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EFFECTIVENESS OF THE «OMEGO PLUS» ROBOTIC REHABILITATION SYSTEM WITH BIOFEEDBACK IN PATIENTS WITH MYOGENIC LOWER LIMB JOINT CONTRACTURES

Introduction

Musculoskeletal injuries are a leading cause of disability, complicated by the development of myogenic contractures in 15–70% of cases [17]. In addition to restricted mobility, these conditions cause chronic pain, deformities, and gait disturbances [16, 20]. In Ukraine, this problem has intensified due to military aggression: combat-related limb injuries account for up to 60% of sanitary losses, with explosive injuries affecting 95% of civilian victims [2, 17]. Large-scale trauma creates a prolonged public health crisis requiring effective recovery strategies [4, 21].

Despite advances in rehabilitation, the effectiveness of treating myogenic contractures remains insufficient due to discrepancies in protocols and limited inpatient stay durations as per National Health Service of Ukraine (NHSU) requirements [7, 10]. A promising direction is the use of robotic systems that provide high movement precision, gait simulation, and biofeedback, thereby saving specialists' time [1, 11].

The study aims to enhance the effectiveness of physical therapy for patients with myogenic lower limb joint contractures using the «Omega Plus» robotic system.

Materials and Methods

The study was conducted in accordance with the principles of the Declaration of Helsinki and approved by the Ethics Committee of DSMU (Protocol №12 dated 25.10.2023). Design: a randomized parallel-group study.

Sample and Criteria: In 2024–2025, 64 patients (aged 18–45) with post-traumatic lower limb joint contractures (mobility restriction of 10–50% of the norm) were examined.

Inclusion criteria: diagnosis of post-traumatic contracture of one or more lower limb joints (hip, knee, ankle) with myogenic mobility restriction (10–50% of the norm, measured via goniometry); age 18–45 years; ability to move independently (with or without assistive devices); healed postoperative wounds; muscle spasms; and written informed consent.

Exclusion criteria: use of external fixation devices; signs of decompensated cardiovascular or other diseases; history of joint diseases leading to persistent mobility restriction; congenital or acquired joint deformities; insufficient cognitive function (Montreal Cognitive Assessment (MoCA) score < 24); pain level ≥ 9 on the Visual Analogue Scale (VAS); refusal of consent; use of analgesics; neurological disorders; "bone-to-bone" end-feel.

Four patients were excluded based on these criteria: two utilized external fixation devices, one scored 22 on the MoCA, and one refused consent. The final study included 60 patients, randomized (via Google Sheets) into two groups of 30. The groups were homogeneous in age and gender (mean age 38.2 ± 9.7 years; 90% male, 10% female). Rehabilitation was conducted according to the subacute period program at Municipal Clinical Hospital №4.

Intervention Protocol and Research Methods

Patients were divided into two groups. The Control Group (CG) received standard physical therapy (60 min/session) based on NICE guidelines (2022), including gait training, stretching, strength, and balance exercises. The program consisted of 4 weeks of inpatient and 2 weeks of outpatient phases (5 times/week). In the long-term period, patients followed an individual program, recording results in an electronic diary (Google Sheets).

The Experimental Group (EG), in addition to the NICE standard, underwent training on the "Omego Plus" robotic system (60 min). The session was divided into two phases: 40 minutes of strength exercises (pedaling, isometric holds, concentric ankle training) and 20 minutes of lower limb endurance exercises. The load was adjusted individually based on the current range of motion and pain levels.

Outcome assessment was performed three times: upon admission (Visit I), on the 14th day of rehabilitation (Visit II), and 3 months after discharge (Visit III). The comprehensive examination included:

Cognitive functions: Montreal Cognitive Assessment (MoCA).

Joint mobility: Goniometry (active and passive range of motion in the hip, knee, and ankle joints).

Muscle strength: Manual Muscle Testing (MMT).

Pain intensity: Visual Analogue Scale (VAS).

Gait and mobility: 10-Meter Walk Test (10MWT) and "Timed Up and Go" (TUG) test.

Statistical Analysis

Data processing was conducted using STATISTICA 6.1. The distribution type was determined using the Shapiro-Wilk test. Quantitative data are presented as M(SD) for normal distribution or Me (Q25; Q75) for non-parametric data. The Mann-Whitney U-test was used for independent samples, and the Wilcoxon test for related samples. Qualitative indicators were analyzed using Pearson's chi-square test. Results were considered statistically significant at $p < 0.05$.

Results

A positive trend in the range of motion of the lower limb joints was observed in both groups. While the experimental group showed significantly better of ankle extension results during the inpatient stage, by Visit III, the differences between the groups were not statistically significant for most parameters. However, the experimental group demonstrated a significantly greater increase in the range during the third visit.

Muscle strength analysis revealed a statistically significant advantage for the Experimental Group (EG) in the hip abductors (Visits II, III) and hip adductors (Visit III). Dynamics in other muscle groups were positive in both cohorts without significant intergroup differences ($p > 0.05$).

Gait speed (TUG and 10MWT) improved in all patients. However, the EG achieved a significantly better result in the 10-meter walk test during the final evaluation (Visit III).

Regarding pain management, robotic therapy proved superior: while there was no significant difference at the start, by Visit III, the pain level in the experimental group was statistically significantly lower than in the control group.

Discussion

Our study confirms the hypothesis that the "Omego Plus" robotic rehabilitation system is an effective adjunct therapy for patients in the subacute period following orthopedic trauma or surgery. The device's advantages stem from the integration of biofeedback for neuromuscular control, high-repetition movements for muscle fiber recovery, and adaptive loading that fills a gap in current recovery protocols.

The results showed a significant advantage for the EG in recovering hip mobility (extension, abduction) and targeted strengthening of the thigh muscles. A key finding was the confirmation of the second hypothesis: focused recovery of body functions and structures directly improves gait

characteristics. Specifically, a significant increase in speed (10MWT) in the EG was recorded at Visit III, a trend not observed in the CG.

In terms of pain management, robotic therapy showed superiority at the end of the program. This partially contradicts Wu et al. (2024), who found no significant VAS differences, but aligns with the review by Banyai et al. (2024). This highlights the specific efficacy of our protocol in reducing receptor sensitization through safe cyclic loading.

Conclusion

1. Integration of the "Omego Plus" system into physical therapy for patients with myogenic contractures significantly improves hip muscle strength, ankle range of motion, gait speed, and analgesic efficacy.

2. The most pronounced advantage of the robotic intervention (gait speed, pain reduction) was identified in the long-term period (Visit III). This indicates the cumulative nature of the therapy and the necessity of extending rehabilitation beyond the inpatient stage for this category of patients.

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