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ORIGINAL ARTICLE

Spinal cord injury: rehabilitation

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DESCRIPTION OF THE EVIDENCE COLLECTION METHOD

This study revised articles from the MEDLINE (PubMed) databases and other research sources, with no time limit. To do so, the search strategy adopted was based on (P.I.C.O.) structured questions (from the initials "Patient"; "Intervention"; "Control" and "Outcome". As keywords were used:

Question 1: (spinal cord injury OR spinal cord injuries OR spinal cord trauma) AND (walking OR gait OR mobility limitation) AND (weight support OR weight-bearing OR body weight OR weight);

Question 2: (spinal cord injury OR spinal cord injuries OR spinal cord trauma) AND (walking OR gait OR mobility limitation) AND (electrical stimulation OR electric stimulation OR electric stimulation therapy OR functional stimulation);

Question 3: (counterindications OR counter indication OR injury OR complication) AND (spinal cord injury OR spinal cord injuries OR spinal cord trauma) AND (stretching OR muscle stretching exercises OR stretch);

Question 4: (spinal cord injury OR spinal cord trauma OR spinal cord traumas OR spinal cord injuries OR spinal cord injury/rehabilitation OR quadriplegia OR tetraplegia) AND (Treatment outcome OR Assessment OR Outcome Assessment/(Health Care) OR Outcome Assessments OR Patient Outcomes Assessment OR Severity of Illness Index OR Injury Severity Score) AND (upper limb OR upper limbs OR upper extremity OR upper extremities OR hand OR arm OR wrist) AND (muscle strength OR Hand strength OR motor activity/physiology OR motor function OR sensory function);

Question 5: (spinal cord injury OR spinal cord trauma OR spinal cord traumas OR spinal cord injuries OR quadriplegia OR tetraplegia OR paraplegia OR parapareses) AND (Outcome Assessment AND (Health Care) OR Outcome Assessments OR Outcomes Assessments OR Outcome Study OR Outcome Studies OR Patient Outcomes Assessment OR Measure, Outcome) AND (Activities of Daily Living OR Activities, Daily Living OR Activity, of Daily Living OR Activity of Daily Living OR Daily Living Activity OR Daily Living Activities OR ADL OR Self Care);

Question 6: (Physical Therapy Modalities OR Physical Therapy Modality OR Physical Therapy Technique OR Physical Therapy Techniques OR Exercise Movement Techniques OR occupational Therapy) AND (spinal cord injuries OR spinal cord trauma OR spinal cord injury OR quadriplegia OR tetraplegia OR paraplegia) AND (Electric Stimulation Therapy OR Stimulation Therapy, Electric OR Therapeutic Electrical Stimulation OR Therapeutic Electric Stimulation OR Functional Electric Stimulation OR Functional Electrical Stimulation OR FES) AND (upper extremities OR upper extremity OR upper limb OR upper limbs OR extremities, upper OR limbs, upper OR hand OR hands OR fingers OR wrist OR thumb);

Question 7: (spinal cord injuries OR spinal cord trauma OR spinal cord injury OR quadriplegia OR tetraplegia OR paraplegia) AND (biofeedback OR biofeedback therapy OR biofeedback training OR electromyographic biofeedback OR emg biofeedback OR electromyography OR Biofeedback, Psychology/methods) AND (upper extremities OR upper extremity OR upper limb OR upper limbs OR extremities, upper OR limbs, upper OR hand OR hands OR fingers OR wrist OR thumb);

Question 8: (spinal cord injury OR spinal cord trauma OR spinal cord traumas OR spinal cord injuries OR quadriplegia OR tetraplegia) AND (Splints OR Splint OR Orthopedic Fixation Devices OR Orthotic Devices OR device orthotic OR devices orthotic OR Orthoses OR Orthosis) AND (Upper Extremity OR Upper Extremities OR Upper Limb OR Upper limbs OR MembrumSuperius OR Extremities, Upper OR Limb, Upper OR Limbs, Upper); (Self-help devices OR Self-help device OR Device, Self-Help device OR Assistive Technology OR Assistive Technologies OR Technologies, Assistive OR Technology, Assistive OR Assistive Devices OR Assistive Device OR Device, Assistive OR Devices, Assistive) AND (daily activities OR daily activity OR activity of daily living OR activities of daily living OR activities of self care OR activity of self care OR usual activities OR usual activity OR usual activity of daily living OR usual activities of daily living) AND (functional independence OR independence) AND (autonomy OR personal autonomy) AND (Spinal Cord Injury OR Spinal Cord Trauma OR Spinal Cord Traumas OR Quadriplegia OR Tetraplegia OR Paraplegia OR Paraparesis);

Question 9: (Spinal Cord Injury OR Spinal Cord Trauma OR Spinal Cord Traumas OR Quadriplegia OR Tetraplegia OR Paraplegia OR Paraparesis) AND (Wheelchairs OR Wheelchair OR wheel chairs OR Wheel chair) AND (activities of daily living OR daily living activities OR activity of daily living OR daily living activity OR Activities, Daily Living OR Activity, Daily Living OR Living Activities, Daily OR Living Activity, Daily OR ADL OR Limitation of Activity, Chronic OR Chronic Limitation of Activity OR Self Care OR Care, Self OR Cares, Self OR Self Cares) AND (daily activities OR daily activity OR activity of daily living OR activities of daily living OR activities of self care OR activity of self care OR usual activities OR usual activity OR usual activity of daily living OR usual activities of daily living);

Question 10: (Self-help devices OR Self-help device OR Device, Self-Help device OR Assistive Technology OR Assistive Technologies OR Technologies, Assistive OR Technology, Assistive OR Assistive Devices OR Assistive Device OR Device, Assistive OR Devices, Assistive) AND (Spinal Cord Injury OR Spinal Cord Trauma OR Spinal Cord Traumas OR Quadriplegia OR Tetraplegia OR Paraplegia OR Paraparesis);

Question 11: (spinal cord injury OR spinal cord injuries OR spinal cord trauma OR quadriplegia OR tetraplegia OR paraplegia) AND (muscle spasticity OR spastic paraparesis OR spaticparapareses) AND (transcutaneous electric nerve stimulation OR trancutaneous electrical nerve stimulation OR percutaneous electrical OR TENS);

Question 12: (spinal cord injury OR spinal cord injuries OR spinal cord trauma OR quadriplegia OR tetraplegia OR paraplegia) AND (Dietary Fiber OR Diet survey OR Food Habits OR Nutritional requirements);

Question 13: (spinal cord injury OR spinal cord injuries OR spinal cord trauma OR quadriplegia OR tetraplegia OR paraplegia) AND (Obesity AND Overweight AND Body Mass Index);

Question 14: (Spinal Cord Injuries OR Quadriplegia) AND (Physical Therapy Modalities OR Breathing Exercises OR inspiratory muscle training) AND (Respiratory Function Tests OR Spirometry OR Forced Expiratory Volume/instrumentation); (Spinal Cord Injuries OR Quadriplegia) AND (Physical Therapy Modalities OR Breathing Exercises) AND (Respiratory Function Tests OR Spirometry OR Forced Expiratory Volume/instrumentation);

Question 15: (spinal cord injuries OR quadriplegia) AND (abdominal binder OR corset) AND maximum inspiratory pressure;

Question 16: (spinal cord injuries OR quadriplegia) AND (vital capacity OR breathing exercises OR glossopharyngeal breathing).

With the above keywords crossings were performed according to the proposed theme in each topic of the (P.I.C.O.) questions. After analyzing this material, *therapy narrow* articles regarding the questions were selected and, by studying those, the evidences that fundamented the directives of this document were established.

LEVEL OF RECOMMENDATION AND EVIDENCE:

A: Strong consistency experimental or observational studies.

B: Fair consistency experimental or observational studies.

C: Case reports (uncontrolled studies).

D: Opinion lacking critical evaluation, based on consensus, physiological studies or animal models.

OBJECTIVES:

Offering information about the treatment and rehabilitation for patients with spinal cord injuries.

CONFLICTS OF INTERESTS:

There are no declared conflicts of interests.

INTRODUCTION

Spinal Cord Injury is the injury to neural elements of the spine which can result in different degrees of sensorimotor deficits and autonomic and sphincter dysfunction. The neurologic deficit or dysfunction can be either temporary or permanent, complete or incomplete[1] **(D)**.

The rehabilitation of patients with spinal cord injury (SCI) is greatly important and promotes longer survival, less morbidity, and higher quality of life. The higher occurrence of incomplete lesions is due to early treatment in rescue and surgery and not to rehabilitation[2] **(A)**.

Respiratory complications are the major mortality and morbidity causes in tetraplegic patients; the greatest incidence of mortality is in the first six months to one year after lesion. The impairment in respiratory musculature strength and in pulmonary function can significantly limit exercises during the rehabilitation of tetraplegic patients[3] **(B)**.

Spinal cord injury SCI is a devastating condition with great impact in a person's life and one of the consequences people with SCI think is the hardest to live with is the loss of the ability to walk and use arms and hands[2,4] **(A,D)**.

The restoration of gait and upper limb function favours the performance of daily life activities, DLA, and the quality of life, QL[2,4] **(A,D)**.

The rehabilitation of people with SCI must involve several health care professionals, be initiated in the acute phase, and continue with special services and different therapeutic approaches[1] **(D)**.

1. In patients with spinal cord injury, can the body-weight-supported treadmill training be more beneficial than overground gait training?

After twelve weeks of body-weight-supported treadmill gait training for twenty to thirty minutes, preceded by stretching exercises for ten minutes and overground gait training and performed, whenever possible, for ten to twenty additional minutes each session, patients with classification ASIA B and C, who completed at least six weeks of treatment in the upper motor neuron and lower motor neuron groups, together (n = 109) and only lower motor neuron lesion (n = 86), no statistical differences were revealed between the two groups. In the experimental group, 33% (7/21) of the patients with incomplete medullary lesions, classified as ASIA B could deambulate six months after intervention[5] **(A).**

No statistical difference was observed in the gait speed between the two groups of patients with lower and upper motor neuron lesion graded as ASIA C and D who had gait and completed at least six weeks of intervention, as well as the patients with lower motor neuron lesion[5] **(A)**.

No significant difference between both interventions was found in ASIA C and D patients, in FIM, gait speed, *endurance,* LEMS (*lower extremity motor score*), *Berg Balance Scale* Score or WISCI (*walking index for spinal cord injury*) *score*[5] **(A)**.

The metanalysis of two controlled randomized studies showed a 0.68 difference (95% of confidence interval [CI] between 0.09-1.26; p = 0.02) between body-weight supported treadmill training and overground training regarding gait independence, measured by FIM after eight to twelve weeks, in favour of overground training. This difference was significant for ASIA C or D (average difference of 0.80, 95% confidence interval 0.04 -1.56m, p = 0.04)[5] **(A)**.

There is moderate evidence that the therapist-assisted body-weight-supported treadmill training is equivalent to overground gait training, regarding speed and ability in patients with less than one year of lesion. Limited evidence indicated that overground gait training is more effective than therapist-assisted body-weight-supported treadmill training to attain independent gait according to the Functional Independence Measure Assessment Scale (FIM)[2] **(A)**.

In patients with incomplete medullary lesions, classified as ASIA C and D, were performed thirty sessions lasting thirty minutes of training with partial body-weight support: passive stretching for thirty seconds of all muscular groups of UULL, lasting, approximately, a total of eight minutes; passive movements of the hip, knee and ankle for five minutes; positioning of patient on the treadmill using body-weight support which stabilizes pelvic region and trunk, evaluation in the first session to determine speed, duration and load-relief percentage during gait training. The trainings started with 40% suspended weight and reduced 10% every ten sessions, maintaining the speed selected by the patient[6] **(A)**.

There were statistically significant differences in kinematic gait parameters. There were improvements in the parameters; spatial-temporal, of walking speed, distance travelled, cadence, step length, cycle time, and swing phase balance time[6] **(A)**.

The analysis of the difference between both groups after twelve weeks of intervention showed that the group submitted to body-weight-supported treadmill training presented statistically superior amplitude of movement during the pre-swing phase of hip extension and plantar flexion in comparison with those submitted to physical therapy-based training[6] **(A)**.

On ASIA C and D patients there was no significant difference on FIM, gait speed, *endurance, Berg Scale or WISCI Scale*[5] **(A)**.

Recommendation

Body-weight-supported treadmill gait training in patients with incomplete medullary lesion did not demonstrate to be superior to overground gait training[2,5] **(A)**.

2. In patients with spinal cord injury, can functional electrical stimulation (FES) provide more benefits to gait training than in patients who do not use functional electrical stimulation?

Partial body-weight-supported gait treadmill training and functional electrical stimulation (FES) is proposed in a customized system. The FES stimulation strategies were customized for each subject. Individuals would deambulate for as long as they could, for a maximum of twenty-five minutes, and were allowed to rest whenever needed. Interventions had duration of approximately one hour[7] **(B)**.

The subjects were randomized in groups according to the sequence of intervention and control: AB (control-intervention) and BA (intervention-control).

All collaborators increased treadmill speed during the intervention time. Group AB (p = 0.001; 95% with confidence interval, 0.116-0.234 m/s) and group BA (p = 0.011; 95% with confidence interval, 0.249-0.240), as well as in the distance travelled. Group AB (p = 0.004; 95 with confidence interval, 165.0-489.6 m) and group BA (p = 0.008; 95% with confidence interval, 103.2-419.2 m). Such increases were accompanied by progressive reduction of the percentage of partial body-weight support and the average reduction was of 18% of body mass in group AB (p = 0.002; 95% with confidence interval, 10.9%-26.3%) and 21,8% of body mass in group BA (p = 0.015; 95% with confidence interval, 6.3%-37.3%)[7] **(B)**.

Recommendation

There is no evidence that functional electrical stimulation (FES) provides more benefits in gait training[7] **(B)**.

3. What are the contraindications of lower limb passive stretching in patients with spinal cord injury?

By stretching ischiotibial muscles in one of the limbs of patients with spinal cord injury for thirty minutes, during four weeks, with equipment consisting of one wheel attached to the side of a physical therapy divan with a splint attached to the wheel, both spinning together and the splint preventing knee flexion, hip abduction, and rotation. A 48 N torque was applied by hanging 18 kg to the wheel, only one patient presented complications during the study (NNH = 5), with autonomic dysreflexia. This, however, was related to the positioning during intervention and not due to the stretching itself[8] **(A)**.

During the stretching performed with an equipment consisting of a wheel attached to a physical therapy divan with a foot platform attached to a wheel that would spin in a sagital plane and with a 7.5 N torque applied by hanging 5 kg to the wheel, of ankle musculature of patients with spinal cord injury for thirty minutes daily, during four weeks, no lesions or complications related to the stretching were observed[9] **(A)**.

Recommendation

There is no evidence of lesion or complication due to passive stretching of patients with spinal cord injury[8] **(A)**.

4. Which assessment scales are most indicated to measure upper limb function in patients with spinal cord injury/ tetraplegia?

The ASIA score protocol is a neurological assessment developed according to the standards established in 1992 by ASIA (American Spinal Injury Association). It allows physicians and therapists to evaluate several spinal cord injury levels and predict prognosis and function level. The ASIA scores are very sensitive in following-up motor evolution of acute spinal cord injury patients receiving rehabilitation treatment when applied at the admission of the patient and after six months[10] **(B)**.

The recording of motor evoked potentials - MEP enables the evaluation of motor medullar injury severity during treatment of patients with spinal cord injury. The MEP of patients with spinal cord injury is effective in predicting function of the abductor digiti minimi muscle (ADM) and hand function itself. It is sensitive in measuring the functional deficit of the analyzed musculatures and contributes in the assessment of hand function when performed together with the ASIA scores. MEP recording is measured in the UULL musculature (brachial biceps and ADM) by means of transcranial magnetic stimulation, with a 13 cm diameter coil, with the current flow clockwise, positioned tangentially to the scalp and centered over Cz (international 10 to 20 electrode location). Transcranial magnetic stimulation performed with the subject in supine position.[10] **(B)**.

This is a method with high cost and difficult access for our means.

When measuring strength of UULL in tetraplegic patients, we have four most used means of assessment: manual muscle testing - MMT; hand-held dynamometer; measurement of pinch grip and prehension with isokinetic dynamometer. The hand assessment (Manual muscle testing - MMT), in which the therapist assesses muscular strength imposing hand resistance and classifying according to a one to six points scale being one point, no contraction and six points, not testable, determined by the *Medical Research Council* (MRC), is poorly sensitive to muscular strength gains in patients between levels four and five, in which, four equals active movement against gravity and some resistance and five equals normal strength. MMT is used to measure strength in the key muscles of the ASIA scores protocol. The use of the hand-held dynamometer shows greater sensitivity to small changes in muscular strength in levels four and five with no disavantadges in relation to the isokinetic dynamometer. Both the hand-held and the isokinetic dynamometers can only be applied to individuals that present MRC classification above three, active movement against gravity[11] **(A)**.

The UULL function evaluation tests must be chosen taking into consideration the parameter to be investigated. Among those tests are used, generally, in the population with spinal cord injury the following: the *Minnesota Rate of Manipulation* (MRM); the *Upper Extremity Function Test* (UEFT); *Purdue Pegboard Test*; *Nine-hole Peg Test Smith hand function evaluation*; *Box & Block Test* (BBT); *Physical Capacities Evaluation of Hand Skill* (PCE); *Action Research Armtest* (ARA); *Sollerman hand function test; Standardised Object Test* (SOT); *Vandenberg hand function test; Grasp Release Test* (GRT); Capabilities of Upper Extremity Instrument (CUE); *Thorson's functional test*. The five former tests were formulated, specifically, for tetraplegic patients, whereas the others are general tests, used in the evaluation of patients with several different diagnoses that present changes in upper limbs function. Tests developed for a specific population, such as SOT and GRT, formulated for tetraplegic patients using neuroprostheses, or the Vandenberg which was created to evaluate hand function in tetraplegic patients who had reconstructing surgery, allow focusing in the aspects one wishes to evaluate in the upper limb during an intervention. The general assessment tools allow comparing different interventions and conditions, however, in several occasions they are not sensitive to certain changes in hand function and do not fit completely to the tetraplegic condition, e.g., most tests required that the patient be seated during their application, however, in the acute phase, the individual, normally, needs to perform them in supine position[11] **(A)**.

Recommendation

The ASIA score is sensitive in determining changes in the UULL function in patients with tetraplegia[10] **(B)**.

Associated with the motor evoked potentials - MEP recording, sensitive in determining changes in the evaluated musculature function, it is effective in determining the level of function of the UULL[10] **(B)**.

To assess muscular strength in UULL of tetraplegic patients, with *Medical Research Council* - MRC classification above three, we have the hand-held and the isokinetic dynamometers, effective and sensitive to changes in it[11] **(A)**.

General assessment tools for the population with affected hand function are useful to make comparisons between diagnoses and interventions[11] **(A)**.

The specific tools developed for the population with tetraplegia are effective in the evaluation of the parameters of UULL function which are important during certain interventions[11] **(A)**.

5. Which scales for classification and evaluation of independence in basic activities of daily life (BADL) and instrumental activities of daily life (IADL) are most indicated for patients with spinal cord injury in rehabilitation treatment?

The Spinal Cord Independence Measure - SCIM is a comprehensive scale to measure the individual's skills during the performance of daily life activities, specifically designed for patients with spinal cord injury. It consists of three subscales, three domains, with a total of nineteen tasks to be assessed: self care, respiration and sphincter management, and mobility[12] **(B)**.

It must be applied by a designated team of health care professionals: physiatry, nursing, occupational therapy, and physical therapy. The scores range from zero to one hundred, in which the highest score indicates greatest ability. The analysis of the instrument's indices is made by observing the patient performing tasks. It is possible, in special cases, to use information provided by the patient for a few indices[13] **(B)**.

The SCIM III tool can be applied to patients with spinal cord injury, aged over eighteen years, i.e., adult and elderly population. This assessment tool, according to *Rash analysis*, has good validity, confidence, and applicability, therefore it can be used to support the clinic[12,13] **(B)**.

For different groups of spinal cord injury, tetraplegia, paraplegia, complete or incomplete, with different etiologies. There are no significant differences in the results of SCIM III application among different countries and cultures, indicating good applicability in different cultural contexts[13] **(B)**.

It is sensitive to changes in the independence and functionality status, therefore, useful in following the patient's evolution in a rehabilitation program[14] **(B)**.

Recommendation

The use of the SCIM III assessment tool is effective for measuring the independence in the activities of daily life of patient with spinal cord injury, BADL and IADL, and for giving support to the practice of health care professionals that work with this population in rehabilitation centers[12-14] **(B)**.

However, translating this scale to Portuguese and validating it to the Brazilian population is required.

6. Is the use of functional electrical stimulation (FES) in patients with spinal cord injury/tetraplegia more effective than conventional therapy in improving upper limb function?

The partially paralysed musculature's strength in patients with spinal cord injury/tetraplegia is directly related to functional independence in this population. The application of Functional Electrical Stimulation, FES, and progressive resistance training are two distinct approaches used to improve strength and resistance to fatigue in patients with spinal cord injury and weakness in the extensor and flexor musculatures of the wrist. The addition of FES to the progressive resistance training program, in six series of ten contractions, three sessions a week, over a period of eight weeks, does not show significant improvement in active movement of the wrist musculature, with FES application using 5 x 5 cm electrodes in the forearm proximal region, with the following parameters: 50 Hz, regular 0.3 ms pulses, in 6 x 6 sec cycles, intensity around 70 mA or regulated according to the patient's tolerance[15] **(A)**.

Compared to conventional therapy, the use of FES and biofeedback in the improvement of tenodesis grasp function in patients with diagnosis of tetraplegia undergoing rehabilitation, over a five to six-week period, five times a week, in twenty-minute sessions, it is verified that all therapies contribute, positively, to the improvement of this function. However, there are no differences, in general, in the effectiveness of one approach over the other[16] **(A)**.

Considering as conventional therapy the passive movement of the UULL joints, use of positioning and dynamic orthoses and tenodesis grasp functional training in a graded activities program. The application of FES must be done according to the following pattern: electrodes positioned on extensor musculature of the wrist and frequency settings 20 Hz, 0.3 msec pulses, 0.8 x 0.8 sec cycle and 0.2 sec ramping modulation[16] **(A)**.

Recommendation

As of this moment, there is no evidence that the Functional Electrical Stimulation - FES, added to the progressive resistance training promotes improvement in muscle strength for the active movement of extensor and flexor muscles of the wrist in tetraplegic patients[15] **(A)**.

The improvement in tenodesis grasp function could have FES as a therapy to be considered, however, it does not have, as of this moment, proof of its difference compared to conventional therapy[16] **(A)**.

7. Does the use of motor biofeedback improve upper limb function in patients with spinal cord injury/tetraplegia?

The use of biofeedback over a five to six-week period, five days a week, in twenty-minute sessions, is effective in the improvement of hand function and strength in patients with spinal cord injury/ tetraplegia regarding three upper limb muscles: biceps, anterior deltoid and long radial extensor of the wrist; regardless of the skill and initial strength levels of these muscles. Therefore, this therapy is effective in the improvement of tenodesis grasp.

The good biofeedback results do not differ in a statistically significant manner from those attained by conventional therapy, application of functional electrical stinulation FES and the combination of Biofeedback and FES, following the application patterns listed, as well as duration and target population. Biofeedback uses a screen for real time observation of electromyography EMG of the muscles to be worked and auditive response, whose duration and volume vary according to the intensity and duration of the muscle contracture. In order to work the long radial extensor muscle of the wrist, the patient must be positioned in a sitting position on a wheelchair or bed and the upper limb must be comfortably put on a table, in neutral prone position. The screen must be visible to the patient. The elbow joint must be stabilized in order to avoid compensatory movements. The therapist identifies the musculature to be monitored by means of palpation and cleans the area where the electrodes are to be applied. The patient is asked to try to follow the EMG pattern displayed on the screen as best as possible[16] **(A)**.

Recommendation

Biofeedback can be considered as a technique for functional improvement by tenodesis in tetraplegic patients and its effectiveness is similar to conventional therapy[16] **(A)**.

8. Does the use of positioning orthoses on upper limbs of patients with spinal cord injury promote the prevention of deformities and contribute to the improvement of function?

Night use over a six-month period of orthosis for positioning thumb in small flexion of the carpometacarpal and metacarpophalangeal joints, with stabilization in wrist extension and other thumb articulations, does not influence the reduction of the extension of the long flexor of thumb. Therefore, consequently, its effectiveness in the improvement of hand function under these conditions of use is proven[17] **(B)**.

Recommendation

Night use of orthosis specific for the reduction of extension of the long flexor of thumb during three months in patients with spinal cord injury does not guarantee improvement in hand function[17] **(B)**.

There are not enough evidences to prove the effectiveness of the use of orthoses for improvement of function and prevention of deformities in the population with spinal cord injury, due to the lack of trustworthy and controlled studies about this matter. It is necessary to highlight how important it is to conduct more researches about this matter, since orthoses are very useful resources and largely used in the practice of rehabilitation professionals[17] **(B)**.

9. Does the indication of technical assistances for the performance of basic and instrumental activities of daily life promote independence and autonomy for the patient with spinal cord injury?

Environmental Control Systems, ECS, consist of equipment that allow independent access to the environment and are very useful for people with important motor limitations, such as tetraplegic patients. Most require the use of finger movements to select their actions[18] **(B)**.

The ECS that senses alpha brain waves, whose threshold is changed with the movement of blinking the eyes, is an alternative to patients who have difficulties in manually accessing the system. The patient uses a cap with the electrodes, which maintain good contact with the scalp, activates the options by blinking the eyes. In the task of watching television, with the options of turning the set on and off, change channels and volume, there is need of short training, resulting in effective use with average time to activate the desired option of 13.18 ± 4.39 seconds and low error index. However, more studies in this area are required[18] **(B)**.

The use of electronic equipment in the Activities of Daily Life (ADL), electronic aids to daily living, EADL, also known as environmental control units, as well as ECS. The best known equipments to this end allow using telephones, television sets, computers, home safety systems, controlling home lighting, among others. They allow greater independence and autonomy for tetraplegic patients in their ADL and their use has positive impacts over the patients' perception of competency, adaptability and self esteem[19] **(B).**

Life expectancy is increasing among severely disabled people, such as patients with tetraplegia due to spinal cord injury. This aging is associated with a hardening of the barriers and difficulties faced in the performance of ADL and IADL. The use of assisted technology allows lesser functional decline over a two-year period. Among the adaptations and equipment, are: support bars, several ADL adaptations, shower chairs, Instrumental Activities of Daily Life adaptations, IADL, wheelchair cushions, toilet equipment, adapted telephones, upper limbs supports, environmental interventions such as ramps, and home modifications[20] **(B)**.

Recommendation

Nowadays, the use of Environmental Control Systems, ECS, and the use of electronic aids to daily living, EADL, appear as positive actions to the improvement of independence and autonomy of the population with severe motor limitation and tetraplegic patients. However, we must consider those as high-cost equipment and yet of difficult access to the Brazilian people, in sight of the socioeconomical conditions of the greatest part of the population[18-20] **(B)**.

The indication of technical aids, such as: support bars, several ADL and IADL adaptations, shower chairs, wheelchair cushions, toilet equipment, adapted telephones, upper limbs supports, environmental interventions such as ramps, and home modifications, contribute to the improvement of functional performance and reduction of functional loss over time in patients with severe motor limitations, such as tetraplegics[20] **(B)**.

It is important to highlight the importance that the evaluation and execution of this indication must be done by qualified experienced professionals, such as an occupational therapist[20] **(B)**.

10. Does the use of appropriate wheelchair improve functional performance of patient with spinal cord injury in the activities of daily life?

By prescribing wheelchair equipment WC for people with spinal cord injury it is understood that this will be, probably, their main mean of locomotion. For an adequate prescription of manual WC it is required to consider the patient's individual posture, function level, environment and available resources. The wheels are items that interfere in the preference of use and effectiveness of the manual WC. By comparing the use of common steel spoke wheels, with the use of composite wheels with carbon spokes, lighter, resistant and durable, in eight-minute circuits to follow a straight lign forward and back, there is no difference in the energetic efficiency between the two types. However, by evaluating the comfort in use, the carbon spoke wheel-equipped WC has showed to be better than the common steel spoke type in a circuit with different obstacles, ramps, unevenness, and different ground textures that can be found in the patients' daily life[21] **(A)**.

The back wheel positioning also influences ergonomy and mobility efficiency in WC users with spinal cord injury, who propel their WC, independently, generally, individuals with paraplegia. By using the WC model that permits changing seat inclination, the change in shoulder to wheel distance is verified when compared the reclining angles 5° and 12°, in order to increase torque and arm strength when in the most reclined position; which affects impulse frequency when propelling the WC and the strength arm changing the propulsion technique. Mechanical efficiency is changed, tending to decrease the higher the recline[21] **(A)**.

Weight distribution is also affected when using a more reclined position and the higher the inclination, the greater the weight distribution in the WC's seat. Comfort in the seating position and propulsion efficiency do no differ when the seat inclination is increased[22] **(A)**.

Regarding individuals with tetraplegia after a spinal cord injury, mobility limitation is, commonly, related to wheelchair WC, when considering the levels of independence in the use of this equipment and the accessibility of disabled people. The powered wheelchair and stair-climbing equipments can be important technologies for patients with UULL impairment. When comparing a conventional powered wheelchair with a model of powered wheelchair capable of climbing stairs, it is verified that the conventional powered WC tends to present advantages regarding the time of displacement in internal and external environments, dimensions and weight, in addition to effectiveness of use. The WC model capable of climbing stairs allows overcoming obstacles, ground unevennesses, climbing stairs independently in most cases, however, this equipment requires more study to facilitate the use of the control and improve its technical performance[23] **(A)**.

The use of composite wheels with carbon spokes compared to the use of common steel spoked wheels, promotes improvement in the functional performance of patients with spinal cord injury. However, the carbon wheels are an item that increases the price of the wheelchair WC and that is not provided in the WCs distributed by the public organs responsible for the supply of this equipment[23] **(A)**.

The increase in the WC seat inclination does not promote improvement in the functional performance of paraplegic patient[23] **(A)**.

Although these are high cost resources destined to a small part of the population of spinal cord injured, powered wheelchairs contribute to the improvement of functional performance of people with severe physical limitations, tetraplegic. It is observed that the use of regular powered wheelchair is more effective regarding use, weight and dimension in internal and external environments when compared to a model of powered wheelchair capable of climbing stairs. However, to overcome obstacles and climb and descend stairs, the model capable of climbing stairs is effective, allowing greater independence and functional performance in this task[23] **(A)**.

Recommendation

The use of wheelchair with composite carbon spoke wheels compared to the use of steel-spoked common wheels promotes improvement in functional performance of patient with Spinal Cord Injury[21] **(A)**.

The increase in inclination of the WC seat does not promote improvement in functional performance of patient with paraplegia[22] **(A)**.

Regular powered WC is more effective regarding use, weight and dimension in internal and external environments when compared to a model of powered wheelchair capable of climbing stairs. However, to overcome obstacles and climb and descend stairs, the model capable of climbing stairs is effective, allowing greater independence and functional performance in this task[23] **(A)**.

11. Is the use of TENS effective in muscle tone adjustment in patients with spinal cord injury and spasticity?

After single application of TENS in common fibular nerve for sixty minutes, with surface alectrodes applied to the area between the common fibular nerve and fibular head and device parameter settings of 0.25 ms, 100 Hz, 15 mA there is immediate reduction of muscle tone in patients with spinal cord injury and spasticy in the lower limbs. Significant reductions were shown by the Composite Spasticity Scale in 29.5% (p = 0.017), resistance to complete passive dorsiflexion of ankle amplitude of movement in 31.0% (p = 0.024) and ankle clonus in 29.6% (p = 0.023) in the TENS group, however, these reductions were not found in the control group[24] **(A)**.

Recommendation

The use of TENS is effective in muscle tone adjustment in patients with spinal cord injury and spasticity[24] **(A)**.

12. Can the parameters used in the evaluation of body fat in the general population be applied to patients with spinal cord injury?

The cutoff for obesity established by the WHO has failed to identify 73.9% of participants as obese. According to this study the cutoff that should be adopted as eutrophy limit in patients with spinal cord injury, is 22.09 kg/m^2. From 22.1 kg/m^2 to 25 kg/m^2 overweight and over 25 kg/m^2, obesity[25] **(B)**.

Another study evaluated patients according to BMI classifications of the WHO, 2000, and with Laughtom, 2009, study, observed:

- BMI cutoff (≥ 22 kg/m^2) → 5 years after discharge, the overweight/obesity risk found was 1.75 times higher. Every ten years of age, people with SCI had 1.2 times higher risk of developing overweight/obesity[25] **(B)**.
- BMI cutoff (≥ 25 kg/m^2) → 1.60 times higher risk of becoming overweight/obese and 2.12 higher chances after five years.

After discharge, patients with spinal cord injury present increased risk of weight gain, mainly, males with diagnosis of paraplegia. The weight excess prevalence in the studied spinal cord injury population is 7% to 19% higher when compared to the population without spinal cord injury[26] **(B)**.

Recommendation

The adoption of cutoffs as upper limits for eutrophy Body Mass Index for the population of patients with spinal cord injury of 22.09 kg/m², provides a more sensitive diagnosis of nutritional status and contributes to the prevention of cardiovascular disease.[25,26] **(B)**.

13. Can inspiratory muscle training improve maximum inspiratory pressure and lung function in patients with spinal cord injury?

Inspiratory Muscle Training, IMT, was performed in twenty patients randomized and divided into two groups, ten in the control group and ten in the training group, using the DHD inspiratory device with six different resistance levels positioned in the supine position of 10° to 15° of elevation, maintaining a respiratory rate of twelve to sixteen respirations per minute. The inspiratory muscle training time was of fifteen to twenty minutes a day, seven days a week, over six weeks. The training group presented statistically significant improvement in inspiratory muscle strength, MIP, in respiratory endurance, and in lung function, in addition to reducing the sensation of dyspnea and respiratory complications[27] **(A)**.

Several studies were conducted in recent years, most protocols could not be combined in a meta-analisys due to the research design, patient characteristics heterogeneity, or differences in the training techniques. None of these studies had incorporated an optimal IMT protocol and presented controverse effects, regardless of the training strategy used, and can be influenced by the result evaluation methods and by the methodological quality of the studies[28,29] **(A)**.

Recommendation

Inspiratory Muscle Training, IMT, is recommended for tetraplegic patients with spinal cord injury with the purpose of improving inspiratory muscle strength, MIP, respiratory endurance, and lung function, in addition to reducing dyspnea sensation and respiratory complications[31,27] **(A)**.

14. Can expiratory muscle training improve maximum expiratory pressure and lung function in patients with spinal cord injury?

Study with twenty-nine tetraplegic patients, sixteen in the training group and thirteen in the control group without resistance, performing expiratory muscle training five days a week, with ten trepetitions, from three to five minutes for six consecutive weeks[32] **(A)**.

There was improvement in both groups when evaluated; forced vital capacity FVC, forced expiratory volume in the first second FEV1, expiratory reserve volume, ERV, maximum inspiratory pressure MIP, and maximum expiratory pressure MEP. This increase was statistically significant in the training group[32] **(A)**.

Inspiratory capacity, IC, total lung capacity TLC, functional residual capacity FRC, and residual volume RV, did not present significant increase in any of the groups[32] **(A)**.

Recommendation

Respiratory muscle training is recommended for the improvement in expiratory muscle strength, MEP, and lung function when performed five times a week for six consecutive weeks[32] **(A)**.

15. Can the use of abdominal binder increase diaphragm contraction strength generating higher volumes and capacities in patients with spinal cord injury?

In twenty patients with complete medullary lesion C5-C8 evaluating deep respiration, respiration with inspiratory and expiratory resistance with and without use of abdominal binder, performing three series of ten repetitions. With the use of abdominal binder, lung volumes at rest were significantly decreased, and there was improvement in the vital capacity. Residual capacity decreased on the three types of respiration[33] **(B)**.

The inspiratory flow peak was higher without the binder. In five patients the vital capacity and alveolar ventilation increased at rest, during deep respiration and breathing with resistance in the expiratory phase with the abdominal binder. The use of abdominal binder provides only peripheral changes during deep respiration exercises and without expiratory resistance, thus being the use of binder questionable. Some patients may benefit from the treatment, not being able to rule out the use of abdominal binder and respiratory exercises[33] **(B)**.

In an observational prospective study with thirty-six patients with spinal cord injury in cervical and thoracic levels, continuous users of abdominal elastic binder, were evaluated in the sitting and in the supine positions. It was observed that, in a sitting position, vital capacity was higher in users than in non-users (0.43 ± 0.39 x -0.05 ± 0.32) $p < 0.0001$[33] **(B)**.

The change in vital capacity in the sitting position was related to the time of lesion (R^2 - 0.47, $p < 0.001$) and not to the body mass index. Vital capacity and inspiratory capacity were improved when using the binder in the sitting position (p = 0.64 CI 95% 0.47 - 0.83 $p < 0.0002$). Binder users decreased the Borg dyspnea index (2.4 ± 1.8 to 0.8 ± 0.8)[34] **(B)**.

Recommendation

The use of abdominal elastic binder is indicated for patients with spinal cord injury when in sitting position, however, it is questionable when associated with respiratory exercises[33,34] **(B)**.

16. Is glossopharyngeal respiration capable of increasing vital capacity in tetraplegic patients?

The use of glossopharyngeal respiration over maximum inspiratory capactity in sixteen healthy women, performing fifteen to thirty respirations three times a week during six weeks, presented significant increase in vital capacity and thoracic expansion in the training group, effects still observed twelve weeks after intervention[35] **(A)**.

In twenty patients with spinal cord injury C4-C8 ASIA A, B or C independent ventilatory, performing ten cycles of glossopharyngeal respiration four times a week, during eight weeks, presented significant increase in vital capacity, expiratory reserve volume, functional residual capacity, residual volume, total lung capacity and thoracic expansion[36] **(B)**.

Case report of a nineteen years old patient with C2 spinal cord injury, thracheostomized, mechanical ventilation-dependent, performed glossopharyngeal respiratory training for five weeks from three to four times a week, presenting improvement in his vital capacity, thoracic expansion and improvement in the cough effectiveness from non-functional to weak functional cough, which allows him to eliminate tracheal secretion[37] **(C)**.

Recommendation

Glossopharyngeal respiration technique when trained for five weeks from three to four times a week, is recommended for the improvement in vital capacity of patients with spinal cord injury[35-37] **(B)**.

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