Bowel Function

Bowel function and how it changes with exoskeleton usage is beginning to be explored in the literature. The majority of the articles (11) look at subjects with spinal cord injury (SCI), while one examines patients with stroke (CVA). Bowel function is mostly discussed in case series (5) or review articles (5). A variety of exoskeletons have been used, and sometimes more than one is used in a single study. Of those that only examine a single device, 2 utilize the Ekso1.1/GT/NR device, referred to as “Ekso” in this paper, and 3 utilize the ReWalk.

Spinal Cord Injury (SCI)

Six articles look specifically at participants with spinal cord injuries. One that only looked at bowel function was a crossover study of 50 individuals where the participants were randomized to which block they received first: 12 weeks of usual activity or 12 weeks of 3 times per week walking in an exoskeleton (Ekso or ReWalk). After the exoskeleton block, regardless of which block was received first, 12% of participants reported a reduced need for external help and 24% reported reduced evacuation time.[1] Bristol Stool Scale data also showed a trend towards a medium stool consistency (score of 4), which is considered normal, after the exoskeleton block that was not seen during usual care block.[1] The percent of loose stools (grade 5 or 6) reduced from 19.1% pre-exoskeleton block to 9.3% post exoskeleton block, whereas it changed from 19% to 15.2% post usual activity block.[1] Sub group analysis showed that percent change in loose stools was only significant in men post-exoskeleton block.[1] Persons who had been injured for more than 2 years improved in the Bowel Management SCI-QOL tool after the exoskeleton block, while those who were injured more recently showed no change in score.[1]

Most articles looked at bowel function as one of many health metrics. Eleven subjects with chronic SCI walked up to 24 sessions in the ReWalk and subjectively, 5 of them (45.45%) reported improved bowel regulation.[2] A similar study including 21 participants who utilized the ReWalk 3 times a week for 8 weeks saw no change in satisfaction with bowel management, time used for bowel management, or the number of fecal incontinence incidents.[3] This could be confounded by low amount of bowel issues at baseline, with number of fecal incontinence episodes at both baseline and post-intervention being 0, and bowel management satisfaction being 4, mostly satisfied, at baseline and post-intervention.[3] Eleven participants who walked in the Atalante device 4 times a week for 3 weeks showed a trend on the Bristol score towards normalization.[4] Forty-five participants utilized the Indego for 26 sessions in an outpatient clinic, and nine (20%) reported a change in bowel management; with eight of those nine subjects reporting improvement, citing fewer instances of neurogenic bowel dysfunction including less incontinence and constipation, as well as decreased time and assistance required for bowel management.[5] One participant reported worsening bowel management, describing a single isolated incident of bowel incontinence while wearing the Indego.[5]

Participants with both chronic (injury more than one year ago, n=27) and acute (injury less than one year ago, n=25) injuries completed 3 walking sessions with the Ekso 3 times a week for 8 weeks. The acute group, while showing no change on the respiration and sphincter management sub-category, increased on the “bowel” and “use of a toilet” score.[6] The chronically injured group significantly increased their score on the respiration and sphincter management sub-category, with “use of toilet” demonstrating biggest improvement.[6] When

assessed on the International SCI Basic Data Sets, six of the 25 recently injured participants improved on the awareness of the need to defecate, though the chronically injured participants did not change on this item.[6]

In one article where participants were randomized to either continue usual activity at home or begin using the ReWalk at home and in the community, the subjects were asked to self-report on any bowel habit changes.[7] There were no significant between-group differences at any time points, though a limitation was that the ReWalk group did not heavily use the device, averaging only 86 minutes per week.[7]

Stroke (CVA)

The single article examining participants with chronic stroke and the effect of using an exoskeleton on bowel function is a randomized controlled trial that placed participants into either an Ekso group (n=15) or a standard gait training group (n=15), with both groups receiving intervention for 3 sessions a week over 8 weeks. The Ekso group achieved a greater improvement in constipation when measured on the Constipation Scoring System (CONST).[8] Median scores on the CONST decreased from 25 to 15, with higher scores (max of 30) indicating greater constipation and challenge with bowel function.[8]

Review Articles

Four review articles include bowel management in their manuscript, and all focus on subjects with spinal cord injury. Most reviews comment on how exoskeletons seem to help with bowel management and intestinal function.[9–11] One review commented that self-reported measures are used to determine the effect that exoskeletons have on bowel function in all 11 studies included in the paper, and that the scale used can change the results.[12]

Conclusion

The research suggests that bowel function may improve due to consistent exoskeleton usage. Challenges seen in the research when measuring bowel function include the use of many different measuring tools, all of which are subjective. A floor effect is also possible in these measures, where low to minimal issues at baseline could result in no significant interventional effect over the duration of the study because there is minimal room for improvement. Bowel health and function need to be studied more to draw larger conclusions.

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All known articles assessing bowel function in participants using an exoskeleton

Title	Authors	Journal	Device	Diagnosis
Exoskeletal-Assisted Walking in Veterans With Paralysis: A Randomized Clinical Trial	Spungen AM, Dematt EJ, Biswas K, Jones KM, Mi Z, Snodgrass AJ, Morin K, Asselin PK, Cirnigliaro C, Kirshblum S, Gorman PH, Goetz LL, Stenson K, White KT, Hon A, Sabharwal S, Kiratli BJ, Ota D, Bennett B, Berman JE, Castillo D, Lee KK, Eddy BW, Henzel MK, Trbovich M, Holmes SA, Skelton F, Priebe M, Kornfeld SL, Huang GC, Bauman WA	JAMA Netw Open. 2024 Sep 3;7(9):e2431501	ReWalk	SCI
Improvement of quality of life after 2-month exoskeleton training in patients with chronic spinal cord injury	Van Nes IJW, van Dijsseldonk RB, van Herpen FHM, Rijken H, Geurts ACH, Keijsers NLW.	J Spinal Cord Med. 2024 May;47(3):354-360	ReWalk	SCI
The Outcomes of Robotic Rehabilitation Assisted Devices Following Spinal Cord Injury and the Prevention of Secondary Associated Complications	Nistor-Cseppento CD, Gherle A, Negrut N, Bungau SG, Sabau AM, Radu AF, Bungau AF, Tit DM, Uivaraseanu B, Ghitea TC, Uivarosan D	Medicina (Kaunas). 2022 Oct 13;58(10):1447	Multiple – Review Article	SCI
Overground robotic training effects on walking and secondary health conditions in individuals with spinal cord injury: systematic review	Tamburella F, Lorusso M, Tramontano M, Fadlun S, Masciullo M, Scivoletto G	J Neuroeng Rehabil. 2022 Mar 15;19(1):27	Multiple – Review Article	SCI
Knowledge Gaps in Biophysical Changes After Powered Robotic Exoskeleton Walking by Individuals With Spinal Cord Injury-A Scoping Review	Yip CCH, Lam CY, Cheung KMC, Wong YW, Koljonen PA	Front Neurol. 2022 Mar 10:13:792295	Multiple – Review Article	SCI
Evaluation of safety and performance of the self balancing walking system Atalante in patients with complete motor spinal cord injury	Kerdraon J, Previnaire JG, Tucker M, Coignard P, Allegre W, Kanppen E, Ames A	Spinal Cord Ser Cases. 2021 Aug 4;7(1):71	Atalante	SCI
The Effect of Exoskeletal-Assisted Walking on Spinal Cord Injury Bowel Function Results from a Randomized Trial and Comparison to Other Physical Interventions	Gorman PH, Forrest GF, Asselin PK, Scott W, Kornfeld S, Hong E, Spungen AM	J Clin Med. 2021 Mar 2;10(5):964	Ekso, ReWalk	SCI

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Does overground robotic gait training improve non-motor outcomes in patients with chronic stroke? Findings from a pilot study	De Luca R, Maresca G, Balletta T, Cannavò A, Leonardi S, Latella D, Maggio MG, Portaro S, Naro A, Calabrò RS	J Clin Neurosci. 2020 Nov:81:240-245	Ekso	CVA
Exoskeleton gait training after spinal cord injury: An exploratory study on secondary health conditions	Baunsgaard CB, Vig Nissen U, Brust AK, Frotzler A, Ribeill C, Kalke YB, León N, Gómez B, Samuelsson K, Antepohl W, Holmström U, Marklund N, Glott T, Opheim A, Penalva JB, Murillo N, Nachtegaal J, Faber W, Biering-Sørensen F	J Rehabil Med. 2018 Sep 28;50(9):806-813	Ekso	SCI
Examining the Effects of a Powered Exoskeleton on Quality of Life and Secondary Impairments in People Living with Spinal Cord Injury	Juszczak M, Galle E and Bushnik T	Top Spinal Cord Inj Rehabil. 2018 Fall;24(4):336-342	Indego	SCI
Robotic Rehabilitation and Spinal Cord Injury a Narrative Review	Mekki M, Delgado AD, Fry A, Putrino D, Huang V	Neurotherapeutics. 2018 Jul;15(3):604-617	Multiple – Review Article	SCI
The ReWalk powered exoskeleton to restore ambulatory function to individuals with thoracic-level motor-complete spinal cord injury	Esquenazi A, Talaty M, Packel A, Saulino M	Am J Phys Med Rehabil. 2012 Nov;91(11):911-21	ReWalk	SCI

CVA = stroke, SCI = spinal cord injury