DOI 10.36074/logos-06.02.2026.056

SPECIFICS OF PHYSICAL THERAPY IN RESTORING GAIT FUNCTION FOR PATIENTS WITH ÖSSUR BIONIC LOWER LIMB PROSTHESES

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The evolution of lower limb prosthetics over the last decade has been marked by a fundamental shift from static, energy-storing designs to active cybernetic systems. Products from the Icelandic company Össur hold an avant-garde position due to the implementation of microprocessor control (MPK) and artificial intelligence, capable of predictive analysis of gait phases in real-time. However, clinical experience proves that the technological perfection of a device does not inherently guarantee functional recovery.

Success in rehabilitation depends on the quality of physical therapy by approximately 70%, which serves as an intellectual bridge adapting the patient's biological resources to complex microprocessor algorithms. As noted by Stevens et al. [6], modern clinical guidelines require therapists to go beyond teaching simple ambulation and focus on forming a stable biomechanical synergy between the user's body and the prosthesis.

Neurophysiological Basis: Overcoming Deafferentation and Sensory Integration.

Amputation causes a massive disruption of afferent impulses, leading to negative plasticity in the somatosensory cortex of the brain. The loss of natural proprioception forces the patient to rely exclusively on visual control, which significantly increases cognitive load and fatigue.

Össur bionic systems partially compensate for this deficit by creating "predictable stability." High-frequency data sampling (up to 1000 Hz) allows the patient's central nervous system to integrate the prosthesis into the internal "body schema" more rapidly. Webster et al. [7] emphasize that the clinical effectiveness of MPKs directly depends on the therapist's ability to stimulate proprioceptive sensation through the socket interface, utilizing the specific resistance of the prosthesis as a source of feedback. Physical therapy in the early stages must focus on the patient's ability to differentiate various levels of joint resistance, which is the key to restoring gait automatism.

In-depth Biomechanical Analysis of Össur Systems.

Rheo Knee: Dynamics of Magnetorheological Damping.

The Rheo Knee system utilizes a unique magnetorheological fluid, the viscosity of which changes under the influence of an electromagnetic field within milliseconds. This provides a smooth, natural resistance that mimics the function of stabilizer muscles.

Descent Kinematics: Unlike hydraulic systems, the Rheo Knee provides controlled flexion under load (yielding), allowing patients to negotiate stairs using a "step-over-step" method. Highsmith et al. [4] demonstrated that this significantly reduces vertical oscillation of the center of mass and decreases the impact load on the intact limb.

Practical Aspect: The therapist must train the patient in the "heel loading" technique to activate flexion resistance, which is critical for safety on inclined surfaces.

Power Knee: Active Power Generation and Metabolic Profile.

The *Power Knee* is the world's first mass-produced system with an active drive that performs the work of the quadriceps muscle. This allows for active stair climbing and rising from a chair without compensatory trunk movements.

Energy Efficiency: Research by Wolf et al. [8] confirmed that active power generation by the prosthesis reduces the metabolic cost of gait by 15–20%. This fundamentally changes the prognosis for elderly patients or those with comorbid cardiovascular pathologies, for whom normal walking was previously an excessive load.

Teaching Methodology: The therapist's key task is to teach the patient the correct timing of the "initiating push" with the residual limb, which serves as a trigger for the motor's activation.

Proprio Foot: Fall Prevention through Active Dorsiflexion.

The *Proprio Foot* bionic ankle automatically adjusts the angle of the ankle joint.

Toe Clearance: Agrawal et al. [1] note that active toe elevation during the swing phase radically reduces the frequency of tripping—the primary cause of falls among prosthesis users.

Adaptability: When walking uphill, the system automatically increases the dorsiflexion angle, which unloads the lumbar spine, a region that typically suffers from hyperlordosis when using passive feet.

The rehabilitation process should not be based on calendar schedules but on objective progression criteria, assessed using the AMPPRO (Amputee Mobility Predictor) scale, as justified by Gailey [2].

Stage I: Fundamental Stabilization and Biomechanical Symmetry

The main goal is to overcome the "fear of loading" the amputated side. With bionic prostheses, the patient should achieve a 50/50 weight distribution in static standing.

Specifics: Weakness of the gluteus medius often leads to compensatory pelvic tilt (Trendelenburg phenomenon), which prevents MPK sensors from correctly recognizing gait phases.

Exercises: Using biofeedback (stabilometric platforms) to visualize the center of pressure. The therapist focuses on the isometric stabilization of the residual limb within the socket.

Stage II: Dynamic Gait Retraining and Automation

In this stage, the therapist implements the External Focus of Attention methodology.

Methodology: Instead of the instruction "flex your knee" (internal focus), the patient is given the task to "step over the line" or "touch the ball with your toe."

Effectiveness: It has been proven that this approach accelerates movement automation by 30%, freeing up the patient's cognitive resources for interacting with the environment.

Stage III: Load Management and Prevention of Secondary Pathologies

Even with ideal prosthetic fitting, the load on the intact limb remains elevated by 20–25%. Kaufman et al. [5] proved that while MPK use improves symmetry, patients still require training in "Load Management" techniques to prevent early osteoarthritis of the healthy leg.

Task: Training gait under dual-tasking conditions—for example, walking while talking or carrying objects, which mimics real-life situations.

Kinesiophobia—the fear of falling or electronic failure—is an independent predictor of poor outcomes. Hafner et al. [3] established that a patient's subjective sense of safety is the primary factor in whether they will utilize the prosthesis to its full capacity. The physical therapist must act as a "cognitive coach," gradually introducing the patient to complex conditions (walking in crowds, on uneven grass, in low light) to build unwavering trust in Össur algorithms.

Conclusions. Individualized physical therapy for Össur bionic systems is an integrated management system for biological adaptation. It is based on an understanding of microprocessor algorithms [4], the reduction of metabolic stress [8], and adherence to evidence-based progression criteria [2]. Only such a comprehensive approach, accounting for neurophysiology, biomechanics, and the patient's psychological state, allows for the achievement of true mobility and high quality of life.

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