# FACTORS AFFECTING LUMBAR KINETICS DURING DEPENDENT TRANSFERS ON AN AIRCRAFT

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## INTRODUCTION

Air travel by people with disabilities poses many challenges to both airport personnel and travelers. Of greatest concern is the potential for injury during the process of transferring a traveler with disabilities between a wheelchair and an aircraft seat. Dependent transfers on board an aircraft are typically performed using a "front-and-rear" technique (Pelosi & Gleeson, 1988), in which the rear transferor bears an estimated 65-75% of the traveler's weight. This places the rear transferor at high risk of a disabling low back injury. To better understand these risks, this study determined the effects of aircraft spatial constraints, transferee weight, and direction of transfer on the lumbar forces and moments in the rear transferor during dependent transfers on an aircraft.

## METHODS

Thirty-three pairs of men (*n* = 42) and women (*n* = 24) worked to transfer two anthropometric dummies between a wheelchair and an airplane seat using the "front-and-rear" technique. The mean ± SD age, height, and mass of the rear transferors were 23.6 ± 4.2 yr, 178.0 ± 7.7cm, and 78.0 ± 13.7 kg. Informed consent was provided.

The transfers were performed in a laboratory simulation of an aircraft interior. A standard economy-class airplane seat was mounted to the floor with the armrests raised. An aircraft aisle wheelchair was placed side-by-side with the seat. A small (mass: 57 kg; height: 165 cm) and a large (mass: 78 kg; height: 178 cm) anthropometric dummy served as the transferee. Removable frames were used to simulate the spatial constraints imposed by the surrounding rows and aisles of seats and the overhead bins.

After instruction, warm-up, and practice, subjects transferred each dummy once for each transfer direction (wheelchair-to-seat, seat-to-wheelchair) under constrained and unconstrained conditions. Transfer positions were self-selected and remained unchanged. The movements of the rear transferor were recorded using a motion capture system. Reaction forces on the feet and thigh were collected using two force plates mounted behind the aircraft seat, flush with the floor, and a custom-built force plate mounted to the aircraft seatback.

Resultant lumbar joint forces and moments were calculated at the level of $L_3/L_4$ using a bottom-up, three-dimensional inverse dynamics approach. These resultant joint forces and moment were then normalized by body weight (BW) and body weight and height (BWxHT), respectively.

Dependent measures consisted of peak lumbar compressive forces (i.e. lumbar loading) and peak lumbar moments about the three principal axes of motion. Three-way repeated measures ANOVA were used to test the effects of dummy size, constraint, and transfer direction on the dependent variables. Pearson correlations to body weight were also computed. Effects were considered significant at $\alpha < .05$.

## RESULTS AND DISCUSSION

Transferee size had the most notable influence on lumbar kinetics during the dependent transfers (Table 1). Transfers of the large transferee resulted in greater lumbar loading, as well as increased extension, bending, and twisting moments ($p<0.001$). On average, the lumbar loading was 14% BW greater while transferring the large dummy compared to the small dummy.

The constraints imposed by the interior of the aircraft had relatively little effect on lumbar kinetics, resulting in only a slight decrease (0.5% BWxHT) in bending moment during the transfers (Table 1). This decrease in bending moment of the rear transferor may be related to the inability of the front transferor to shift laterally during the transfer under constrained conditions.

The direction of transfer appeared to have no influence on lumbar moments, whereas increased lumbar loading occurred during outboard transfers (~ 4% BW). It may be that, during inboard transfers, the high seatback provides support during initiation of the transfer, decreasing lumbar loading.

Lumbar loading was inversely related to the body weight of the individual performing the transfer (Figure 1; $R^2$=0.53, p=0.001). Lighter transferors experienced larger loading, possibly due to the fact that the weight of the transferee represents a greater proportion of the transferor's body weight.

## SUMMARY/CONCLUSIONS

These results indicate that transfers of larger individuals put the rear transferor at greater risk of low back injury during a dependent transfer on an aircraft, whereas surrounding spatial constraints and the direction of transfer have little effect. The potential for injury also appears to be greater during transfers performed by smaller transferors.

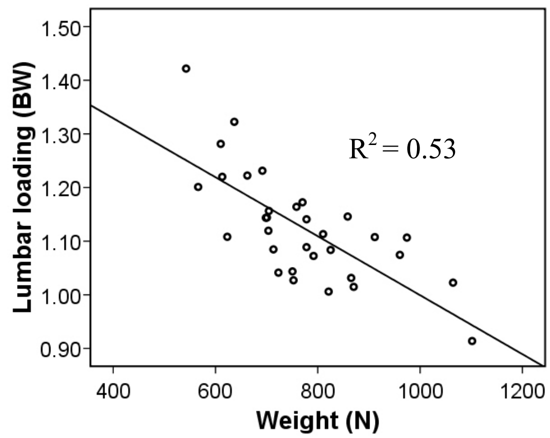


**Figure 1:** Relationship between lumbar loading and transferor weight.

## REFERENCES


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## ACKNOWLEDGEMENTS


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**Table 1:** Influence of transferee size, constraint, and direction of transfer on lumbar loading ($F_c$), and extension ($M_{ext}$), bending ($M_{bend}$), and twisting ($M_{twist}$) moments (mean ± SD). Lumbar loading and moments are expressed as %BW and %BWxHT, respectively. *p<0.001**;** †p<0.01

| | Size | | Constraint | | Direction | |
|---|---|---|---|---|---|---|
| | Small | Large | Constrained | Unconstrained | Inboard | Outboard |
| $F_c$ | 109.2 ± 14.7 * | 123.2 ± 20.9 | 116.5 ± 18.7 | 115.8 ± 17.0 | 114.2 ± 18.7 * | 118.1 ± 17.0 |
| $M_{ext}$ | 18.0 ± 2.8 * | 21.2 ± 5.1 | 19.7 ± 4.0 | 19.4 ± 4.0 | 19.5 ± 4.0 | 19.5 ± 4.0 |
| $M_{bend}$ | 3.8 ± 1.1 * | 5.1 ± 1.1 | 4.2 ± 1.1 † | 4.7 ±1.1 | 4.5 ± 1.1 | 4.3 ± 1.1 |
| $M_{twist}$ | 2.9 ± 1.1 * | 3.8 ± 1.1 | 3.4 ± 1.1 | 3.3 ± 1.1 | 3.4 ± 1.1 | 3.3 ± 1.1 |