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Evaluation of Patients Who Received Robotic Therapy after Spinal Cord Injuries

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Abstract

Background: This study aims to evaluate the effectiveness of the robotic device used in lower limb rehabilitation to reduce motor impairment and improve motor performance in patients with traumatic spinal injury. **Methods:** The data were obtained by retrospective analysis of patients who underwent lower extremity rehabilitation after traumatic spinal injury by robot-assisted rehabilitation in the hospital between December 2017 and December 2019. The results were statistically analyzed and shown as mean ± SD (min-max). **Results:** A total of 51 patients with mean age of 59.51 ± 8.2 (38 - 72) were admitted to the clinic. Mean ages of thirty-one male patients and twenty females patients were 58.74 ± 8.88 (38 - 77) and 60.7 ± 7.09 (44 - 72), respectively. Comparing ages in terms of gender, it was not statistically significant ($p = 0.441$). Body mass indexes of male patients were 32.84 ± 6.52 (20 - 48) and 31.4 ± 7.73 (18 - 48) for females. Body mass index of patients was not statistically significant in terms of their gender ($p = 0.478$). Oswestry disability index scores were 32.04 ± 10.74 (16 - 58) before treatment and 30.69 ± 10.31 (15 - 55) after treatment. Oswestry disability index values before and after robotic rehabilitation were statistically significant ($p < 0.001$). Significant improvement was observed in ASIA scale values after rehabilitation. **Conclusions:** The motor function gains obtained during the robot-assisted treatment of traumatic spinal injury patients showed robotic device was useful in the training program. Robotic rehabilitation was effective in the improvement of the lower extremities during motor examination.

Keywords

Oswestry Disability Index, Robotic Rehabilitation, Spinal Cord Injury

1. Introduction

Traumatic spine injury affects communities socially, psycho-socially and eco-

nomically, resulting in a significant loss of workforce [1]. While damage to the spine primarily affects the bone structure and connective tissue, it also leads to a mechanical imbalance, pain and impaired mobility, whereas damage to the spinal cord usually results in partial or complete paralysis as the neurological structures are damaged [2] [3] [4].

Spinal cord injury is a devastating and life-changing condition. Primary neurological effects can lead to serious disability by affecting the physical functionality and independence and increasing the risk of secondary complications associated with a lack of weight bearing activity [5] [6].

Robotic devices applied to the extremities are used as a promising rehabilitation method designed to heal motor deficits and gait disorders after spinal cord injury [7]. In patients with motor deficits and imbalances after spinal trauma, robotic rehabilitation has been proven to provide significant improvements in locomotor ability, motor function, and balance. In addition, it is an important aid, especially for patients who need walking assistance, and especially physiotherapists [8]. Existing robotic training devices can reduce staffing requirements and physical demands for the physiotherapist [9].

Oswestry disability index (ODI) is an important scale for physical therapy, neurosurgery, orthopedics, and physiotherapists developed to evaluate the degree of dysfunction in pain. It is an important parameter used to evaluate robotic rehabilitation in patients with spinal trauma [10].

Body mass index (BMI) is a parameter that shows whether the weight is normal according to the height. BMI was found to be important in patients with spinal trauma. Higher-BMI people with spinal cord injury are thought to increase the risk and severity during injury [11].

ASIA scale findings are important guides in the treatment and follow-up of patients with traumatic spinal injuries. It is of great importance to standardize communication by providing easy and objective definition with motor examination findings in the process from the first admission of patients to discharge to the hospital [12].

The aim of this study was to investigate the effectiveness of the robotic device for lower limb rehabilitation of patients after traumatic spinal injury and also to show benefits and importance of rehabilitation with robotic device in patients with spinal trauma.

2. Methods

This study was retrospectively conducted, and received ethical permission with approval number 10 on 25.02.2020 from the Local Ethics committee. Patients with spinal cord trauma lower extremity parasite between December 2017 and December 2019 were evaluated before and after robotic rehabilitation. While selecting these patients, we took the cases who applied to our clinic as we mentioned earlier and had motor losses in the lower extremities that we thought would benefit from the device we used. If sample size is meant the number of cases, a decision was made by following previous studies and publications. It is

the evaluation of patients with muscle strength around 1/5 or 2/5 in the lower extremities, muscular atrophies, sensory problems and spasticity in their lower extremities.

Data were obtained through a retrospective analysis of patients who underwent a 15-week rehabilitation program including robot-assisted therapy of the lower extremity therapy. Robot-assisted vehicle has lower extremity exoskeletons, including Robogait® (Bama Technology, Turkey) (Figure 1). Exercises to strengthen the lower extremities were performed with the robotic device used. In these patients, the application of robot-assisted therapy to strengthen the lower extremity both increases muscle endurance and increases the patient's psychic adaptation to the daily life, aiming to correct the postural posture, in short, a state of well-being occurs.

The ODI scale values were recorded for each patient with lower extremity paralysis. The values of the ASIA scale of the lower extremity paralysis patients before and after the robotic rehabilitation were obtained. Oswestry scale, it was aimed to evaluate the effects on the lumbar region in patients with spinal cord injury and its effects on the daily life of the patient. It is important to evaluate the motor and sensory state of the patient with the ASIA classification and to benefit the patient from the treatment accordingly.

The way of working, especially the patients who developed motor deficits as a result of spinal cord lesions in their lower extremities, were evaluated. The improvement and recovery in motor functions in these patients were followed.

Statistical Analysis

The results were shown as mean ± SD (min-max), statistical significance was checked. The Mann-Whitney U test was performed in terms of their gender The Wilcoxon statistical test was applied to the values before and after the rehabilitation of the patients.

3. Results

A total of 51 patients admitted to the clinic with the mean age of 59.51 ± 8.2 (38

Figure 1. Robotic device rehabilitated for patients with spinal trauma.

- 72). The mean ages of 31 male and 20 female patients were 58.74 ± 8.88 (38 - 77) and 60.7 ± 7.09 (44 - 72), respectively. In terms of gender, comparison of ages was not statistically significant (p = 0.441) (Figure 2(A)). BMI of male patients was 32.84 ± 6.52 (20 - 48) and female was 31.4 ± 7.73 (18 - 48). BMI of patients was not statistically significant in terms of their gender (p = 0.478) (Figure 2(B)). ODI scores before treatment was 32.04 ± 10.74 (16 - 58) and 30.69 ± 10.31 (15 - 55) after treatment. ODI values before and after robotic rehabilitation were statistically significant (p < 0.001) (Figure 2(C)). ASIA scale values of patients before and after rehabilitation are shown in Figure 2(D). Significant improvement was observed in ASIA scale values after rehabilitation. After rehabilitation, there were 18 patients on the E scale (Table 1).

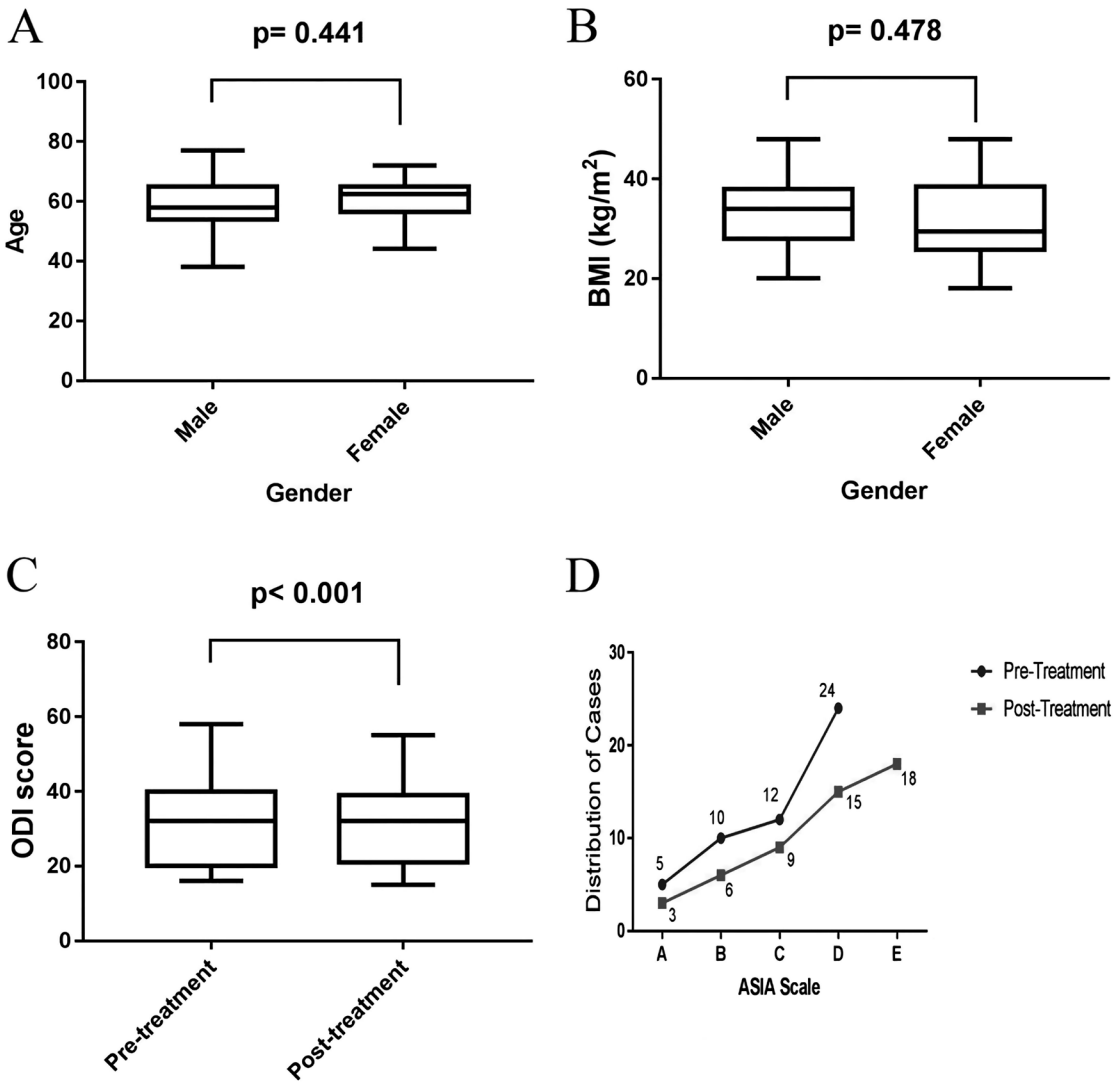

Figure 2. Evaluation of patients with traumatic spinal cord injuries. (A). No statistically significant difference was found between male and female patients in terms of age (p = 0.441). (B). No statistically significant difference between females and males in terms of BMI (p = 0.478). (C). Statistically significant difference was found between pre-treatment and post-treatment in terms of ODI score (p < 0.001). (D). ASIA scale values of patients before and after rehabilitation.

Table 1. Socio-demographic and clinical characteristics participants.

	Male	Female
Age of Patients	58.74 ± 8.88 (38 - 77)	60.7 ± 7.09 (44 - 72)
Body mass indexes of patients	32.84 ± 6.52 (20 - 48)	31.4 ± 7.73 (18 - 48)
Oswestry disability index scores	32.04 ± 10.74 (16 - 58) before treatment	

Comparing ages in terms of gender, it was not statistically significant ($p = 0.441$). Oswestry disability index values before and after robotic rehabilitation were statistically significant ($p < 0.001$). Significant improvement was observed in ASIA scale values after rehabilitation.

We did not encounter any complicated situation in this study. No abnormal situation was developed in our patients.

4. Discussion

Trauma to the spinal cord is a destroying situation and major reason for morbidity and mortality, which increases frequencies [13]. Depending on the spine level of patients with spinal cord trauma, we experience various symptoms; some of these include motor weaknesses, sensory abnormalities, muscle atrophy, pain, spasticity and contracture of the upper and lower extremities [14]. Treatments in the acute injury process are intended to limit more pressure on the spinal cord from secondary injury [15]. However, effective therapeutic strategies to prepare a treatment plan according to neurological stages and to support axon regeneration are not yet at the desired level [16]. Rehabilitation applications for potential recovery in patients with a spinal injury are currently providing improvement in motor function in a short and long period [17]. Walking-supported devices such as walking sticks, walkers or wheelchairs are used in spinal cord injury (SCI) patients with independent walking difficulties. Recently, diverse robotic rehabilitations have been used to strengthen mobility and walking exercises.

In recent years, rapid technological advances have allowed the technology of robotic devices applied to limb rehabilitation. Studies have proven that robotic devices are an indispensable component for improving limb rehabilitation [18]. Robotic devices are designed to perform different rehabilitation with multi-tasks options at. While robotic devices can be used for passive mobilization in light motor deficits, active-assisted exercises can be used for severe and moderate disorders. Active exercises can be supported and guided by feedback from non-motorized sensor-powered devices. In addition, robotic rehabilitation helps to improve physical, neurological recovery and adapt to new deficiencies and has an important ability to improve motor functions when reintegrated into society [5]. Delayed diagnosis of SCI and improper treatment can result in neurological injury, chronic pain, deformity in patients [19].

SCI patients who were rehabilitated using an exoskeleton working with lower limbs improved in walking distance and speed and their spasticity decreased [20].

In the study of Yang *et al.*, the age of patients with traumatic spinal cord injuries did not differ significantly between male and female patients [21]. In our study, there was no statistical difference in terms of gender.

BMI is the parameter that shows body fat based on weight and height. Obesity is a common social public health problem all over the world, especially in developed countries. It is a risk factor for various chronic diseases and develops due to genetic and environmental factors such as inactivity and stress [22]. In our study, mean BMI of both male and female patients was found to be obese (BMI = 30 kg/m^2 or more). The BMIs of patients with traumatic spinal cord injury was not statistically significant in terms of their gender.

ODI was developed to evaluate the degree of loss of function in lower extremity pain. The aim of robotic rehabilitation is to reduce pain, strengthen weak muscles, stretch contracted muscles, reduce mechanical stress on the spinal structures and correct posture [23]. Hornby *et al.* recorded significant improvements in the walking abilities of patients with spinal cord injuries after robotic rehabilitation in their study [9]. In our study, robotic rehabilitation was found to be significantly improved in SCI patients according to the statistical comparison of ODI scale.

It performs primary treatment and rehabilitation processes for diseases, trauma, painful conditions or congenital acute and chronic problems in the musculoskeletal and nervous system.

Being able to walk again is very important for patients with spinal cord injuries and is one of the main goals of rehabilitation programs. In recent years, many pharmacological treatments and rehabilitation approaches have been developed to increase the locomotor capacity of patients with spinal cord injuries.

Robot-assisted walking training is the re-teaching of movement with robotic systems specific to the function and work in order to regain the motor functions of walking. It is recommended to be used together with other methods in the rehabilitation of spinal cord injuries.

The robot minimizes leg movement and allows controlled variation of the leg in a certain trajectory, speed, and acceleration during treadmill walking, which is essential in motor learning [24]. Improving the locomotor abilities of muscle strength in people with SCI is the main goal of treatment [25]. In studies where musculoskeletal evaluations were performed according to the ASIA scale, a significant improvement was shown when the motor examination findings of SCI patients before and after robotic rehabilitation training were evaluated [12] [26]. In our study, the ASIA scale findings improved after robotic rehabilitation.

As a result, robotic rehabilitation is critical for increasing the effectiveness of lower limb muscle strength in patients and can be actively involved in training SCI patients. During robotic training, a controlled resistance load on the legs can be applied to help improve motor function in patients with SCI.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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