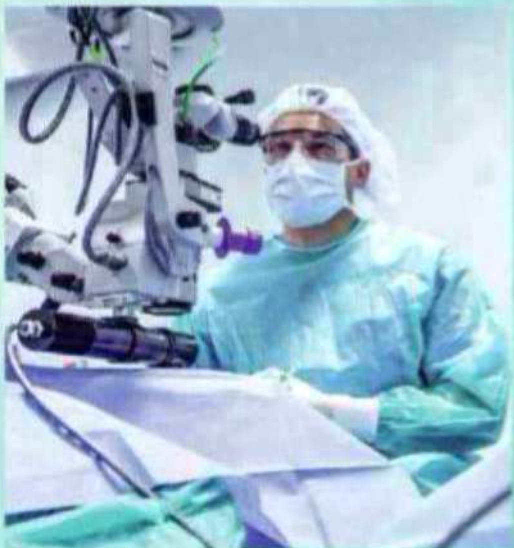
New Day in Medicine
Новый День в Медицине
NDM

TIBBIYOTDA YANGI KUN

Ilmiy referativ, marifiy-ma'naviy jurnal



AVICENNA-MED.UZ

ISSN 2181-712X.
EiSSN 2181-2187

8 (82) 2025

ТИББИЁТДА ЯНГИ КУН
НОВЫЙ ДЕНЬ В МЕДИЦИНЕ
NEW DAY IN MEDICINE

Илмий-реферaтив, маънавий-маърифий журнал
Научно-реферативный,
духовно-просветительский журнал

УЧРЕДИТЕЛИ:

БУХАРСКИЙ ГОСУДАРСТВЕННЫЙ
МЕДИЦИНСКИЙ ИНСТИТУТ
ООО «ТИББИЁТДА ЯНГИ КУН»

Национальный медицинский
исследовательский центр хирургии имени
А.В. Вишневского является генеральным
научно-практическим
консультантом редакции

Журнал был включен в список журнальных
изданий, рецензируемых Высшей
Аттестационной Комиссией
Республики Узбекистан
(Протокол № 201/03 от 30.12.2013 г.)

8 (82)

2025

август

www.bsmi.uz
https://newdaymedicine.com E:
ndmuz@mail.ru
Тел: +99890 8061882

Received: 20.07.2025, Accepted: 06.08.2025, Published: 10.08.2025

UDC 616.

USE OF EXOSKELETON-ASSISTED REHABILITATION IN PATIENTS WITH COMPLICATED THORACOLUMBAR SPINAL INJURIES

[1] Gulomjon Abdugafforovich Boymurodov, https://orcid.org/0009-0002-7548-2115
[2] Yadgarova Shokhsanam Sharafovna https://orcid/0009-0009-6903-4923

[1]National Center for Rehabilitation and Prosthetics for Persons with Disabilities, Tashkent, Uzbekistan
[2]Tashkent Medical University, Tashkent, Uzbekistan

✓ ***Resume***

Patients with complicated thoracolumbar spinal injuries post-surgery require assistive devices to stabilize the body. Traditional corsets have been replaced by advanced fixators that not only provide stabilization but also enhance mobility for walking. Exoskeletons represent a promising solution in this regard. This study aims to enhance rehabilitation outcomes in patients with complicated spinal injuries through early-stage exoskeleton-assisted therapy. We evaluated the inpatient treatment outcomes of 82 patients with complicated thoracolumbar spinal injuries, treated at the Vertebrology Department of the National Center for Rehabilitation and Prosthetics of Persons with Disabilities, Uzbekistan, from 2023 to 2025. The cohort included 66 men and 16 women, divided into two groups: the main group (n=42) received conservative treatment, physical therapy, and exoskeleton-assisted therapy (E-Helper), while the control group (n=40) received only conservative treatment and physical therapy. Outcomes were assessed using the Frankel scale (A–E). Pre-treatment, the main group had 8 patients in category A, 12 in B, and 22 in C; the control group had 7 in A, 18 in B, and 15 in C. Post-treatment results showed superior outcomes in the main group compared to the control group, demonstrating the efficacy of exoskeleton-assisted rehabilitation.

Keywords: Exoskeleton, thoracolumbar spine, complicated injury, rehabilitation, disability.

Introduction

Injuries to the spinal cord, vertebrae, or intervertebral discs are serious conditions with potentially severe consequences, regardless of their extent. The spine, a complex structure comprising muscles, connective tissues, and neural elements, is critical for musculoskeletal function, as well as central, peripheral, and autonomic nervous system activity. Spinal trauma can also affect internal organs through compression or structural changes, leading to unpredictable outcomes.

Spinal injuries constitute approximately 4% of musculoskeletal traumas, with spinal cord and nerve root injuries accounting for 20% of these cases [3]. Paresis and paralysis complicate patient care, early mobilization, and rehabilitation, resulting in long-term disability in up to 80% of cases, as reported by various studies [3]. Outcomes depend heavily on timely surgical intervention and appropriate treatment strategies, including single- or multi-stage surgeries [2,3,4,5,6,7,8].

Modern surgical approaches to complicated spinal fractures emphasize complete decompression of the spinal cord, nerve roots, and vasculature, alongside robust stabilization of the affected segment. These interventions facilitate early mobilization, verticalization, and rehabilitation, reducing hospital stays [4,5,6,7,8].

Exoskeletons, derived from the Greek terms for “external” and “skeleton,” are devices designed to augment human strength via an external framework [1]. The ExoAtlet P, for instance, integrates human and robotic functions through mechano-tactile interactions [8]. Recent literature highlights passive exoskeletons, such as a soft pneumatic model developed by researchers from Carnegie Mellon, Harvard, USC, MIT, and BioScience. This device uses flexible artificial muscles, lightweight sensors, and elastic polymers to replicate the biological structure of the lower leg, enabling ankle movement through artificial tendons and hyperelastic strain gauges. While effective in laboratory settings for a 27-degree range of motion, its flexible materials pose control challenges compared to rigid exoskeletons [9,10]. Exoskeletons reduce metabolic costs during walking, making them valuable for stroke recovery and spinal cord injury rehabilitation [11,12].

Цель исследования: изучит применение экзоскелетной реабилитации у пациентов со сложными травмами грудопоясничного отдела позвоночника

Materials and Methods

This study aimed to improve rehabilitation outcomes for patients with complicated thoracolumbar spinal injuries using exoskeleton-assisted therapy in the early post-injury period.

We conducted a retrospective analysis of 82 patients treated at the Vertebrology Department of the National Center for Rehabilitation and Prosthetics of Persons with Disabilities, Uzbekistan, from 2023 to 2025. The cohort comprised 66 men and 16 women, divided into two groups. The main group (n=42) received conservative treatment, therapeutic exercise, physiotherapy, and exoskeleton-assisted therapy (E-Helper). The control group (n=40) received only conservative treatment, therapeutic exercise, and physiotherapy. All patients underwent clinical and instrumental assessments, including X-ray, multislice computed tomography (MSCT), magnetic resonance imaging (MRI), and electromyography (EMG).

The main group received exoskeleton-assisted therapy (E-Helper) alongside standard interventions, supervised by specialists. The E-Helper system features:

- Rapid customization to patient anthropometric data
- Up to 8 hours of battery life; net weight 28 kg
- Suitable for patients weighing up to 110 kg and height 150–190 cm
- Capabilities for stair climbing and turning
- Integrated microcomputer for patient data and statistics
- Independent motor power adjustment for limbs (useful for hemiparesis)
- Dynamic spasticity assessment via motor effort monitoring
- First-step initiation to detect and amplify minimal muscle efforts
- Functional electrical stimulation (FES) connectors for muscle activity control
-

Figure 1. Design of the E-Helper exoskeleton.

Results and Discussion

Treatment outcomes were evaluated using the Frankel scale (A–E). Pre-treatment, the main group had 8 patients in category A, 12 in B, and 22 in C, while the control group had 7 in A, 18 in B, and 15 in C.

All patients showed positive outcomes post-treatment. After three 12-day inpatient treatment cycles, the main group demonstrated significant improvements: 7 of 8 category A patients progressed to B (1 unchanged), 12 of 14 category B patients progressed to C (2 unchanged), and all category C patients advanced to D. In the control group, only 2 of 7 category A patients moved to B (5 unchanged), 4 of 18 category B patients moved to C (14 unchanged), and 5 of 15 category C patients moved to D (10 unchanged). These results are summarized in Table 1.

Figure 2. Patient B, aged 21, with a complicated lower thoracic spinal injury (Frankel C). After three courses of exoskeleton-assisted rehabilitation, the patient exhibited improved smooth and amplified joint movements in the lower extremities.

Figure 3. Patient C, aged 24, with a complicated upper lumbar spinal injury (Frankel C). After two courses of exoskeleton-assisted rehabilitation, positive dynamics were observed.

Table 1. Frankel scale outcomes before and after treatment

Group	Category	Before treatment (n)	After treatment (n)
Main	A	8	1 (7 to B)
	B	12	2 (10 to C)
	C	22	0 (22 to D)
Control	A	7	5 (2 to B)
	B	18	14 (4 to C)
	C	15	10 (5 to D)
Total Main	D	0	20
Total Control	D	0	5

Conclusions

Patients receiving exoskeleton-assisted rehabilitation alongside standard therapies demonstrated significantly better outcomes compared to the control group. Exoskeleton use reduced staff workload and improved joint movement smoothness in patients with spinal conduction impairments, highlighting its potential in early-stage rehabilitation for complicated thoracolumbar spinal injuries.

LIST OF REFERENCES:

1. Louie, D. R., Eng, J. J., Lam, T. (2015). Gait speed using powered robotic exoskeletons after spinal cord injury: a systematic review and correlational study. //Journal of NeuroEngineering and Rehabilitation, 2015;12(1):82.
2. Miller L. E., Zimmermann, A. K., Herbert, W. G. (2016). Clinical effectiveness and safety of powered exoskeleton-assisted walking in patients with spinal cord injury: systematic review with meta-analysis. // Medical Devices: Evidence and Research, 9, 455–466.
3. Afaunov, A. A., Usikov, V. D., Afaunov, A. I. (2004). Possibilities of transpedicular osteosynthesis in the treatment of injuries of the thoracic and lumbar spine. // Vestnik Travmatologii i Ortopedii, 2004;(4):68–74.
4. Bekov, M. M. (2010). Surgical treatment of injury of the thoracic and adjacent spine and spinal cord [dissertation]. // St. Petersburg. 2010;112 p.
5. Esquenazi A., Talaty M., Packel, A., Saulino M. (2012). 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.
6. Kozlowski, A. J., Bryce, T. N., Dijkers, M. P. (2015). Time and effort required by persons with spinal cord injury to learn to use a powered exoskeleton for assisted walking. // Topics in Spinal Cord Injury Rehabilitation 2015;21(2):110–121.
7. Yang, A., Asselin, P., Knezevic, S., Kornfeld, S., Spungen, A. M. (2015). Assessment of in-hospital walking velocity and level of assistance in a powered exoskeleton in persons with spinal cord injury. // Topics in Spinal Cord Injury Rehabilitation, 2015;21(2):100-109.
8. Hartigan C., Kandilakis C., Dalley S., Clausen M., Wilson, E., Morrison S., ... Farris, R. (2015). Mobility outcomes following five training sessions with a powered exoskeleton. // Topics in Spinal Cord Injury Rehabilitation, 2015;21(2):93–99.
9. Gagnon, D. H., Vermette, M., Duclos, C., Aubertin-Lehëudre, M., Ahmed, S. (2019). Cardiorespiratory demands and physical workload of robotic-assisted walking in non-ambulatory patients with spinal cord injury. // Journal of NeuroEngineering and Rehabilitation, 2019;16(1):131.
10. Baunsgaard, C. B., Nissen, U. V., Brust, A. K., Frotzler, A., Ribelli, M., Kalke, Y. B., ... Norbye, J. M. (2018). Exoskeleton gait training after spinal cord injury: an overview of the field and critical appraisal of the state of the art. // Journal of NeuroEngineering and Rehabilitation, 2018;15(1):117.
11. Moberg, W. T., Harvey, L. A. (2021). The use of exoskeletons in rehabilitation of spinal cord injury: A narrative review. // Journal of Spinal Cord Medicine, 2021;44(1):1-9.
12. van Dijsseldonk, R. B., van Nes, I. J. W., Geurts, A. C. H., Keijsers, N. L. W. (2020). Exoskeleton home use for people with spinal cord injury: A qualitative study of the benefits and barriers. // Journal of NeuroEngineering and Rehabilitation, 2020;17(1):25.

Entered 20.07.2025