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Physical activity and exercise participation of adults with spinal cord injury. Influence on health-related physical fitness, functional independence and quality of life.

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Research Center in Physical Activity, Health, and Leisure (CIAFEL)

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Academic dissertation with the purpose of obtaining a doctoral degree in Physical Activity and Health designed by Research Centre in Physical Activity, Health and Leisure, Faculty of Sport, University of Porto, under the law 74/2006 from March 24th.

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my parents Valmor and Rogéria, to my sister Paula,
to my aunts Lolo, Zanza and Dadá, my cousins Pretas
and to my love Ivo.

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RESUMO

O objetivo desta tese foi perceber a influência potencial da atividade física e do exercício físico na aptidão física relacionada com a saúde, na independência funcional e na qualidade de vida de pessoas com paraplegia crônica, usuários de cadeira de rodas manual e habitantes da comunidade. Três estudos foram elaborados: o *Estudo I* reviu a literatura dos programas de exercício físico relativos à parte superior do corpo para pessoas com paraplegia crônica e usuários de cadeira de rodas manual que poderiam ser desenvolvidos em contexto comunitário e verificou os seus efeitos na independência funcional e na qualidade de vida dos mesmos. Foram pesquisadas as bases eletrônicas com acesso a estudos quasi-experimentais, ensaios clínicos controlados e não controlados publicados na língua Inglesa e que combinavam palavras chave, tais como, "paraplegia", "exercício físico", "independência funcional", "qualidade de vida" e respectivos sinônimos. Os outros estudos analisaram o papel desempenhado pelo desporto adaptado (*Estudo II*) e os efeitos de um programa de treino de resistência em circuito adaptado com pesos-livres e banda elástica (*Estudo III*) no nível de atividade física, aptidão física relacionada com a saúde, independência funcional e qualidade de vida de habitantes da comunidade com paraplegia crônica e usuários de cadeiras de rodas manual. O *Estudo II* englobou 25 indivíduos divididos em grupo desportivo e grupo não desportivo, enquanto que o *Estudo III* foi conduzido com um homem de 67 anos que participou num programa de 12 semanas. Ambos os estudos avaliaram: i) a atividade física através de acelerômetro (ActiGraph GT3X); ii) a independência funcional através do circuito de cadeira de rodas; iii) a qualidade de vida através do WHOQOL-BREF; iv) a aptidão física relacionada com a saúde: a composição corporal segmentada pela absorciometria radiológica de dupla energia (DEXA) (massa gorda, massa magra, massa total e percentual de gordura dos braços, tronco e do corpo inteiro; densidade mineral óssea do punho); a força muscular: força isocinética do ombro - avaliou bilateralmente os movimentos de flexão/extensão, adução/abdução rotação interna/externa a 60º/s, resultando em valores de pique torque (Nm) e do défice bilateral (%) (Estudo II e III), e força máxima – teste de

repetição máxima (só o *Estudo III*); e a aptidão respiratória (VO_{2PICO}) através do teste do tapete rolante. Esta tese verificou que, apesar da qualidade insuficiente dos achados, o exercício aeróbico (ergômetro de braço) e de resistência são os principais tipos de exercício desenvolvido em contexto de comunidade, principalmente em casa, ambos induzindo efeitos positivos na qualidade de vida. Adicionalmente, o exercício de resistência melhorou a independência funcional. A participação no desporto e no circuito de treino de resistência adaptado pareceu influenciar positivamente a independência funcional, o domínio físico e geral da qualidade de vida dos indivíduos com paraplegia, usuários de cadeira de rodas manual habitantes da comunidade Portuguesa. No entanto, só a prática desportiva mostrou um efeito positivo na aptidão cardiorrespiratória, enquanto a metodologia adotada no circuito de treino não foi suficiente para neutralizar o declínio da aptidão cardiorrespiratória num participante idoso.

PALAVRAS CHAVE: LESÃO MEDULAR, ATIVIDADE FÍSICA, EXERCÍCIO FÍSICO, APTIDÃO FÍSICA RELACIONADA A SAÚDE, INDEPENDÊNCIA FUNCIONAL, QUALIDADE DE VIDA.

ABSTRACT

This thesis aimed to understand the potential influence of physical activity and physical exercise on health-related physical fitness, functional independence and quality of life of people with chronic paraplegia, manual wheelchair users and community dwellers. Three studies were conducted: *Study I* reviewed the literature of upper body exercise programs that could be developed in a community setting for people with chronic paraplegia and manual wheelchair users and verified their effects on functional independence and quality of life. Electronic databases with access to quasi-experimental studies have been searched for uncontrolled and controlled clinical trials published in English language, that combined the keywords paraplegia, exercise, functional independence and quality of life and respective synonyms. The other studies analyzed the role of adapted sport *(Study II*) and the effects of a circuit resistance training program adapted with free-weights and elastic-bands (*Study III*) on physical activity level, health-related physical fitness, functional independence and quality of life of community dwellers with chronic paraplegia and manual wheelchair users. *Study II* comprised 25 individuals divided into a sport and non-sport group, while *Study III* was conducted with a 67-year-old man who participated in a 12-week program. Both studies evaluated: i) physical activity by the accelerometer (ActiGraph GT3X); ii) functional independence through the wheelchair circuit; iii) quality of life by WHOQOL-BREF; iv) health-related physical fitness: body composition segmented by the absorption of dual energy X-rays-DXA (fat percentage and fat, lean and total mass of arms, trunk and whole body, and wrist bone mineral density); muscle strength: isokinetic shoulder strength - flexion/extension, adduction/abduction and internal/external rotation bilateral movements at 60º/sec, resulting in peak torque (Nm) and bilateral deficit (%), and maximal strength - the repetition maximum test (only *Study III*); and cardiorespiratory fitness (VO_{2PEAK}) by the treadmill test. The present thesis has found that despite the insufficient quality evidence, aerobic (arm ergometer) and resistance exercise are the mainly type of exercise developed in the community setting, mainly home-based, inducing both positive effects on quality of life, and

resistance exercise improved functional independence. Participation in sports and in the adapted circuit resistance training seems to influence positively functional independence and physical domain and general quality of life of individuals with paraplegia, manual wheelchair users and Portuguese community dwellers. Nonetheless, only sport practice has showed a positive cardiorespiratory fitness effect, while the current circuit training methodology was not enough to counteract the decline of cardiorespiratory fitness in an older man.

KEYWORDS: SPINAL CORD INJURY, PHYSICAL ACTIVITY, EXERCISE, HEALTH-RELATED PHYSICAL FITNESS, FUNCTIONAL INDEPENDENCE, QUALITY OF LIFE

LIST OF ABBREVIATIONS

adapted-CRT	:	adapted circuit resistance training
ASIA	:	American Spinal Cord Injury Association Impairment Scale
AT	:	aerobic training
BMD	:	bone mineral density
BMI	:	body mass index
CF	:	cardiorespiratory fitness
CRT	:	circuit resistance training
DXA	:	dual-energy X-ray absorptiometry
Fat%	:	fat percentage
FI	:	functional independence
FM	:	fat mass
HRQL	:	health-related quality of life
LM	:	lean mass
LTPA	:	leisure-time physical activity
MVPA	:	moderate-vigorous physical activity
MWC	:	manual wheelchair
MWCU	:	manual wheelchair user
MWCU-P	:	manual wheelchair user with paraplegia
PA	:	physical activity
HR_{PEAK}	:	heart rate – peak
QoL	:	quality of life
RM	:	repetition maximum
RM_1	:	repetition maximum pre-intervention (0-week)
RM_2	:	repetition maximum – 4^{th} week (4-week)
RM_3	:	repetition maximum – 8^{th} week (8-week)
RM_4	:	repetition maximum post-intervention (12-week)
REPS	:	repetitions
RPE	:	rate perceived exertion
RT	:	resistance training

SCI	:	spinal cord injury
SF-36	:	Short-form 36
T_1	:	pre-intervention evaluation
T_2	:	intermediate-intervention evaluation
T_3	:	post-intervention evaluation
VO_{2max}	:	maximal oxygen consumption
VO_{2PEAK}	:	peak oxygen uptake
V_1	:	moment two
V_2	:	moment one
WHOQOL-BREF	:	World Health Organization Quality of Life – bref version
WT	:	resistance used in the last repetition
Δ_{T1-2}	:	result of intermediate-intervention evaluation minus results of pre-intervention evaluation
Δ_{T2-3}	:	result of post-intervention evaluation minus results of intermediate-intervention evaluation
Δ_{T1-3}	:	result of post-intervention evaluation minus results of pre-intervention evaluation
Δ_{RM1-2}	:	results of 0-week rm minus results of 4-week rm
Δ_{RM2-3}	:	results of 8-week rm minus results of 4-week rm
Δ_{RM3-4}	:	results of 12-week rm minus results of 8-week rm
Δ_{RM1-4}	:	results of 12-week rm minus results of 0-week rm

CHAPTER I

GENERAL INTRODUCTION / THEORETICAL BACKGROUND

SPINAL CORD INJURY

Among the multiple forms of impairment that can affect the human being, the spinal cord injury (SCI) is one of the most serious, with enormous physical, psychic and social repercussions (Ehrman et al., 2013; World Health Organization, 2013). Spinal cord is the main channel through which sensory and motor information travels between the brain and the body (Kirshblum et al., 2011). Thus, if the spinal cord is damaged, this messaging system will not work and may interfere with motor, sensory or autonomic body functions, depending on the extent and level of the injury (Figure 1) (Ehrman et al., 2013; Kirshblum et al., 2011; Webborn & Goosey-Tolfrey, 2008; World Health Organization, 2013).

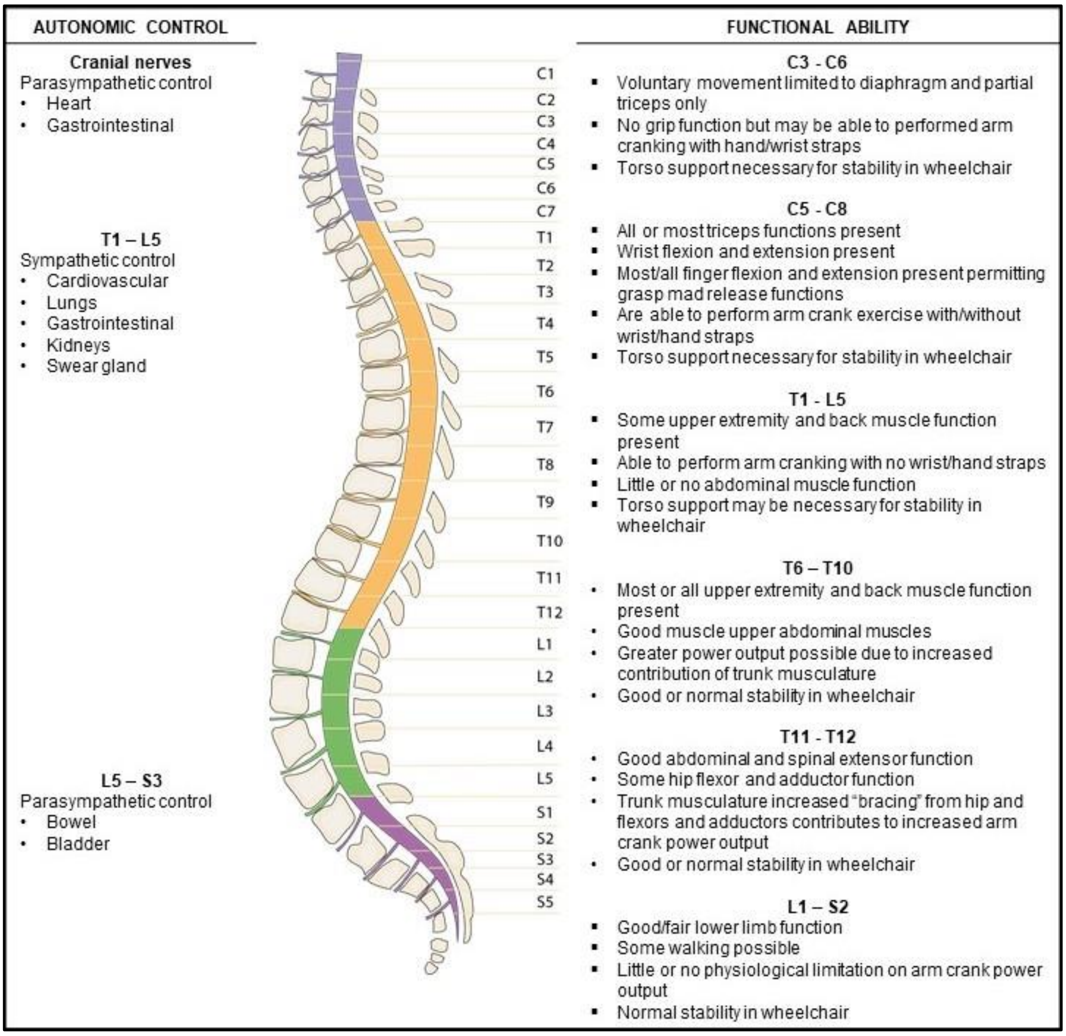

Figure 1. Functional ability and autonomic control in relation to level of injury. Adapted from Phillips et al. (1998).

The international standards for neurologic and functional classification of SCI describe the level and the extent of the injury based on examination of the motor, sensory and neurological functions (Webborn & Goosey-Tolfrey, 2008). A SCI in the cervical region is defined as tetraplegia. Tetraplegia typically results in the loss or impairment of function of arms, trunk, legs, and pelvic organs. SCI in the thoracic, lumbar or sacral segments is defined as paraplegia. Depending on the level of injury, trunk, legs and pelvic organs might be affected, resulting in the impairment or loss of motor and sensory function in these areas. Nevertheless, arm function is preserved (Brasil-Ministério da Saúde, 2013; Kirshblum et al., 2011; Webborn & Goosey-Tolfrey, 2008; World Health Organization, 2013).

Complementarily, through the American Spinal Cord Injury Association Impairment (ASIA) Scale it is possible to consider motor and sensory functions and classify SCI as a complete or incomplete injury. A complete injury corresponds to a full loss of motor and sensory functions at the distal level of injury. The incomplete is when the motor and sensory function is preserved partially below the neurological level. Table 1 presents information about the neurological level (Brasil-Ministério da Saúde, 2013; Ehrman et al., 2013; Kirshblum et al., 2011; World Health Organization, 2013).

Table 1. ASIA Scale

GRADE	CONDITIONS OF IMPAIRMENT
A	Complete: in the sacral segments, S4-S5 no motor or sensory function preserved.
B	Incomplete: sensory but no motor function is preserved below the neurological level and includes the sacral segments S4-S5.
C	Incomplete: below the neurological level preserved motor function; and more than half of key muscles below the neurological level has a muscle grade of <3.
D	Incomplete: below the neurological level preserved motor function; and at least half of key muscles below the neurological level has a muscle grade of ≥ 3.
E	Normal: Motor and sensory functions are normal.

From: Ehrman, J. K., Gordon, P. M., Visich, P. S., & Keteyian, S. J. (2013). Clinical Exercise Physiology: Human Kinetics.

EPIDEMIOLOGY

The global incidence of SCI is about 40 to 80 million new cases per million inhabitants each year (World Health Organization, 2001). Epidemiological information, updated in 2011, estimated at 23 per million, or 179,312 new cases of traumatic SCI per year (Lee et al., 2014). The most common etiology is due to motor vehicle accidents and falls (Brasil-Ministério da Saúde, 2013; World Health Organization, 2013), but also sports injuries and high levels of violence have been reported (Figure 2). Although we found some epidemiological data about the SCI origin, consistent results are still scarce, especially when dealing with non-traumatic injuries of origin, that is, those of congenital and genetic origin, as well as degenerative conditions, neoplastic tumors, autoimmune and vascular diseases (Kang et al., 2017; World Health Organization, 2013).

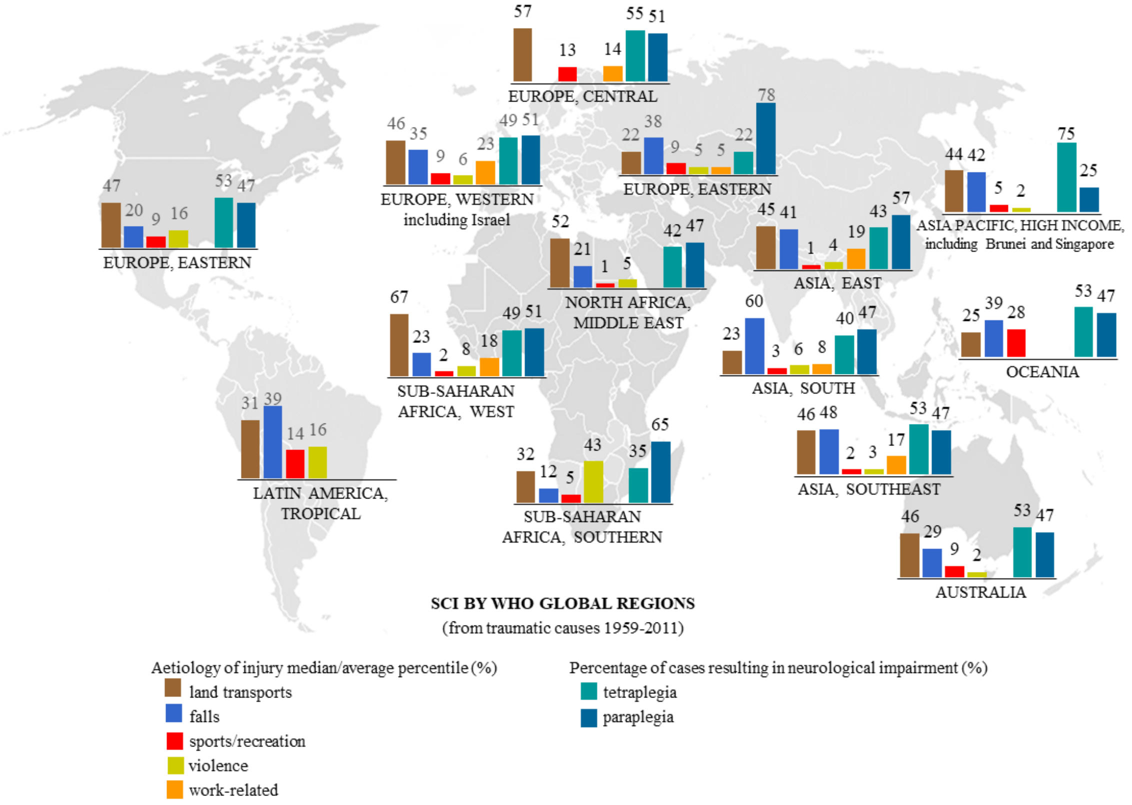

Figure 2. SCI by World Health Organization Global Regions from traumatic causes 1959-2011. Adapted from Lee et al. (2014)

In general, SCI is more common in men than in women, usually in young adults, aged 20-29 years old (World Health Organization, 2013). The traumatic

injury in both developed and developing countries is predominantly male (aged 18-32 years), but in developing countries due to the aging of the population, it also affects men and women over 65 (Lee et al., 2014). Data showed that in Japan the combination of an aging population (more falls), possibly aggravated by genetic factors, has the highest proportion of tetraplegia in the world (World Health Organization, 2013). Traumatic injury from violence is highlighted in regions of conflict or high availability of weapons (both firearms and white arms). The firearm is prominent in South Africa and countries such as the United States and Brazil. However, self-violence gains prominence in Western Europe, as suicide attempt rate is high, predominantly in Greenland (Lee et al., 2014).

Under a historical perspective, a very high mortality rate is associated with SCI. In the last years, the survival of someone suffering from a SCI was significantly reduced (World Health Organization, 2013). Unfortunately, this reality persists in low-income countries where people with SCI die prematurely from injury (Gosselin & Coppotelli, 2005; Myers et al., 2007; World Health Organization, 2013). Currently, the mortality rates reflect the importance of cardinal health care for SCI people and these rates might be connected to the country's general resources (World Health Organization, 2013). These changes are mainly noted in high-income countries, where better conditions and rehabilitation opportunities, technical aids, social services, physical environment, as well as health interventions are part of the daily lives of people with SCI (Myers et al., 2007; World Health Organization, 2013). Although there is a positive historical evolution around the SCI people´s mortality and quality of life (QoL), there is still a global lack of information concerning factors such as annual cases, the number of people living with SCI, the origin and type of injury, especially in underdeveloped countries (World Health Organization, 2013).

Concerning Portuguese SCI reality, there is limited knowledge since there are no national data about the global information of SCI (Campos et al., 2017). Data extracted from the center region indicated a higher incidence in men and group ages between 15-24 and 55-74 years old, being traffic accidents and falls the main causes (Martins et al., 1998). However, a recent Report Country about people with SCI in Portugal suggests that the traffic accident rate has been

decreasing and the incidence of falls and non-traumatic injuries increasing. Currently, the survival rate of SCI people has enhanced significantly, meaning that these people are getting older as of the general Portuguese population (Campos et al., 2017). Although, access to health care and rehabilitation need in specialized institutions is uneven throughout the country, in general, all the patients have, at least, one wheelchair and/or another kind of assistive technology devices for their daily life (Campos et al., 2017).

HEALTH RELATED PHYSICAL FITNESS AND SCI

According to Short (2010), health-related physical fitness is defined as a state characterized by a capacity to perform and maintain daily activities. Moreover, these capacities are associated to a lower risk of premature development of illnesses and movement related conditions. It also relates to components that are affected by routine physical activity and are related to health status, such as body composition, cardiorespiratory fitness, muscular endurance and strength, and flexibility (Short, 2010). After SCI, some of these components trigger important concerns, as described above.

BODY COMPOSITION

The SCI characterizes not only a drastic modification in the expected body functioning, but also changes in the individuals` body composition, namely loss of lean tissue mass (LM) and bone mineral density (BMD) vs. fat mass (FM) gain (Fang et al., 2017; Jones et al., 1998). During the first six months after injury, body composition undergoes drastic changes and both, a severe decrease in LM below the level of injury and an increase in FM may be observed (Castro et al., 1999; Gorgey et al., 2014; Jones et al., 1998; Yarar-Fisher et al., 2013). These adverse changes in body composition resulting from immobilization and skeletal muscle denervation may be related with a high prevalence of disorders, such as carbohydrate intolerance, insulin resistance, lipid abnormalities, and cardiac diseases that occur prematurely and in higher prevalence in SCI individuals (Jones et al., 1998).

After the injury SCI individuals present a rapid BMD decreasing in the first three years, around 60% (Draghici & Shefelbine, 2016). Within a few weeks of injury, individuals with complete and incomplete SCI undergo dramatic muscle atrophy, and this continues until the end of the first year (Gorgey & Dudley, 2007). Literature indicates that after six weeks of injury, SCI individuals, compared with matched age and weight individuals, can experience a loss of 18-46% in the cross-sectional area size of sub-injured skeletal muscles (Castro et al., 1999). The total LM decreases by around 9.5% in the first six months after the injury (Baldi et al., 1998), while the FM in the leg decreases by around 15.1% after one year of the injury (Castro et al., 1999).

The decline in LM coincides with the increase in body fat (whole body, intramuscular, abdominal and visceral) (Fang et al., 2017), which together with sedentary behavior contribute to a decrease in the metabolic rate and a positive energy balance, leading to a cycle that leads, among other consequences, to overweight and obesity (de Groot et al., 2014). Obesity is one of the many secondary complications in the population with paraplegia. About 66% of this population is obese (Rajan et al., 2008). Liusuwan et al. (2007) indicate that obesity is already prevalent in adolescents with SCI. Also, (Buchholz & Pencharz, 2004) describe that after five years of the rehabilitation process, 21% of the individuals are overweight, while 54% are obese. Obesity may compromise locomotion (wheelchair propulsion), transference tasks and increases the risk of bedsores and surgery (Liusuwan et al., 2007; Nash et al., 2001), thus causing damage to skeletal muscle and impair the mobility and functioning of individuals with SCI (Gagnon et al., 2015).

Regarding the obesity evaluation, the body mass index (BMI), the most utilized assessment method for the general population, has not been quite consistent to be used on SCI people (Yarar-Fisher et al., 2013). Jones et al. (2003) found similar BMI values for people with paraplegia and control peers. However, it is important to consider not only morphological changes (weight and height) but mainly body composition analysis. Their body composition analysis explored through dual-energy x-ray absorptiometry (DXA), showed that people with paraplegia had only 16% LM and, in opposition, had a FM greater than 47%,

even when they did not appear to be obese (Jones et al., 2003). A more recent study found that BMI among people with SCI (tetraplegic and paraplegic) had no significant difference in BMD related to the non-disabled group, although the FM and fat% analyzed by DXA were higher in the group with SCI (Miyahara et al., 2008). A review of the literature found very few validation studies for each measure of obesity in the SCI population. Although there is already a classification of obesity adjusted to BMI at ≤ 22 $kg.m^2$ (Laughton et al., 2009), the values have not been extensively tested and validated, yet. Still, the same study points out that the other standards for this type of evaluation are computed tomography and DXA, because they provide a fat percentage of the entire body, as segmented, among other body composition values (Silveira et al., 2017).

In addition to FM and LM, there is a bone loss that results in an increased risk of fracture (Sezer et al., 2015). Bone loss is high in the first six months and stabilizes around 30% between 12 and 16 months (Franceschini et al., 2003). This bone loss seems to be influenced by factors as the level of the injury, muscle overload on the bones, time and type of injury and aging (Jiang et al., 2006; Sezer et al., 2015; Zehnder et al., 2004). This bone loss can lead to a bone fracture, and possible to a period of immobilization and limb rehabilitation, which may cause a significant impact on daily autonomy, mainly when the injury affects the upper limbs. Furthermore, there is also the risk of developing bone pathologies, such as osteoporosis (Sezer et al., 2015; Zehnder et al., 2004).

MUSCULAR STRENGTH

People with SCI are recognized as having low physical fitness, often resulting from the extension of paralyzed body segments that do not allow or impair voluntary exercise (Nash, 2005). Still, during the rehabilitation the patients begin a process to maximize the available muscular function (Beninato et al., 2004). Muscle strength recovery and gains are essential contributions to functional independence during rehabilitation (Drolet et al., 1999; Kilkens et al., 2005), and important for community-dwelling life (Bernard et al., 2004; Jacobs et al., 2001; Zwinkels et al., 2014). Wheelchair users will use lifelong upper trunk, especially the upper limbs for mobility in the wheelchair. Some injuries,

specifically higher injuries, may cause loss of muscle mass in these muscle groups that are responsible for moving and stabilizing the trunk, resulting in an increased demand for the arms to generate propulsive force, as well as stabilizing the trunk during movements in a wheelchair (Nash, 2005).

Two phases, propulsion and recovery, characterize the wheelchair propulsion (Kilkens et al., 2003). Propulsive phase starts when the hand touches the pushrim and continues until the point at which contact is removed at the end of the stroke cycle. The recovery phase involves the motion when the hands disengage from the pushrim until the upper extremities swing back to contact the pushrim again. Literature points that, as a result of muscle propulsion time, shoulder muscle activity during the propulsion phase (flexors, adductor, and internal rotators) may be stronger than muscle activity involved in the recovery phase (Mulroy et al., 1996). Muscle imbalance, as well as repetitive movements are associated with some limiting problems, such as shoulder pain (Burnham et al., 1993; Kemp et al., 2011).

Besides mobility, upper-limb muscle strength is essential for other daily life activities, such as body weight relief and body transfers to the wheelchair. Subbarao et al. (1995) indicated that the propulsion and wheelchair transfer require about 50% of the strength of repetition maximum (RM). So, preserved upper extremity muscle is determinant for wheelchair user and therefore, should be measured to keep or improve the performance of daily life activity with a wheelchair (Nash, 2005). Besides RM (i.e. 1RM, 10RM), which is the most traditional and clinically accessible assessment of muscular strength (Nash, 2005), hand-held dynamometers may be used in the clinical setting to evaluate hand grip and pinch muscle strength (Peek, 2014). Furthermore, isokinetic dynamometer has been used to assess shoulder strength in different movements (Ambrosio et al., 2005; Bernard et al., 2004) and evaluate muscular imbalance, which may limit the activities of daily living (Bernard et al., 2004).

CARDIORESPIRATORY FITNESS

Cardiorespiratory fitness is another health-related physical fitness component that has gained attention in SCI context. Community-dwelling

individuals with chronic SCI presented low aerobic fitness levels (van der Scheer et al., 2015), that, in turn, have been directly linked with secondary health conditions, such as metabolic syndrome and cardiovascular disease (Bauman & Spungen, 1994; Cowan & Nash, 2010). Cardiovascular diseases represent the most frequent cause of death among people surviving more than thirty years after SCI (Cowan & Nash, 2010; Jacobs & Nash, 2004).

Many factors, with and without injury relation, can affect cardiorespiratory fitness in SCI population, such as level and severity of the injury, age, and degree of physical deconditioning (Nash, 2005). Greater muscle paralysis reflects in less physical capacity and ability to perform voluntary exercise at sufficiently high metabolic rates to stimulate the cardiopulmonary system and reach adequate aerobic fitness levels (Jacobs & Nash, 2004). Consequently, studies have been showing that individuals with lower injury have higher aerobic levels than individuals with higher injuries (Janssen et al., 2002; Simmons et al., 2014). Reference fitness values classification in untrained SCI population differ between tetraplegia and paraplegia (Simmons et al., 2014). Furthermore, different paraplegia level reflects in different values, where individuals with higher paraplegia (T1-T5) report aerobic fitness (VO_{2PEAK}) of 1.68±0.45 (L/min) while lower paraplegia (below T10) present 1.98±0.57 (L/min) (Janssen et al., 2002). Simmons et al. (2014) reported that SCI individuals decline 0.01 L/min in absolute VO_{2PEAK} per year, approximately 10% to 13% decline per decade.

Another factor that interferes in cardiorespiratory fitness values is the physical activity level. Janssen et al. (2002) analyzed 5 studies with SCI individuals, who had different physical activity levels, comprising levels between 0 h/week and above 6 h/week, and established the VO_{2PEAK} (L/min) reference values as (i) <1.33 , (ii) 1.34-1.72, (iii) 1.73-2.00 (iv) 2.01-2.31 and (v) >2.31; which was calculated for five quintiles of physical capacity parameter based on percentiles: (i) below 20th percentile = poor, (ii) 20th to 40th percentile = fair, (iii) 40th to 60th percentile = average, (iv) 60th to 80th percentile = good, and (v) above 80th = excellent. Whereas reference values based in individuals with SCI and wheelchair users, who do not train for at least one month, the referred

VO_{2PEAK} (L/min) values are: (i) <1.06, (ii) 1.06-1.27, (iii) 1.28-1.41 (iv) 1.42-1.68 and (v) >1.68 (Simmons et al., 2014).

Maximal volume of oxygen consumed per unit time (VO_{2max}) is the gold criterion to measure cardiorespiratory fitness in general population. In chronic disease and health conditions, particularly, when maximum performance is limited by local muscular factors rather than central circulatory dynamics, the VO_{2PEAK} is the most used (American College of Sports Medicine, 2018). A recent review study that summarized information about the maximal and submaximal protocol for wheelchair dependent with SCI concluded that submaximal testing is relevant for assessing performance at daily life intensities and estimating VO_{2PEAK} (Eerden et al., 2018).

There are different protocols and equipment used to measure cardiorespiratory fitness, being the most used, the arm crank ergometry, which is less strenuous than wheelchair ergometry (Haisma et al., 2008; Tørhaug et al., 2016; van der Woude et al., 2001). Another instrument reported in the literature is a motor-driven treadmill (American College of Sports Medicine, 2018; Kilkens et al., 2003), that has been indicated as a good methodology to reproduce realistic circumstances, such as slope and speed alteration (Vanlandewijck et al., 2001). Moreover, these situations become common and often limiting functional independence of a community-dwelling wheelchair user in its daily life activities (Kirby et al., 2016).

FUNCTIONAL INDEPENDENCE

Whether traumatic or non-traumatic in origin, SCI is a meaningful health and functional condition that implies a need for the right treatments and rehabilitation process. During rehabilitation, even when hospitalized, the patient can improve levels of independence in specific skills. Patient can be trained in several advanced skills to perform activities of daily living, transfer and mobility (Jacobs & Nash, 2004). Rehabilitation aims to maximize the recovery and development of functional skills for daily life activities, as well as for interactions with the environment, thus improving QoL (Merolla et al., 2014). In this sense,

patients should be assessed at the beginning and the end of the rehabilitation program to verify their functional gains (Silva et al., 2012). Discharge from an inpatient rehabilitation program marks the beginning of the lifelong process of adapting to changes in physical abilities, community reintegration, and participation in routine life activities (Merali et al., 2016).

Taking into account that approximately 80% are dependent on a wheelchair for their mobility for the rest of their lives (Post & Noreau, 2005), an essential aspect of daily life for most people with SCI is to acquire the skills required for wheelchair handling aiming their independence, especially those with paraplegia (Haisma et al., 2008). Mobility is fundamental to independence and social participation, encompassing the ability to transfer the body to/from the wheelchair and overcome a range of environmental barriers encountered during life (Routhier et al., 2003; World Health Organization, 2001). Therefore, the wheelchair ability command can make the difference between daily life dependence and independence (Best et al., 2017; Desai et al., 2013).

Thus, to a better evaluation of the functional independence, studies have used a variety of instruments for analyzing the mobility in a wheelchair through real functional analyses. In general, the skills involved in the tests can be categorized in wheelchair maneuvering and basic daily living skills, obstacles negotiating skills, wheelie, and making transfers (Fliess-Douer et al., 2010). Wheelchair maneuvering and basic daily living skills refer to perform tasks at the level of wheelchair propulsion, forward - backward, maneuvering, parking, and sprint. The obstacles to negotiating skills cover tasks related to slope and level changes. The wheelie included task stationary, forward and backward, and turn while wheelie. The last category, making the transfer, can be horizontal (i.e., transfer into and out of a car), vertical (i.e., up and down) and other (Fliess-Douer et al., 2012; Kilkens et al., 2003).

QUALITY OF LIFE

As functional independence, QoL has been the rehabilitation final goal for people with SCI (Noreau et al., 1993). The World Health Organization defines

QoL as “an individual’s perception of their position in life in the context of the culture and value systems in which they live and about their goals, expectations, standards, and concerns” (The WHOQOL Group, 1995). The population with SCI generally presents inferior values of QoL when compared with non-disabled people (Kannisto & Sintonen, 1997; Trgovcevic et al., 2014). The SCI presents a set of physiological, behavioral and social changes that involve huge changes in lifestyle (Ehrman, 2013; Organization & Bickenbach, 2013), such as the level of accessibility, at home and in public spaces, education and means of transport, social support and independence, which address aspects that directly interfere in their perception of QoL (Dijkers, 1997; Rimmer et al., 2011; Sweet et al., 2013).

Different and interconnected factors have been studied on researches about QoL, such as functional independence, injury aspects and physical activity practice. Functional independence has been emphasized by its meaning of independence/autonomy in the performance of daily tasks (Dijkers, 1997). The responsibility and opportunity to control your own life, as well as the ability to engage significantly in personal pursuits collaborate with the QoL (Hammel et al., 2015). The injury time was also pointed out as a factor that influences QoL (Dijkers, 1997) and over time it can improve and even be kept at higher levels (Sakakibara et al., 2012).

Quality of life evaluation is complex since there are many tools available. Furlong and Connor (2010) study presented a summary of the assessments used to evaluate wheelchair users. Over the last 10 years, General QoL has been evidencing among others, such as Life Satisfaction Questionnaire, World Health Organization Quality of Life (WHOQOL), EuroQoL-5D; while for Health-related quality of life (HRQOL), the Short Form 36 (SF-36), the Nottingham Health Profile, the General Health Questionnaire and others have been highlighted.

For Post and Noreau (2005) the most common tool used for HRQOL in SCI is the SF-36. This instrument allows the evaluation of three relevant HRQOL domains, physical, mental, and social (Whitehurst et al., 2014), including for SCI population (Post & Noreau, 2005). In a more restricted way, general QoL in SCI studies has been measured by WHOQOL, version *bref* (WHOQOL-BREF) (Post & Noreau, 2005), despite a previous study instrument validation for people with

SCI (Jang et al., 2004). This tool also allows exploring different domains, namely physical, mental, social, and environmental (Canavarro et al., 2007), which are pertinent topics when exploring people with SCI in the community.

PHYSICAL ACTIVITY AND EXERCISE

Physical inactivity is known as a risk of developing secondary health problems in general population (American College of Sports Medicine, 2018), as well as in people with SCI (Brasil-Ministério da Saúde, 2013; S. Jörgensen et al., 2017; Nash, 2005). The increasing of sedentary lifestyle risk may result in reduced mobility after SCI (Taylor et al., 1998), thus triggering a negative network of physiological and psychological events, which eventually exacerbate secondary health conditions (S. Jörgensen et al., 2017; Maher et al., 2017). In contrast, physical activity, defined as any movement produced by the skeletal muscle that requires energy expenditure (American College of Sports Medicine, 2018), can not only counteract these disease problems but also potentialize several health benefits (American College of Sports Medicine, 2018; S. Jörgensen et al., 2017).

Physical activity include leisure-time physical activity (LTPA; for example: walking, dancing, gardening, hiking, swimming, sports or planned exercise, etc.), transportation (e.g. walking or cycling), occupational (i.e. work), household chores, in the context of daily, family, and community activities (World Health Organization, 2013). Evidence suggested that people with SCI that participate in LTPA can experience several benefits for physical fitness and functional independence (Martin Ginis et al., 2012). Furthermore, LTPA participation can positively influence in overall well-being, psychosocial factors and QoL (Sweet et al., 2013). In this way, LTPA participation is essential to SCI individuals (Sophie Jörgensen et al., 2017), especially for manual wheelchair users (Best et al., 2017; Martin Ginis et al., 2010).

People with SCI have a typical lifestyle with low levels of physical activity (Buchholz et al., 2003) and about 50% do not report any physical activity in leisure time (Martin Ginis et al., 2010). Anneken et al. (2010) identified similar values, for

people with SCI and wheelchair users, where 48.5% were not actively involved in LTPA, especially sport. Compared with general population, individuals with SCI have more difficulty to start or adhering LTPA programs due to physical, environmental and psychological barriers (Boutevillain et al., 2017). Furthermore, the lack of specialized exercise professionals and specific guidelines can be also identified as another barrier.

In fact, the first physical activity guidelines for adults with SCI were defined only in 2011 (Martin Ginis et al., 2011). To achieve fitness benefits, at least 20 minutes of aerobic activity were recommended in moderate to vigorous intensity, two times per week, as well as strength training exercise (3 sets of 8-10 repetitions), two times per week. Recently, these guidelines were updated, and the evidence-based scientific exercise guidelines for adults with SCI report for cardiorespiratory fitness and muscle strength benefits, 20 minutes of aerobic training in moderate to vigorous intensity, twice a week plus three sets of strength training (each major function muscle groups). For cardiometabolic health benefits, the recommendation is 30 minutes of moderate to vigorous intensity of aerobic exercise, 3 times per week (Martin Ginis et al., 2018)

Exercise is a LTPA developed in a planned, structured, and repetitive way in order to improve or maintain one or more health-related physical fitness components (American College of Sports Medicine, 2018; Martin Ginis et al., 2010). In this sense, literature presents different exercise programs that have been studied to validate the effects, not only in health-related physical fitness, but also in functional independence and QoL of people with chronic SCI (Chen et al., 2006; Hicks et al., 2003), including those using a wheelchair (Jacobs, 2009; Mulroy et al., 2015; Serra-Añó et al., 2012).

Aerobic exercise programs for SCI individuals who use wheelchair usually involve arm ergometer, handcycling and wheelchair ergometer/propulsion have found several positive responses in terms of cardiorespiratory fitness and body composition (Nash, 2005). For example, a recent study concluded that arm crank ergometry (10 weeks) in high SCI (C7-T5) improve aerobic fitness and community mobility (Bresnahan et al., 2019). Also, a case study with a male with chronic SCI that performed a high-intensity interval training showed a 52% increase in

VO_{2PEAK}, a reduction of body fat percentage but lean mass practically unchanged (Di Battista et al., 2018). In the same way, wheelchair users with chronic SCI that participated in 16 weeks handcycling training were able to improved VO_2 and daily physical activity levels, measured by subjective assessment (Bakkum et al., 2015). Also, cardiorespiratory fitness level improved after wheelchair ergometer interval-training (6 weeks) individualized to each paraplegic subject (Bougenot et al., 2003).

Resistance training, on the other hand, conducted with a sample with paraplegia was favorable to the lowering of fat mass and the augmenting of lean mass, as well as the increase of shoulder functionality and QoL (Serra-Añó et al., 2012). Furthermore, resistance programs seem to be favorable to reduce pain (Kemp et al., 2011; Mulroy et al., 2011), maintain or improve functional independence (Kirby et al., 2016; Mulroy et al., 2011) and enhance QoL (Kemp et al., 2011; Mulroy et al., 2011; Nightingale et al., 2018). Besides some contradictory results, combined aerobic and muscle strength training may induce some positive results on aerobic fitness, muscle strength, function and QoL in chronic SCI (Bochkezanian et al., 2015). For example, after long-term combined exercise training (with aerobic and resistance components in each session) in SCI population was effective in increasing arm ergometry performance, strength, as well as several components of QoL and psychological well-being (Hicks et al., 2003). Furthermore, aerobic and resistance training have been combined in circuit regime. Circuit resistance training (CRT) conducted with a specialized gym machine, has been shown to induce beneficial effects on fitness, atherogenic lipid profiles (Nash et al., 2001) and on shoulder pain reduction (Nash et al., 2007). An original CRT was compared with an adapted CRT using elastic resistance bands, presenting the individuals with chronic paraplegia similar metabolic and heart rate responses (Nash et al., 2002). A recent case study suggested that an adapted home-based CRT can be a simple and easily accessible exercise practice, that can induce improvements in cardiovascular fitness and upper extremity strength, as well as shoulder pain and weight reductions (Sasso & Backus, 2013). However, either adapted CRT studies are limited on the training effects over functional independence and QoL, and the studies involving adapted

CRT with community-dwelling with chronic paraplegia and manual wheelchair users are scarce (Nash et al., 2002).

In a community setting sports activity are exercise alternatives. Community-dwelling with SCI emphasizes a positive effect of this participation (Tasiemski et al., 2005). Besides presenting benefits in health-related physical fitness, namely in upper-body strength, the sportive participation also can induce positive effects on BMD and lean mass in wheelchair athletes with different disabilities (Sutton et al., 2009). Furthermore, wheelchair athletes with SCI exhibit a higher reduction in fat mass according to the weekly time practice (Inukai et al., 2006). Also, the amount of weekly sport participation was directly related with VO_{2PEAK}, when comparing different study results with individuals with SCI (Janssen et al., 2002). Despite the evident benefits in health-related physical fitness, the results are not specific for people with paraplegia, hence emphasizing the need to better understand jointly the sportive practice effects on different health-related physical fitness components and QoL in this population.

Paralympic athletes reported that sport was a way by which they acquired their most essential skill of wheelchair mobility (Fliess-Douer et al., 2012). Thus, wheelchair skills seem to be favored by sport practice (Martin Ginis et al., 2012). However, studies involving community-dwelling individuals, that are not necessarily involved in high-performance sports, should also be explored. Literature still seems to have some restrictions regarding the jointly comparison of health-related physical fitness, functional independence and QoL of individuals living in the community and who practice sport as an LTPA practice as a strategy to improve physical activity levels.

Additionally, there is still a concern in the literature about the potential effect of exercise programs in incrementing physical activity levels. A recent literature review identified only six intervention programs as being able to effectively increase physical activity levels (Rezende et al., 2018). Moreover, the authors highlighted that most of these studies used self-reports for physical activity measures (Arbour-Nicitopoulos et al., 2009; Froehlich-Grobe et al., 2014; Froehlich-Grobe & White, 2004; Zemper et al., 2003), mainly using the physical activity recall assessment for individuals with SCI (PARA-SCI) instrument (Martin

Ginis et al., 2010). Also, programs did not necessarily involve exercise training, thus restricting information on how exercise practice can improve physical activity levels.

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CHAPTER II

AIMS AND STRUCTURE

AIMS

The overall aim of this Ph.D. thesis was to understand the potential influence of physical activity and exercise on health-related physical fitness, functional independence and quality of life of people with chronic paraplegia and community-dwelling manual wheelchair users. For that, the three following studies supported its specific aims:

Study I: Systematic Review

To review the literature on upper body exercise programs that can be developed in a community setting for people with chronic paraplegia and manual wheelchair users and to verify their effects on functional independence and quality of life.

Study II: Cross-sectional

To analyze the role of adapted sport on physical activity levels, health-related physical fitness, functional independence and quality of life of spinal cord injury community dwellers and manual wheelchair users.

The hypothesis is that sport practitioners, community-dwelling persons with paraplegia and wheelchair users present better physical activity levels, physical fitness, functional independence and quality of life outcomes than non-sport practitioners.

Study III: Case-study

To analyze the effects that an adapted circuit resistance training could have on health-related physical fitness, functional independence and quality of life of an older male with paraplegia and manual wheelchair user living in the community.

We hypothesized that an adapted circuit resistive training program with free weights and elastic band exercises could interfere positively in health-related physical fitness components, functional independence and quality of

life in a community-dwelling older male with paraplegia and manual wheelchair user.

GENERAL ORGANIZATION

Table 1 presents the chapters included in the present thesis elaborated according to the rules and guidelines for writing and presentation of dissertations of Faculty of Sport of Porto University.

Table 1. Thesis structure presented by chapter

Chapter I	**General Introduction – Theoretical Background** This chapter presents a broad general introduction which synthesizes the state of the art and identifies some gaps in the literature that justify the creation of future studies that designed this thesis.
Chapter II	**Aim and Structure** It contains the aims and the explanation of the thesis structure.
Chapter III	**Studies**
	Study I. Systematic Review The effectiveness of community-based upper body exercise programs in persons with chronic paraplegia and manual wheelchair users: A systematic review
	Study II. Cross-sectional Physical activity, health-related physical fitness, functional independence and quality of life between sport and non-sport manual wheelchair users with paraplegia
	Study III. Case-study Adapted circuit resistance training effects on health-related physical fitness, functional independence and quality of life: A case study with an older manual wheelchair user with paraplegia
Chapter IV	**General Discussion** This chapter presents a general discussion about three studies, indicating also their limitations and future research.
Chapter V	**Conclusions and future researches** It presents the thesis conclusion.
Appendices	**Appendices** It presents the thesis appendices.

CHAPTER III

STUDIES

STUDIES

Figure 3 shows a summary of the methodology used in the studies that compose this thesis detailing for each paper the study design, sample size, mean age, outcome variables, measurement technique and statistical analyses.

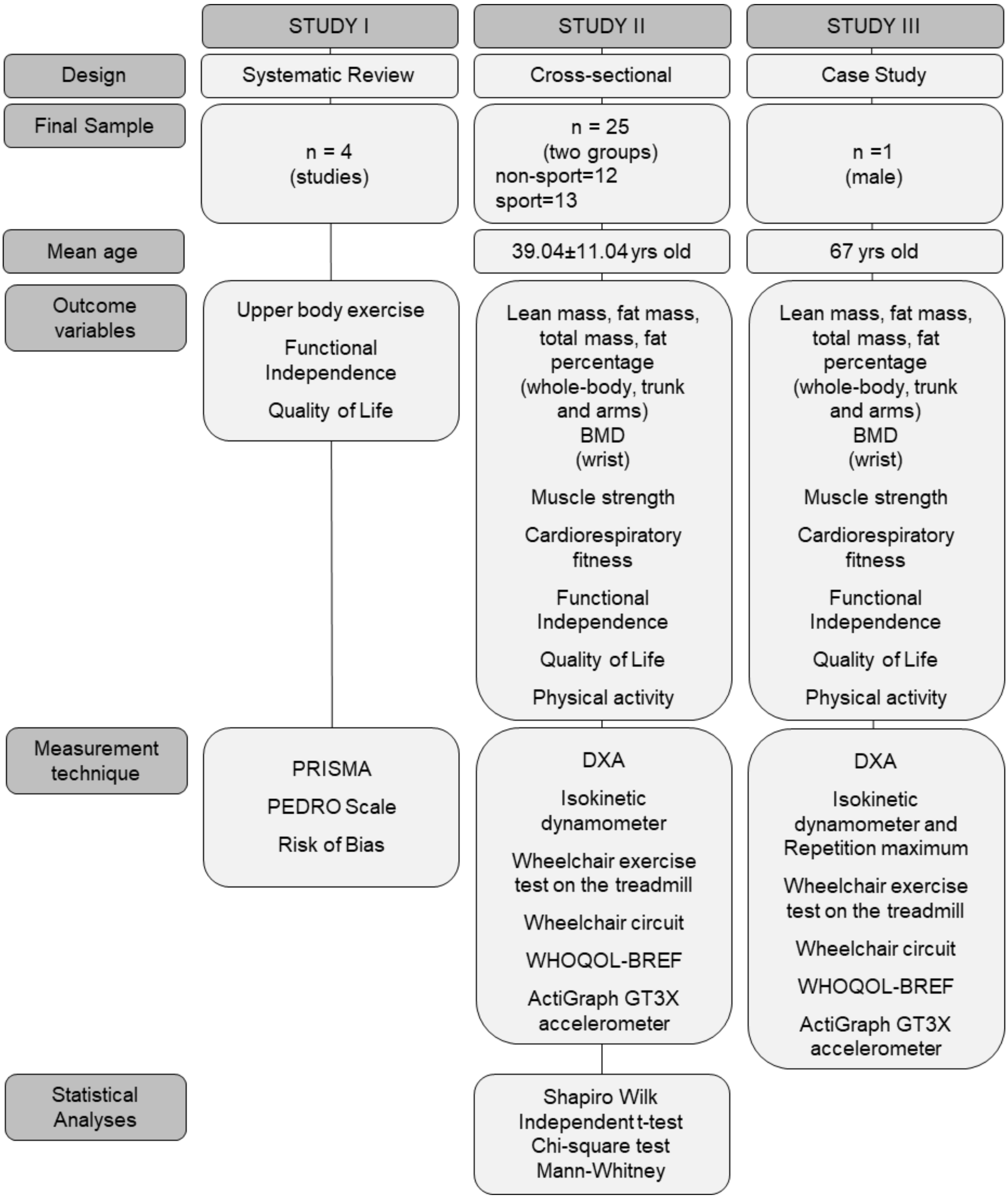

Figure 3. Schematic model of the studies (study design, sample size, mean age, outcome variables, measurement technique and statistical analyses).

STUDY I – Systematic review

The effectiveness of community-based upper body exercise programs in persons with chronic paraplegia and manual wheelchair users: A systematic review

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ABSTRACT

Context: Physical activity has been beneficial to health, functional independence and quality of life in spinal cord injury population. There is no consensus concerning the effects of community-based upper-body exercise in manual wheelchair users with chronic paraplegia. **Objective:** Conduct a systematic review of evidence of upper-body exercise effects able to be developed in a community-setting, on both functional independence and quality of life, for manual wheelchair users with chronic paraplegia. **Methods:** Electronic databases (PubMed, Scopus, Ebsco, SportDiscus and Web of Science) with access to randomized controlled trials, uncontrolled clinical trials and quasi-experimental studies published in the English language**.** Studies combined keywords (paraplegia, exercise, functional independence, quality of life and respective synonyms) and had functional independence or quality of life as outcome. PEDro scale and the Cochrane tool analyzed methodological quality and bias risk, respectively. **Results:** We selected 4 studies out of 2051. Studies conducted aerobic arm-ergometer and resistance training, predominantly at home. Upper-limb functionality and wheelchair propulsion assessed functional independence, but only the first had positive effects after resistance training. Resistance and aerobic arm-ergometer training seemed to improve health-related and subjective quality of life. **Conclusion:** Lower methodological quality and high bias risk in studies reflect insufficient quality evidence. Aerobic arm-ergometer and resistance training were the most upper-body exercise used. Resistance training improved functional independence while both types of exercise induced positive effects on quality of life. Future studies with uniform and high-quality methodology should be conducted with exercise in community-dwelling manual wheelchair users with paraplegia.

Key-words: spinal cord injury; exercise; functional independence; quality of life

INTRODUCTION

Per year, between 250 and 500 million people become spinal cord injured. Although the number of people living with spinal cord injury (SCI) is uncertain, life expectancy has increased (World Health Organization, 2013). SCI is a highly disabling condition affecting many functional aspects and consequently everyday life autonomy and quality of life (QoL) (van Diemen et al., 2017; World Health Organization, 2013). SCI people face functional impairments, including motor and sensory, injury level related. Paraplegia is a thoracic, lumbar or sacral injury that can result in functional loss or damage of the trunk, legs, and pelvic organs, commonly preserving upper-limb functioning (Ehrman et al., 2013). In the chronic phase, injury stabilizes (the neurological deficits stabilize), and this occurs about 1 to 2 years after injury (Webborn & Goosey-Tolfrey, 2008). Less than 1% of patients experience complete neurological recovery at hospital discharge (Ehrman et al., 2013). Many individuals will depend on a wheelchair as the primary mobility mean (Merolla et al., 2014). The wheelchair allows those who cannot walk the ability to move in daily living activities and consequently maintain their independence (Kilkens et al., 2003; Oyster et al., 2012).

After the first discharge, most individuals begin a chronic period of progressive physical deconditioning, due to their limited mobility and lack of physical activity (PA) (Miller & Herbert, 2016). People with mobility impairments are at very high risk of disease related health problems (Washburn & Figoni, 1999). Physical inactivity can also play a major role in contributing to secondary conditions related to primary impairments and disabilities and the reduction in QoL (Kinne et al., 2004). Although wheelchair use changes PA characteristics, it has been suggested that using a manual wheelchair (MWC) is better to improve or maintain fitness, while power wheelchair may invite to deconditioning (Hastings et al., 2011).

A systematic review indicated that PA is strongly correlated with variables of QoL and/or functional independence (FI) in SCI adults (Kawanishi & Greguol, 2013). However, authors reported an inconsistency in different factors such as evaluation methods, sample selected and PA analysis type. It is important to

demonstrate the relevance of studies that delimit sample aspects (e.g., injury level and other characteristics) and PA specificities (Kawanishi & Greguol, 2013).

Review studies verified that exercise programs presented benefits for physical fitness, namely muscular and aerobic fitness, in adults with different SCI levels (Hicks et al., 2011; van der Scheer et al., 2017). Resistance exercise, arm-ergometer and electrostimulation protocols seem to be effective in improving aerobic capacity and muscular strength of chronic SCI people, but similar conclusions have not been established for acute injury (Hicks et al., 2011). A more recently study showed that upper-body aerobic exercise (2/3 x week, 20-40 min, moderate to vigorous intensity) in addition to strength exercise (3 sets, 10 repetitions, 50% - 80% of 1RM) can improve fitness and cardiometabolic health of chronic SCI adults (Martin Ginis et al., 2018).

Different upper-body exercise reported positive effects to maintain and improve muscular strength and aerobic fitness of SCI adults (Hicks et al., 2011; van der Scheer et al., 2017). The effects of different types of upper-body exercise, when developed in a community context, on FI and QoL of chronic SCI people and manual wheelchair users (MWCU) are still not well established (Hicks et al., 2011). A literature review is needed to compile and synthesize evidence to aggregate the most meaningful literature with a broader perspective on upper-body exercise interventions for individuals with a SCI specific type.

This study aims to present the results of a systematic review of published studies on upper-body exercise programs that can be developed in a community setting for the manual wheelchair users with chronic paraplegia (MWCU-P) to identify and verify their effects on FI and QoL. The findings can provide a comprehensive resource of current evidence that might support physicians and health care providers in selecting exercise based in interventions for MWCU-P.

METHODS

This systematic review followed the PRISMA recommendation (Moher et al., 2009).

Eligibility criteria

Type of study**:** studies needed to be randomized controlled trials (RCTs), uncontrolled clinical trials and quasi-experimental to be included. Observational, cross-sectional, case-study, case-control, theses, doctoral dissertations were excluded.

Type of participants**:** studies included adults aged 18 years and older, with SCI defined as paraplegia (injury below T1), identified as MWCU and with time injury more than one year. Studies that did not have all participants meeting the inclusion criteria, i.e., a sample with tetraplegia or another disease/disability, an electric-powered wheelchair, injury time less than 1year were excluded.

Type of interventions**:** studies had to employ an upper-body exercise and describe duration, frequency and intensity. Studies were excluded if the intervention was not typical of community-setting exercise, which commonly deploys only voluntary muscles. Studies were excluded if the interventions involved any of the following exercises: functional electrical stimulation, with partial body-weight-support and intervention involving robotic or exoskeleton equipment. These interventions are usually not available in a community-based exercise setting, thus becoming the reason for these exclusions.

Type of outcomes**:** studies that reported measuring FI or QoL variables for baseline and post-interventions.

Studies published over the last 20 years (between January 1998 until December 2018), in English language and with full-text access were considered.

Information sources and search

Two evaluators conducted an independent search, in December 2018, in electronic databases, PubMed, Scopus, Ebsco, SportDiscus and Web of

Science. Group descriptors were A, B, C and D. Inside the groups OR logic operator was used among terms. Groups were:

A – *Paraplegia*: spinal cord, spinal cord injury, spinal cord injuries, paraplegia, paraplegic, spinal cord lesion;

B – *Exercise*: acute exercise, acute exercises, adapted physical activity, adapted sport, adapted sports, aerobic exercise, aerobic exercises, aerobic training, endurance exercise, endurance exercises, endurance training, endurance, exercise prescription, exercise therapies, exercise therapy, exercise training, exercise, exercises, isometric exercise, isometric exercises, physical activities, physical activity, physical education, physical exercise therapy, physical exercise, physical exercises, resistive exercise, resistive training, sport training, sport, strength training, training, strength;

C - *Functional independence*: functional independence, functional capacity, functionality, daily living activity, daily living activities, mobility, ADL, activity daily living, activities daily living;

D – *Quality of life*: quality of life, life quality.

Descriptors A, B, and D were used based on Medical Subject Heading (MeSH), with respective synonyms. Functional independence belonging to C Group did not exist in MESH, therefore the present study considered this group as the ability to conduct daily living activities (Fiatarone, 1996).

The search phrase used the AND logic operator among A, B, C or D groups. Additionally, a search phrase, AND NOT logic operator was used before animal groups descriptor (animals or rat or rats or mouse or mice). Other systematic reviews and selected studies were consulted to find other studies that could be added manually.

Study selection

FI and QoL database were mixed and duplications eliminated. After, studies were screened according to the eligibility criteria. References that could not be excluded by title or abstract were retrieved and reviewed. All process was

screened independently by two authors (RW and IG). Studies selected in disagreement were defined by discussion or through a third reviewer (NS).

Data extraction and analysis

The following data were extracted in the select studies by RW: study design, sample characteristics (size, age, time of injury), intervention (type, duration, frequency and intensity) and FI and QoL results. The second reviewer (IG) checked the extracted outcomes and disagreements were resolved with a debate between reviewers.

Quality of Study and Risk of bias assessments

PEDro Scale assessed the quality of the study. The scale evaluates the following 11 items: 1) participants' eligibility; 2) random distribution; 3) concealed distribution; 4) comparison of groups at baseline; 5) blinding of participants; 6) blinding of therapist; 7) blinding of evaluators; 8) measurement of at least one key outcome in 85% of subjects allocated; 9) intention to treat; 10) comparison between groups; 11) measures of accuracy and variability. A study received 1 point if it met the requirement for the item and 0 points if it did not. The final score is the sum of 10 items (2 to 11 item), where the higher scores indicate better methodological quality ("PEDro—Physiotherapy Evidence Database", 1999).

Cochrane Scale assessed the risk of bias (Higgins et al., 2011). Seven items were evaluated as *high, uncertain* or *low* risk of bias in this scale: 1) randomization; 2) allocation concealment; 3) blinding of participants; 4) blinding of evaluators; 5) incomplete outcome data; 6) selective reporting; 7) other sources of bias. The risk of bias was classified as: LOW RISK – all items received a *low-risk* assessment; HIGH RISK – if any item received *high-risk* classification; UNCERTAIN RISK – if at least one item received the *uncertain* classification.

RESULTS

Figure 1 shows the extracted studies for this systematic review. A total of 4004 studies were identified in database searching. Any study was identified in manual search. Then, 1953 duplicate studies were eliminated. Furthermore, 1690 and 290 studies were excluded due to title and abstract, respectively, since they did not meet the inclusion criteria. A total of 67 papers was removed after failing to meet the eligibility criteria, 17 by type of study, 37 by sample characteristics, 9 by type of intervention and 4, as it was impossible to access the full paper. Only 4 of these studies met the selection criteria and were included in this review (Kemp et al., 2011; Mulroy et al., 2011; Nightingale et al., 2018; Serra-Añó et al., 2012).

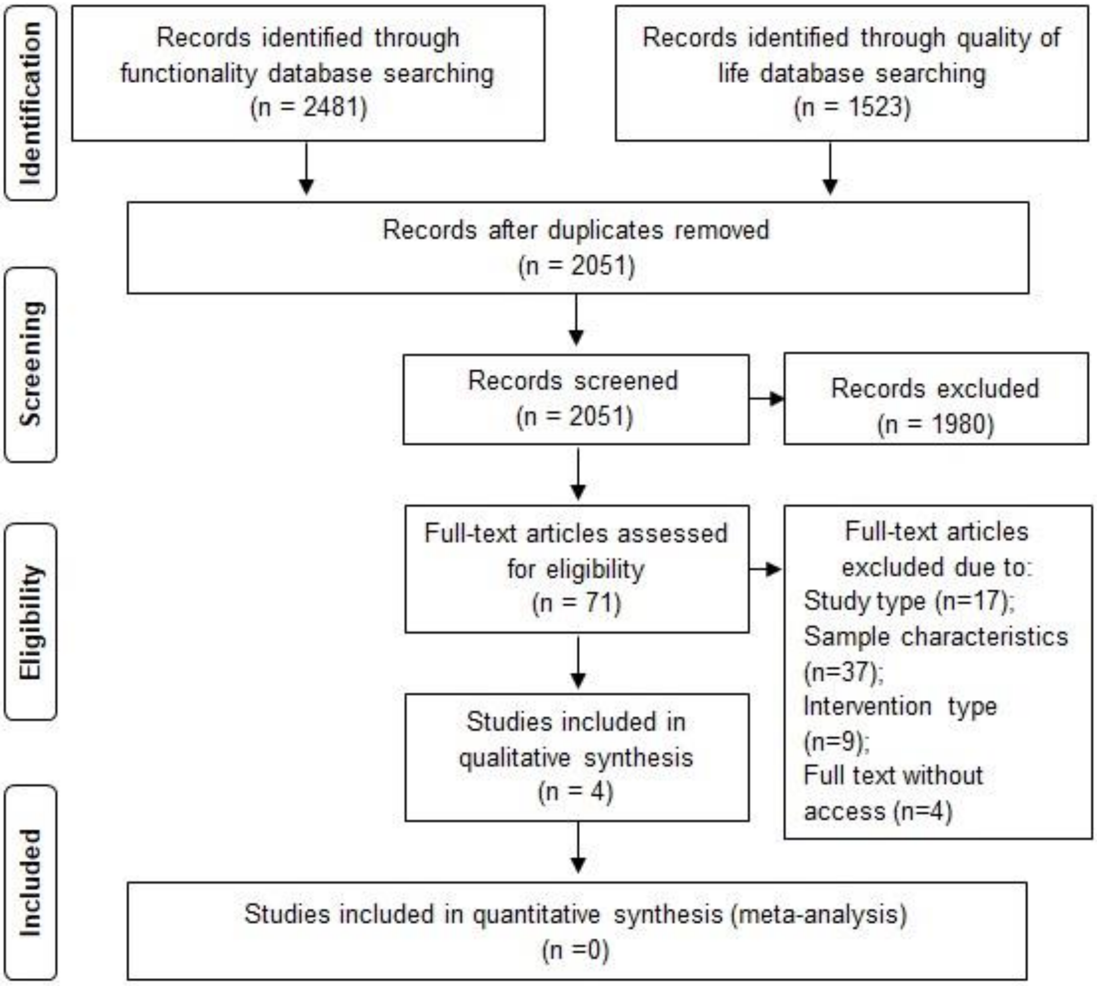

Figure 1. Flow diagram

Table 1 shows the selected studies characteristics. Studies designs were RCT (Kemp et al., 2011; Mulroy et al., 2011; Nightingale et al., 2018) and time-series (Serra-Añó et al., 2012). Three studies conducted the intervention at home (Kemp et al., 2011; Mulroy et al., 2011; Nightingale et al., 2018). Concerning the outcomes, two involved FI and three evaluated QoL. FI explored different aspects, arm functionality (Serra-Añó et al., 2012) and wheelchair ability – speed (Mulroy et al., 2011). Only arm functionality presented better results after upper-body exercise (Serra-Añó et al., 2012). Different methodologies assessed QoL, but all results were positive after intervention. Studies examined health-related quality of life (HRQL) (Kemp et al., 2011; Mulroy et al., 2011; Nightingale et al., 2018) and subjective QoL (Kemp et al., 2011; Mulroy et al., 2011).

Table 2 shows exercise intervention characteristics. Type of exercise was aerobic (Nightingale et al., 2018) and strength (Kemp et al., 2011; Mulroy et al., 2011; Serra-Añó et al., 2012). Exercise programs lasted from 8 to 12 weeks (Kemp et al., 2011; Mulroy et al., 2011; Nightingale et al., 2018) and frequency was 3 (Kemp et al., 2011; Mulroy et al., 2011; Serra-Añó et al., 2012) or 4 times weekly (Nightingale et al., 2018). Exercise intensity was moderate in arm-ergometer (Nightingale et al., 2018), while resistive training applied different intensities based on distinct repetition maximum (RM) protocols (Kemp et al., 2011; Mulroy et al., 2011; Nightingale et al., 2018).

Table 3 presents the methodological quality of the study. Through PEDro Scale analysis two studies had a 3 score (Kemp et al., 2011; Serra-Añó et al., 2012) and other studies were ranked as 5 (Nightingale et al., 2018) and 6 (Mulroy et al., 2011). Table 4 shows the risk of bias. All studies (Kemp et al., 2011; Mulroy et al., 2011; Nightingale et al., 2018) had a high bias risk, except Serra-Añó et al. (2012), that presented an uncertain risk.

Table 1. Characteristics of the studies included

Study	Aim	Design	Sample	Intervention	Measures
Kemp (2011)	Examine changes in social interaction and QoL after an exercise treatment for shoulder pain in people with paraplegia.	RCT	n=58 Age: 45±11.2 yrs I. Level: paraplegia I. Time: 20.1±10.5	Home-Program: Physical exercise and strategies to optimize transfers, depression raises, and wheelchair propulsion technique.	SQoL
Mulroy (2011)	Determine the effects of an exercise program and instructions to optimize the performance of upper-extremity tasks on shoulder pain in people with paraplegia from SCI.	RCT	n=80 (52 included into analysis) Age: 45±11.2 I. Level: below T2 I. Time: 20±11 yrs	Home-Program: Physical exercise and strategies to optimize transfers, depression raises, and wheelchair propulsion technique.	Wheelchair propulsion speed (WPS) Social Interaction Inventory (SII) SQoL SF-36
Serra-Añó (2012)	Determine the effects of a shoulder resistance training program on isokinetic and isometric strength, body composition, pain and functionality in subjects with paraplegia	Times series	n=15 Age: 26-70 yrs (40.27±11.09 yrs) I. Level: T4-T12 I. Time: 1-48 yrs (14.37±13.14)	Resistance Training Program	DASH questionnaire: upper-limb functionality
Nightingale (2018)	Assess the influence of a home-based exercise intervention on indices of HRQL in persons with SCI.	RCT	n=21 Age: 47±8 yrs I. Level: below T4 I. Time: 16±11 yrs	Home-based: Moderate-Intensity aerobic exercise	HRQL SF-36: physical and emotional; quality-adjusted to life yrs

I. Level: level of injury; I. Time: time of injury; HRQL: health-related quality of life; SQoL: Subjective QoL scale.

Table 2. Intervention protocol and main results

Study	Exercise type	Duration	Frequency	Intensity	Session protocol	Main results
Kemp (2011)	Resistive exercise (RE): Hypertrophy: shoulder adduction and external rotation. Endurance: shoulder elevation in the scapular plane and scapular retraction Stretching: anterior and posterior joint capsules and surrounding musculature, plus the upper trapezius muscle. Warm-up: 4 non-resisted active exercises (equal RE)	12 weeks	3 p/wk	Initially: participant ability (based ACSM) Resistance adjusted: color and length resistive band or weight in the hand 8 RM resistance (hypertrophy) 15 RM resistance (endurance)	Stretching Warm-up RE: 3-sets/8-rep. (ex. hypertrophy) + 3-sets/15-rep. (ex. endurance)	QoL: CG (CG no significant change) and ↑IG (9%) *SIG
Mulroy (2011)	Resistive exercise: Hypertrophy: shoulder adduction and external rotation. Endurance: shoulder elevation in the scapular plane and scapular retraction Stretching: anterior and posterior joint capsules and surrounding musculature, plus the upper trapezius muscle. Warm-up: 4 non-resisted active (equal RE)	12 weeks	3 p/wk	Initially: participant's ability (based ACSM) Resistance adjusted: color and length resistive band or weight in the hand 8 RM resistance (hypertrophy) 15 RM resistance (endurance)	Stretching Warm-up RE: 3-sets/8-rep. (ex. hypertrophy) + 3-sets/15-rep. (ex. endurance)	WPS: not ≠ in CG and IG SQoL: =CG and ↑IG (10%) PCS: ↓GC (1%) and ↑IG (12%) MCS: ↓GC (4%) and ↑IG (7%)

Serra-Añó (2012)	Resistive exercise: shoulder muscles (lateral raise, latissimus pull-down, horizontal row, biceps curl and internal and external rotation with 90° of abduction and in the neutral position). Warm-up: stretch shoulder muscles	8 weeks	3 p/wk	Initially established: 70% of 1RM Week 1-8: 7 or 8 RPE (1-10)	Warm-up: 10 min. RE: 3-sets/8-12 rep.	DASH score: ↓IG (6%) (improve functionality)
Nightingale (2018)	Arm-crank ergometer desktop set up (at home): aerobic moderate-intensity exercise	6 weeks	4 p/wk	Weeks 1-3: ≅60%VO2PEAK Weeks 3-6: ≅65%VO2PEAK RPE (0-10): 7±1	Session: 44±1 min; PO: 46±18W HR: 144±11 bpm	CG and IG: not ≠ at baseline Physical QoL: ↑CG (2%) and ↑IG (27%) *SIG Mental QoL: ↓CG (1%) and ↑IG (19%) QoLaY: ↓CG (5%) and ↑IG (8%)

QoLaY: quality of life-adjusted life years; p/wk: sessions per week; PO: power output; HR: heart rate; ex.: exercise; *SIG – Different significantly from pre to post within IC.

Table 3. Methodological quality of analyzed studies

Study	1	2	3	4	5	6	7	8	9	10	11	SCORE
Kemp (2011)	1	1	1	0	0	0	1	0	0	0	0	3/10
Mulroy (2011)	1	1	1	1	0	0	1	0	0	1	1	6/10
Serra-Añó (2012)	1	0	0	0	0	0	0	1	1	0	0	3/10
Nightingale (2018)	1	1	0	1	0	0	0	0	1	1	1	5/10

Table 4. Risk of bias of analyzed studies

Study	1	2	3	4	5	6	7	RISK
Kemp (2011)	Low	Low	Low	Low	Low	High	Low	High
Mulroy (2011)	Low	Low	Low	Low	High	Low	Low	High
Serra-Añó (2012)	Uncertain	Uncertain	Low	Low	Low	High	Low	Uncertain
Nightingale (2018)	Low	Low	Low	Low	High	Low	Low	High

DISCUSSION

Main findings

Two types of upper-body exercise, resistive training (RT) (Kemp et al., 2011; Mulroy et al., 2011; Serra-Añó et al., 2012) and aerobic training (AT) (Nightingale et al., 2018), in a community appropriate setting were conducted with MWCU-P. RT lasted 8 or 12 weeks, 3 times a week. Each session had 3 sets of 12 repetitions each, with 70% 1RM intensity and 7-8 in the subjective perception scale, when training aimed strength (Serra-Añó et al., 2012). The other studies (Kemp et al., 2011; Mulroy et al., 2011) had 3 sets of 8/15 repetitions and the intensity was equivalent to 8/15 RM in hypertrophy and endurance exercises, respectively. This training aimed at reducing pain, which was also associated with recommendations for the wheelchair task performance optimization. AT training lasted 6 weeks, 4 times per week, with moderate intensity (60% VO_{2PEAK} in the first three weeks and over 3 weeks at 65%, and RPE of 7) (Nightingale et al., 2018). RT targeting strength had a positive effect on FI, when assessed through shoulder functionality (Serra-Añó et al., 2012). RT associated to the movement performance optimization (Kemp et al., 2011; Mulroy et al., 2011) and AT (Nightingale et al., 2018) showed improvements in QoL, despite the different methodologies used. In general, RT and AT, developed in a community setting had favorable effects on QoL, whereas strength training seemed to favor FI when analyzed through upper-limb functionality.

Strength and limitation

Most of the studies were RCTs; only one was time-series (Serra-Añó et al., 2012). One (Mulroy et al., 2011) of the selected studies presented methodological quality equal to 6 in the PEDro scale (range 0-10), the others were lower (Kemp et al., 2011; Nightingale et al., 2018; Serra-Añó et al., 2012). Concerning the risk of bias, three presented high-risk (Kemp et al., 2011; Mulroy et al., 2011; Nightingale et al., 2018), and only one was uncertain (Serra-Añó et al., 2012). The predominant high-risk of bias and low study quality in our results limited the evidence found to generalize decision-making. The assessment of

studies quality and risk of bias allow interpreting the effect of clinical and biological heterogeneities in results (Fuchs & Paim, 2010), thus reducing the uncertainties for evidence-based health decision-making (de Carvalho et al., 2013).

Both types of exercise identified (AT and RT) are those found in the scientific exercise guidelines of SCI adults with benefits in cardiorespiratory fitness, muscle strength and cardiometabolic health (Martin Ginis et al., 2018). However, a comparative analysis among exercise programs is restricted by the principles and goals of the exercise and investigation. Nightingale et al. (2018) verified positive effects on HRQL after AT, while studies that conducted RT were planned to measure the effects on muscle strength (Serra-Añó et al., 2012) and reduce shoulder pain (Kemp et al., 2011; Mulroy et al., 2011).

The comparative limitation occurred also between RT protocols, both being planned with exercises designed for shoulder muscles but with different goals and prescription. Serra-Añó et al. (2012) developed a 8-week training program (3 times/week), comprising 3 sets of 8-12 repetitions of 8 exercises, with an initial load of 70% 1RM. While, Kemp et al. (2011) and Mulroy et al. (2011) conducted a 12-week training program (3 times/week), 3 sets of 8 or 15 repetitions of 4 exercises (2 exercises for each goal, hypertrophy and endurance). The initial load was according participant`s ability and adjusting the resistance load and length of the elastic-band to achieve 8RM or 15RM in hypertrophy and endurance, respectively. Both presented different protocols with scarce information in training intensity. For a successful implementation of a RT, proper prescription and supervision are important, both depending on goal setting, adequate exercise technique, assessment and training methods appropriate to training goals (Kraemer & Ratamess, 2004).

Two RT studies evaluated FI (Mulroy et al., 2011; Serra-Añó et al., 2012), but with different methodologies that hindered data analysis. Serra-Añó et al. (2012) used a questionnaire to assess upper-limb functionality. Satisfactory shoulder function is essential for daily living activities, dressing, washing, independent transferring (Merolla et al., 2014; Mulroy et al., 2011). Mulroy et al. (2011) evaluated a 25m wheelchair propulsion at a self-selected speed, to drive

people using independently manual wheelchairs, as they must possess a variety of wheelchair skills (Kilkens et al., 2003).

Three studies assessed QoL. Two explored HRQL (Mulroy et al., 2011; Nightingale et al., 2018), and two evaluated the subjective QoL (Kemp et al., 2011; Mulroy et al., 2011). AT and RT, the latter associated with the movement performance optimization, evaluated HRQL through SF-36. Both studies presented positive values in physical and mental components. However, only the physical component presented a significant difference (Mulroy et al., 2011; Nightingale et al., 2018), as it encompasses factors such as functional (physical) capacity, physical performance and pain (Whitehurst et al., 2014). However, these studies appear to have been developed with the same sample group, which is a limitation for the present study.

Interpretation

Regarding the study sample, this study presented a specific restriction to synthesize specific information. The small number of selected studies is related to the restriction of studies that had been conducted only with MWCU-P. This choice is relevant to synthesize specific information that can help professionals in the future. There is an inverse relationship between FI and neurological level injury (Middleton et al., 1998). Injury level can interfere in aspects related to functional activities (Chen et al., 2003). Only interventions performed in voluntary exercise, avoiding special equipment, such as functional electrical stimulation or treadmill, that might be developed in a community setting (Harvey et al., 2009; Merali et al., 2016; Valent et al., 2007) were considered.

Although the types of exercise identified (AT and RT) are included in the exercise guidelines for SCI adults, only Nightingale et al. (2018) study is entirely in line with these recommendations. The recommendation for cardiometabolic health benefits stated that SCI adults should engage in at least 30 min of aerobic exercise in moderate to vigorous intensity, 3 times/week adding another type of exercise at least twice a week of combined upper-body aerobic plus strength exercise, 20 min in moderate to vigorous intensity and 3 sets of 10 repetitions, at 50-80%1RM for each major function muscle groups. Consequently, to comply

with the exercise recommendations, exercise professionals need to understand the relation between injury level and active muscle preservation, referred as a barrier to exercise practice by SCI people (Sliwinski et al., 2018).

The two types of training identified as possible to be developed in the community are essential since community-dwelling SCI individuals present low values of physical and muscular fitness (van der Scheer et al., 2015). RT proved to be capable to alter shoulder functionality when evaluating daily tasks, which in general do not necessarily involve the wheelchair propulsion (Merolla et al., 2014). This is probably why RT did not show a positive effect to alter the wheelchair propulsion performance, the increase in muscle shoulder strength is not necessarily a strategy to optimize manual wheelchair propulsion (Ambrosio et al., 2005). Upper-body training, both AT and RT, improved physical capacity (Hicks et al., 2011; van der Scheer et al., 2017), thus collaborating to understand the positive and significant results found on QoL physical component.

The involvement of SCI people in exercise programs is often restricted by physical barriers (i.e. transportation, facilities) or by the lack of knowledge of how to deal with these people and with exercise prescription, according to the level and preservation of muscle function (Gorgey, 2014; Merali et al., 2016). Although the results are simple, they may contribute to the evidence that upper-body exercise, especially AT and RT, is possible to be developed in a community context. We could verify beneficial effects on FI, specifically on functionality (Serra-Añó et al., 2012), and in QoL of MWCU-P (Kemp et al., 2011; Mulroy et al., 2011; Nightingale et al., 2018). Previous studies have reported benefits to other health-related aspects, aerobic capacity (VO_{2PEAK}), maximal power and muscular strength (Hicks et al., 2011) and other components of wheelchair propulsion capacity, anaerobic capacity and mechanical efficiency (Zwinkels et al., 2014).

The implication for further research

The restriction in specific characteristics of MWCU-P has limited the selected studies number, thus, highlighting the lack of studies with specific information on different characteristics about SCI (Kawanishi & Greguol, 2013).

As already reported, QoL and FI presented different measures, which made it difficult to analyze these variables (Kawanishi & Greguol, 2013). Since these two aspects are essential for the SCI rehabilitation (Ehrman et al., 2013), future studies should consider more congruent assessment measures to a community context and consider different participants' specificities. The lack of a common descriptor for FI emphasized many interpretations for its evaluation (Kilkens et al., 2003; Mulroy et al., 2011; Serra-Añó et al., 2012). Further studies can help to delineate with more specificity an evaluation methodology, mainly for a community context. Further studies involving upper-body exercise intervention, that assess FI and QoL of MWCU-P should be developed to better define the effects of such programs. However, future research should be encouraged with high methodological quality and less risk of bias for greater approval by the scientific and the professional community and by SCI community-dwellers. Additionally, further studies should provide systematic information about other aspects such as motivation. If the level of motivation is too low, people may not be sufficiently motivated to practice at all, and no significant effects will occur.

CONCLUSOIN

The growing SCI adult's life expectancy warrants an urgent need to define interventions beyond the clinical environment that optimize their FI and QoL. Although exercise has been described as important for physical fitness and secondary health conditions in SCI subjects, a small number of clinical and randomized controlled trials was found in literature, specifically with MWCU-P.

Despite the scarce literature, current research identified that upper-body exercise developed in a community context for MWCU-P is mainly based in arm-ergometer AT and RT, preferentially at home. Both types of exercise had positive results regarding the effects on QoL, with the most significant findings on the physical component. Notwithstanding, RT showed positive results on FI when evaluated through the upper limb functionality. However, given the limitations imposed by the predominance of studies with low methodological quality and high risk of bias, careful interpretation of data is necessary.

Efforts to strengthen uniformity and methodological quality in studies conducted with exercise in MWCU community-dwellers with paraplegia have potential to future research.

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STUDY II – Cross-sectional

Physical activity, health-related physical fitness, functional independence and quality of life between sport and non-sport manual wheelchair users with paraplegia

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ABSTRACT

This study analyzed the role of adapted sport on physical activity levels (PA), health-related physical fitness, functional independence (FI) and quality of life (QoL) of community-dwelling manual wheelchair users with paraplegia. Twenty-five participants were divided into non-sport and sport group. Wrist-accelerometer measured PA (min/day). WHOQOL-BREF measured QoL. Wheelchair-circuit evaluated FI resulting in ability and performance-time score. Dual-energy X-ray absorption measured body composition (whole-body/trunk/arms: fat-percentage, fat, lean and total mass; forearm bone mineral density). Isokinetic shoulder strength was evaluated (flexion-extension/adduction-abduction/internal-external rotation movements; 60º/sec) resulting in peak-torque (Nm) and bilateral-deficit (%) values. Treadmill-test evaluated cardiorespiratory fitness (CF) resulting in VO_{2PEAK} (L/min) values. Descriptive statistics presented data and comparison was performed by Independent t-test and Chi-square test. Differences between groups were significant on general (p=0.016) and physical domain (p=0.05) of QoL, FI score-time (p=0.004) and CF (p=0.002). Adapted sport seems important to maintain FI, CF and QoL of manual wheelchair users with paraplegia.

Key-words: spinal cord injury, community-dwellers, adapted sport

INTRODUCTION

Spinal cord injury (SCI) is a highly disabling condition that impacts upon individual´s physiological, mental, and social well-being. The injury that occurs above the thoracic segment is defined as paraplegia and is usually associated with preserved upper-limb function but depending on the injury level it can interfere in other segments below the injury (World Health Organization, 2013). Estimated 80% of people with paraplegia need a manual wheelchair to perform their life activities (Post et al., 1997). Restriction in mobility promotes greater risk of physical inactivity and low physical fitness (Taylor et al., 1998). Physical fitness has been related to independent wheelchair use (Kilkens et al., 2005; Taylor et al., 1998). Also, an active lifestyle has been indicated as beneficial for physical fitness and quality of life (QoL) in SCI population (Martin Ginis et al., 2010).

Around 50% of SCI individuals reported not participating in any leisure-time physical activity (LTPA) (Martin Ginis et al., 2010). LTPA encompasses those activities performed in an individual's free time and includes participation in different activities, among them sports activities (Bouchard & Shephard, 1994). Sport has been used in the rehabilitation process of SCI people because it is an alternative to stimulate and develop physical, psychological and social aspects (Franz et al., 2018). Its benefits are extendable beyond rehabilitation (Wu & Williams, 2001). Moreover, participation in sports after SCI has been associated with a better social integration and QoL (McVeigh et al., 2009). A qualitative study identified a variety of sports benefits such as socialization, development of increased awareness about health and wellness issues, development and functional independence (Stephens et al., 2012). Paralympic athletes reported that sport is a way to achieve essential mobility skills with the wheelchair (Fliess-Douer et al., 2012).

Sports practice and physical fitness components were examined in different studies, involving wheelchair high-performance athletes, analyzing isolated parameters and different impairments that can influence on the potential sport participation and its benefits. Martin Ginis et al. (2010) study reports that gender, age, time/type/complexity of the injury and wheelchair type can interfere in LTPA practice. Sports practice has been showing physical fitness benefits

(Martin Ginis et al., 2012). However, studies have been comparing athletes with paraplegia with sedentary people without disability showing that male **a**thletes with paraplegia presented better values on upper limb strength (Burnham et al., 1993), as well as on bone mineral density and lean mass (Miyahara et al., 2008). Besides, wheelchair athletes with SCI with higher weekly training load presented lower upper limbs and trunk fat percentage (Inukai et al., 2006). On the other hand, wheelchair athletes presented higher cardiorespiratory fitness normative values (Janssen et al., 2002) than inactive SCI individuals (Simmons et al., 2014)

Furthermore, the literature lacks studies that analyzed manual wheelchair skills performance as a functional independence measure in SCI individuals (Kawanishi & Greguol, 2013; Martin Ginis et al., 2012; Sarsak, 2018) especially those that practice sport only as LTPA. Thus, this study aims to analyze the role of sport as a LTPA, on physical activity levels, health-related physical fitness, functional independence and QoL of community-dwelling manual wheelchair users with paraplegia.

METHODS

Participants

This cross-sectional study had 25 participants (twenty-one men, four women) aged between 22 and 67 years with chronic paraplegia and manual wheelchair users. Inclusion criteria were: (i) SCI classified as paraplegia (injury below T1), (ii) injury-time ≥1 year (chronic), (iii) aged over 18 years, and (iv) manual wheelchair users (at least 80% of daily activities). Exclusion criteria were: (i) cognitive impairment; (ii) established cardiovascular diseases; (iii) any orthopedic impairment that hampers assessment; and (iv) upper extremity skeletal muscle severe complaints that limit evaluation. Participants were divided into sports and non-sports groups screened by physical activity diary. Sports group had to meet the criteria to perform systematic sports activity, at least twice a week (≥ 180 min/week) and at least for one year.

Procedures

Participants were recruited through the contact with the Portuguese Association of Disabled People - district delegations of northern region, North Rehabilitation Center and Portuguese Federation of Sport for People with Disabilities. After screened for inclusion criteria, participants were personally invited to participate in the study. Participants provided informed consent and presented a medical clearance before initiating evaluations. The study was conducted in full compliance with the Helsinki Declaration and the Institutional Ethics Committee Board from the Faculty of Sports of the University of Porto, who approved the present study (CEFADE 07.2016). After voluntary acceptance, the evaluation was scheduled in the laboratory as the following: 1stday - self-report about injury and health history, followed by QoL assessment, body composition and functional independence; 2ndday – isokinetic shoulder strength; 3rdday - cardiorespiratory fitness and physical activity. To avoid possible influence on results, participants were advised to intake a light meal, to refrain from smoking, drink coffee and alcohol at least 2 hours before each measurement day and empty the bladder before evaluations. Also, the participants were told to wear

light clothing. All measurements were conducted and analyzed by the same team (the laboratory technician and two investigators).

Measures

Physical activity

Physical activity (PA) was measured through the GT3X accelerometer (Actigraph, Pensacola, FL, USA) worn on a non-dominant wrist, for seven consecutive days, except while sleeping, bathing and in water-based activities. Activity monitor recorded the acceleration of participant´s movement in three axis/dimensions, providing an intensity objective record, frequency and activity duration performed during wear time, summarized in “counts” unit of the composite vector magnitude of three axes. The accelerometer was programmed to record triaxial data at a 30 Hz frequency and 30 s length epochs. Actilife software (Actigraph, Florida, USA, version 6.9) was used to process accelerometer data. Non-wear time was defined as 90 consecutive min of zero counts, with an allowance of 2 min of nonzero counts if there were 30 min consecutive zero count windows up and downstream (Choi et al., 2011). Non-wear time was excluded from the analysis. Valid data was a minimum of 4 days (3 weekdays and 1 weekend day) with at least 8 hours/day of wear-time. Actigraph output was given in counts per minute (counts/min) derived from vector magnitude. The average min/day spent at two different categories of PA intensity was determined according to the cut point that relates PA to counts/min: less moderate-vigorous physical activity (MVPA) (<3643 counts/min) and MVPA (>3644 counts/min) (Learmonth et al., 2016). Also, PA Diary was used to identify participants´ week schedule and to characterize their PA and sport practice habits. Thus, allowing the division of groups into non-sports and sports according to the sport practice characteristics described above.

Functional independence

Functional independence was assessed through the wheelchair skill performance and determined through the ability and performance-time score over the wheelchair circuit, a validated test battery used in a previous study with SCI

population (Kilkens et al., 2005). Participants used their wheelchair to perform eight standardized tasks: figure-of-eight, crossing a doorstep (height 0.04m), mounting a platform (height 0.10 m); performing a 15-m sprint; 3% slope (on treadmill); 6% slope (on treadmill); 180-s - wheelchair propulsion (on treadmill), and transferring (from the wheelchair to a treatment table). Performance-time score was total time spent over figure-of-eight and 15-m sprint. Ability score was the sum points from all tasks (range 0-8). Task scores were 1 point (when the task was performed adequately and independently) or 0 points (not performed). Three tasks (crossing a doorstep, mounting a platform and transferring) could also be scored with 0.5 points when the task was partially performed (Kilkens et al., 2005).

Quality of life

The World Health Organization Quality of Life Assessment instrument WHOQOL-BREF was used to assess QoL (Canavarro et al., 2010; Jang et al., 2004). The questionnaire comprises 26 questions. Scores are calculated by four domains: physical health (7), psychological health (6), social relationships (3) and environment (8); and general- QoL was assessed by two questions (QoL overall perception and health satisfaction). Each question was rated on the five-point Likert-scale. Higher scores indicated better QoL. Scores were transformed linearly into a 0-100 scale, using coded syntax in the Statistical Package for Social science (SPSS, version 24), provided by the World Health Organization (Canavarro et al., 2010).

Health-related physical fitness

Body composition

Dual-energy X-ray absorption scans (DXA, QDR 4500A, Hologic, Bedford, MA) were used to assess body composition. The whole-body scan provided total mass (kg), fat mass (kg), lean mass (kg) and fat percentage (%) for whole-body, trunk, left and right arms segments. Wrist scan provided bone mineral density (g/cm^2) in both segments (Jones et al., 1998). A certificated manufacture operator

performed all DXA procedures, scan evaluation and data analysis using standard procedures, as described in the Hologic user´s manual.

Muscle strength

Muscle strength was assessed by an isokinetic dynamometer (Biodex System 4 Pro; Biodex, Shirley, NY) according to the testing protocol previously described (Ambrosio et al., 2005; Jacobs et al., 2002). Concentric shoulder strength of left and right segments was measured at a constant 60º/s speed in the following movement order: flexion/extension (sagittal plane from 0° to 50°), adduction/abduction (frontal plane from 25° to 75º), internal/external rotation (transverse plane from 0° to 45°) (Souza et al., 2005). After demonstration and familiarization (five submaximal repetitions) periods, five maximal repetitions were performed for each movement, starting with non-dominant upper limb. Peak torque (N-m) and bilateral deficit (%) values were used.

Cardiorespiratory fitness

Cardiorespiratory fitness (CF) was assessed with an adapted version of submaximal wheelchair exercise test on the treadmill (Kilkens et al., 2005). Speed of 0.83 $m.s^{-1}$ or 1.11 $m.s^{-1}$, according to participants´ injury level, was constant along the whole protocol and treadmill slope incremented 0.36º/min (Kilkens et al., 2005). Treadmill (h/p/cosmos, Germany) had a width and a length to allow wheelchair propulsion. Participant´s wheelchair was fastened to the treadmill by safety straps attached above to both front casters (Fig. 1). Also, a specific area was determined on the treadmill as the wheelchair propulsion perimeter (Fig. 1). Criteria for stopping the test were when the participant: (i) asked to stop the test, by exhaustion or (ii) could not maintain the wheelchair propulsion within the safety delimited area. Oxygen consumption was measured continuously using a portable gas analysis system ($K4b^2$, Cosmed, Rome, Italy) and heart rate (HR) was measured at 5s intervals by a heart rate monitor (Polar, Team System, Finland). The highest mean value of oxygen consumption over 30s during the test was considered as VO_{2PEAK} (L/min). Moreover, the highest HR

recorded during the test was considered as HR_{PEAK} (beats per minute) (Kilkens et al., 2005).

Figure 1. The cardiorespiratory set up test (the limit area for propulsion and safety straps are identified).

Data analysis

Statistical analysis was performed using the IBM SPSS 24 software (SPSS, USA). Normal data distribution was examined by the Shapiro Wilk test. Descriptive statistics were used to summarize sample characteristics, PA levels, health-related physical fitness, functional independence and QoL from the overall sample and groups. Data are expressed as the mean ± standard deviation for variables with normal distribution, and as median and range for non-normal distribution variables (General QoL, performance-time score, and flexion deficit). A comparison was performed between groups by the Independent *t*-test and Chi-square test, when appropriate. The non-parametric Mann-Whitney test was used to compare variables without normal distribution. Statistical significance was established for $p \leq 0.05$.

RESULTS

Table 1 displays the overall sample and group characteristics. On average, participants were 39.05±11.04 yrs old and 21 participants (84%) were male. In the whole sample data, 84% (n=21) had lower paraplegia and injury time was 14.95±12.11 yrs and PA levels were 2242.83±834.33 counts/min. There were no significant differences on age, gender, injury characteristics and PA levels between non-sports and sports groups. Sports practiced were wheelchair handball (n=7) and basketball (n=2), rowing (n=3), running (n=1), swimming (n=1), hand cycling (n=1) and three individuals participated in more than one modality. Sports group mean practice was 5.02±2.52 h/week (301.15±151.4 min). Also, table 1 shows functional independence and QoL results. Sports group presented a lower value in the performance-time score of functional independence evaluation than the non-sports ($p<0.01$). Despite the lower range (6-8) of the non-sports group on ability score, both groups presented the same median value. Sports group tended to present higher QoL values, however only exhibited a significant difference on general QoL ($p< 0.01$) and physical domain ($p\leq 0.05$).

Health-related physical fitness results of each group are presented in figure 2, 3 and 4. Sports group exhibited better mean values in most body composition outcomes (figure 2). However, only fat % of left upper limb had a significant difference (figure 2). Shoulder strength, despite the mean values for all movements evaluated in both segments, tended to be higher in the sports group and no significant differences were found between groups (figure 3). Figure 4 showed the CF test results. Sports group had a significant higher value on VO_{2PEAK} (L/min) and $HR_{MÁX}$, (bpm) comparatively to non-sports group ($p=0.002$ and $p\leq0.001$, respectively).

Table 1. Main characteristics, physical activity levels, functional independence and quality of life of the overall sample and groups, and comparison between groups.

	Overall n=25	Non-sports n=12	Sports n=13	p
Age, years (mean±SD)	39.04±11.04	39.67±12.49	38.46±10.01	.794
Male, (n, %)	21 (84)	10 (83.3)	11 (84.6)	.930
Injury				
Time, years (mean±SD)	14.95±12.11	12.92±11.23	16.82±13.04	.430
Level				
High (n, %)	4 (16)	3 (15)	1 (8)	.238
Low (n, %)	21 (84)	9 (75)	12 (92)	
Type	n=23	n=11	n=12	
Complete (n, %)	18 (75)	9 (75)	9 (69)	.478
Incomplete (n, %)	6 (15)	2 (15)	4 (31)	
	Overall n=25	Non-sports n=12	Sports n=13	p
Physical activity levels (mean ± SD)				
VM, counts per minute	2242.83 ± 834.33	2091.44 ± 1085.85	2381.61 ± 525.73	.417
MVPA, min/day	112.46 ± 55.51	98.71 ± 68.31	125.06 ± 39.46	.265
Functional independence [mean ± SD/median (range)]				
Ability score	8 (6-8)	8 (6-8)	8 (7-8)	.295
Performance-time score, sec	17.1 (14.79 - 35.52)	18.83 (16.66 - 35.52)	16.64 (14.79 - 21.80)	.004**
Quality of life [mean ± SD/median (range)]				
General QoL	75 (12.5 - 87.5)	75 (12.5 - 87.5)	75 (62.5 - 87.5)	.016**
Physical health	74.14 ± 14.15	68.15 ± 17.06	79.67 ± 8.04	.05*
Psychological	80.33 ± 13.79	77.08 ± 17.36	83.33 ± 9.16	.267
Social health	73.00 ± 19.58	67.36 ± 23.15	78.21 ± 14.65	.172
Environment	69.63 ± 16.35	65.10 ± 19.85	73.80 ± 11.59	.190

Note: *p ≤ .05, **, p ≤ .01. High = injury between T1-T5, Low = injury in T6 and below, SD = standard deviation, VM = vector magnitude, MVPA = moderate-vigorous physical activity, QoL = quality of life.

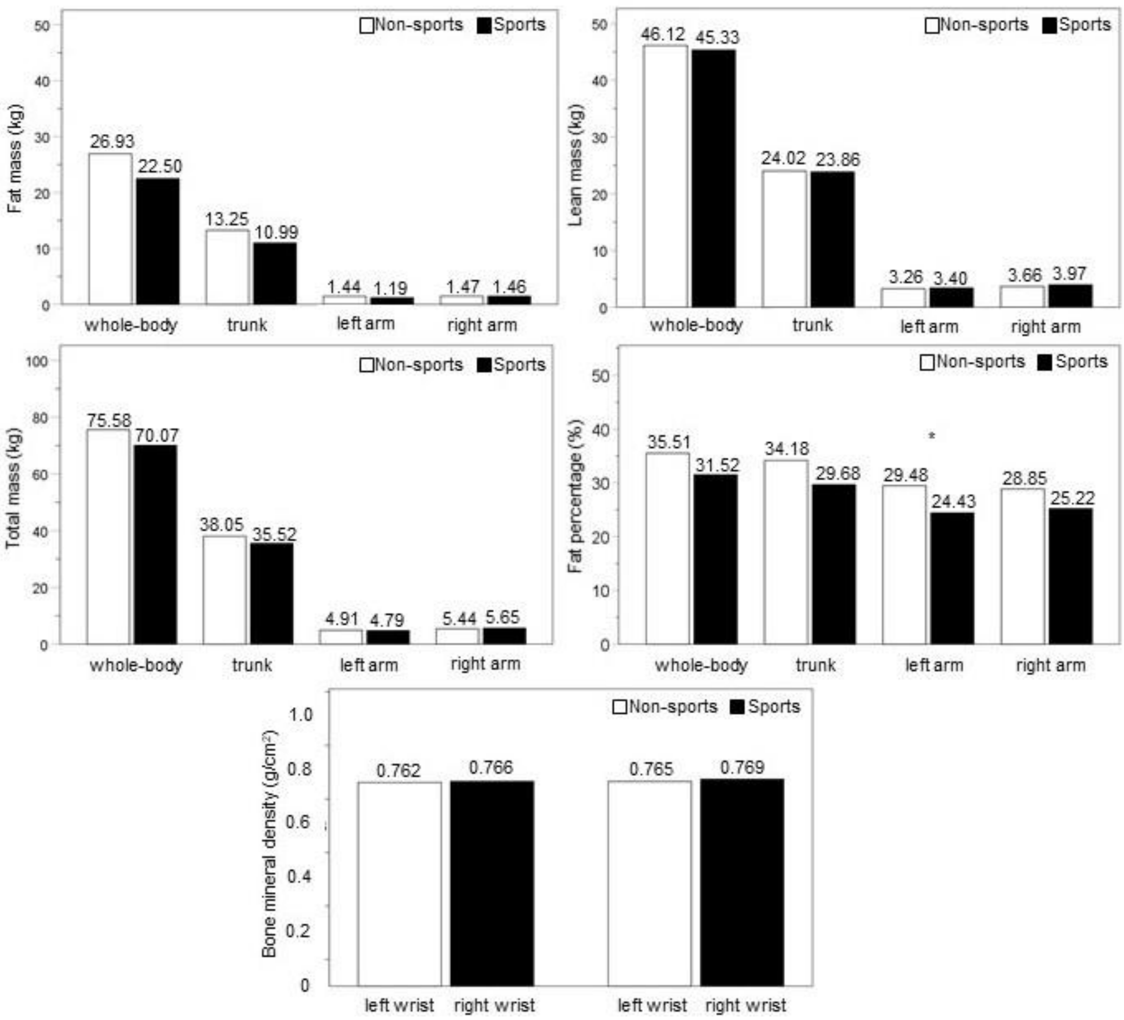

Figure 2. Total-body and segmental body composition mean in non-sports and sports groups. Notes. * Denotes statistical significance ($p \leq .05$).

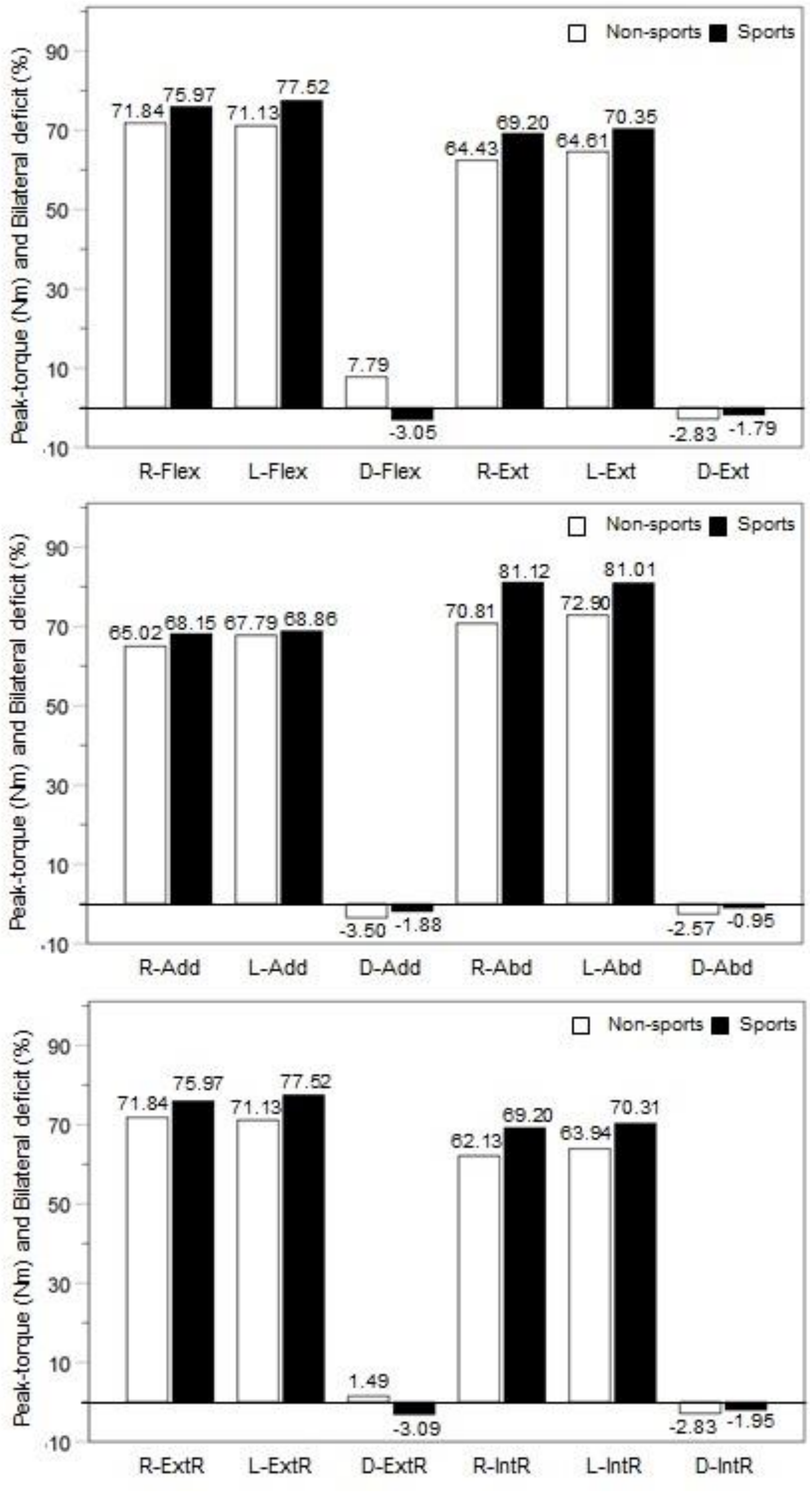

Figure 3. Isokinetic shoulder strength mean and median (+) values in non-sports and sports groups. Notes: R: right; L: left; -Flex: flexion; -Ext: extension; -Add: adduction; -Abd: abduction; -ExtR: external rotation; -IntR: internal rotation.

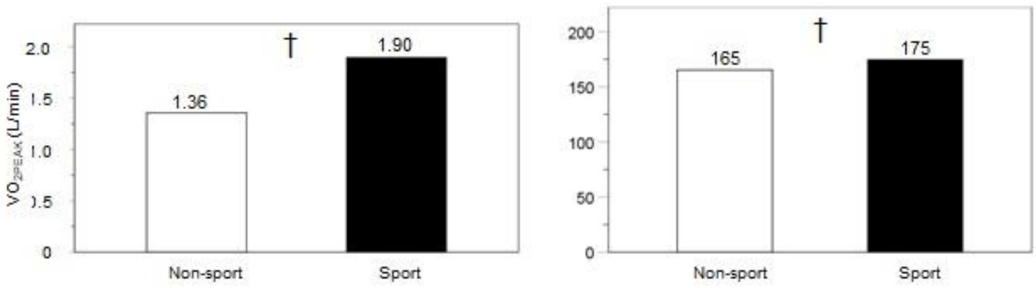

Figure 4. Cardiorespiratory fitness and heart rate mean values in non-sports and sports groups. Notes: †Denotes statistical significance ($p \leq .01$).

DISCUSSION

This study aimed to analyze the role of adapted sport, as LTPA, on PA levels, health-related physical fitness, functional independence and QoL of the community-dwelling manual wheelchair user with paraplegia. We compared sports (mean practice was 5.02±2.52 h/week) with non-sports (0 h/week) group, which presented significant differences in functional independence performance-time score evaluation, in general QoL and physical domain. Despite sports group tended to present better values in body composition, shoulder strength and CF, only left upper-limb fat percentage and CF presented significant differences between groups. Probably, the lack of differences exhibited between groups may be related to the high level of PA presented by both groups.

Our study presents PA levels (overall and groups sample) higher than literature. SCI people (tetraplegia and paraplegia) and manual wheelchair user presented approximately 62 min/day of MVPA, evaluated objectively through an accelerometer, wear wrist plus wheelchair (McCracken et al., 2018). Also, Nooijen et al. (2016) presented MVPA values after a year of rehabilitation discharge of 72 min/day in the intervention group and 50 min/day in the control group, which were evaluated by objective measurements in SCI individuals and manual wheelchair user.

Even expecting higher PA values in the sports group, probably daily PA is more determinant for the overall PA levels. Tawashy et al. (2009) identified that 90% of the time spent in PA refers to daily life activities, reporting 98 min/day of PA for SCI individuals, mainly with paraplegia and a manual wheelchair user. Despite the differences in the methodology, this study showed mean values similar to ours, when comparing the overall sample. The authors reinforce that this high PA may help to understand the positive results exhibited by functional independence assessment on wheelchair performance skills (median 8) in the wheelchair performance test (Tawashy et al., 2009). This can explain both the absence of differences and the ceiling effect in the ability score (0-8) presented by our sample, which scores are 7-8 in our sports group and 6-8 in non-sports group (Fliess-Douer et al., 2013). As expected, the sports group exhibited

significant lower performance-time score. Wheelchair sport often demands considerable skill with a wheelchair, which reflects on task execution time (Borges et al., 2017; Rhodes et al., 2017). Handball and basketball wheelchair, the most practiced by our sample, require different wheelchair skills, the latter making part of the modality performance test (de Witte et al., 2017; Yanci et al., 2015).

Sports group showed higher values in QoL. Evidence presented a positive impact of sports practice on QoL of manual wheelchair user (Côté-Leclerc et al., 2017) and in individuals with paraplegia (Medola et al., 2011), namely in basketball athletes (Chatzilelecas et al., 2015). General QoL and physical domain were significantly higher in the sports group. Yazicioglu et al. (2012) also found significant differences in general QoL and in the physical domain when comparing sports and non-sports groups. Contradictorily to our data, psychological and social domains have also displayed significant differences in the Yazicioglu et al. (2012) study. These differences can be due to Yazicioglu´s mixed disability sample, that comprises individuals with paraplegia and amputees, with 63.4% of sports group (elite athletes) exhibiting disability as an ambulatory characteristic (Yazicioglu et al., 2012). Elite athletes with more severe disability tend to have lower perception scores in the psychological and social domains (Ciampolini et al., 2018).

Sports group presented some better body composition outcomes. Similar results were found in wheelchair female athletes (Sutton et al., 2009). However, these authors also found positive sports benefits in arms lean mass and fat %. Probably the absence of body composition improvements in our sample, except left arm fat percentage that presented a significant difference, can be related with the sample size that limited statistical power and with a 5.02 hours/week time practice. Mojtahedi et al. (2008) study showed lower fat mass in whole-body and trunk than our sports group. However, these SCI athletes had higher weekly practice time (12h sports practice plus 3h resistance training). Nevertheless, the significant difference observed in the left arm fat percentage, which was the non-dominant upper limb in most of our sample was important. The predominance of sports practice with aerobic component training with simultaneous upper limb movements could help to understand this result (Goosey-Tolfrey, 2010).

Furthermore, we can consider the lack of dietary control evaluation of our study a gap in body composition analysis. The current literature presents the benefits to attain a healthy weight in SCI people through a multidisciplinary program of a dietary recommendation/control and a circuit resistance training (resistance and aerobic components) (Brochetti et al., 2018).

Moreover, although the sports group has presented a tendency of higher muscle strength values, there were no statistical differences between groups. Once again, probably the higher values of PA can explain this data. Peak torque mean values in both groups were higher than in Ambrosio et al. (2005), that analyzed a similar sample to ours. However, their study does not report participants´ PA level. Additionally, the differences in methodology can also explain our results, at least in part. Kulunkoglu et al. (2018) assessed muscle strength with a different protocol and reported better muscle strength in wheelchair basketball practice. Despite these non-significant differences, it is important to notice that when we observed the bilateral deficit value, obtained by analyzing and comparing both segments (calculated by the software), both groups presented an acceptable range of -10% and 10% (Hologic, 2005), which can reflect on the ability to perform functional maneuvers with a wheelchair (Kilkens et al., 2005). This is of importance, since long-term wheelchair propulsion coupled with other tasks, transfer or weight-relieving maneuver, can create muscle imbalance and contribute to shoulder disorders (Fullerton et al., 2003). Moreover, this can trigger other problems, such as shoulder pain, that translates into lower PA levels (Mulroy et al., 2015), function and autonomy of wheelchair users (Fullerton et al., 2003). Higher PA levels, related with daily life activities and/or sport practice, seem to be important to promote muscle strength that, in turn, can improve wheelchair ability performance (Kilkens et al., 2005) and decrease shoulder injury risk (Mulroy et al., 2015; Sinnott et al., 2000), which are essential factors for these individuals´ functional independence.

On the other hand, both groups presented significant differences in CF. This result was expected as wheelchair sports require a high aerobic component demand during practice (Bhambhani, 2002; Goosey-Tolfrey, 2010). The non-sports group presented values in average class when compared with reference

fitness values in untrained SCI population (Simmons et al., 2014). Moreover, the sports group was classified as average class according to normative values designed from a SCI individuals´ sample with different hours of weekly sports practice (Janssen et al., 2002). Still, sports practice seems to be a good tool for maintaining high levels of VO_2 throughout life with a SCI. Athletes with SCI who remained involved in sports practice were able to maintain high VO_2 values over 20 years (Shiba et al., 2010). Additionally, higher CF values have been associated with higher functional status (Dallmeijer & van der Woude, 2001), which consequently favors QoL (Hicks et al., 2011).

Although adding some important clues of the potential impact of adapted sports activities, as a LTPA, for physical fitness, functional independence and QoL of manual wheelchair user community-dwellers with paraplegia, there are certain limitations in this study. Participants´ number was reduced, thus restricting the analysis between groups and demanding some caution in data interpretation. Future studies should recruit more volunteers and include other regions to allow greater representation of the Portuguese reality. Functional independence evaluated by the performance skill was limited by a ceiling effect, as reported by Fliess-Douer et al. (2013). The wheelchair circuit involves simple and representative daily life tasks; further studies should explore other tasks, especially when those assessed have a high PA level. The lack of caloric intake control was a limitation that could help to understand body composition outcomes (Brochetti et al., 2018). Furthermore, more studies are needed to confirm our data and further researches should consider strategies to involve strength training in addition to sports practice to verify the possible effects on shoulder strength and body composition, functional independence and QoL. If these benefits are found, they can favor functional independence and QoL of manual wheelchair user with chronic paraplegia who live in the community.

CONCLUSION

The comparison between sports and non-sport groups that practice sport as a leisure physical activity to maintain health and well-being has shown a significant difference in performance-time score of wheelchair task performance, general QoL and physical domain, as well as in health-related physical fitness, especially in FC and left upper-limb fat percentage. Moreover, because our sample comprised people with paraplegia that use a manual wheelchair and live in Portugal´s northern, who presented high PA levels, further studies should be conducted to confirm our results. We can conclude that sport practice seems to be a relevant strategy for maintaining functional independence, CF and QoL of community dwellers with paraplegia and manual wheelchair user. Therefore, professionals should encourage and implement sport activities, as well as motivate these individuals and others to maintain higher levels of daily PA.

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STUDY III – Case study

Adapted circuit resistance training effects on health-related physical fitness, functional independence and quality of life: A case study with an older manual wheelchair user with paraplegia

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ABSTRACT

Background: Spinal cord injury and the lack of physical activity trigger a negatively impact on spinal cord injury population daily life activities. Awareness of the importance of prescribing a customized exercise program that meets the goals of persons with SCI should be highly considered in the rehabilitation community. However, there is a lack of scientific literature providing information on how to develop appropriate exercise training programs for SCI individuals, namely in the older ones, based on evidence. Therefore, the present study intends to observe the effects of an adapted circuit resistance training program on health-related physical fitness, functional independence and quality of life in an older male manual wheelchair user with paraplegia. **Methods**: This case study was conducted with a 67-year-old male manual wheelchair user with paraplegia (24-month). An adapted circuit resistance training lasted 12 weeks (three sessions/week) and comprised six exercises performed in pairs that were interleaved with a 2-minute arm-ergometer. Health-related physical fitness was evaluated by body composition (whole-body/trunk/arms: fat-percentage, fat, lean and total mass; forearm bone mineral density was assessed by dual-energy x-ray absorption); muscle strength that explore the isokinetic shoulder strength (flexion-extension/adduction-abduction/internal-external rotation movements at 60º/sec) and one repetition maximum; and cardiorespiratory fitness (treadmill-test). Also, functional independence was obtained by wheelchair circuit (expressed by performance time and ability score). Quality of life was evaluated by WHOQOL-BREF measured QoL and wrist-accelerometer measured PA. All variables were measured pre, intermediate and post-program. **Results:** Whole-body lean mass increased 6%, total fat-mass reduced 4%, and forearm bone mineral density decreased 5% and 3% in the dominant segment and non-dominant segment, respectively. Estimated repetition maximum in all exercises increased. Maximal oxygen peak decreased (26%). Functional independence improved by increasing the ability-score (7%) and by reducing the performance-time score (10%). The general quality of life did not change pre to post-intervention, while daily physical activity increased 10%. **Conclusions:** The adapted circuit resistance training program might be beneficial in some physical

fitness variables, functional independence and physical activity level improvements.

Key-words: aging, functional independence, health-related physical fitness, quality of life, spinal cord injury, upper body exercise, wheelchair user

INTRODUCTION

A sedentary lifestyle adopted by spinal cord injury (SCI) individuals accelerates physical deconditioning, mainly represented by diminished endurance and strength capacities (Dunlop et al., 2015; Sisto & Evans, 2014), which is especially harmful in older people (Chen et al., 2003). Independently of age, severity and injury level, physical inactivity contributes to several medical complications, including cardiovascular diseases, osteopenia, obesity and secondary conditions (S. Jörgensen et al., 2017; Sophie Jörgensen et al., 2017; Sisto & Evans, 2014). Moreover, SCI itself and the lack of physical activity in SCI individuals, especially older people, negatively impact in daily life activities (Sonenblum et al., 2012) and induce to social restrictions, which are associated with a lower level of well-being and a relatively poor quality of life (Nas et al., 2015).

Most people with SCI are manual wheelchair users and depend on upper limb performance for mobility and daily activities (Haisma et al., 2006). Consequently, individuals' independence relies on skills acquisition and upper body muscles functioning (Oyster et al., 2012). Indeed, evidence shows that manual wheelchair skills performance is positively associated with a higher participation in daily life activities and consequently with functional independence in SCI people (Kilkens et al., 2005).

Previous studies showed that both upper body exercise aerobic training (Hicks et al., 2003; Nightingale et al., 2016) and resistance training (Crane et al., 2017; Hicks et al., 2003; Nightingale et al., 2016) improve physical fitness (Hicks et al., 2003; Nightingale et al., 2016), functionality (Crane et al., 2017) and quality of life (Hicks et al., 2003) in SCI individuals. Circuit resistance training programs combine aerobic and resistance exercises in a circuit regime (Jacobs et al., 2001) and these programs seem to have a positive effect on physical fitness (Jacobs et al., 2002; Nash et al., 2007; Sasso & Backus, 2013), pain reduction (Nash et al., 2007) and diminished pro-atherogenic lipid profile (Nash et al., 2001) in younger SCI samples (Jacobs et al., 2001; Nash et al., 2001; Nash et al., 2002; Nash et al., 2007). Additionally, circuit resistance training is usually performed with expensive specific wheelchair training machines (Jacobs et al., 2002; Jacobs et

al., 2001; Nash et al., 2001; Nash et al., 2007), compromising study replications in community-based contexts for SCI individuals. Therefore, the development of low cost-effective exercise programs for manual wheelchair users with paraplegia might be helpful.

This case study aims to analyze the effects of an adapted circuit resistance training program on health-related physical fitness, functional independence and quality of life in an older male manual wheelchair user with paraplegia.

METHODS

Study design and participant

This was a case study conducted with an elderly volunteer. The male participant was 67-year-old with an injury level classified as paraplegia (level T12; reason: surgery) for two years and used a manual wheelchair as a primary mode of locomotion.

After acceptance, the first appointment was scheduled in the laboratory and the participant was assessed on the quality of life, body composition and functional independence. Isokinetic strength has been evaluated after 36 hours and cardiorespiratory fitness and physical activity after 72 hours. Following baseline measurements, the participant started a 12-week adapted circuit resistance training (adapted-CRT) program in the Rehabilitation Centre and returned to the lab to perform intermediate and post-program assessments according to the same baseline schedule. Evaluations were conducted in 3 moments: pre (T_1, baseline), intermediate (T_2, after six weeks) and post (T_3, after twelve weeks) adapted-CRT.

Participant provided informed consent signed by himself and presented a medical clearance before initiating evaluations. The study was conducted in full compliance with the Helsinki Declaration and the Institutional Ethics Committee Board from the Faculty of Sports of the University of Porto approved the present study (CEFADE 07.2016).

Procedures

Health-related physical fitness

Body composition

Body composition was assessed by dual-energy X-ray absorption (DXA, QDR 4500A, Hologic, Bedford, MA) (Jones et al., 1998). The whole-body scan provided total mass (kg), fat mass (kg), lean mass (kg) and fat percentage (%) for whole-body, trunk, left and right arm segments. Moreover, wrist scan provided bone mineral density (g/cm^2) in the left (dominant) and the right (non-dominant) segments. A certificated manufacture operator performed all procedures, scan

evaluation and data analysis, using standard procedures, as described in the Hologic user´s manual.

Muscle strength

Isokinetic strength: isokinetic shoulder strength was evaluated by an isokinetic dynamometer (Biodex System 4 Pro; Biodex, Shirley, NY) according to the testing protocol previously described (Ambrosio et al., 2005; Jacobs et al., 2002). Concentric shoulder strength of both segments (left and right) was measured at a constant 60º/s speed in the following movement order: flexion/extension (sagittal plane from 0° to 50°), adduction/abduction (frontal plane from 25° to 75º), internal/external rotation (transverse plane from 0° to 45°) (Souza et al., 2005). After demonstration and familiarization periods (five submaximal repetitions), five maximal repetitions were performed for each movement, starting with non-dominant upper limb. Peak torque (Nm) and bilateral deficit (%) values were used.

Maximum strength: maximum strength was assessed by one-repetition maximum (1RM) and was estimated according to Jacobs et al. (2002) and Nash et al. (2001). Briefly, the protocol aims the achievement of a resistance that allows between 3 to 8 repetitions according to proper technique, and 1RM was estimated using the Mayhew regression equation Mayhew et al. (1992):

$$1RM = WT/ (0.533 + 0.419^{-0.55*REPS})$$

where “1RM” is the estimated one-repetition maximum, “WT” is the resistance used in the last set between 3 to 8 repetitions, and “REPS” is the number of repetitions completed in the last set.

Previously to assessments, the participant performed one set of each exercise and rested for 2 minutes before the test start. Recovery time between repetitions was 2-4 minutes. 1RM was estimated for all exercises except the seated latissimus pull-down, which was performed with an elastic-band/TRX-door. To control the exercise intensity, estimated 1RM was assessed every four weeks, i.e., before intervention (RM_1), at the end of the fourth (RM_2) and eighth (RM_3) week and after the intervention (RM_4).

Cardiorespiratory fitness

Cardiorespiratory fitness was assessed with an adapted version of submaximal wheelchair exercise test on the treadmill (Kilkens et al., 2005). Speed (1.11 $m.s^{-1}$) was constant along with the whole protocol and treadmill inclination incremented 0.36º/minute (Kilkens et al., 2005). The treadmill (h/p/Cosmos Quasar med, Nussdorf-Traunstein, Germany) had a width and length to allow wheelchair propulsion. Participant´s wheelchair was fastened to the treadmill by safety straps attached above both front casters. Also, a specific area was set on the treadmill as the wheelchair propulsion perimeter. Criteria for stopping the test were when the participant: (i) asked to stop the test, by exhaustion or (ii) could not maintain the wheelchair propulsion, within the safety delimited area. Oxygen consumption was continuously measured using a portable gas analysis system ($K4b^2$, Cosmed, Rome, Italy) and heart rate was measured at 5 seconds intervals by a heart rate monitor (Polar, Team System, Finland). The highest mean value of oxygen consumption over 30 seconds during the test was considered as VO_{2PEAK} (L/min). Moreover, the highest heart rate recorded during the trial was considered as HR_{PEAK} (beats per minutes) (Kilkens et al., 2005).

Functional independence

Functional independence was assessed through the wheelchair skill performance and determined through the performance time and ability score over the wheelchair circuit, a validated test battery used in a SCI previous study (Kilkens et al., 2005). Participant used his wheelchair to perform eight standardized tasks: figure-of-eight, crossing a doorstep (height 0.04m), mounting a platform (height 0.10m), performing a 15-m sprint, 3% slope (on treadmill), 6% slope (on treadmill), 180 seconds - wheelchair propulsion (on treadmill), and transferring (from the wheelchair to a treatment table). Performance time score was total time spent over figure-of-eight and 15-m sprint. Ability score was the sum points from all tasks (range 0-8). Task scores were 1 point (when the task was adequately and independently performed) or 0 points (not performed). Three tasks (crossing a doorstep, mounting a platform and transferring) could also be

scored with 0.5 points when the task was partially performed (Kilkens et al., 2005).

Quality of Life

The World Health Organization Quality of Life Assessment instrument WHOQOL-BREF was used to assess the quality of life (Canavarro et al., 2007). This self-report questionnaire is not a specific tool for SCI persons but might be used by this population (Jang et al., 2004). Also, this instrument was validated to Portugal´s language (Canavarro et al., 2007). This 26-question questionnaire calculates the scores in four domains: physical health (7 items), psychological health (6 items), social relationships (3 items) and environment (8 items). Still, two questions assess the overall perception of quality of life and satisfaction with health. These items are reported as the general quality of life. Each item was rated on a five-point Likert-scale and the highest scores indicated better quality of life. Scores were linearly transformed into a 0-100 scale using coded syntax in the Statistical Package for Social Science (SPSS, version 24), provided by the World Health Organization (Canavarro et al., 2007).

Physical activity level

Physical activity assessment used a triaxial accelerometer (ActiGraph GT3X, Pensacola, FL, USA) that measured acceleration in three individual orthogonal planes (vertical, anteroposterior and mediolateral) and provided activity counts as a composite vector magnitude of these three axes (Sasaki et al., 2011). The acceleration signal is digitized by a 12-bit analog-to-digital converter, at a sampling rate of thirty times per second (30Hz). The GT3x accelerometer was worn on the non-dominant wrist (Learmonth et al., 2016), for seven consecutive days, except while sleeping, bathing and water-based activities. The accelerometer was programmed to record triaxial data at a 30 Hz frequency and 30 seconds length epochs. Actilife software (ActiGraph, Florida, USA, version 6.9) was used to process the accelerometer data. The accelerometer signal was processed into 30 seconds epochs. Non-wear time was

defined as 90 consecutive minutes of zero counts, with an allowance of 2-minutes of nonzero counts, provided that there were 30-minutes consecutive zero count windows up and downstream (Choi et al., 2011). Non-wear time was excluded from the analysis. Valid data considered a minimum of 5 days (4 weekdays and 1 weekend day) with at least 9 hours/day of wear-time. The ActiGraph output was given in counts per minute derived from vector magnitude. The average minutes/day spent at two different categories of physical activity intensity was determined according to a cut-point that relates physical activity to counts/min: less moderate-vigorous physical activity (MVPA) (<3643 counts/min) and MVPA (>3644 counts/min) (Learmonth et al., 2016).

Changes (Δ) between each moment in all variables were computed:

$$(V2-V1)/V1 \times 100$$

where V1 represents the initial/anterior value and V2 is the posterior/final value; and to be presented in $\Delta_{T1\text{-}2}$ (T_1-T_2), $\Delta_{T2\text{-}3}$ (T_2-T_3) and $\Delta_{T1\text{-}3}$(T_1-T_3) and $\Delta_{RM1\text{-}2}$ (RM_1-RM_2), $\Delta_{RM2\text{-}3}$ (RM_2-RM_3), $\Delta_{RM3\text{-}4}$(RM_3-RM_4) and $\Delta_{RM1\text{-}4}$(RM_1-RM_4) in percentage.

Exercise protocol

Participant underwent a 12-week adapted-CRT, performed three times a week, on non-consecutive days, Mondays, Wednesdays and Fridays. Participant undertook two familiarization weeks before starting 1RM measurement and adapted-CRT. Each session lasted approximately 60 minutes. Resistance exercises (i.e., free-weights and elastic-band) and aerobic exercise (arm-ergometer) were executed in a circuit-training regime. Traditional circuit resistance training exercises from Multigym machine (Jacobs et al., 2002; Nash et al., 2001) were modified to be performed with free-weights or elastic-band, the latter supplemented with TRX-door anchor (Fitness Anywhere, San Francisco, California), and have been conducted in his wheelchair or on a training bench (table 1).

Each training session started with a 4-minute warm-up in an arm-ergometer without resistance and was followed by the circuit training exercises

(3 sets). After resistance exercises, the session was concluded with cool-down and stretching exercises, allowing heart rate recovery close to baseline values.

Table 1. Exercise description of adapted-CRT

A. Seated Shoulder Press: wheelchair + free-weight
On the wheelchair, bring the hands to shoulder level (with elbow flexion) with dumbbell pronated grip. Push the dumbbell by extending the elbow (above the head). Return to the initial position.
B. Seated Row: wheelchair + free-weight
On the wheelchair, lean forward with the chest on the lower limbs. Starting with the arms extended fully down toward the floor. Holding the dumbbells pull the elbows up and back, compressing the shoulder blades. When the shoulder and elbow are aligned, return to the initial position.
C. Seated Curls: wheelchair + free-weight
On the wheelchair, the upper limbs extended parallel the trunk and the hands in neutral position grasping the dumbbell. Flex the elbow, raising the forearm towards the shoulder (while up, rotating the wrist to until the palm facing up). Return to the initial position.
D. Chest fly: training bench + free-weight
Transfer to the training bench. Lie on the back, keeping the spine neutral and head remaining on the surface. Flex the knee and a strap around the legs above the knees may be used to keep the legs correctly positioned. The fitness professional will hand the dumbbells after the participant is positioned correctly. The shoulder at 90º flexion with the weights in hands (palms facing palms) and a slight flexion in the elbow, open both arms together, then extend them out to the sides and return to the initial position.
E. Seated Latissimus Pull-Down: wheelchair + elastic-band – trx-door anchor
On the wheelchair facing the door. At the door, there is a trx-door that suspends the elastic tape and the bar. Grasp the bar with palms facing forward (the grip should be wider than shoulder-width apart). Extend elbows fully and pull the bar toward the upper chest and return to the initial position.
F. Seated Dips: wheelchair + free-weight
On the wheelchair, with a small forward lean. To maintain the position, between the chest and the wall we used a bar attached to the wall or small foam roller chest press. The exercise initial position involves holding the weight by moving the elbow behind the body line to maintain the elbow at 90 degrees. The movement involves the elbow extension and the return to the initial position.

Each set of the circuit training comprised six exercises grouped in pairs: seated overhead shoulder press (A), seated row (B), seated curls (C), chest fly (D) seated latissimus pull-down (E), seated dips (F) (table 1) (i.e. AB, CD, EF). Each set pair was interleaved with a 2- minutes arm ergometer exercise (high speed and low resistance). The time between exercises was limited to the

minimum time needed by the participant to get to the subsequent exercise, which characterizes an incomplete heart rate recovery.

Free-weights exercise intensity was 50% to 60% of 1RM according to the estimation of the repetition maximum test as proposed by (Jacobs et al., 2002) and described above. Whenever necessary, to guarantee the progression in training load over the four weeks, a volume training adjustment was made according to the number of repetitions per week (8-10 repetitions), as considered in other studies with SCI. A 3:3 (concentric/eccentric) seconds velocity was requested for each of the 8 to 10 repetitions (Jacobs et al., 2002; Jacobs et al., 2001; Nash et al., 2001; Nash et al., 2007).

Seated latissimus pull-down (elastic-band/TRX-door) intensities were defined as the maximal number of repetitions that was performed with the correct range of motion and speed. After that, volume-intensity was calculated as a percentage of total repetitions. In weeks 1 and 2, volume-intensity was 50%, and in weeks 3 and 4, volume-intensity was 55% and 60%, respectively. Two elastic-bands were used simultaneously in the exercise (red - 9kg and black - 15kg).

Additionally, a 65% to 75% of the maximum heart rate established according to the maximum exercise test was required (Ostertag & Blair, 2012); participant's heart rate was monitored continuously with a heart monitor throughout all training session (Polar Team System, Kemple, Finland). Moderate training intensity (5-7 points) was also monitored by self-report after each set using a Borg Scale (0-10 points) of rated perceived exertion (Ostertag & Blair, 2012).

The attendance rate of adapted-CRT was calculated by dividing participant´s number of exercise sessions attended by the full amount of sessions he was expected to perform throughout the study (3 days/week × 12 weeks = 36 sessions).

RESULTS

Adapted-CRT attendance rate was approximately 96%. Table 2 shows the participant´s sociodemographic and injury characteristics.

Table 2. Participant´s sociodemographic characteristics and injury information

Sociodemographic characteristics	
Age (years)	67
Height (m)	1.62
Weight (kg)	63.43
Dominant limb	left
Marital status	married
Profession	retired
Injury Information	
Level	T12
Duration (years)	2
Origin	surgery

Health-related Physical Fitness

Except for the dominant arm that increased 4%, participant's body fat mass decreased from pre to post adapted-CRT (Δ_{T1-3}) in 4%, 8% and 8% on whole-body, trunk, and non-dominant arm, respectively. Despite observing a decline from T_1 to T_2 (Δ_{T1-2}), there was an increase from T_2 to T_3 (Δ_{T2-3}) in all segments, except on non-dominant arm, that has always decreased (table 3). Also, table 3 shows that lean mass indexes improved from T_1 to T_3 in all segments in 6%, 6% and 11% on whole-body, trunk, and dominant arm respectively, except on the non-dominant limb that decreased 2%. Observing in a segmented way, whole-body, trunk, dominant and non-dominant arm improved in Δ_{T1-2} (7%, 9%, 8%, and 6% respectively), whereas all lowered in Δ_{T2-3}, except in the dominant arm that raised 2%. Concerning bone mineral density, apart from Δ_{T2-3} dominant arm that increased 1%, there was a decline in dominant (5%) and non-dominant (3%) forearm in all Δ.

Additionally, table 3 presents muscle strength results. Peak torque isokinetic shoulder strength results in ΔT_1-T_3 are positive for abduction, adduction and external rotation movements on both upper limbs, and negative on flexion

and extension movements of dominant upper limb (6% and 7%, respectively) and internal rotation of non-dominant upper limb (12%). In Δ_{T1-2} only dominant upper limb extension and abduction were negative (4% and 13%). Moreover, Δ_{T2-3} peak torque values improved on dominant upper limb in abduction (43%), external (3%) and internal (11%) rotation movements and on non-dominant upper limb flexion (1%) and abduction (51%) movements. While dominant upper limb flexion (8%), extension (4%) and adduction (22%) movements and non-dominant upper limb in extension (5%), adduction (8%), external (1%) and internal rotation (12%) movements decreased. Bilateral deficit before and after intervention presented an increasing in adduction and internal rotation, but only the latter presented result higher 20%. All the other values were lower than 10%. Flexion, extension and abduction movement values decreased. External rotation remained practically unchanged (table 3). A positive change from before to after program was verified on 1RM. The same occurred in intermediate measures apart from chest fly in Δ_{T1-2} and seated curl in Δ_{T2-3} (table 3).

Cardiorespiratory fitness data showed that VO_{2PEAK} (L/min) reduced only 4% in Δ_{T1-2} and lowered 26% from pre to post program (table 3).

Table 3. Participant´s health-related physical fitness - body composition, isokinetic strength, repetition maximum, cardiorespiratory fitness.

	Body composition					
	T_1	T_2	T_3	Δ_{T1-2}	Δ_{T2-3}	Δ_{T1-3}
Whole-body						
Fat Mass (kg)	22.66	21.10	21.67	-7%	3%	-4%
Lean Mass (kg)	38.31	41.17	40.65	7%	-1%	6%
Total Mass (kg)	63.43	64.75	64.85	2%	0%	2%
Fat percentage (%)	35.7	32.6	33.4			
Trunk						
Fat Mass (kg)	12.82	11.46	11.84	-11%	3%	-8%
Lean Mass (kg)	21.52	23.38	22.91	9%	-2%	6%
Total Mass (kg)	34.95	35.47	35.38	1%	0%	1%
Fat percentage (%)	36.7	32.3	33.5			
Dominant arm						
Fat Mass (kg)	1.09	0.93	1.13	-14%	21%	4%
Lean Mass (kg)	2.61	2.83	2.89	8%	2%	11%
Total Mass (kg)	3.89	3.95	4.21	2%	7%	8%
Fat percentage (%)	27.9	23.6	26.8			

Non-dominant arm						
Fat Mass (kg)	1.41	1.32	1.30	-6%	-2%	-8%
Lean Mass (kg)	2.95	3.13	2.91	6%	-7%	-2%
Total Mass (kg)	4.56	4.65	4.40	2%	-5%	-3%
Fat percentage (%)	30.8	28.4	29.5			
Bone mineral density forearm						
Left (g/cm^2)	0.780	0.734	0.742	-6%	1%	-5%
Right (g/cm^2)	0.765	0.757	0.744	-1%	-2%	-3%

	Muscle strength							
Repetition maximum	RM$_1$	RM$_2$	RM$_3$	RM$_4$	Δ_{RM1-2}	Δ_{RM2-3}	Δ_{RM3-4}	Δ_{RM1-4}
Shoulder press	3.5	4.0	4.9	5.9	14%	23%	20%	69%
Seated row	5.0	5.4	6.0	6.3	8%	11%	5%	26%
Seated curls	3.6	4.7	4.3	5.3	31%	-9%	23%	47%
Chest fly	4.6	3.0	4.3	5.2	-35%	43%	21%	13%
Seated dips	2.5	2.9	3.0	3.0	16%	3%	0%	20%

Isokinetic shoulder strength (Nm)		T$_1$	T$_2$	T$_3$	Δ_{T1-2}	Δ_{T2-3}	Δ_{T1-3}
	Dominant	51.2	52.3	48.3	2%	-8%	-6%
Flex	N-Dominant	44.3	44.1	44.7	0%	1%	1%
	Deficit (%)	13.4	15.7	7.5			
	Dominant	53.0	50.9	49.1	-4%	-4%	-7%
Ext	N-Dominant	48.1	55.2	52.4	15%	-5%	9%
	Deficit (%)	9.1	8.4	6.7			
	Dominant	46.0	39.9	57.0	-13%	43%	24%
Abd	N-Dominant	37.0	38.3	57.8	4%	51%	56%
	Deficit (%)	19.6	4.0	1.5			
	Dominant	43.5	56.7	44.4	30%	-22%	2%
Add	N-Dominant	43.3	52.2	47.9	21%	-8%	11%
	Deficit (%)	0.5	8.0	7.8			
	Dominant	20.0	21.2	21.8	6%	3%	9%
Ext. R	N-Dominant	19.1	21.0	20.8	10%	-1%	9%
	Deficit (%)	4.4	1.2	4.5			
	Dominant	27.1	31.2	34.7	15%	11%	28%
Int. R.	N-Dominant	29.5	29.6	26.1	0%	-12%	-12%
	Deficit (%)	8.6	5.0	24.8			

	Cardiorespiratory fitness					
	T$_1$	T$_2$	T$_3$	Δ_{T1-2}	Δ_{T2-3}	Δ_{T1-3}
VO$_{2PEAK}$ (L/min)	1.37	1.32	1.01	-4%	-23%	-26%
HR$_{PEAK}$ (bpm)	155	161	153	4%	-5%	-1%

Note: Flex: flexion, Ext: extension; Abd: abduction; Add: adduction; Ext. R: external rotation; Int. R: internal rotation.

Functional Independence

Table 4 presents functional independence results. Ability score had a positive value (7%) in $\Delta_{T1\text{-}3}$. Score improved 0.5 points from T_1 to T_2, resulting from the task of mounting a platform. Participant changed from “partially able” to “perform adequately and independently.” The maximal score was maintained between T_2 and T_3. Participant´s performance-time score after adapted-CRT exhibited a 10% positive change, thus reflecting a gradual reduction among the evaluation moments (T_1=21.2, T_2=19.6 and T_3=19.0 seconds).

Quality of Life

Table 4 shows quality of life scores assessment results. Participation in the adapted-CRT induced improvements in physical (16%) and environment (75%) domains and decreased on the psychological (5%), while the social relation domain and general quality of life maintained. Except the psychological domain that sustains the score in $\Delta_{T1\text{-}2}$, other domains increased in 16%, 33%, 13% and 25% in physical health, social relations, environment and general quality of life, respectively. The environment domain increased 56% and the physical did not change in $\Delta_{T2\text{-}3}$, while psychological, social relations and general quality of life reduced 5%, 25%, and 20%, respectively.

Physical Activity Level

Vector magnitude counts per minute increased by 10% from pre to post adapted-CRT (table 4), always presenting a progression of 4% and 6%, in $\Delta_{T1\text{-}2}$ and $\Delta_{T2\text{-}3}$, respectively. The average MVPA per day increased by 37%, 26%, and 115%, in the total-week, weekdays and weekend-days, respectively. The average MVPA per day, separating week from weekend days during the protocol presented a more pronounced increase between $T_{1\text{-}2}$ (47%) in weekdays and in $T_{2\text{-}3}$ (69%) in weekend days. Between $T_{1\text{-}2}$ weekdays and in $T_{2\text{-}3}$ weekend days the average MVPA per day decreased 34% and 16% respectively (table 3).

Table 4. Participant´s functional independence, quality of life and physical activity level.

	Functional independence					
	T_1	T_2	T_3	Δ_{T1-2}	Δ_{T2-3}	Δ_{T1-3}
Ability score	7,5	8	8	7%	0%	7%
Performance-time score (sec)	00:21,2	00:19,6	00:19,0	-7%	-3%	-10%
	Quality of life					
	T_1	T_2	T_3	Δ_{T1-2}	Δ_{T2-3}	Δ_{T1-3}
Physical health	46.3	53.6	53.6	16%	0%	16%
Psychological	87.5	87.5	83.3	0%	-5%	-5%
Social relations	50.0	66.7	50.0	33%	-25%	0%
Environment	50.0	56.3	87.5	13%	56%	75%
General quality of life	50.0	62.5	50.0	25%	-20%	0%
	Physical activity level					
	T_1	T_2	T_3	Δ_{T1-2}	Δ_{T2-3}	Δ_{T1-3}
Vector magnitude (counts per minute)						
Total week	2759.4	2861.4	3042.6	4%	6%	10%
Time average in MVPA per day (min/day)						
Total week	94	119	129.2	27%	8%	37%
Weekdays	102.9	151.2	130.1	47%	-16%	26%
Weekend-days	58.5	38.5	125.5	-34%	69%	115%

MVPA: moderate-vigorous physical activity.

DISCUSSION

The present study aimed to observe the effects of an adapted-CRT, using low-cost devices (i.e., sports materials) that can be easily applied in different community contexts, even at home, on health-related physical fitness, functional independence and quality of life in an older man with paraplegia and manual wheelchair user. The adapted-CRT improved health-related physical fitness and functional independence in a 67-year-old male. These findings are in alignment with other studies that have shown circuit resistance training benefits for SCI individuals (Jacobs et al., 2002; Jacobs et al., 2001; Nash et al., 2001; Nash et al., 2002). This program seems to counteract the age-related changes in health and fitness of an elderly manual wheelchair user with SCI.

Body composition assessment presented mixed results. Body weight increased through the reduction in fat mass and increased in lean-mass, in trunk and whole-body, and this improvement was more evident between T_1 and T_2. Contrary to what we expected, bone mineral density of both segments in the forearm region scan decreased, being more evident in $\Delta T_{1\text{-}3}$. This result can be related with the injury but also with the age of our participant. Studies estimate that 5% to 34% of individuals will experience a fracture within the first five years after SCI (Jiang et al., 2006; Lazo et al., 2001) and aging negatively affects bone mineral density (Dolbow et al., 2013), thus accelerating the SCI-related decline process (Dolbow et al., 2011)

Literature reports after injury a dramatic reduction in muscle cross-sectional area and bone mass (Jones et al., 1998; Mojtahedi et al., 2009; Vlychou et al., 2003), while body fat increases (Jacobs, 2009; Pelletier et al., 2016). These modifications are a strong trend of SCI population justified by the nature of the injury and by the adoption of an extremely sedentary lifestyle, leading to multimorbidity. Bone mineral density has been correlated with health status and with the mobility degree of SCI population (Saltzstein et al., 1992). Evidence suggested that increased upper limb load from activity movements after SCI may contribute to a higher bone mineral density in wheelchair athletes (Vlychou et al., 2003). According to our best knowledge, only one study evaluated body composition through body weight, that changed after a circuit resistance training

in a community-dweller, reporting 2% decrease in body weight in an adult man with paraplegia (44-yrs., injury T12) (Sasso & Backus, 2013). Agreeing with Fisher et al. (2015), future studies are warranted to investigate circuit resistance training effects on body composition, specially bone mineral density analysis in SCI subjects, and in older individuals.

The novelty of our study was the adaptation of a circuit resistance training with free-weight and elastic-band, which seemed to be beneficial for participant's muscle strength. The Δ_{RM1-4} presented positive values for all exercises (table 2). Nevertheless, dominant upper limb flexion and extension and non-dominant upper limb internal rotation did not exhibit improvements on isokinetic strength. The difference between 1RM and isokinetic shoulder strength results probably can be explained by a better approach to the daily and training movements in repetition maximum analysis (Jacobs et al., 2001; Nash, 2005). Also, the absence of internal rotation positive changes may be related with our training protocol, which was limited by the lack of specific exercise for these muscle group (Jacobs et al., 2001). Thus, future studies with circuit resistance training should include this muscle group.

The repetition maximum strength is in agreement with other studies that conducted circuit resistance training with specific resistance machines (Jacobs et al., 2002; Jacobs et al., 2001; Nash et al., 2001; Nash et al., 2002) or solely with elastic-band (Sasso & Backus, 2013) in SCI adults. Yildirim et al. (2016) also found positive results to all isokinetic analyses after rehabilitation, which is opposite to our findings. However, this study was conducted as a complementary rehabilitation program, with a different goal and prescription (3 series - 50, 75 and 100% of 10RM; 8 different exercises – elbow and shoulder muscles strengthening). In rehabilitation the improvements are accentuated, since the individual starts from an extremely restrictive situation for the need to recover/develop the necessary strength to perform tasks that reflect in their functional independence (Drolet et al., 1999) .

Other positive analysis from isokinetic results was observed in bilateral deficit. The majority of the movements has shown a reduced deficit value from pre to post adapted-CRT, except internal rotation, whose value was 10% higher.

After the adapted-CRT all the other movements presented values within the limit percentage for an acceptable muscular imbalance (-10% to +10%) (Hologic, 2005). Upper limb muscle strength and balance are essential for manual wheelchair users (Janssen et al., 2002; Reyes et al., 1995), since wheelchair propulsion, transfers, and other daily activities are executed with the upper limbs, thus predisposing these individuals to shoulder overuse and muscle imbalance (Van Straaten et al., 2017).

Unexpectedly, in opposition to literature, which showed an increase in participants' VO_{2PEAK} values after circuit resistance training, participant´s cardiorespiratory fitness presented a reduction over three months, being more pronounced in T_3. A possible explanation can be linked with the age-related changes in this aerobic capacity (American College of Sports Medicine, 2018) . As in non-disabled population (American College of Sports Medicine, 2018), wheelchair users decrease VO_{2PEAK} with increasing age and the absolute VO_{2PEAK} can reduce by 0.01 L/min per year (Janssen et al., 2002). In fact, all studies had a younger sample than our participant (Jacobs et al., 2002; Jacobs et al., 2001; Nash et al., 2002; Nash et al., 2007; Sasso & Backus, 2013). Probably the adapted-CRT was not enough to attenuate the age-related changes in cardiorespiratory fitness. Thus, it can be speculated that the current training methodology that presented an aerobic component (18 minutes divided into 2-minute bouts, per session) was not enough to improve cardiorespiratory fitness in a manual wheelchair user with paraplegia and aged over 60 years.

Differences in cardiorespiratory fitness assessment methodologies can also explain the inconsistency between studies, as most of them conducted protocols with arm-ergometer, and we performed the propulsion of the wheelchair on a treadmill. Both protocols were validated for SCI individuals and wheelchair users, but a wheelchair on a treadmill is more realistic for manual wheelchair users in daily life activities (Jacobs & Nash, 2004). Additionally, this methodology is linked to the wheelchair circuit, an instrument used in the present study to evaluate functional independence (Kilkens et al., 2005).

Manual wheelchair skill performance was used to evaluate functional independence. Adapted-CRT practice seems to be favorable to reduce

performance-time score and increase ability score, and the latter reached the maximal score in T_2 and kept it in T_3. This result agrees with other studies, which have found functional independence improvements after circuit resistance training (Duran et al., 2001; Yildirim et al., 2016). Moreover, task performance allowed to identify autonomy acquisition in a chore. Before the program, the participant was partially unable to mountain a platform, and after he was completely able. This positive achievement, when considering that manual wheelchair users must have wheelchair skills, will allow him to deal independently with the physical barriers that he will inevitably encounter in various environments (Fliess-Douer et al., 2013). Hence, mastering wheelchair skills can represent an important difference between dependence and independence in everyday life (Haisma et al., 2006; Hicks et al., 2003; Kilkens et al., 2005). This prompts us to suggest that this adapted-CRT was favorable to improve wheelchair skills performance evaluated by protocol with task performance.

Quality of life measures showed positive changes in physical health and environment domains, no changes in social relations domain and general quality of life, but a negative change in the psychological domain after adapted-CRT, observed after Δ_{T2-3} moment. It is believed that these results can be linked with the absence of social support related with the individualized training sessions. Literature states that social network can successfully favor psychological quality of life after the injury (Lude et al., 2014; McColl et al., 1995). Moreover, group exercise programs in Portuguese elderly can improve their health-related quality of life perception (Wanderley et al., 2013).

The most notable improvement in the environment domain, which inserts leisure activities into its analysis, could be related to the positive results in physical activity levels. Stevens et al. (2008) described a significant and moderately strong positive relationship between physical activity level and quality of life in SCI adults. The participant presented a progressive MVPA increase, suggesting that adapted-CRT not only raised MVPA levels during the training sessions as expected, but also collaborated to increase MVPA aside the intervention periods, especially on weekend days. An adapted-CRT seems to be an encouraging strategy for improving physical activity levels. This is of

importance if we consider that people with SCI are more likely to lead physically inactive lives rather than the general population (Buchholz et al., 2003; Sophie Jörgensen et al., 2017; Kawanishi & Greguol, 2013; Stevens et al., 2008). Therefore, optimizing physical activity levels is crucial to improve quality of life and health in either SCI individuals (Stevens et al., 2008) and elderly (Phillips et al., 2013). Moreover, knowing that the comparison of results should be made with caution because of the different methodologies used (Ferri-Caruana et al., 2018; Learmonth et al., 2016; McCracken et al., 2018; Warms et al., 2008). Regarding physical activity levels, our results after the program (129.2 min/day) appear to be positive when compared to the literature. Adults with paraplegia and WCU presented a 29 min/day value (Ferri-Caruana et al., 2018), while SCI individuals (tetra and paraplegia) presented 61.7 min/day in MVPA (McCracken et al., 2018).

Although our case study has shown some trends on the potential effects of an adapted-CRT in an older person with paraplegia and manual wheelchair user, and taking into account the relevance of promoting physical activity for this particular population to improve quality of life, functional independence and health-related physical fitness components, further investigations with objective and standardized measures and involving classifications on the intensity of activities for this population should be conducted. Although we are aware of the restriction and extrapolation of outcomes, these results are relevant, since they stimulate regular physical activity, thus counterpoising a SCI "typical" sedentary lifestyle. Also, they are able to counteract physical and functional deconditioning, accelerated by aging, thus favoring daily independence and possibly reflecting upon quality of life.

This study presented some limitations related to the study design, which did not comprise a robust sample, the lack of dietary control and the evaluation of secondary health conditions. Consequently, its design, by its nature, limits the statistical analysis and the generalization of findings. The lack of studies with the same target population restricted a comparative analysis of outcomes. The increase in life expectancy after a SCI, as well as to have a SCI in advanced age, show the need for a better understanding of the aging process and its consequences in aspects related to health, functional independence and quality

of life of SCI people, especially for those with paraplegia and manual wheelchair users.

CONCLUSION

The present study data suggested that the adapted-CRT with free weights and elastic-band can be developed with older individuals with paraplegia and manual wheelchair users. The program seemed to have positive effects on health-related physical fitness, namely on body composition and muscle strength. Also, the adapted-CRT seemed to be favorable for functional independence, promoting higher daily physical activity levels. However, the current methodology of the program was not enough to maintain or improve cardiorespiratory fitness, as well as some domains of quality of life for 12 weeks of intervention. Despite the benefits suggested in this case study, studies with a more significant number of participants should be conducted, including a sample with older adults and with different time of injury in the chronic phase.

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Conflict of interest

The authors report no conflict of interest.

Authors´ contributions

RMW participated in the design of the study, contributed to data collection, data analysis and interpretation of results. LB, RC and JC participated in the design of the study, data analysis and interpretation of results. MRC participated in data analysis and interpretation of results. All authors contributed to the manuscript writing. All authors have read and approved the final version of the manuscript and agree with the order of presentation of the authors.

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CHAPTER IV

GENERAL DISCUSSION

GENERAL DISCUSSION

The SCI population life expectancy has improved gradually over time (De Souza & Frank, 2018; World Health Organization, 2013) and is higher in individuals with paraplegia (Devivo, 2012). This reflects the increasing number of people who are getting older with SCI (Devivo, 2012). Despite the non-existent Portuguese national data about SCI, Campos et al. (2017) reported that patients with SCI are living longer, with an average life expectancy close to the Portuguese population in general. Therefore, the understanding and the contribution for people with SCI can live healthily, autonomously and with QoL become important.

In the rehabilitation, PA has been encouraged to optimize SCI recovery, contributing to the autonomy and tackling secondary complications, benefits that also can be extended throughout life (Nas et al., 2015; Nash, 2005). PA is considered an essential determinant for health and functionality, both in general (American College of Sports Medicine, 2018) and in SCI population (Martin Ginis et al., 2012) . Although the studies have proposed PA recommendations (Martin Ginis et al., 2011) and exercise guidelines (Martin Ginis et al., 2018) for adults with SCI (tetraplegia and paraplegia), this population tends to be very inactive throughout life.

Exercise has also been pointed out as a strategy for improving subjective well-being, such as QoL and depression (Martin Ginis et al., 2003). Unfortunately, it is estimated that 50% of this population engages in no LTPA whatsoever (Martin Ginis et al., 2010). Although SCI and the use of wheelchair limit the LTPA practice, currently there is a variety of upper body exercises available. However, there is a lack of scientific literature providing information on how PA and particularly adjusted exercise/sport training programs can benefit community-dwelling SCI manual wheelchair users. Thus, this thesis aimed to understand the potential influence of PA and exercise on health-related physical fitness, functional independence and QoL of people with chronic paraplegia and community-dwelling manual wheelchair users.

To achieve this goal, this thesis was gradually constructed with three studies. The first study, which aimed to identify the literature regarding upper

body exercise, can be implemented in the community setting and verify their effects on the functional independence and QoL of people with chronic paraplegia and manual wheelchair users. Despite the upper body exercise (aerobic and strength training) has been advantageous for functional independence and QoL (*Study I*) and beneficial for health (Martin Ginis et al., 2018), literature showed lower LTPA levels (McCracken et al., 2018; Todd & Martin Ginis, 2019) and reported that 47% of SCI people were involved in exercise or sports (Martin Ginis et al., 2010).

Consequently, the second study aimed to analyze the role of adapted sport in PA levels, health-related physical fitness, functional independence and QoL of community dwellers with paraplegia and manual wheelchair users. Adapted sport (*Study II*), as well as strength and aerobic training solely implemented (*Study I*), seems to be positive for functional independence and QoL of this population. However, adapted sports did not have similar benefits as suggested by the guidelines on health-related physical fitness. In fact, the adapted sport showed to be beneficial to cardiorespiratory fitness but did not interfere in muscle strength. This data stimulated our interest to verify if a combined training program could have health-related fitness benefits similar to those suggested by the guidelines (Martin Ginis et al., 2018).

Literature involving people with paraplegia indicated CRT as a combined exercise program designed to improve strength and minimize the common overload in aerobic training (Jacobs et al., 2002; Nash et al., 2001). However, this CRT was elaborated with specialized equipment. Customized fitness equipment and sports facilities, as used in CRT, have been reported as a determinant barrier for practice by wheelchair users (van den Akker et al., 2019). Thus, exercise opportunities should develop using low-price and accessible equipment for easy access, allowing it to be implemented in fitness and community settings and even at home. Interventions involving LTPA need to be transferred from laboratory or clinical environments to community settings to bring about significant changes, as well as barriers to PA for people with SCI should be taken into account (Todd & Martin Ginis, 2019). Thus, we conceive an exercise program that besides meeting planned goals, can be developed with simple material that is easier to

access and implement in different community settings, such as free-weights and elastic-band. Subsequently, the third study was outlined, which aimed to verify the effects that an adapted CRT (adapted-CRT) for easy reapplication in a community context could have on an elderly man with chronic paraplegia and manual wheelchair users on PA levels health-related physical fitness, functional independence and QoL.

The PA level analysis is essential, since, as already referred, low PA levels have been observed (Ferri-Caruana et al., 2018; Kawanishi & Greguol, 2013; van den Akker et al., 2019) and, in contrast, a physically active lifestyle may help everyday functioning, reducing the risk of secondary health problems in wheelchair users with SCI (van den Akker et al., 2019). Subjective measures are an extensively available tool for measuring PA, as verified in *Study II*. However, a subjective measure data collection is limited to the ability to remember, thus favoring bias (Ma et al., 2018). Also, monitors associated with the wheelchair, which can measure distance and speed traveled, may misrepresent the intensity of some non-rotating activities, such as arm ergometer movement (Nightingale et al., 2017). For this reason, monitors that measure upper-body movement, such as accelerometers worn on the wrist, can be considered as a meaningful objective measure of PA (Nightingale et al., 2015). People with paraplegia, characterized by the preservation of upper limbs (World Health Organization, 2013), present a greater PA, measured by the wrist accelerometer, comparatively to those who do not have upper-limb movements, which is probably related to the manual wheelchair use (Zbogar et al., 2016). Thus, the PA level assessment methodology should also consider aspects such as the injury level and technical aids used. Because MVPA cutoff point used in this thesis was validated for the accelerometers worn on the wrist in a MWCU sample, which included persons with paraplegia, but not exclusive for SCI subjects (Learmonth et al., 2016), future studies should use a specific SCI cutoff point. According to (McCracken et al., 2018) people with SCI, due to the variety of motor, sensorial, and autonomic deficiencies are unique, thus requiring specific cutoff points.

Physical activities, as LTPA, seems to interfere differently in health-related physical fitness. Adapted sports practice was positive for left-arm fat% in adults

(*Study II*), while combined training seems to be favorable for fat and lean mass in the trunk and whole-body values in an older man (*Study III*). Body composition was analyzed by DXA, considered an accurate measurement for SCI people and wheelchair athletes (Mojtahedi et al., 2009). The body composition evaluation is important, among other factors, due to the high rate of overweight and obesity that SCI population exhibit, which is about 65% (Rajan et al., 2008). Obesity has been recognized as a public health problem, since it is strongly related to other diseases, such as cardiovascular and metabolic diseases (Gorgey & Gater, 2007). Consequently, searching for tools that may collaborate in maintaining body composition is fundamental. Our studies, in agreement with the literature (Fisher et al., 2015; Hicks et al., 2011; Maher et al., 2017), showed that exercise and adapted sports are not enough to promote significant changes in SCI individuals body composition. Probably, for better results, nutritional strategies should be controlled and associated with LTPA practice, thus favoring positive changes and the understanding of body composition changes (Tanhoffer et al., 2014). Unfortunately, the absence of nutritional control was a limitation in this thesis.

Still, body composition assessment allowed BMD analysis, which has shown an abrupt decrease in the first two years after SCI, thus resulting in other problems (Jacobs & Nash, 2004). Associated to this BMD decline are problems such as osteoporosis and the associated risks (Adriaansen et al., 2016; Cao et al., 2019; Miyahara et al., 2008). Osteoporosis is a serious and debilitating secondary health problem in complete SCI (Rodríguez-Gómez et al., 2019) and is a worrying health problem in the older population (Dolbow et al., 2013). When the high risk of fractures comes true it can lead to a prolonged recovery time (Giangregorio & McCartney, 2006; Lazo et al., 2001), thus causing long periods of immobilization and serious medical complications, such as pressure ulcers, which limit the mobility and consequently functional independence (Jacobs & Nash, 2004). Although literature points to better BMD values in wheelchair athletes (Miyahara et al., 2008), adapted sport and combined training (adapted-CRT) were not enough to present better BMD results in adults and in an elderly with paraplegia (*Study II* and *III*, respectively). According to Miyahara et al. (2008)

the high value in arm BMD in wheelchair athletes comparatively with non-disabled athletes is related with the fact that wheelchair athletes often use their arms to locomotion and all other daily life activities. The difference in studies may be related to the weekly sports practice time. Wheelchair athletes in Miyahara`s study presented 8.7 h/week, while our studies presented values of 5.03 h/week and 3 h/week for adapted sports and adapted-CRT practice, respectively. Corroborating with the above idea, a recent study found no improvement in BMD in individuals with SCI after an exercise program with a 1.5 h/week practice time (Bresnahan et al., 2019).

Another important physical fitness component related to functional independence of MWCU is muscle strength (Ambrosio et al., 2005). Reduced muscle and cardiorespiratory fitness may limit mobility with a wheelchair (Hinrichs et al., 2016; R. Lee Kirby et al., 2016; van der Scheer et al., 2015). The lack of muscular strength and the necessary resistance to get active in physically demanding environments, such as street and slope, can impair them as participatory community members (van der Westhuizen et al., 2017). *Study III* results corroborate with the literature. After the combined training, the participant positively improved strength values (repetition maximum and isokinetic), as well as performance in the wheelchair circuit. In this latter, the participant was able to mountain a platform (simulating a curb climbing) after having started adapted-CRT program and consequently improving his muscle strength values, while the adapted sports practice did not promote significant differences in strength values between practitioners and non-practitioners (*Study II*). This latter finding was unexpected taking in consideration that the majority of the sport group individuals' practices in a court sport (handball and basketball). The ability to maneuver and control the wheelchair is important to wheelchair sport, hence the attainment of success in court is linked to the upper extremity muscle strength (Basar et al., 2013; Nash et al., 2007; Price et al., 2007). Despite the expectation due to the type of practice of wheelchair sports, both groups seemed to have control and maneuver the wheelchair, confirmed through the PA level and ability score. Therefore, the information about the training specificity could have contributed to understand this result, since combined training (resistance and aerobic)

programs have shown improvements in strength values (Nash et al., 2007), as occurred in our *Study III*. However, studies with a more robust sample should be conducted to confirm our assumptions.

Moreover, our studies used the isokinetic dynamometer and this instrument allowed to verify the bilateral difference deficit shoulder strength. In opposition to the literature on wheelchair athletes (Bernard et al., 2004), our results suggested that the adapted sports practice was not enough to show significant changes in this parameter. However, due to the acceptable values (between -10 and 10%) found in the sport-group (*Study II*) and in the older man after combined training (*Study III*), we believe that these two LTPA (adapted sport and adapted-CRT) may be favorable to muscle imbalances. Further investigations should be conducted to confirm this hypothesis, given the importance that muscle imbalance can cause in the MWCU daily life. Muscle imbalance associated with overused shoulder has been related to shoulder problems, such as pain, which has been linked to restrictions on wheelchair ability (Jörgensen et al., 2017; Mulroy et al., 2015). In this sense, we identified that shoulder pain control was a limitation of this thesis. Shoulder movement and pain disorders lead to significant functional limitation, directly affecting everyday professional and sports activities (Keskula & Lott, 2001), also reflecting in another life aspect such QoL (Tavakoli et al., 2016) and functional independence (van der Westhuizen et al., 2017). Preventive measures should be implemented, thus seeking to better understand the role of adapted sport and combined training (adapted-CRT) emerges as a starting point.

The last physical fitness component in our studies was cardiorespiratory fitness. Unfortunately, low cardiorespiratory fitness has been reported in SCI population (Jacobs & Nash, 2004). High cardiorespiratory fitness is associated with a decreased risk of heart disease (Nash, 2005), which is one of the leading causes of death in this population (Cowan & Nash, 2010; Warburton et al., 2007, and with high levels of habitual PA (Sisto & Evans, 2014). People with paraplegia have lower physical fitness with increased injury time, explained by the increased chances of secondary complications leading to a reduction in PA (de Groot et al., 2016) and subsequent deconditioning (Jacobs & Nash, 2004). As expected, the

adapted sport practice was significant for better cardiorespiratory fitness values. Wheelchair athletes were able to keep their VO_2 values stable over time when they continued to practice sports (Shiba et al., 2010). Still, cardiorespiratory fitness has been mentioned as very important for wheelchair games (Vanlandewijck et al., 1999), modalities practiced by 69% of the participants in *Study II*. On the other hand, the methodology used in the adapted-CRT was not able to maintain or improve the cardiorespiratory fitness levels in an older man with paraplegia (*Study III*), contrary to the expected result. Positive changes were observed in cardiorespiratory fitness after combined training in adults with paraplegia (Jacobs et al., 2001; Nash et al., 2007; Sasso & Backus, 2013) and in elderly without disability (Cadore et al., 2014). Consequently, increasing the aerobic component in the adapted-CRT can be an added advantage, considering that wheelchair sports due to their high aerobic component can result in better cardiorespiratory fitness levels.

The literature contains several protocols with different equipment for cardiorespiratory fitness evaluation. The equipment choice should consider the test objective and participants ability (Eerden et al., 2018). Overall, the arm ergometer is the common methodology used to measure the VO_{2PEAK} in a MWCU, inclusive in SCI individuals (Eerden et al., 2018). However, this test can result in a non-functional movement pattern for MWCU (Callahan & Cowan, 2018). Therefore, the present thesis adapted a Kilkens et al. (2005) protocol conducted on a treadmill, which besides being part of the wheelchair circuit (an instrument used to evaluate functional independence), is based on the wheelchair propulsion, which is the base of daily life movement.

Also, this circuit has a task battery that simulates everyday wheelchair skills (Kilkens et al., 2005), which was used in *Study II* and *III* to assess functional independence. Functional independence, due to the lack of a specific definition, allows different decisions regarding the evaluation methodology. Therefore, our *Study I* identified that resistance training was positive for functional independence when assessed through upper-limb functionality (Serra-Añó et al., 2012), but the same did not occur in the evaluation with wheelchair propulsion (Kemp et al., 2011; Mulroy et al., 2011). However, using just one task (mobility) as a measure

could be very restrictive. MWCU require different skills for different tasks aiming their functional independence in community life (Kirby et al., 2018; R. L. Kirby et al., 2016; Oyster et al., 2012), which could favor variations in functional independence measures after resistance training (Yildirim et al., 2016). In this line, *Study III* agrees with the latter statement, as the participation in the adapted-CRT was favorable to the assessment of functional independence measured through the improvements in the ability and performance-time score of wheelchair circuit.

However, concerning sports practice for at least one year and that 69% of adapted sports practitioners were involved in wheelchair handball and basketball, we believe that better significant results would be found in both ability and performance-time scores of sports practitioners. This is because, in addition to both modalities mentioned above, it requires a constant and diverse interaction between the participant and the wheelchair (Borges et al., 2017; Feter et al., 2018; Frogley, 2010). Also, as reported by all participants in *Study II,* other daily tasks, as the transfer between wheelchairs or other equipment are required to enable the practice of adapted sports. Still, the best results in the performance-time score may be related to the two tasks (15-m sprint and figure-8) that were inserted in this evaluation. Speed tests are required in the modality-specific tests (wheelchair basketball and handball), and likewise, the figure 8 performance is characterized by direction changes, movements that are widely used for both clearing and dribbling during the practice of wheelchair handball (Araujo et al.; Borges et al., 2017) and basketball (Feter et al., 2018; Frogley, 2010). Also, the lack of difference in our ability score can be related to functional independence results, which evaluated the mobility in different wheelchair tasks representative of daily life activity. Probably the absence of differences in these two variables is related with PA levels of the entire sample, independently of being sport or non-sport practitioners (*Study II*). In fact, despite groups differ in their LTPA participation, in general, they have high PA levels compared to the literature (Ferri-Caruana et al., 2018; Warms et al., 2008), which can express the considerable independence in the activities with the wheelchair of both groups (*Study II*). MWCU must have a set of wheelchair skills to function independently

and overcome physical barriers that several environments present (Kilkens et al., 2002; R. L. Kirby et al., 2016; Pierce, 1998). If the adapted sports practice was not enough to increase PA levels, combined training presented itself as a positive strategy. An adapted-CRT was favorable to increase PA levels in an older individual with paraplegia (*Study III*), which can be suggested as an important health and functional auxiliary strategy (Maher et al., 2017). Regular PA has proven to be safe to healthy and frail older people, reducing the risks of developing cardiovascular and metabolic diseases, obesity, falls, osteoporosis and muscle weakness (McPhee et al., 2016). The increase in PA level through the participation in exercise programs has been verified in older people (McPhee et al., 2016; Taylor, 2014). Regular PA has been referred as an excellent strategy to combat age-related decline (Hamer et al., 2014). In fact, literature shows a significant linear decline with age and functional independence, estimated by functional independence measure (Putzke et al., 2003), being this loss of functional independence characteristic of aging in the general population (Spirduso, 2005) and SCI population (Hinrichs et al., 2016).

Although the general and SCI population are getting older, they do not have the same perspectives on QoL. People with SCI still have lower values of QoL than the general population (Ghazwin et al., 2015; Lude et al., 2014; Westgren & Levi, 1998). The longer the injury time the easier the adjustment to daily life and this might improve QoL (Saadat et al., 2010; Westgren & Levi, 1998). Exercise has been a strategy for improving subjective well-being, such as QoL and depression in SCI individuals (Martin Ginis et al., 2003). According to our studies, upper-body exercise, through the aerobic, strength and combined (adapted CRT) training, as well as adapted sports practice, can promote beneficial results in QoL, especially in the physical domain in individuals with paraplegia and MWCU, independently of the age and despite the different methodologies used. While resistance and aerobic training have their results based on the SF-36 assessment, combined training and adapted sports results were based in WHOQOL-BREF questionnaire. The first measure has been the most widely used (Ravenek et al., 2012), but the second was elaborated by World Health Organization to allow a global insight (Canavarro et al., 2007; Jang et al.,

2004). Therefore, the latter was our preferred. However, both result in a physical analysis, the first addressing physical function, physical performance, body performance and overall health (Nightingale et al., 2018; Whitehurst et al., 2014); while the second explores pain/discomfort, energy/fatigue, mobility, activity daily life, medication dependence and work ability (Canavarro et al., 2007; Jang et al., 2004). Although they do not exactly address the same issues, they both have a relationship to body function and performance (Wolfe et al., 2013; World Health Organization, 2001). Therefore, different LTPA, such as upper body exercise in its several structures (aerobic and combined with strength) and adapted sport have shown improvements in physical fitness and functional independence, and it is understandable that they also have had improvements in the physical domain of QoL in our studies.

In summary, our results suggested that in community-dwellers with paraplegia and MWCU, the LTPA, especially upper-body exercise and adapted sport, can play an essential role in maintaining or improving some aspects of health-related physical fitness, functional independence and QoL throughout life. Intrinsically, LTPA can be an important public tool with possible benefits on the health, physical and psychological well-being and QoL of this population.

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CHAPTER V

CONCLUSIONS AND FUTURE RESEARCHES

CONCLUSIONS

Considering the results drawn from the different studies that structured this thesis, it is possible to highlight the following conclusions:

Study I. The lower methodological quality and high risk of bias in studies reflect insufficient quality evidence. However, our review was able to identify that aerobic and strength training were the most upper body exercises implemented in community-setting, being the home- based exercises most used option. Moreover, findings suggested that resistance training improved functional independence, while both types of exercise induced positive effects on quality of life, mainly in the physical domain.

Study II. Regular participation in adapted sports, as a leisure-time physical activity, can induce favorable effects on cardiorespiratory fitness, left arm fat% and functional independence (in score time of wheelchair circuit tasks), as well as on general quality of life and physical domain.

Study III. The circuit resistance training adapted with free-weight and elastic-band can be developed with an older individual with paraplegia and manual wheelchair user. The program was favorable for functional independence, and for promotion of higher daily life physical activity levels. Still, the participation in the program helped to maintain social relations and general quality of life, as well as to improve physical health and environment domains. Moreover, participation seems to have had a positive effect on some segments of body composition and muscle strength. However, the current exercise methodology implemented was not enough to maintain or improve cardiorespiratory fitness in an older individual with paraplegia and manual wheelchair user.

This thesis identified that adapted sport and combined training seem to play different roles on health-related physical fitness and moderate-vigorous physical activity levels, emphasizing the positive role of adapted sport on

cardiorespiratory fitness community dwellers with chronic paraplegia and manual wheelchair user. Leisure-time physical activity practice was favorable for functional independence and quality of life, especially in the physical domain.

FUTURE RESEARCHES

Further researches comprising body composition analysis should include diet intake and shoulder pain control. Also, we suggest that the current methodology conducted with the adapted circuit resistance training ought to be tested in adults. Moreover, aerobic component adaptations must be made and investigated in an elderly population with spinal cord injury aiming possible improvements on cardiorespiratory fitness outcomes. Furthermore, despite the difficulties, future studies should be conducted with a larger sample size to corroborate our findings and include individuals from other country regions to allow a national representativeness. In addition, investigations about community dwellers with paraplegia and manual wheelchair user should guarantee a higher methodological quality.

APPENDICES

I. ETHICS COMMITTE

U. PORTO
FACULDADE DE DESPORTO
UNIVERSIDADE DO PORTO

Ethics Committee

ETHICS OPINION

Process **CEFADE 07.2016**

The Ethics Committee of the Faculty of Sport from the University of Porto analyzed the project entitled "Capacidade Física, Capacidade Funcional, Composição Corporal e Qualidade de Vida de Pessoas com Lesão Medular" presented by MSc. Renata Matheus Willig. Considering the project's characteristics, as well as the competence of the research team, the Ethics Committee addresses a positive opinion, because the ethical principles that govern this type of scientific work are respected.

Porto and Faculty of Sport, 12th April, 2016

The chairman of the Ethics Committee,

José Alberto Ramos Duarte

II. PRISMA CHECKLIST

Section/topic	#	Checklist item	Reported on page #
ITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	43
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	45
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	47
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	48
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	N/A
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	49
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	49
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	49
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	50
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	51
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	49
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	51
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	N/A
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.	N/A

Section/topic	#	Checklist item	Reported on page #
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	N/A
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	51
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	Figure 1
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	Table 1
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	Table 4
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	Table 2
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	N/A
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	Table 4
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	Table 3
DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	58
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	58
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	63
FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	Acknowl-edgment

From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLoS Med 6(7): e1000097. doi:10.1371/journal.pmed1000097

For more information, visit: **www.prisma-statement.org**

III. INFORMED CONSENT FORM – STUDY II

TERMO DE CONSENTIMENTO LIVRE E ESCLARECIDO

Este termo tem como objetivo esclarecer e solicitar o seu consentimento para participar no Projeto denominado **Capacidade Física, Capacidade Funcional, Composição Corporal e Qualidade de Vida de adultos com lesão medular,** elaborado para a realização da tese de doutoramento da aluna Renata Matheus Willig, sob a orientação da Professora Doutora Joana Carvalho e coorientação do Professor Doutor Rui Corredeira.

INFORMAÇÃO AO PARTICIPANTE

Caro participante,

Este documento descreve o estudo para o qual está a ser convidado a participar de forma voluntária.

Por favor, leia-o atentamente. Antes de dar a sua autorização é importante a total compreensão das questões contidas neste documento. Sinta-se à vontade para colocar todas as questões ao investigador presente. Caso decida participar, e se surgirem novas questões, poderá contactar o investigador para esclarecê-las.

A qualquer momento pode desistir de participar deste estudo, sem nenhuma penalidade e sem perder os benefícios aos quais tenha direito.

No fim o investigador irá perguntar-lhe se concorda em participar no estudo.

OBJETIVOS DA INVESTIGAÇÃO

O objetivo principal deste estudo é observar a potencial influência da atividade física e do exercício físico na aptidão física relaciona a saúde (composição corporal, aptidão cardiorrespiratória e força muscular), independência funcional e qualidade de vida de pessoas com lesão medular.

EXPLICAÇÃO DOS PROCEDIMENTOS

O presente estudo apresenta um conjunto de procedimentos descritos a seguir.

Primeiramente irá responder de forma escrita ou oral a uma Ficha de Anamnese e três questionários (IPAQ – Questionário Internacional de Atividade Física, MIF – Escala de Independência Funcional, e WHOQOL – Bref – Questionário de Qualidade de Vida).

Também lhe será solicitada a utilização de um acelerómetro durante 7 dias (utilizado similarmente a um relógio) para verificar o nível de atividade física, juntamente com o preenchimento de um diário de atividade física que servirá para complementar as informações do acelerómetro.

Para além disso, serão realizados mais quatro procedimentos práticos:

1. Circuito em cadeira de rodas: verifica a sua habilidade com a cadeira de rodas;
2. Teste de esforço máximo no tapete rolante: permite verificar o consumo de oxigênio e a frequência cardíaca;
3. Força muscular de membro superior (ombro) realizado em um dinamómetro isocinético;
4. Avaliação da composição corporal: realizada no DEXA (exame de absorciometria por raio x com dupla energia), diferenciando a massa gorda, massa magra e massa óssea, realizado na posição de deitado e sentado na própria cadeira.

Este conjunto de procedimentos estão estruturados para decorrer durante dois ou três dias, de modo a que seja possível avaliar todos os parâmetros de forma legítima e com o menor desconforto possível para o participante.

Durante todos os procedimentos estão disponíveis técnicos e auxiliares para garantir a segurança e um melhor funcionamento das atividades.

INCÓMODOS DERIVADOS DA PARTICIPAÇÃO

Os questionários podem causar algum desconforto ou constrangimento ao serem respondidos, visto que contêm perguntas que envolvem aspetos pessoais, e que podem estar relacionadas com as dificuldades quotidianas. Para garantir o menor desconforto possível nesse momento, será solicitado que os documentos sejam preenchidos apenas com as iniciais do seu nome (como forma de já codificar a sua participação). Posteriormente os seus dados serão repassados para um banco de dados de forma codificada (letra e números), em que só o pesquisador principal terá conhecimento do real nome do participante.

Já os procedimentos de terreno podem causar algum desconforto ou cansaço, uma vez que exigem movimentos não rotineiros que poderão ser de difícil execução para alguns participantes. Para garantir a segurança durante os procedimentos práticos, será disponibilizado sempre um auxiliar para acompanhar as atividades, que possa ajudar e dar segurança durante todo o protocolo.

Devido às caraterísticas da atividade, as atividades práticas irão exigir a utilização de equipamentos específicos (roupas de fácil mobilidade) pelos participantes.

No que diz respeito ao DEXA, é uma técnica que usa raio x com uma dose de radiação muito baixa, e está comprovado que a sua exposição esporádica não desenvolve problemas de maior.

Em caso de desconforto durante a realização de qualquer teste, o investigador principal compromete-se a interromper os mesmos.

BENEFÍCIOS ESPERADOS

O envolvimento no estudo irá permitir ao participante obter informações sobre sua composição corporal (massa gorda, massa magra e massa óssea), aptidão cardiorrespiratória, força muscular, quanto a sua habilidade com a cadeira de rodas e nível de atividade física diária. Estas informações ainda poderão auxiliar outros profissionais que trabalhem ou venham a trabalhar com o participante.

CARÁTER VOLUNTÁRIO DA PARTICIPAÇÃO E POSSIBILIDADE DE SAÍDA DO ESTUDO

Os participantes terão total liberdade para decidir se desejam ou não participar do estudo ou parte do estudo, sem qualquer prejuízo para o próprio. Também poderão optar por retirar-se do estudo a qualquer momento, sem que tal decisão comprometa o seu relacionamento com a equipa de investigação e demais setores envolvidos, nem os respetivos direitos à assistência que lhes é devida.

A participação neste estudo é de caráter totalmente voluntário, sem nenhum fim lucrativo. Ressalva-se que as deslocações para as avaliações na Faculdade de Desporto da Universidade do Porto são da inteira responsabilidade da equipa responsável pelo projeto.

GARANTIA DA PRIVACIDADE E DA CONFIDENCIALIDADE

Os dados recolhidos terão fins exclusivamente científicos e a identidade do participante será mantida no anonimato, mesmo após a publicação dos resultados desta pesquisa. Para este fim, os documentos serão preenchidos apenas com letras iniciais dos nomes, e posteriormente, a cada indivíduo será atribuído um código constituído por letras e números. Apenas os responsáveis pelo estudo terão acesso à listagem dos códigos e respetiva identidade nominal.

Todas as informações e dados recolhidos serão guardados por profissionais devidamente capacitados e experientes. Apenas a equipa de investigadores terá acesso aos dados recolhidos, que serão mantidos na máxima privacidade e confidencialidade. O material ficará disponível para o participante sob solicitação escrita.

Eu, ____,
maior de idade, nascido _____/ _____/ 19____, abaixo-assinado, declaro que me sinto esclarecido com as informações que me foram prestadas e que foram respondidas todas as questões que julguei necessárias até ao presente momento. Declaro com a minha assinatura, que consinto na minha participação neste estudo.

Porto, _____ de ____________ de 20 ____.

O Participante O Investigador

CONSENTIMENTO PARA FOTOGRAFIAS

Permito que os investigadores obtenham para fins de pesquisa:

( ) fotografias e vídeos ( ) apenas fotografias ( ) apenas vídeos

( ) Concordo que o material obtido possa ser publicado em aulas, congressos, palestras ou periódicos científicos. Porém, a minha identidade não deverá ser revelada através do meu nome em qualquer uma das vias de publicação ou uso.

( ) Não concordo que o material obtido possa ser publicado com a minha imagem em aulas, congressos, palestras ou periódicos científicos.

Porto, _____ de ____________ de 20 ____.

O Participante O Investigador

Qualquer dúvida, por favor não hesite em contactar-nos:

Msc. Renata Matheus Willig – Telemóvel: 915885352
e-mail: rewillig@gmail.com

IV. INFORMED CONSENT FORM – STUDY III

TERMO DE CONSENTIMENTO LIVRE E ESCLARECIDO

Este termo tem como objetivo esclarecer e solicitar o seu consentimento para participar no Projeto denominado **Capacidade Física, Capacidade Funcional, Composição Corporal e Qualidade de Vida de adultos com lesão medular,** elaborado para a realização da tese de doutoramento da aluna Renata Matheus Willig, sob a orientação da Professora Doutora Joana Carvalho e coorientação do Professor Doutor Rui Corredeira.

INFORMAÇÃO AO PARTICIPANTE

Caro participante,

Este documento descreve o estudo para o qual está a ser convidado a participar de forma voluntária.

Por favor, leia-o atentamente. Antes de dar a sua autorização é importante a total compreensão das questões contidas neste documento. Sinta-se à vontade para colocar todas as questões ao investigador presente. Caso decida participar, e se surgirem novas questões, poderá contactar o investigador para esclarecê-las.

A qualquer momento pode desistir de participar deste estudo, sem nenhuma penalidade e sem perder os benefícios aos quais tenha direito.

No fim o investigador irá perguntar-lhe se concorda em participar no estudo.

OBJETIVOS DA INVESTIGAÇÃO

O objetivo principal deste estudo é observar a potencial influência da atividade física e do exercício físico na aptidão física relaciona a saúde (composição corporal, aptidão cardiorrespiratória e força muscular), independência funcional e qualidade de vida de pessoas com lesão medular.

EXPLICAÇÃO DOS PROCEDIMENTOS

O presente estudo está dividido em dois grandes momentos. O primeiro destina-se à avaliação geral da capacidade física, capacidade funcional, composição corporal, qualidade de vida e nível de atividade física das pessoas com lesão medular. Enquanto o segundo é destinado ao desenvolvimento de um programa de treino em circuito.

1º MOMENTO

Na primeira etapa irá responder de forma escrita a uma Ficha de Anamnese e três questionários (IPAQ – Questionário Internacional de Atividade Física, MIF – Escala de Independência Funcional, e WHOQOL – Bref – Questionário de Qualidade de Vida).

Também lhe será solicitada a utilização de um acelerómetro durante 7 dias (utilizado similarmente a um relógio) para verificar o nível de atividade física, juntamente com o preenchimento de um Diário de Atividade Física que servirá para complementar as informações do acelerómetro.

Para além disso, serão realizados mais quatro procedimentos práticos:

2. Circuito em cadeira de rodas: verifica a sua habilidade com a cadeira de rodas;
3. Teste de esforço máximo no tapete rolante: permite verificar o consumo de oxigênio e a frequência cardíaca;
4. Força muscular de membro superior (ombro) realizado em um dinamómetro isocinético;
5. Avaliação da composição corporal: realizada no DEXA (exame de absorciometria por raio x com dupla energia), diferenciando a massa gorda, massa magra e massa óssea, realizado na posição de deitado e sentado na própria cadeira.

Este conjunto de procedimentos estão estruturados para decorrer durante dois ou três dias, de modo a que seja possível avaliar todos os parâmetros de forma legítima e com o menor desconforto possível para o participante.

Durante todos os procedimentos estão disponíveis técnicos e auxiliares para garantir a segurança e um melhor funcionamento das atividades.

2º MOMENTO

Nesta fase será desenvolvido um programa de treino em circuito. Este está previsto para decorrer três vezes na semana, durante 12 semanas, com duração de 45-60 minutos cada sessão. O Circuito consta de uma sequência de 6 exercícios de força mais um exercício de caráter aeróbico, e a sequência será repetida três vezes, respetivamente.

Após as avaliações do 1º momento serão realizadas duas semanas de adaptação ao programa de exercício. No último dia do período de avaliação será efetuado um teste de força máxima para que seja possível realizar o correto planeamento do treino.

O teste de força máxima consiste na avaliação da força máxima em cada exercício pré-definido ao circuito a ser realizado. Ele será realizado antes de iniciar o programa, na 4ª, 8ª e 12ª semanas de treino. As avaliações em diferentes momentos servem como forma de planear e controlar a performance de cada participante.

Durante esse período do Programa de Treino serão realizadas algumas avaliações semelhantes às do 1º MOMENTO. Na 8ª semana será reaplicado o acelerómetro, força de membro superior, teste de esforço máximo, circuito e cadeira de rodas, questionário de qualidade de vida e composição corporal.

Na 12ª semana serão refeitos todos os testes, quer do 1º MOMENTO como os iniciais do 2º MOMENTO. Você será convidado novamente a repetir estas avaliações após a 24ª semana do início do período de treino.

O Programa de treino e as avaliações da força máxima ocorrerão na mesma dependência do Programa de Treino; já o circuito em cadeira de rodas, o teste de esforço máximo, a composição corporal e a força de membro superior serão realizados no Centro de Investigação em Atividade Física, Saúde e Lazer, na Faculdade de Desporto da Universidade do Porto.

O presente estudo apresenta um conjunto de procedimentos descritos a seguir.

Na primeira etapa irá responder de forma escrita ou oral a uma Ficha de Anamnese e três questionários (IPAQ – Questionário Internacional de Atividade Física, MIF – Escala de Independência Funcional, e WHOQOL – Bref – Questionário de Qualidade de Vida).

Também será solicitada a utilização de um acelerómetro durante 7 dias (utilizado similarmente a um relógio) para verificar o nível de atividade física, juntamente com o preenchimento de um Diário de Atividade Física que servirá para complementar as informações do acelerómetro.

Para além disso, serão realizados mais quatro procedimentos práticos:

3. Circuito em cadeira de rodas: verifica a sua habilidade com a cadeira de rodas;

4. Teste de esforço máximo no tapete rolante: permite verificar o consumo de oxigênio e a frequência cardíaca;

5. Força muscular de membro superior (ombro) realizado em um dinamómetro isocinético;

6. Avaliação da composição corporal: realizada no DEXA (exame de absorciometria por raio x com dupla energia), diferenciando a massa gorda, massa magra e massa óssea, realizado na posição de deitado e sentado na própria cadeira.

Este conjunto de procedimentos estão estruturados para decorrer durante dois ou três dias, de modo a que seja possível avaliar todos os parâmetros de forma legítima e com o menor desconforto possível para o participante.

Durante todos os procedimentos estão disponíveis técnicos e auxiliares para garantir a segurança e um melhor funcionamento das atividades.

INCÓMODOS DERIVADOS DA PARTICIPAÇÃO

Os questionários podem causar algum desconforto ou constrangimento ao serem respondidos, visto que contêm perguntas que envolvem aspetos pessoais, e que podem estar relacionadas com as dificuldades quotidianas. Para garantir o menor desconforto possível nesse momento, será solicitado que os documentos sejam preenchidos apenas com as iniciais do seu nome (como forma de já codificar a sua participação). Posteriormente os seus dados serão repassados para um banco de dados de forma codificada (letra e números), em que só o pesquisador principal terá conhecimento do real nome do participante.

Já os procedimentos de terreno podem causar algum desconforto ou cansaço, uma vez que exigem movimentos não rotineiros que poderão ser de difícil execução para alguns participantes. Para garantir a segurança durante os procedimentos práticos, será disponibilizado sempre um auxiliar para acompanhar as atividades, que possa ajudar e dar segurança durante todo o protocolo.

Devido às caraterísticas da atividade, as atividades práticas irão exigir a utilização de equipamentos específicos (roupas de fácil mobilidade) pelos participantes.

No que diz respeito ao DEXA, é uma técnica que usa raio x com uma dose de radiação muito baixa, e está comprovado que a sua exposição esporádica não desenvolve problemas de maior.

Em caso de desconforto durante a realização de qualquer teste, o investigador principal compromete-se a interromper os mesmos.

BENEFÍCIOS ESPERADOS

O envolvimento no estudo irá permitir ao participante obter informações sobre sua composição corporal (massa gorda, massa magra e massa óssea), aptidão cardiorrespiratória, força muscular, quanto a sua habilidade com a cadeira de rodas e nível de atividade física diária. Estas informações ainda poderão auxiliar outros profissionais que trabalhem ou venham a trabalhar com o participante.

BENEFÍCIOS ESPERADOS

O envolvimento no estudo irá permitir ao participante obter informações sobre a sua capacidade física, capacidade funcional, composição corporal (massa gorda, massa magra e massa óssea) e nível de atividade física diária. Estas informações ainda poderão auxiliar outros profissionais que trabalhem ou venham a trabalhar com o participante.

CARÁTER VOLUNTÁRIO DA PARTICIPAÇÃO E POSSIBILIDADE DE SAÍDA DO ESTUDO

Os participantes terão total liberdade para decidir se desejam ou não participar do estudo ou parte do estudo, sem qualquer prejuízo para o próprio. Também poderão optar por retirar-se do estudo a qualquer momento, sem que tal decisão comprometa o seu relacionamento com a equipa de investigação e demais setores envolvidos, nem os respetivos direitos à assistência que lhes é devida.

A participação neste estudo é de caráter totalmente voluntário, sem nenhum fim lucrativo. Ressalva-se que as deslocações para as avaliações na Faculdade de Desporto da Universidade do Porto são da inteira responsabilidade da equipa responsável pelo projeto.

GARANTIA DA PRIVACIDADE E DA CONFIDENCIALIDADE

Os dados recolhidos terão fins exclusivamente científicos e a identidade do participante será mantida no anonimato, mesmo após a publicação dos resultados desta pesquisa. Para este fim, os documentos serão preenchidos apenas com letras iniciais dos nomes, e posteriormente, a cada indivíduo será atribuído um código constituído por letras e números. Apenas os responsáveis pelo estudo terão acesso à listagem dos códigos e respetiva identidade nominal.

Todas as informações e dados recolhidos serão guardados por profissionais devidamente capacitados e experientes. Apenas a equipa de investigadores terá acesso aos dados recolhidos, que serão mantidos na máxima privacidade e confidencialidade. O material ficará disponível para o participante sob solicitação escrita.

Eu, ____,
maior de idade, nascido _____/ _____/ 19____, abaixo-assinado, declaro que me sinto esclarecido com as informações que me foram prestadas e que foram respondidas todas as questões que julguei necessárias até ao presente momento. Declaro com a minha assinatura, que consinto na minha participação neste estudo.

Porto, _____ de ____________ de 20 ____.

O Participante O Investigador

CONSENTIMENTO PARA FOTOGRAFIAS

Permito que os investigadores obtenham para fins de pesquisa:

( ) fotografias e vídeos ( ) apenas fotografias ( ) apenas vídeos

( ) Concordo que o material obtido possa ser publicado em aulas, congressos, palestras ou periódicos científicos. Porém, a minha identidade não deverá ser revelada através do meu nome em qualquer uma das vias de publicação ou uso.

( ) Não concordo que o material obtido possa ser publicado com a minha imagem em aulas, congressos, palestras ou periódicos científicos.

Porto, _____ de ____________ de 20 ____.

O Participante O Investigador

Qualquer dúvida, por favor não hesite em contactar-nos:
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e-mail: rewillig@gmail.com