Gait analysis in children and adolescents with spinal cord injuries.

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BACKGROUND/OBJECTIVE: Improving ambulation in patients with spinal cord injuries (SCIs) is a major challenge for the clinician. Physical examination can be supplemented with biomechanic information from the gait laboratory to comprehensively evaluate and improve walking. Gait analysis is an effective method to evaluate 3-dimensional dynamic joint range of motion (kinematics) and forces (kinetics) occurring at the hip, knee, and ankle/foot. Clinical gait analysis has proved to be essential for surgical and rehabilitative planning and posttreatment assessment in many neuromuscular disorders. Benefits of gait analysis also may apply to walking patients with SCIs. The goal of this study was to demonstrate the utility of gait analysis in children and adolescents with SCIs. METHODS: Motion analysis evaluations and physical examinations were performed on 33 children and adolescents with SCIs (16 males, 17 females). Mean age at time of gait analysis was 11.7 years, with an age range of 2.5 to 21 years. RESULTS: Abnormal kinematic patterns, which were repeatable over several years, were demonstrated in the patients with SCI. Gait analysis was beneficial in making educated treatment decisions about orthotic prescription, surgery, postsurgical evaluation, prescription of new therapy, evaluation of spasticity medications, and experimental treatments. Another advantage of gait analysis is recording and reviewing changes in gait over time. In our study, 22 of the 33 patients received a 1-year follow-up gait analysis. Patients followed over multiyear intervals have demonstrated characteristic changes in mobility patterns, resulting in changes in prescription of mobility aids. The benefits of gait analysis are demonstrated by case presentation. CONCLUSION: Improved ambulation for patients with SCI can be accomplished with physical therapy, orthotics, spasticity management, and surgery. These treatments, as well as innovative new areas such as functional electrical stimulation and robotic-assisted therapy, rely on gait analysis to provide a template of normal walking patterns and to measure function and document improvements.

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Clinical applications of electrical stimulation after spinal cord injury.

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During the last one-half century, electrical stimulation has become clinically significant for improving health and restoring useful function after spinal cord injury. Short-term stimulation can be provided by electrodes on the skin or percutaneous fine wires, but implanted systems are
preferable for long-term use. Electrical stimulation of intact lower motor neurons can exercise paralyzed muscles and reverse wasting; improve strength, endurance, and cardiovascular fitness; and may reduce the progression of osteoporosis. Other potential therapeutic uses being investigated include reduction of spasticity, prevention of deep vein thrombosis, and improvement of tissue health. Pacing of intact phrenic nerves in high tetraplegia can produce effective respiration without mechanical ventilation, allowing improved speech, increased mobility, and increased sense of well-being. Improvement of cough has also been demonstrated. Stimulation of intact sacral nerves can produce effective micturition and reduce urinary tract infection; it can also improve bowel function and erection. It is usually combined with posterior sacral rhizotomy to improve continence and bladder capacity, and the combination has been shown to reduce costs of care. Electroejaculation can now produce semen in most men with spinal cord injury. Significant achievements have also been made in restoring limb function. Useful hand grasp can be provided in C5 and C6 tetraplegia, reducing dependence on adapted equipment and assistants. Standing, assistance with transfers, and walking for short distances can be provided to selected persons with paraplegia, improving their access to objects, places, and opportunities that are inaccessible from a wheelchair. This review summarizes the current state of therapeutic and neuroprosthetic applications of electrical stimulation after spinal cord injury and identifies some future directions of research and clinical and commercial development.

Publication Types:
- Review
- Review, Tutorial

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are modalities being used to reduce the high risk for pressure ulcers in the SCI population. Research on shoulder stressors is being applied to transfer techniques, exercise regimens, adaptive equipment and wheelchair mechanics to minimize shoulder pain, another common complication. The effectiveness of rehabilitation interventions needs to be documented by evidence-based research. Researchers are focusing on the identification of outcomes measures that will form the basis for established standards of care for individuals with SCI. Perhaps the combination of conventional and newer therapies may enhance neurological recovery. Well-designed studies are needed before we can make this determination.

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Effects of a simple functional electric system and/or a hinged ankle-foot orthosis on walking in persons with incomplete spinal cord injury.

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OBJECTIVES: To compare the effect of functional electric stimulation (FES) with that of a hinged ankle-foot orthosis (AFO) for assisting foot clearance, gait speed, and endurance and to determine whether there is added benefit in using FES in conjunction with the hinged AFO in persons with incomplete spinal cord injury (SCI). DESIGN: Within-subject comparison of walking under 4 conditions: AFO, FES, AFO and FES, and no orthosis. A plastic hinged AFO was used for all AFO conditions. SETTING: Tertiary rehabilitation center. PARTICIPANTS: Nineteen subjects with incomplete SCI. INTERVENTIONS: Not applicable. MAIN OUTCOME MEASURES: The self-selected gait speed, 6-minute walk distance, and foot clearance values were compared between conditions. RESULTS: Gait speed increased with FES (P<.05) and with the AFO (P=.06). Six-minute walk distance also increased with the AFO (P<.05). No difference was found between the 2 forms of orthoses in either gait speed or endurance. The greatest increase in gait speed and endurance from the no-orthosis condition occurred with the combined AFO and FES condition. Foot clearance improved with FES but not with AFO. Subjects whose gait speed increased with FES had weaker hip flexors, knee flexors, and ankle dorsiflexors than those who did not benefit from FES. CONCLUSIONS: Both FES and the hinged AFO promote walking and FES is only superior to the AFO in increasing foot-clearance values. The hinged AFO and FES together may offer advantages over either device alone.

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Exercise recommendations for individuals with spinal cord injury.

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Persons with spinal cord injury (SCI) exhibit deficits in volitional motor control and sensation that limit not only the performance of daily tasks but also the overall activity level of these persons. This population has been characterised as extremely sedentary with an increased incidence of secondary complications including diabetes mellitus, hypertension and atherogenic lipid profiles. As the daily lifestyle of the average person with SCI is without adequate stress for conditioning purposes, structured exercise activities must be added to the regular schedule if the individual is to reduce the likelihood of secondary complications and/or to enhance their physical capacity. The acute exercise responses and the capacity for exercise conditioning are directly related to the level and completeness of the spinal lesion. Appropriate exercise testing and training of persons with SCI should be based on the individual's exercise capacity as determined by accurate assessment of the spinal lesion. The standard means of classification of SCI is by application of the International Standards for Classification of Spinal Cord Injury, written by the Neurological Standards Committee of the American Spinal Injury Association. Individuals with complete spinal injuries at or above the fourth thoracic level generally exhibit dramatically diminished cardiac acceleration with maximal heart rates less than 130 beats/min. The work capacity of these persons will be limited by reductions in cardiac output and circulation to the exercising musculature. Persons with complete spinal lesions below the T(10) level will generally display injuries to the lower motor neurons within the lower extremities and, therefore, will not retain the capacity for neuromuscular activation by means of electrical stimulation. Persons with paraplegia also exhibit reduced exercise capacity and increased heart rate responses (compared with the non-disabled), which have been associated with circulatory limitations within the paralysed tissues. The recommendations for endurance and strength training in persons with SCI do not vary dramatically from the advice offered to the general population. Systems of functional electrical stimulation activate muscular contractions within the paralysed muscles of some persons with SCI. Coordinated patterns of stimulation allows purposeful exercise movements including recumbent cycling, rowing and upright ambulation. Exercise activity in persons with SCI is not without risks, with increased risks related to systemic dysfunction following the spinal injury. These individuals may exhibit an autonomic dysreflexia, significantly reduced bone density below the spinal lesion, joint contractures and/or thermal dysregulation. Persons with SCI can benefit greatly by participation in exercise activities, but those benefits can be enhanced and the relative risks may be reduced with accurate classification of the spinal injury.

Publication Types:

- Review

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Motor function is severely disrupted following spinal cord injury (SCI). The spinal circuitry, however, exhibits a great degree of automaticity and plasticity after an injury. Automaticity implies that the spinal circuits have some capacity to perform complex motor tasks following the disruption of supraspinal input, and evidence for plasticity suggests that biochemical changes at the cellular level in the spinal cord can be induced in an activity-dependent manner that correlates with sensorimotor recovery. These characteristics should be strongly considered as advantageous in developing therapeutic strategies to assist in the recovery of locomotor function following SCI. Rehabilitative efforts combining locomotor training pharmacological means and/or spinal cord electrical stimulation paradigms will most likely result in more effective methods of recovery than using only one intervention.

Publication Types:
- Review

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training. Gait ability improved in all four patients; three patients could walk independently on the floor with the help of technical aids, and one required the help of one therapist after therapy; gait speed and endurance more than doubled, and the gastrocnemius activity increased in the patients with a central paresis. CONCLUSION: This combined technique allows intensive locomotor therapy in SCI subjects with reduced effort from the therapists. The patients' improved walking ability confirmed the potential of locomotor therapy in SCI subjects.

Publication Types:

- Case Reports

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Effect of load during electrical stimulation training in spinal cord injury.

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Electrical stimulation training is known to alter skeletal muscle characteristics after a spinal cord injury, but the effect of load on optimizing the training protocol has not been fully investigated. This study investigated two electrical-stimulation training regimes with different loads on intramuscular parameters of the paralyzed lower limbs. Six paraplegic individuals with a spinal cord injury underwent electrical stimulation training (45 min daily for 3 days per week for 10 weeks). One leg was trained statically with load, and the contralateral leg was trained dynamically with minimal load. Isometric force assessed with 35-HZ stimuli increased significantly in both legs from baseline, with the static-trained leg also being significantly higher than the dynamic-trained leg. The vastus lateralis muscle of the statically trained leg showed a significant increase in type I fibers, fiber cross-sectional area, capillary-to-fiber ratio, and citrate synthase activity when compared to both baseline and the dynamically trained leg. Relative oxygenation of the vastus lateralis muscle as determined by near infrared spectroscopy was also significantly greater after static training. This study indicates that the load that is applied to paralyzed muscle during an electrical stimulation training program is an important factor in determining the amount of muscle adaptation that can be achieved.

Publication Types:

- Clinical Trial

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