The Impact of Powered Exoskeleton Technology on Posture and Respiratory Function in Spinal Cord Injured Individuals

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Background

- After SCI paralysis and loss of upright function resulting in wheelchair use is common.
- Long term wheelchair use is linked to impaired posture and respiratory function. Specifically, serious posture-related chronic health problems affect individuals with mid-thoracic SCI[1].
- SCI can cause compensatory posture mechanisms at the pelvis, Tsp and Lsp[2].
- Recent innovations have made powered exoskeletons available for SCI users allowing a range of previously impractical functional exercise to be considered.

Objective

To compare lumbothoracic, cervicocranial and upper limb postural measures and peak expiratory flow (PEF) in wheelchair users before, during and after therapeutic intervention using the ReWalk™.

Methods

Six wheelchair users (5 male, 1 female, injury site C3 –T12, age=43 ± 8.2 years) diagnosed with complete (American Spinal Injury Association (ASIA) classification A; n=3) and incomplete (ASIA B-C; n=3) SCI completed testing. Measurements completed with the participant sitting in their wheelchair (SIT_PRE), followed immediately by standing in the powered exoskeleton (STAND) and finally again sitting in their wheelchair after exoskeleton use (SIT_POST).

Postural Analysis

Sagittal plane photographic measurement of the: sagittal head angle (**SHA**), cervical angle (**CA**), protraction/ retraction angle (**PRA**), arm angle (**AA**) and thoracic angle (**TA**) following the procedures of van Niekerk et al.[3]

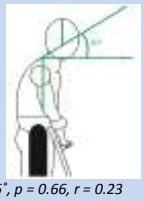
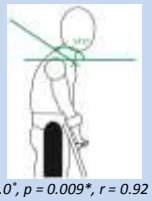
Peak Expiratory Flow Rate (PEF)

- Mini-Wright Peak Flow Meter (open circuit method)
- Three practice efforts.
- Mean score calculated from three maximal efforts

Statistical Analysis

Paired sample t-tests analysed significant difference in postural measures and PEF; SIT_PRE:SIT_POST, and SIT_PRE:STAND. Statistical significance was set at $p \leq 0.05$ and Cohen's effect size (r) was also calculated to investigate clinical relevance.

Results: Posture

	SIT_PRE	SIT_POST	STAND
SHA			
	SIT_PRE:SIT_POST -> 2.0 ± 6.6°, p = 0.54, r = 0.32; SIT_PRE:STAND -> 0.8 ± 7.9°, p = 0.83, r = 0.11		
CA			
	SIT_PRE:SIT_POST -> 3.6 ± 4.8°, p = 0.17, r = 0.64; SIT_PRE:STAND -> 1.0 ± 4.6°, p = 0.66, r = 0.23		
PRA			
	SIT_PRE:SIT_POST -> 13.2 ± 13.7°, p = 0.09, r = 0.73; SIT_PRE:STAND -> 36.2 ± 17.0°, p = 0.009, r = 0.92*		
AA			
	SIT_PRE:SIT_POST -> -4.2 ± 10.35°, p = 0.42, r = 0.41; SIT_PRE:STAND -> -7.0 ± 19.0°, p = 0.46, r = 0.38		
TA			
	SIT_PRE:SIT_POST -> 1.2 ± 5.0°, p = 0.62, r = 0.26; SIT_PRE:STAND -> Not assessed due to exoskeleton backpack		

Results: PEF

	SIT_PRE	SIT_POST	STAND
PEF (L/min)	427.8 ±89.9	440.0 ±77.8	407.8 ±84.7
	SIT_PRE:SIT_POST - Change = 12.22 ±18.6, T (DF) = -1.609 (5), p = 0.17; SIT_PRE:STAND - Change = -20.00 ±44.8, T (DF) = 1.095 (5), p = 0.32		

Conclusion

- High variability in participants, though possible proof of concept that walking in an exoskeleton can positively affect respiratory function, perhaps through improved diaphragmatic and intercostal efficiency.
- Pattern of changes may suggest apical breathing was enhanced accounting for the 12.22 L/min (2.85%) increase in PEF which had a large effect size.
- Further research should consider a comparison of therapeutic exoskeleton use with other forms of exercise.

References

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