


Use of a Robotic Exoskeleton in the Teenage SCI Population



ReWalk
More Than Walking



Shriners Hospitals
for Children

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1



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2

Objectives

- Describe the ReWalk exoskeleton and its purpose
- Compare other modes of upright mobility for people with SCI
- Identify appropriate candidates using the ReWalk Evaluation Form, including indications, precautions, contraindications
- Learn the benefits and potential risks of using ReWalk
- Recommend PT interventions and activities that can be performed at home to prepare a potential ReWalk candidate for use of the ReWalk device.
- Outline the Basic Skills Inventory, Advanced Skills Inventory, and training protocols.
- Discuss the process of obtaining a ReWalk device for personal use
- Understand the current literature regarding the use of exoskeletons like the ReWalk by patients with SCI




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Love to the rescue!

3


Introductory Video of the ReWalk Exoskeleton

♥ <https://youtu.be/2Xd27c-pz4Y>




4

Introduction to the ReWalk




- The ReWalk was the first FDA-approved (2014) wearable, battery-powered lower limb exoskeleton that allows persons with motor-complete SCI to walk independently¹.
- Invented by Dr. Amit Goffer, who sustained a SCI after an ATV accident in 1997. He is the founder of Argo Medical Technologies in Israel. ReWalk Robotics is a global company with HQ in Israel, Germany, and USA.
- ReWalk Rehabilitation and ReWalk Personal devices.
- ReWalk Robotics also received FDA approval in 2019 for the ReWalk Restore Exo-suit for post-stroke gait rehabilitation.




5

ReWalk™ Components¹⁻³



- Robotic exoskeleton has bilateral hip and knee motors contained in upper and lower leg frames which allow the user to stand upright and walk.
- Provides user-integrated mobility with a wearable brace support, a computer-based control system, and motion sensors.
- Rigid pelvic band with 3-D accelerometer/tilt sensor
- Spring-assisted dorsiflexion footplates inside user's shoe
- Straps at chest, waist, upper and lower legs
- Rechargeable batteries (4 hrs of walking) and a computerized control system stored in a backpack (3.5 kg)
- Forearm crutches for standing stability
- Wireless communicator ("The Watch") used to select sit, stand, walk, (stairs,) and manual modes



6

ReWalk Components



- ReWalk software translates individualized settings to the device:
 - Joint angles/step length
 - Step time
 - Delay between steps
 - Tilt angle
 - Safety features^{2,4}
- Device detects user's change in COG forward and lateral in order to trigger a step with right leg first, with several sensors to detect upper-body tilt angle, joint angles, and ground contact^{1,3,4}



7

Comparing Modes of Upright Mobility for Patients with SCI



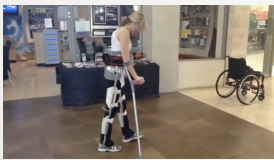
- Architectural and environmental limitations in wheelchair use discussed in the literature¹
- Decreased loading of the LEs
- Pressure sores
- Joint contractures
- Shoulder overuse syndrome
- Neuropathy
- Decreased eye-to-eye social interaction with non wheelchair users



8

Comparing Modes of Upright Mobility for Patients with SCI



- KAFOs: heavy, cumbersome, difficult to don, inefficient gait, overuse in UEs^{1,4,5}
- RGOs or ARGOs: difficulty attaining skills and strength required to utilize, high energy costs, overuse in UEs^{1,4,5}



9

Comparing Modes of Upright Mobility for Patients with SCI

- ♦ FES: very limited distances, require functioning LMN and complete sensory loss to tolerate, all motor units stimulated simultaneously leading to fatigue¹
- ♦ BWSTT – robot-assisted (Lokomat or ReoAmbulator) or clinician-assisted stepping: incomplete injury, improved balance and ambulation, improved LE motor scores, unable to continue therapy at home⁵

10


Comparing Modes of Upright Mobility for Patients with SCI

- ♦ ReWalk Exoskeleton: closely replicates normal gait, more efficient, enable user to perform functional and/or vocational standing and walking outside of rehab setting^{1,4,5}





11

User Selection: Indications^{1,2}




- ♦ Complete or incomplete T4 or below SCI
- ♦ LE paralysis or paresis with \leq fair UE strength and trunk control that can support crutches and maintain balance
- ♦ 5'3" – 6'2" height, but primarily dependent on femur length
- ♦ \leq 220 lbs
- ♦ BMD $>$ -2.5 and no fractures
- ♦ Tolerate regular standing and gait program
- ♦ Intact skin
- ♦ Hemodynamic stability
- ♦ Sufficient ROM in hips (0°), knees ($\leq 10^\circ$ contracture), and ankles (neutral)
- ♦ MAS $<$ 3 for LE spasticity
- ♦ Motivated to walk



12

User Selection: Contraindications^{1,2}


- History of severe neurological injuries other than SCI (MS, CP, ALS, TBI, etc.)
- Uncontrolled spasticity/clonus (Modified Ashworth ≥ 4)
- Unstable spine or unhealed limbs or pelvic fractures
- Low BMD or fractures
- Heterotopic ossification that limits joint mobility
- Significant contractures (PF $>0^\circ$, knee $>10^\circ$, hip extension $>0^\circ$)
- Severe comorbidities: cardiopulmonary, etc.
- Psychiatric or cognitive issues that may interfere with safe use of the device
- DVT
- Pregnant/lactating
- Infection
- Pressure sores
- Contractures



13


ReWalk Evaluation Form

- Used to identify appropriate candidates




14

Benefits of Using the ReWalk




- Safe and well tolerated with regards to falls, skin integrity, cardiovascular health, pain, fatigue, and musculoskeletal problems^{3,5}
- Maintain bone mass⁶
- Improve sitting balance/trunk control⁶
- Improve sleep and decrease fatigue throughout the day⁶
- Improve mental health^{1,6}
- Decrease pain levels^{1,6}
- Improve body conditioning and decrease weight gain⁶
- Provide pressure relief and prevent pressure ulcers⁶




15

Benefits of Using the ReWalk




- Improved bowel function^{1,6}
- Improved bladder function and decreased risk of UTI⁶
- Improved spasticity¹
- Moderate level exercise intensity and may help improve general health status and decrease risk of heart disease, stroke, diabetes^{1,6,7}
- May improve ankle dorsiflexion and hip extension ROM⁸
- May be used as a training tool to increase neuronal activity of the CPG circuits in those with incomplete SCI³




16

Risks of Using the ReWalk ^{1,9}




- Falls and associated injuries
- Autonomic dysreflexia
- Dizziness, light headedness
- Skin breakdown
- Edema of LEs
- Neck and shoulder pain
- None of the health benefits remain after training stops



17

Interventions to Prepare for ReWalk Training


- Standing program – every day, at least 1 hour in stander
- Stretching program – gastrocnemius, hamstrings, hip extensors including passive stretching with assistance and independently and prolonged positioning (prone, AFOs, knee immobilizers, etc.)
- UE and core strengthening program with resistance if appropriate
- Sitting and standing (if appropriate) balance training
- Cardiovascular endurance training – long distance/continuous wheelchair propulsion, UBE, FES cycle, UE aerobics, aquatics, etc.
- Independence with skin checks and pressure releases
- Transfer training for independence with transfer between wheelchair and ReWalk
- Patient/companion education regarding ReWalk management
- Can perform pre-ReWalk training program at home or in rehab setting



18

ReWalk Training Videos

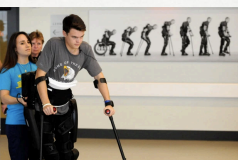

- <https://youtu.be/J9PQiWkJCtI>
- <https://youtu.be/WW-z0G5IDl>



19

Training with the ReWalk



- Basic Clinical Certification for Clinicians – 16 hr course, written exam and competencies, 40+ hours with user experience, ≥ 1 user completes ReWalk Basic Skills Inventory; Advanced Clinical Certification²
- User given HEP with focus on flexibility and balance prior to training with ReWalk device²
- User and companion must train and be scored by a PT on Basic and Advanced Skills Inventories
- Tiered approach for ReWalk skills training to train user and companion²

20

Basic Skills Inventory



- Transfers in/out of ReWalk
- Manual joint adjustment
- Donning/doffing the device
- Standing balance
- Sit<->stand
- Communicator use
- 10M walk test ≥0.15 m/s
- Turning L/R/180°
- Walking through doorway
- Stopping
- Graceful collapse
- Bypass mode
- Skin check
- General equipment knowledge
- Wall rest
- Advanced skills in the home and community, at work

21


Advanced Skills Inventory

- Advanced walking skills – conversing
- Advanced walking skills – noisy environment
- Reaching – counter and shelf
- Doorway navigation
- Timed door navigation
- Timed walking
- Sitting on/standing from bench
- Ramps
- Side angle walking
- Multiple surfaces
- Fall recovery
- 10 MWT ≥ 0.4 m/s
- 6MWT ≥ 110 m
- Curb cut-outs





22

Training with the ReWalk




- Various protocols regarding frequency in the literature – here at Shriners we have found 2 hours training 5 days per week for 2-4 weeks is most efficient
- Decreased LOA required as user's skill improves and increased walking speed^{2,4}
- Balance training prior to initiating ambulation²
- Initial ambulation tolerance ~30 minutes and with training effects, able to increase to 1.5-2 hrs⁵
- Obtain limited community ambulation speed (0.40 m/s) with training^{5,9}
- Monitor proper fit of device and apply proper padding to prominences, BP, HR, RPE, VAS pain and fatigue scales^{3,9}
- Functional outcome tests include TUG, 6MWT distance, 10-m timed walk, 3D gait analysis^{1,3,5,9}




23

Obtaining a ReWalk Personal Unit



- Potential user deemed appropriate for ReWalk based on user selection criteria and cleared by MD.
- User trains at a ReWalk training center and user and companion are checked off on all ReWalk skills by a PT.
- User works with ReWalk for custom fit if deemed appropriate.
- Financing: insurance, fundraisers, out of pocket
- \$140,000 for ReWalk Rehabilitation
- \$125,000 for ReWalk Personal (comes with 5 year warranty)



24

