

Effect of strength training on physical and mental health and quality of life of people with spinal cord injury: a literature review

Joel Alves Rodrigues¹, Eveline Torres Pereira¹, Claudia Eliza Patrocínio de Oliveira¹, Osvaldo Costa Moreira²

¹Departamento de Educação Física, Universidade Federal de Viçosa, Viçosa, MG, Brasil. ²Instituto de Ciências Biológicas y de la Salud, Universidad Federal de Viçosa, Campus Florestal, Florestal, MG, Brasil.

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Summary

Life expectancy of individuals with spinal cord injury (SCI) has increased over the years; although not proportional or equal to that of the general population, there is a slight approximation in life expectancy between the groups. However, the mortality rate in individuals with SCI remains high. SCI is a serious medical condition that causes functional, psychological and socioeconomic disorders. Therefore, people with SCI experience significant disabilities in various aspects of their lives. Strength training has been used as an instrument to improve functional, cardiorespiratory, psychological and quality of life (QoL) parameters. However, studies that discuss the effect of strength training on health-related aspects of people with SCI are still rare. The aim of this study is to review the literature on the effects of strength training on physical and mental health and QOL of people with SCI. A bibliographic research was conducted with subjects related to the SCI, strength training, functionality, health and mental state and QOL. SCI is a complex disability that causes many changes, which can be physical, psychological and social. It is accompanied by comorbidities, which directly affect the health status and, consequently, the QOL of the affected individual. In general, exercise has been postulated as an alternative for health promotion and QOL in people with SCI. In particular, strength training is used to promote physical and mental health and QOL as it produces positive results for different aspects of health and QOL, especially muscle strength and functional capacity, reducing symptoms of anxiety and depression and increasing indicators of QOL in people with SCI.

Key words:

Spinal cord injury.
Strength training. Mental health.
Quality of life.

Efecto del entrenamiento de fuerza en la salud física y mental y la calidad de vida de personas con lesión medular espinal: una revisión de la literatura

Resumen

La esperanza de vida de las personas con lesión de la médula espinal (LME) ha aumentado con los años; aunque no es proporcional o igual al de la población general, existe una ligera aproximación en la esperanza de vida entre los grupos. Sin embargo, la tasa de mortalidad en individuos con LME sigue siendo alta. ML es una condición médica grave que causa trastornos funcionales, psicológicos y socioeconómicos. Por lo tanto, las personas con LME experimentan discapacidades significativas en varios aspectos de sus vidas. El entrenamiento de fuerza se ha utilizado como un instrumento para mejorar los parámetros funcionales, cardiorrespiratorios, psicológicos y de calidad de vida (CV). El objetivo de este estudio es revisar la literatura sobre los efectos del entrenamiento de fuerza sobre la salud física y mental y la CV de las personas con LME. Se realizó una investigación bibliográfica con temas relacionados con ML, entrenamiento de fuerza, funcionalidad, salud y estado mental y CV. La LME es una discapacidad compleja que causa muchos cambios, que pueden ser físicos, psicológicos y sociales. Se acompaña de comorbilidades, que afectan directamente el estado de salud y, en consecuencia, la CV del individuo afectado. En general, el ejercicio se ha postulado como una alternativa para la promoción de la salud y la CV en personas con LME. En particular, el entrenamiento de fuerza se utiliza para promover la salud física y mental y la calidad de vida, ya que produce resultados positivos para diferentes aspectos de la salud y la CV, especialmente la fuerza muscular y la capacidad funcional, reduciendo los síntomas de ansiedad y depresión y aumentando los indicadores de CV en personas con LME.

Palabras clave:

Lesión medular espinal.
Entrenamiento de fuerza.
Salud mental. Calidad de vida.

Correspondence: Joel Alves Rodrigues
E-mail: joel.a.rodrigues1@gmail.com

Introduction

The life expectancy of individuals with spinal cord injury (SCI) has increased over the years. Nevertheless, the mortality rate in individuals with SCI remains high^{1,2}. It's possible that rehabilitation and treatment methods for health have evolved, and the increase in life expectancy is directly related to this evolution³. The evolution of rehabilitation has occurred as a change in its final goal over time: previously, the purpose was to increase life expectancy, and at present, the focus is on functional independence and quality of life (QoL)⁴.

Physical training has been used as a implement to improve functional, cardiorespiratory, psychological, and QoL parameters⁵. One type of physical training is strength training (ST), which is widely used for its beneficial effects on health-related risk factors such as insulin resistance, resting metabolic rate, blood pressure, and body composition, as well as strengthening of the musculoskeletal system, contributing to the maintenance of functionality, and preventing osteoporosis, sarcopenia, heart disease, and various cancers⁶.

However, studies that discuss the effect of ST on health-related aspects of people with SCI are still rare. Given the awareness of the increased life expectancy of individuals with SCI, the ease and low cost of performing ST, and the benefits of this type of training for the health of the general population, understanding the possible effects of ST on the health of individuals with SCI may constitute to a non-drug intervention strategy to promote improvements in health, functional independence, and QoL of these individuals.

Thus, the aim of the present study is to perform a literature review about the effects of ST on the physical and mental health and QoL of people with SCI.

Spinal cord injury: definition and classifications

SCI is mainly caused by external trauma and has the potential to unexpectedly modify the life of the injured individual and interfere with professional, recreational, and social activities⁷. It is caused by any trauma that damages the structures contained in the medullary canal, causing temporary or permanent motor, sensory, autonomic, and psychoactive changes or losses⁸.

SCI can be classified on the basis of its severity (complete or incomplete) and the level of injury occurrence, and the symptoms presented by individuals with SCI will depend on these two factors. According to the American Spinal Cord Injury Association (ASIA)⁹, when there is total loss of voluntary and sensory motor activity in S4–S5, the lesion is classified as complete. When there is any maintenance of motor activity or sensitivity to the sacral segment S4–S5 the lesion is classified as incomplete. As to the level of occurrence of the injury, the loss of trunk, upper, and lower limb function is defined as quadriplegia, and the loss of trunk and lower limb function, as paraplegia¹⁰.

A systematic review analyzing studies published between 2000 and 2016 showed that the worldwide incidence of SCI is 10.5 cases per 100,000 people, resulting in an estimated 768,473 new cases annually¹¹. The highest incidence of SCI was found in low- and

middle-income countries, affecting more males aged 20–24 years (80% of cases)^{8,12}.

Regardless of the cause and classification, an SCI can affect the person's physical and mental health, as well as their QoL. Understanding how SCI can affect these aspects of a person's life can aid in the design of intervention strategies to improve their overall health and QoL.

Aspects related to physical and mental health and quality of life of people with spinal cord injury

After SCI, several changes may occur in physiological, physical, psychological, and social aspects of life¹³. These may alter the individual's health condition, leading to reduced life satisfaction and emotional well-being, decreased life expectancy, and consequently, increased mortality¹⁴.

The impact of SCI on the individual's health condition is directly or indirectly related to their physical and psychological diagnosis, and the activity limitations and participation restrictions it imposes on the person in their socio-cultural environment⁷. These impacts may cause several impairments, such as reduced functionality, impairment of body systems, QoL, and psychological aspects such as depression and anxiety.

The health status of an individual with SCI is also compromised by secondary comorbidities such as complications of the urinary, respiratory, and intestinal systems, as well as changes in skin sensitivity and muscle tone^{14–19}.

SCI can cause long-term complications in the urinary system, leading to bladder dysfunction, often called neurogenic bladder²⁰. The most important factor in controlling dysfunction is maintaining continence and preventing the development of upper urinary tract dysfunction.

Respiratory complications in SCI can lead to respiratory muscle failure, reduced vital capacity, ineffective cough, and reduced lung and chest compliance. These respiratory complications will depend on the level of SCI and the degree of impairment¹⁵. Bowel problems may also occur as a consequence of SCI, common in between 27% and 62% of individuals. The most common complications are constipation, distension, abdominal pain, rectal bleeding, hemorrhoids, and autonomic hyperreflexia. These complications are related to the sacral region. Anterior sacral root stimulation between S2 and S4 may reduce some of the damage²¹.

Below the level of the lesion, some or all of the skin's sensitivity will be compromised by failure to send information through the afferent nerves, and this damage can cause heat, cold, impact, and prolonged pressure injury such as pressure ulcer, which is a leading cause of SCI hospitalization^{14,22}. Muscle tone dysfunction may also occur, with spasticity being the most common type. Muscle spasticity is characterized by involuntary and continuous muscle contractions caused by changes in and increased excitability of motoneurons and interneurons¹⁶.

Another dimension of health affected by SCI is mental health, especially due to the onset of symptoms related to depression and anxiety. Individuals with SCI have a high incidence of anxiety or post-discharge depression, especially among younger patients (<50 years)²³. The causes of depression and anxiety are unclear, but some factors assumed to

be involved are the abrupt and unexpected nature of the injury itself; the person is unprepared to cope with their new reality and may have difficulties coping²⁴. In addition, deterioration of function (for example: respiratory disorder, sexual functioning, balance)²⁰, pain associated with changes in cognition, anger, or psychosocial impairment²⁵, and the need for retrofitting of the body in space and the fact that this process is dependent on the help of others, may be factors that help explain the high incidence and prevalence rate of depression and anxiety in individuals with SCI.

All these comorbidities affect the general health status of individuals with SCI and can directly impact their QoL, since health is understood as an element of QoL. However, QoL and health can be understood as two distinct concepts, and correlating the two can be a mistake, as a totally healthy life may not result in high QoL²⁶.

In addition, the concept of QoL is characterized as aspects of an individual's subjective experience that are directly and indirectly related to health, illness, disability, and treatment effectiveness²⁷. It has objective and subjective dimensions. The subjective dimension assumes that QoL may be partially independent of health status and is a reflection of the way individuals perceive and react to their health status and other non-medical aspects of their lives, i.e., the subjective dimension refers to one's own perceptions. On the other hand, the objective dimension is composed of observable conditions or physical functioning and can be assessed by external persons (researcher, physician, evaluator) and/or physical tests²⁸. Thus, QoL should be evaluated on the basis of the individual's own concept and not associated with the quantification of objective dimensions related to health.

Accordingly, the theory of the disability paradox, in which people with disabilities who are supposed to have depressed QoL levels report good QoL²⁹, allows us to understand why, when observing an individual with MSD, their situation may seem adverse; however, they may be able to perform desired activities, and their self-perception of QoL may be positive. Thus, health-related QoL cannot be used exclusively by researchers and physicians as a reference to patients' perceived health³⁰.

QoL is generally lower in individuals with SCI than in those without SCI, being justified by the severity of the injury and difficulties with adaptation after injury³¹. When assessed by the World Health Organization (WHOQOL) Brief Self-completed questionnaire, the QoL of individuals with SCI was significantly lower than in the general population in the physical, social relationship, and psychological domains. However, the authors suggest that despite the difference, subjective assessment is necessary to better understand the results³².

A recent cohort study looked at 1-, 2-, and 5-year-olds with SCI, and researchers found that QoL increased over time³³. The authors' argument to justify this result was that individuals with SCI learn over time to adapt to their situation, and this adaptation seems to reflect a progressive disconnect between symptoms and physical or mental health, leading to a real improvement in physical functioning over time.

Death can be considered to have the greatest negative impact on people with SCI. A higher percentage of individuals with severe injury die in the first year after injury; the most common causes of death are pulmonary alterations, cardiovascular diseases, and infectious diseases^{34,35}.

One of the causes of mortality in people with SCI is a reduced ability to produce autonomic actions from the central nervous system, thus

causing dysfunction in the control of the heart rate and blood pressure and rendering communication between the nervous system and other body systems inefficient³⁶.

Another important cause of mortality is cardiovascular disease, which is generally associated with sedentary behavior. The low level of physical activity in people with SCI induces a decrease in energy expenditure, which may cause changes in the health condition of these people, such as fat accumulation and overweight and obesity³⁷. The combination of SCI and insufficient levels of physical activity can lead to metabolic changes such as hyperinsulinemia, insulin resistance, type 2 diabetes, dyslipidemia, and cardiovascular disease³⁸. Thus, a sedentary lifestyle, glucose intolerance, insulin resistance, and a reduced metabolic rate result in a general deconditioning of the individual, with a consequent increased risk of mortality³⁹.

For all these changes presented by people with SCI, in physical and mental health, as well as in QoL and increased mortality, it is up to professionals involved with the health care of these people to seek strategies to reduce these negative changes caused by SCI. Along these lines, physical exercise has been postulated as a possible non-pharmacological treatment strategy to combat some of these negative changes in the health and QoL of people with SCI.

Benefits of regular exercise for people with spinal cord injury

In an attempt to "cure" and/or rehabilitate an injured/mutilated body, sometimes the process of insertion of physical exercise for people with SCI is palliative, without consideration of its value for leisure, as well as social, psychological, and physiological well-being.

In general, the regular practice of physical exercise has several beneficial effects for individuals with SCI; the most prominent and researched of these are the benefits that it brings to the functional state and QoL⁴⁰. The effects of exercise on psychological health, especially on the symptoms of depression and anxiety, are still not well studied.

Recently, new guidelines on the prescription of exercise to promote physical and cardiometabolic health in people with SCI⁴¹ stipulate that, in order to improve cardiorespiratory fitness and muscle strength, individuals with SCI should practice at least 20 minutes of moderate to vigorous exercise twice a week and three sets of strength exercises for muscle groups with moderate–vigorous intensity, also twice a week. For cardiometabolic health benefits, the guidelines state that at least 30 minutes of moderate to vigorous aerobic exercise should be performed three times a week.

The lower values of volume and intensity are due to the fact that people with SCI are less active, thus adopting a sedentary behavior and, consequently, lower their level of physical conditioning^{42,43} argue that the dose response for physical exercise will depend on several factors and that health benefits can be achieved with lower volumes and intensities in apparently healthy individuals and those with chronic clinical conditions. Thus, individuals with SCI may experience improvements in fitness and health indices from lower doses of exercise⁴¹.

ST has been evidenced in the exercise prescription guidelines for people with SCI, as it is a type of exercise that provides improvements

in neuromuscular, cardiometabolic, and functional components⁴¹. In addition, this type of exercise also seems to induce improvements in overall physical health, mental health, and QoL, and is therefore a possible strategy to use when promoting health and QoL of people with SCI.

Effects of strength training on functional aspects of people with spinal cord injury

One of the main goals of ST for individuals with SCI is to increase strength to improve functionality in activities of daily living⁴⁴. However, for the promotion of benefits in functional capacity and strength of people with SCI, there is no well-defined standardization regarding intensity and volume. The average of intervention is 2x to 3x per week lasting 40 minutes, with intensity that can vary from 50% to 100% of the maximum dynamic strength (1RM), and the main focuses are the superior functional muscles^{41,45}.

Serra-Añó⁴⁶ conducted a study to evaluate the effect of a resistance shoulder training program on isokinetic and isometric strength, body composition, pain, and functionality in paraplegic individuals. The program lasted 8 weeks with a frequency of 3 times a week, with 8 exercises performed at 70% of 1RM. The results showed increased isometric and isokinetic shoulder strength, increased fat-free mass, reduced arm fat mass, reduced shoulder pain, and increased functionality.

Bye⁴⁷ studied the effect of ST on partially paralyzed muscles of newly injured individuals who underwent 12 weeks of training, with a weekly frequency of 3 times, using isometric exercises and concentric actions. Subjects were stimulated into a target muscle on one side of the body, and the control was the unstimulated opposite side. Training increased isometric strength in trained and unstimulated muscles, suggesting improvement in strength of partially paralyzed muscles, although it is not clear whether the training effect was clinically significant.

ST for individuals with SCI has also shown positive effects, such as increased muscle strength, anaerobic power, and increased peak oxygen uptake (VO_2peak) in response to a 12-week training program with an intensity of 60% to 70% of 1RM and the use of a hand cycle ergometer, with an intensity between 70% and 85% of the heart rate⁴⁸.

Thus, ST programs with different configurations and different volumes and intensities induce an increase in muscle strength in individuals with SCI, which can directly or indirectly impact the improvement of these individuals' functional capacity. However, few studies use only ST as an intervention strategy, since ST is often associated with a rehabilitation program.

Effect of strength training on mental health and quality of life of people with spinal cord injury

In addition to the intrinsic relationship of QoL with general health, mental health is also inserted in this context, since psychological problems such as depression and anxiety can negatively affect QoL. Along

these lines, regular exercise has beneficial results and has been shown to reduce symptoms of depression and anxiety^{49,50}.

The benefits of regular exercise for relieving symptoms of depression and anxiety can be proposed as distraction, self-efficacy, and social interaction. Distraction is related to the deviation of unfavorable stimuli that can lead to mood improvement after exercise. Self-efficacy proposes that the challenging view of exercise can stimulate self-confidence. Finally, the social interaction inherent in the practice of supportive physical exercise among those involved can lead to positive effects on psychological health⁵¹.

The discussion about QoL is directly involved with the discussion about the most diverse aspects of the health of people with SCI. Along these lines, different exercise programs can be used to promote health and QoL in these people.

Kemp *et al.*⁵² evaluated the effect of a 12-week ST program, 3 times per week, with an average of 11 repetitions using low-intensity exercises, by supporting the body itself, on the relationship between pain and shoulder movement in individuals with SCI. The results showed a two-thirds reduction in basal shoulder pain levels, and this pain reduction allowed individuals to successfully participate in their social and daily life activities, with consequent improvement in QoL and physical and social functions. However, there was no increase in physical activity level (assessed by wheelchair propulsion speed and physical activity scale score for individuals with physical disabilities). The authors admit that the questionnaire may not have been sufficient to evaluate, since it only analyzes quantity and not quality of physical activity.

Another study showed that both the traditional rehabilitation method (5 days a week, 60-minute daily sessions for 6 weeks, including sitting, balancing, wheelchair transfer, mobilization, and functional exercise) and addition of circuit training performed for 6 weeks, 5 days a week, and lasting 60 minutes with progressive loads of 50% to 100% of 10RM were able to increase QoL due to increased functionality⁵³.

Thus, ST programs also seem to be an efficient alternative intervention in people with SCI when aiming at improving mental health and QoL. Future studies on this topic will define the mechanisms by which exercise would act on the symptoms of anxiety and depression, as well as determine the magnitude of the impact of participation in ST programs on the improvement of QoL in people with SCI.

Conclusion

SCI is a complex disability that causes many changes, which can be physical, psychological, and social. It is accompanied by comorbidities, and these directly affect the health status and, consequently, the QoL of the affected individual.

In general, physical exercise has been postulated as an alternative for health promotion and QoL in people with SCI. ST especially is a strategy to promote physical health, mental health, and QoL, as it presents positive results in different aspects, especially in terms of improving muscle strength and functional capacity, reducing symptoms of anxiety and depression, and increasing the general indicators of QoL in people with SCI.

Conflict of interest

The authors do not declare a conflict of interest.

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