

EVALUATION OF POWERED WHEELCHAIRS WITH SUSPENSION AND EXPOSURE TO WHOLE-BODY VIBRATION

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Introduction

Although wheelchair users are regularly subjected to whole-body vibrations little research has been conducted to assess these vibrations or attempt to reduce them [2,3,5]. Most of the wheelchair and whole-body vibration research done to this point has been conducted on manual wheelchairs. Van Sickle et al showed that manual wheelchair propulsion over a simulated road course produces vibration loads that exceed the ISO 2631-1 standards for the fatigue-decreased proficiency boundary at the seat of the wheelchair as well as the head of the user [6]. In a study by Boninger et al [1], 66% of wheelchair users reported neck pain since acquiring their wheelchair. One of the key reasons believed to be the cause of pain, was the exposure to whole-body vibration. Kwarciak et al [4] and Wolf et al [7] performed similar studies using two methods of analysis to evaluate vibrations on suspension and non-suspension wheelchairs while descending curbs of varying heights. Both studies revealed no significant difference in the abilities of the wheelchairs to reduce the amounts of vibrations transferred to the wheelchair user. Although the efforts of wheelchair companies to reduce the amounts of whole-body vibration transmitted to wheelchair users through the addition of suspension systems is encouraging, the technology is not yet ideal. Additionally, the research to date has focused on manual wheelchairs exclusively, while little attention has been shown to powered wheelchairs.

Methods

This study includes the use of two suspension electric powered wheelchairs: The Quickie S-626 and the Invacare 3G Torque SP Storm Series. Each subject tested all of the configurations of the suspension wheelchairs. These included the Invacare with suspension, the Quickie with suspension set to three settings (most stiff, least stiff, and 50% stiffness), and both wheelchairs with solid inserts to act as non-suspension wheelchairs. Sixteen able bodied subjects have been recruited for this study so far. In each of the configurations of the wheelchairs, the subjects traversed an Activities of Daily Living (ADL) course. Vibrations were collected from a tri-axial accelerometer attached to a seat plate beneath the cushion during driving over the activities course. A mixed model ANOVA was used to determine if there were differences between suspensions based on Vibration Dose Value (VDV).

Results

Statistical analyses of the VDV data revealed significant differences between the six different suspensions over each of the obstacles in the activities of daily living course. Post-hoc analyses revealed that for each of the obstacles, significant differences existed between the Invacare suspension and the Invacare solid insert. For the Quickie power wheelchair the solid insert setting was not significantly different from the most-stiff setting for each of the obstacles

except the smooth surface. The solid insert setting was significantly different than the lowest and mid stiffness settings for all of the obstacles except the smooth surface and the deck surface.

Table 1 – Average and total VDV values ($\text{m/s}^{1.75}$) for each suspension setting

	Invacare Insert	Invacare Suspension	Quickie Insert	Quickie Least Stiff	Quickie Mid-Stiff	Quickie Most Stiff
Deck	0.23	0.26	0.25	0.23	0.23	0.25
Door	1.07	0.72	0.81	0.56	0.51	0.77
Curb	2.45	1.56	2.87	1.41	2.06	2.78
Dimple	0.69	0.61	0.69	0.59	0.58	0.68
Smooth	0.14	0.11	0.14	0.12	0.12	0.15
Carpet	1.00	0.83	1.16	0.71	0.70	1.02
Total VDV	2.55	1.65	2.91	1.55	2.10	2.87

Discussion

Although most of the suspension systems are capable of reducing the amounts of vibration transmitted to the users, the exception being the Quickie S-626 with the most-stiff suspension setting (this setting was not significantly different from the solid insert setting for all obstacles except the smooth surface), the results of the vibration dose values seem to indicate that they may not reduce them enough to reduce probability of injury in powered wheelchair users. When examining the total VDV over the entire activities of daily living course, in relation to the Health Guidance Caution Zone (HGCZ), there is not significant time allowed before WBVs are considered dangerous.

The information on the transmissions of vibrations from different suspension systems can lead to improvement in their design and function allowing powered wheelchairs to adequately reduce the amount of whole-body vibrations experienced by their users. Future research should investigate vibrations experienced by wheelchair users in real environments over extended periods of time.

References

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