent rationale, however, is for redistribution of pressure as a strategy for reducing risk of pressure ulcers and increasing user comfort. It has been clearly substantiated that the larger the angle of tilt, the greater the reduction of pressure at the interface between the buttocks and seat cushion. However, given the various implications (both positive and negative) of increasing tilt angle, clinicians must negotiate these variables in order to provide an optimal recommendation for wheelchair prescription. Best practice suggests that the clinical reasoning process incorporate user-specific needs and preferences, clinical experience, and empirical evidence.

For clinicians working with individuals with SCI, evidence that provided information about the relative pressure reduction benefit of incremental angles of tilt would be practically useful for discerning both the type of wheelchair (i.e., required tilt range) as well as the specific tilt angle prescribed for each unique client. Consequently, the objectives of this study were to: 1) measure the relative pressure reduction at the ischial tuberosities (IT) and sacrum for 10° increments of tilt among individuals with SCI; 2) compare subgroups with tetraplegia and paraplegia to determine whether level of injury might influence pressure reduction patterns; and 3) compare SCI results with healthy participants from a pilot study to determine whether TIS impacts diagnostic groups differently.

METHODS

This was a repeated-measures design study. A total of 18 participants were recruited through an out-patient SCI clinic in a Canadian tertiary care rehabilitation hospital. Participants ranged in age from 26 to 53 years (Mean 42.6) and from 1 to 31 years post-injury (Mean 18.2). Ten were tetraplegic and all but one were male. Participants were seated in the study TIS wheelchair (Quickie Iris with a Jay2

cushion) using a standardized positioning protocol. Interface pressure (IP) at the left and right IT and the sacrum was measured using the Force Sensitive Application pressure mapping system calibrated to 300 mmHg by the manufacturer. IP was measured at neutral (0°) and then subsequently at 10° increments from 10° to 50°; a 10-second pressure reading was taken at each angle to reduce the impact of aberrant readings. Peak Pressure Index (PPI) was used to calculate maximum pressure at the three sites. PPI is an average value of four adjacent pressure sensors covering an area of 9-10 cm^2, providing greater stability than using a single-sensor value (6). Pressure values and relative pressure reduction were compared between the IT using t-tests, and relative pressure reduction with increasing tilt angle was analyzed using repeated measures ANOVA. Differences between the tetraplegic and paraplegic groups were compared using independent groups t-tests, and between the SCI and Healthy (pilot study) groups using repeated-measures ANOVA.

RESULTS

When the data collected from the left and right IT were compared, there were no statistically significant differences for either the mean IPP or the relative reduction in pressure from baseline (0°). The angle of tilt produced a highly significant effect on relative pressure reduction for both IT (p=.000). Relative IP reduction from baseline for the successive tilt angles from 10° to 50° were: 1.5%, 10.9%, 26.2%, 44.8% and 69.2% for the right IT and 5.0%, 13.2%, 27.0%, 49.0% and 72.4% for the Left IT. Each successive 10° tilt produced a larger relative reduction than the preceding one. The initial 10° tilt did not produce a significant reduction in pressure from baseline for either IT, while a marginally significant reduction was obtained at 20° of tilt (Right: p=.034, Left: p=.001). The subsequent increments all produced significant changes in IP (p=.000).

Similarly, at the sacrum, no significant reduction was observed at 10° or 20° of tilt. The mean IP at the sacrum was, in fact, 8.4% higher at 10° compared to baseline, although this increase was not statistically significant (p=.060). Tilt increments beyond 20° all produced a significant reduction in IP at the sacrum (p=.000).

When the tetraplegic and paraplegic subgroups were compared, there were no statistically significant differences in mean IP or relative IP reduction at the IT with tilt angle. The mean IP at the sacrum was higher in the tetraplegic group at 0°, 10°, and 30°; however, the relative reduction in pressure with tilt was not different between the two groups (p=.246).

The SCI study group was also compared with a pilot-study using healthy participants. The pattern of IP reduction between the two groups was significantly different for the Right IT ($F(1,36)=4.58$, p=.039) with the SCI group demonstrating increasingly greater reduction with incremental tilt.

DISCUSSION

For many clinicians, prescribing a TIS wheelchair and client-specific guidelines for positioning is a challenging process that involves negotiating clinical and research evidence as well as the demands, needs and preferences of the user and the context in which they live. Evidence that contributes practically to this process is worthy of pursuit. The results of this study confirm the premise that incremental tilt angle provides increasing pressure reduction at the IT and sacral locations. However, the relationship between tilt angle and IP reduction has been further clarified. The benefits between tilt and pressure-reduction are not simply linear; successive incremental tilts demonstrated increasingly substantial changes from baseline IP. This would suggest that, from the vantage point of pressure redistribution, additional tilt at larger angles produces a greater effect than at smaller angles. Small tilt angles seem better suited to applications where trunk control and stability are being addressed, rather than reducing pressure-related risks (7). Even a tilt of 20° has an effect size of only .5 and reduces IP by less than 15%. Perhaps more concerning is the apparent increase in pressure at the sacrum with these smaller tilt angles. While not a statistically significant difference, the additional loading of the sacrum at 10° may be a clinically important issue for prescribers to be

aware of. Furthermore, the data suggest that pressure reduction at the sacrum is not achieved without at least 30° of tilt.

The TIS intervention produced a comparable benefit of pressure reduction for the tetraplegic and paraplegic subgroups; this was true for both the IT and sacrum locations. However, mean sacral IP appeared to be higher in the tetraplegic group. This may be useful knowledge for clinicians. First, it may be that tetraplegics are at higher risk for sacral pressure. This may be a result of greater limitations in trunk control and a tendency to assume a more sacral-sitting posture. Even so, the study results suggest that regardless of initial pressure intensity, whether due to level of injury or other individual-specific factors, the pressure redistributing effects of TIS angle appear to be consistent and comparable.

Interestingly, the SCI group demonstrated more substantial benefits in pressure reduction than the healthy participant pilot-study group. The benefits of TIS appear to be particularly striking for this diagnostic group. While the SCI group had about 30% higher baseline IP values than those in the healthy study (data not shown), separate analysis in both groups indicated relative reduction in pressure was independent of the initial pressure value. The explanation for the apparent additional benefit among those with SCI would be speculative at this point, but may relate to motor function in the non-SCI group that permits some capacity for postural control or potentially distribution of body mass. This question warrants further study. Regardless, both the healthy study group and particularly the SCI group demonstrated greater pressure reduction at the IT than would be predicted using a theoretical model based on the cosine of tilt angle; this was particularly true beyond 30° of tilt.

CONCLUSION

Prescription of a TIS wheelchair and positioning guidelines for individuals with SCI is complex. The individual user needs and abilities must be considered in light of the context of use and the intervention goals. This clinical reasoning process is guided by the users priorities and preferences, clinician experience and empirical evidence. This study provides additional evidence to inform this decision-making process by identifying a relationship between tilt angle and pressure reduction at both the IT and sacrum locations. The benefits of pressure reduction at less than 30° are minimal, particularly with regard to the sacrum, and these small tilt angles seem best suited for addressing postural control and functional issues. The benefits for pressure reduction appear comparable between individuals with tetraplegia and paraplegia, but are more substantial than in a healthy comparison group.

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