Does using in-wheel suspension help to reduce neck and back pain over time?

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Introduction: 60% of manual wheelchair users (MWUs) report neck and/or back pain and 40% modify daily activities as a result (Ref 1). Prolonged sitting, awkward postures, working with hands above shoulder level and whole body vibration (WBV) are risk factors. MWUs living in the community are exposed to WBVs from the surfaces they ride on.

Figures 1 and 2: Targeted efforts to reduce WBV with in-frame and front caster suspension show mixed results

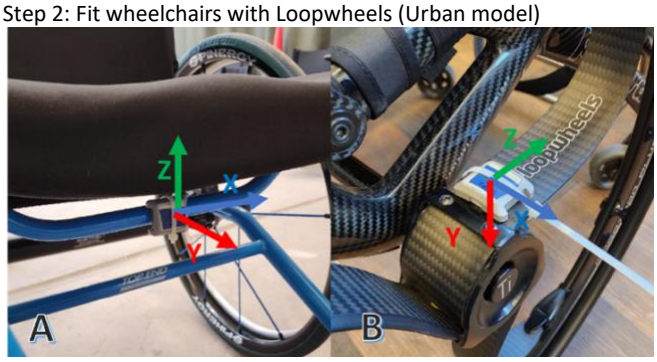
*Figure 2: Loopwheel. In-wheel suspension is a novel approach which can easily retrofit onto existing wheelchair frames. Two previous studies (ref 2, 3) tested in-wheel suspension **in a controlled laboratory setting** only.*

Study aims: Conduct a longitudinal (12 week) study on Loopwheels during home/community use, and investigate effects on WBV, pain, fatigue and participation: **Hypotheses: 1:** MWUs will report significantly less neck pain, back pain, and fatigue; **2:** MWUs will encounter more environmental features & avoid fewer obstacles; **3:** Community WBV exposure will be within safe levels of HGCZ

Methodology: Experimental protocol. Step 1: Baseline questionnaires

- International SCI Pain Data Set: Number of pain problems (0 to 5 or more) and Pain interference (3 questions) ranging from 0 (no interference) to 10 (extreme interference) over the last week
- Numerical rating scale for Pain: Neck, upper back and lower back areas over the last 24 hours from 0 (no pain) to 10 (worst pain imaginable)
- Fatigability Index for SCI: 4 questions about fatigue caused by wheelchair use over last 24 hours from 0 (no fatigue) to 3 (extreme fatigue)
- Environmental Aspects of Mobility Questionnaire (EAMQ): 36 items: Encounters (scores range 21 to 105) and Avoidance (15 to 75) of obstacles

Step 2: Fit wheelchairs with Loopwheels (Urban model)



Step 3: Mid way fitted with Verisense IMU Sensors ~10 days of data

- Frame sensor (A) collected accelerations
- Wheel sensor (B) collected distance and propulsion activity
- 52 Hz sampling frequency

Step 4: Post-intervention completion of baseline questionnaires

Data Analysis: Questionnaire scores analyzed pre-post using Wilcoxon Ranked Sign test or paired t-test. For sensor data, distance & propulsion minutes in a day determined and averaged over data collection days; Daily average root mean square (RMS) and shock vibrational dose values (VDV) values determined during periods of propulsion and non-propulsion for entire day, averaged over all data collection days

Participants and Results:

N: 26

2 dropped out, 24 completed.

Age (years)		43 ± 12
Height (m)		1.7 ± 0.1
Weight (kg)		83.4 ± 18.0
Time since SCI (years)		18.7 ± 14.9
Gender:	Male	18 (75%)
	Female	6 (25%)
ASIA Scale	A	12 (50%)
	B	4 (17%)
	C	2 (8%)
	D	6 (25%)

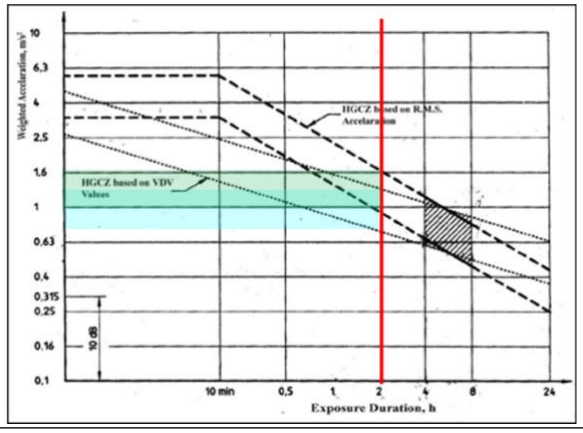
1. Health Outcomes

Outcomes	Baseline	Post	Pvalue
Weekly Pain Interference (0-10)	**3.5 (2.8) 3.0**	**2.0 (2.4) 0.5**	**0.02**
Number Pain Problems (0-5+)	**2.7 (1.6) 3.0**	**1.6 (1.8) 1.5**	**0.01**
Fatiguability Index (0-3)	**1.7 (0.7) 1.8**	**1.4 (0.4) 1.5**	**0.01**
NRS Neck Pain (0-10)	**2.6 (2.9) 1.5**	**1.1 (1.9) 0**	**0.01**

2. Community Activity and Vibration

Outcomes	Average	Std Dev
Daily Distance (meters)	1208.1	969.5
Daily Propulsion Time (minutes)	114.2	80.5
Propulsion RMS (m/s^2)	0.29	0.16
No Propulsion RMS (m/s^2)	0.13	0.07
Propulsion VDV (m/s^1.75)	8.7	4.8
No Propulsion VDV (m/s^1.75)	9.9	3.7

3. Comparison to Health Guidance Caution Zone (HGCZ)



Discussion:

Reduction in RMS vibrations: Prior community based vibration study found average daily RMS = 0.83 (0.17) m/s^2 and 17.3 (3.2) m/s^1.75 VDV (Ref 4) **Loopwheels showed ~35% less RMS and ~50% less VDV** This study showed Loopwheels MWUs should be able to propel up to 14-16 hours per day before being exposed to a harmful amount of WBV

Wide range of feedback relate to performance and acceptability. Positives: a smoother ride and shock absorption; Negatives: weight (0.5kg higher than spoked wheel) and increased propulsion cost (Ref 3)

Conclusions / Clinical Implications:

In-wheel suspension is a potential option to consider to support individuals who experience neck/back pain with propulsion. Given the weight and propulsion costs it could be a very good option for users of power assist (add-on) devices and those that spend a lot of time on outdoor terrain.

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