

## **Bladder Function**

The effect of walking in an exoskeleton has on bladder health and function has not been thoroughly studied in the literature. All eight known articles focus on participants with spinal cord injuries, and two of those are review articles. Of the articles that look at one or two exoskeleton devices, two utilized on the Ekso1.1/EksoGT/EksoNR, referred to as “Ekso” in this paper, while two more utilize the ReWalk. Scales used to measure bladder function were mostly subjective and included bladder diaries, self-reports, and the SCI basic data set.

### **Spinal Cord Injury (SCI)**

Only one known study uses an objective measure to examine urinary tract function. In this study, five subjects with SCI at least 7 months post injury were randomized to walk in either the Ekso (n=3) or Lokomat (n=2) for 36 sessions over 12 weeks and completed the protocol.<sup>1</sup> The Lokomat is a stationary robotic walking device, as compared to the Ekso which is an overground exoskeleton. Pelvic floor muscle recruitment was tracked using electromyography (EMG) which showed that two of the three Ekso participants had bilateral pelvic floor muscle activity while walking in Ekso.<sup>1</sup> This was not seen in the participants who walked in Lokomat.<sup>1</sup> Urodynamic studies were also completed, but changes were minor and variable across the sample.<sup>1</sup>

Of the trials that examined subjective improvements in bladder function, all were case series. Some found positive effects of exoskeleton training on bladder function. Of twelve subjects who utilized the ReWalk for up to 24 sessions, some reported improvements in bladder function, but what that means was not expanded upon in this manuscript.<sup>2</sup> A similar study used ReWalk for 24 sessions for 21 subjects and found that satisfaction with bladder management improved from a median of 3 to 4 out of a possible 5 points, where higher scores indicate higher satisfaction.<sup>3</sup> In a study of 45 participants who walked in Indego for 26 sessions, only 4 participants reported a positive change in their bladder management routine including decreased incontinence episodes and increased bladder control.<sup>4</sup> The other 41 participants reported no change, with none reporting worsening bladder function.<sup>4</sup>

Some studies, however, showed no changes in bladder function. Eleven subjects completed 12 training sessions with the Atalante over three weeks and no difference was seen in the Qualiveen questionnaire which assesses urinary disorder-specific quality of life.<sup>5</sup> No significant changes in the number of urinary incontinence episodes per week was noted in a study using ReWalk for 24 sessions.<sup>3</sup> Another study of 52 participants who walked in Ekso for 24 sessions demonstrated no change on the bladder score in the Respiration and Sphincter Management sub-category of the SCIM-III.<sup>6</sup>

### **Reviews**

Two review articles include analysis regarding use of an exoskeleton and its impact on bladder function. Both look at a variety of secondary complications. One review only looks at 2 articles that examined bladder function and no significant effects of training were seen.<sup>7</sup> The other review noted that most studies use subjective scales to measure changes in bladder function, and that the choice of which scale is used can change results.<sup>8</sup>



### Conclusion

Only a small number of studies exist that examine changes in bladder function that occur from exoskeleton usage. Of these, there is a mixed consensus, with some studies suggesting that using an exoskeleton improves bladder function and others reporting no change.

## References

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2. Esquenazi A, Talaty M, Packel A, Saulino M. The ReWalk Powered Exoskeleton to Restore Ambulatory Function to Individuals with Thoracic-Level Motor-Complete Spinal Cord Injury. *American Journal of Physical Medicine & Rehabilitation*. 2012;91(11):911-921. doi:10.1097/PHM.0b013e318269d9a3
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4. Juszcak M, Gallo E, Bushnik T. Examining the Effects of a Powered Exoskeleton on Quality of Life and Secondary Impairments in People Living With Spinal Cord Injury. *Topics in Spinal Cord Injury Rehabilitation*. 2018;24(4):336-342. doi:10.1310/sci17-00055
5. Kerdraon J, Previnaire JG, Tucker M, et al. Evaluation of safety and performance of the self balancing walking system Atalante in patients with complete motor spinal cord injury. *Spinal Cord Ser Cases*. 2021;7(1):71. doi:10.1038/s41394-021-00432-3
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7. Tamburella F, Lorusso M, Tramontano M, Fadlun S, Masciullo M, Scivoletto G. Overground robotic training effects on walking and secondary health conditions in individuals with spinal cord injury: systematic review. *J NeuroEngineering Rehabil*. 2022;19(1):27. doi:10.1186/s12984-022-01003-9
8. Yip CCH, Lam CY, Cheung KMC, Wong YW, Koljonen PA. Knowledge Gaps in Biophysical Changes After Powered Robotic Exoskeleton Walking by Individuals With Spinal Cord Injury—A Scoping Review. *Front Neurol*. 2022;13:792295. doi:10.3389/fneur.2022.792295

## All known articles assessing bladder function in participants using an exoskeleton

| Title  | Authors   | Journal  | Device                    | Diagnosis |
|--|---|--|---------------------------|-----------|
| 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       |
| 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       |
| Exoskeleton gait training to improve lower urinary tract function in people with motor-complete spinal cord injury: A randomized pilot trial | Williams AMM, Deegan E, Walter M, Stothers L, Lam T   | J Rehabil Med. 2021 Aug 26;53(8):jrm00222            | Ekso, Lokomat             | 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       |
| 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, Bushnik T  | Top Spinal Cord Inj Rehabil. 2018 Fall;24(4):336-342 | Indego                    | SCI       |
| 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       |
| 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       |

SCI = spinal cord injury