Functional implications of strength training on older adults: a literature review

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Summary

Aging is a set of processes, inherent of living beings, of which induce loss of capacity to adapt into the environment by decreased functionality. It is associated to a declivity of the functions of the musculoskeletal and neuromuscular systems converging in degrowth of all expressions of muscular strength, including maximum, power and the reaction time. The functional capacity makes reference to a multidimensional quality, however, for the particular aspect of physical functioning, it is considered as the physiologic capacity to perform activities of daily living safely and independently, without provoking exhaustion. To fight the phenomena that promote the continued loss of functional capacity, they require strategies that promote benefits in musculoskeletal and neuromuscular systems, especially if you manage to decrease the speed of deterioration, benefit the quality of life, functional independence and influence increased life expectancies. Both older men and women, the different modalities of strength training can constitute a proper strategy to combat these effects. The purpose of this review article was to systematize the alterations of skeletal muscle during aging and the derivatives muscular adaptations of the different strength training in older adults systems, based on the most conspicuous and relevant scientific literature. The synthesis of results justifies the importance of the application of strength training to avoid sarcopenia, dynapenia and optimize the functional capacity in older adults. Is paramount the knowledge on muscle characteristics (morphological and neuromuscular) necessary in the implementation of the different modalities of training. The adaptations provided by the reagent system training, showing greater functional benefits for older adults, collated with traditional training modalities and the power training.

Key words:
Aging. Older adult. Frail elderly. Muscle strength. Resistance training.

Implicaciones funcionales del entrenamiento de la fuerza en el adulto mayor: una revisión de literatura

Resumen

El envejecimiento es un conjunto de procesos, inherente a los seres vivos, los cuales inducen a la pérdida de la capacidad de adaptación al ambiente mediante la disminución de la funcionalidad. Está asociado a un declive de las funciones de los sistemas osteomuscular y neuromuscular, convergiendo en el decrecimiento de todas las expresiones de la fuerza muscular, incluyendo la máxima, la potencia y también el tiempo de reacción. La capacidad funcional hace referencia a una cualidad multidimensional, sin embargo, para el aspecto particular de funcionalidad física, se considera como la capacidad fisiológica para realizar las actividades de la vida diaria de forma segura y autónoma, sin provocar agotamiento. Para batallar los fenómenos que promueven la perdida continua de la capacidad funcional, se requieren de estrategias que promuevan beneficios en los sistemas osteomuscular y neuromuscular, especialmente sí logran disminuir la velocidad de deterioro. Las diferentes modalidades de entrenamiento de la fuerza pueden constituir una estrategia adecuada para combatir estos efectos. El objetivo de presente artículo de revisión fue sistematizar las alteraciones del músculo esquelético durante el envejecimiento y las adaptaciones musculares derivadas de los diferentes sistemas entrenamiento de la fuerza en adultos mayores, con base a la literatura científica más conspicua. La síntesis de resultados justifica la importancia de la aplicación del entrenamiento de la fuerza para evitar la sarcopenia y optimizar la capacidad funcional en adultos mayores. Es de suma importancia el conocimiento sobre las particularidades musculares (morfológicas y neuromusculares) necesarias en la implementación de las diferentes modalidades de entrenamiento. Las adaptaciones proporcionadas por el sistema de entrenamiento reactivo, muestran mayores beneficios funcionales para los adultos mayores, cotejado con las modalidades de entrenamiento tradicional y de potencia.

Palabras clave:
Envejecimiento. Adulto mayor. Adulto mayor frágil. Fuerza muscular. Entrenamiento resistido. Entrenamiento de la fuerza.

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Introduction

Changes to the skeletal muscle during the ageing process are linked to the reduction in morphological characteristics and in neuromuscular function, inducing the deterioration of maximum voluntary strength, power and muscle reaction time[1]. The main morphological deterioration during ageing can been seen in the cross sectional area reduction and in muscle thickness decrease, a phenomenon associated with the reduction in the total number of muscle fibres, mainly type IIX, responsible for producing rapid strength[2].

The motor unit recruitment model, the trigger rate and the synchronisation of the neuromuscular function are gradually involved in the ageing of tissues, altering the intramuscular coordination and the mechanics of movement, factors that have a negative impact on the capacity to generate strength[3]. Together, these important events for the functionality of the skeletal muscle particularly affect the muscles that activate the lower limb joints, affecting physical independence and the level of physical activity, a phenomenon known as Dynapenia[4].

To fight against this phenomenon, strategies are required that promote benefits to the skeletal-muscle system, especially if they manage to reduce the speed of the deterioration. It has been shown that strength training is a suitable strategy that has a positive impact on the strength, quality and volume of muscle, as well as the optimisation of body balance in older adults[5,6].

The greater the skeletal muscle's efficiency in generating tension in the body segments, the greater the individual's functional capacity[7]. The contractibility capacity of the skeletal muscle to induce the movement of the joints depends on morphological and physiological factors conditioned by biological age, and at the same time, the state of completeness or the level of deterioration depends on morphological and physiological factors conditioned by biological age, and in turn, on the state of completeness or deterioration of the skeletal muscle system, thus influencing general physical health[8,9].

To carry out every day activities (EDA), such as sitting and standing from a chair, climbing stairs or moving an object, it is important for the skeletal muscle to retain the ability to produce reactive strength and for the muscle reaction times to be coherent with the task[10,11], so that both the functional capacity related to strength, as well as preventive muscle mechanisms can be maintained, so as to reduce the risk of falls in older adults[12].

General adaptations based on strength training (ST) reduce the speed at which muscle fibres deteriorate, having a positive influence on the risk of falls and preserving physical independence. This review study aims to systematise the changes associated with ageing in the skeletal muscle and the muscle adaptations with the different strength training systems in this demography.

Methodology

Search strategy

In the period between October 2015 and February 2016, an exhaustive search was performed of the scientific literature concerning the existing links between the physiological repercussions of skeletal muscle ageing and the different modalities of strength training in older adults. To discover and obtain the academic articles, PubMed, Scopus and Ovid databases were used. The following search terms were used: *"older adult", "Ageing" and "Frail Elderly"* associated with the terms: *"skeletal muscle", "resistance training", "resistance exercise"* and *"strength training".*

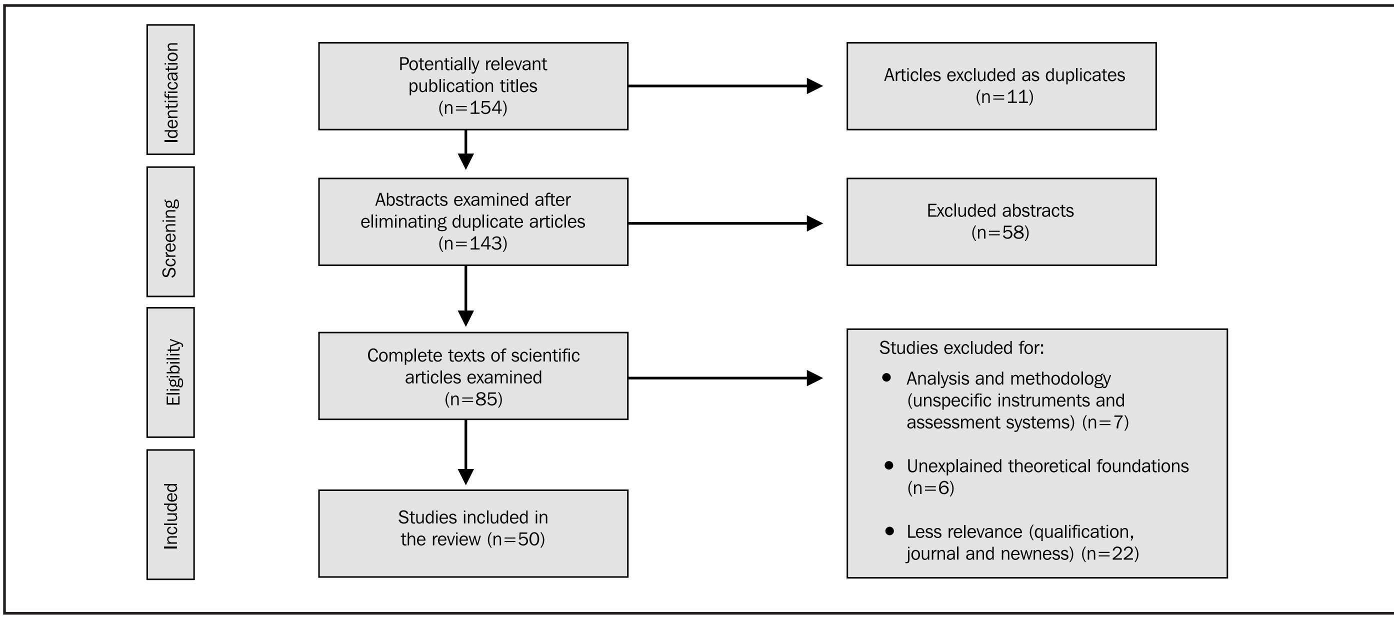
Study selection

The articles compiled are in Spanish, English and Portuguese. To obtain the different studies, those that were supported with theoretical arguments based on personal opinion were excluded, with preference for tested clinical trials and world-renowned expert opinions on this particular subject. The selection was performed using three filters: 1) The articles taken from the database were initially selected for their titles, ruling out publications that were clearly not related to the study objective; 2) Next, the abstracts were read, selecting the studies that were directly related to the central interest of this work, identifying the publications that appeared in more than one database. Then the complete texts of the potential articles were recovered to be put through the final filter; 3) In this phase a critical reading, analysis and assessment was performed on each study, to check the methodological truthfulness and quality. Tools were used to assess the articles, using the CONSORT 2010 check list for experimental studies with a clinical trial structure, and the PRISMA check list was applied for expert reviews. Each study was assessed independently by at least 3 of the authors and the grades obtained were averaged to prioritise the selection of the studies with the most points. Finally, to develop each component of this study, publications with the highest grading, relevance and importance were included, those in which the authors guaranteed the theoretical contextualisation with the most relevance to the main study idea and that backed up their findings with internationally valid clinical trials (Figure 1).

Results

Next the exhaustive review of the literature obtained during the search of the consulted databases uncovered a total of 85 potentially conspicuous articles, of which a sample of 50 articles was taken of those in which the authors backed up their findings with the best theoretical bases, as well as using effective methodology and having greater scientific relevance. In general terms, a significant amount of works were found related to the specific changes of skeletal muscle ageing, as well as a moderate amount of studies that linked specific ST mechanisms to functional abilities and their scope in the ageing of the skeletal muscle system. The creation of the findings summary and the scientific discoveries that link the general characteristics of skeletal muscle ageing, ST and the functional abilities of older adults is displayed in the following sections.

Figura 1. Diagrama de flujo que representa la estrategia de búsqueda y selección de artículos académicos en los que se basa la presente revisión.



Ageing of the skeletal muscle

Once the skeletal muscle reaches physical maturity in human beings, it displays a significant reduction in lean muscle mass, around 10% to 16%, following the loss of bone and muscle mass and the total body water content, phenomena related to the ageing of the human body[13-15].

The gradual loss of skeletal-muscle mass is known as sarcopenia, and is accompanied by the loss of strength, and can also lead to the decay of joint mobility and functional capacity, which increases with age, thus converging into the dynapenia of the older adult[16]. Dynapenia is a generic term that describes the loss of muscle mass, strength and quality, which has a significant influence within the field of public health, due to its well-known functional consequences in walking and balance, expanding the risk of falls and the loss of physical independence, just as it influences the increase of the risk of developing non-transmittable chronic diseases such as diabetes, osteoporosis and heart disease[17].

Within the morphological alterations related to the skeletal muscle in ageing, the following can be highlighted: 1). Reduction of the cross-sectional area of muscle fibres in people aged over 70, as well as changes in the shape of the fibres[18]; 2). Reduction of the muscle area of up to 40% between 30 to 80 years[18]; 3). Reduction of the total number of muscle fibres of up to 39%[7]; 4). Selective reduction of the size of the type 8 muscle fibres or glycolytic quick muscle fibres of up to 26%[19]; 5). Differentiation in the configuration of the muscle area, compared to young adults, in whom 70% of muscle mass is made up of muscle fibres, in older adults this percent drops to 50%[20]. Effectively, from 25 years old the reduction of muscle mass is caused both by the reduction of the number of fibres (especially type 2) as well as by the drop in their size[21].

In older adults, neuromuscular changes can be seen that have a direct influence on the generation of strength, such as the reduction in the number of motor units associated with an increase in the size of low-threshold motor units and a loss in the number of spinal cord alpha motor neuron units, with the subsequent decay of their axons[2]. Indirect evidence of this neuro-degenerative process is the increase in the groups of fibre types found in older adult muscles, expressed by the different cycles of denervation, followed by reinnervation, which occur in muscle fibres[11]. These alterations to the neurogenic process, which generally start at around 50 years of age, explain why when the reinnervation capacity is so reduced, the fibres that are left completely denerved are replaced by fat or fibrous tissue[17,22].

Various mechanisms are linked to the alteration of the functionality of motor-neurons in ageing, such as the alteration of the functioning of the mitochondria, feasibly linked to mitochondrial DNA mutations and oxidative damage, as well as the reduction in some of the neurotrophic factors deriving from the brain, such as neurotrophin (NT) 3, 4 and 5 and the leukaemia inhibitor factor (LIF), which could have a harmful effect on the motor-neuron function[14, 23, 24].

Moving to the neurological and morphological alterations of the skeletal muscle, the literature also describes the alterations of ageing on the metabolism of muscle fibre[25]. The increase of age is related to an approximate reduction of 25% of the oxidative muscle capacity of the blood perfusion during contractile activity[26], in the resting glycogen muscle concentration, as well as a reduction in the myofibrillar

ATPase activity, the glycolytic and oxidative enzymes, the ATP, CP and mitochondrial protein stores[27, 28].

The skeletal muscle regeneration capacity is also affected by the ageing process. Factors surrounding the regeneration of muscle fibre that are altered with the ageing process are the fibroblast growth factor (FGF), somatomedin-C (IGF-1 or the type 1 insulin growth factor) and the nervous growth factor (NGF)[28]. These factors are important regulators of cell growth precursors to the skeletal muscle, as well as the maintenance or establishment of neuro-muscular contact[27].

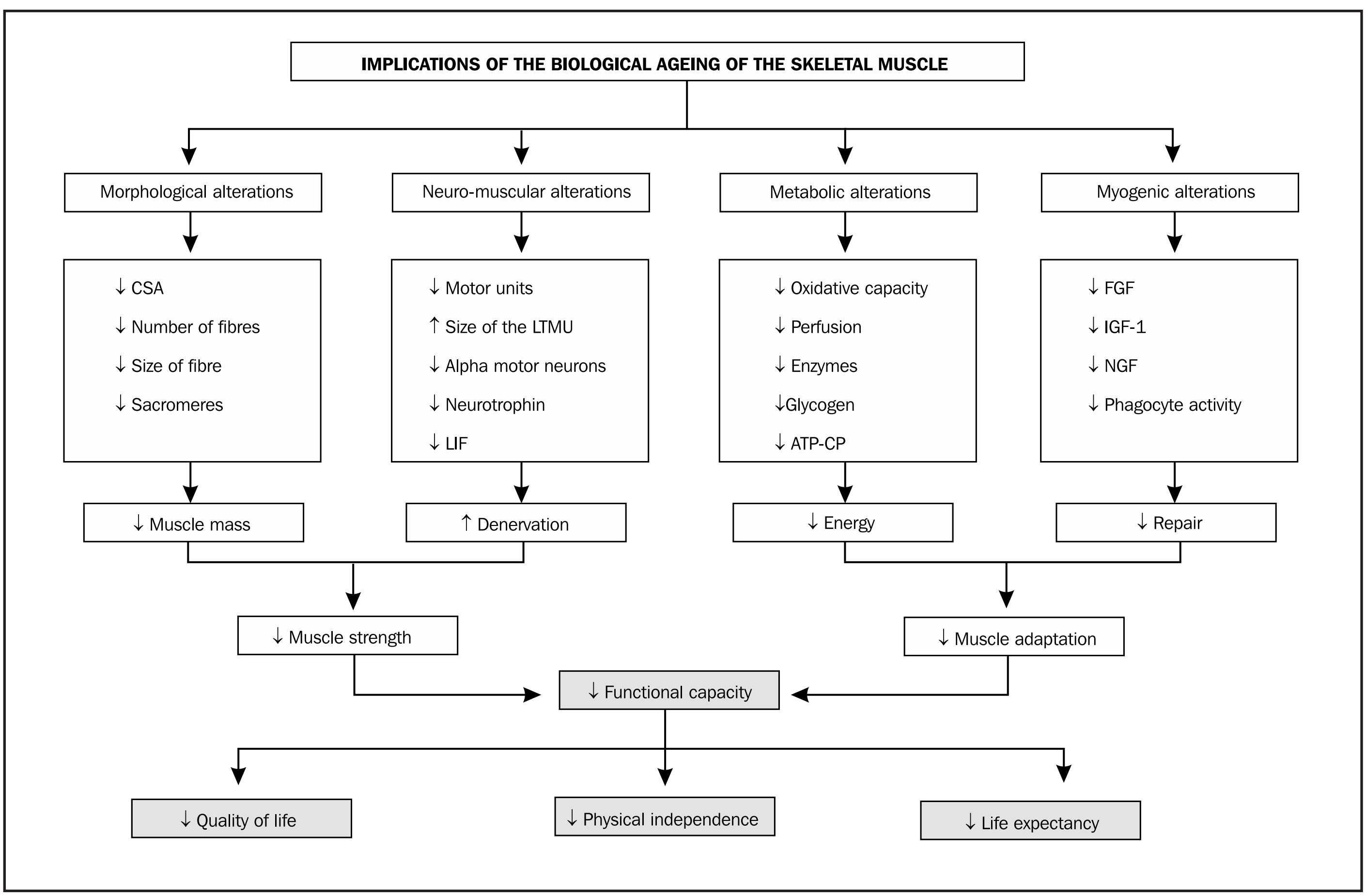
In parallel to these phenomena associated with muscle dysfunctions with ageing, there is also the reduction in phagocyte activity, a phenomenon that directly influences the decrease in efficiency during the repair of injured tissue or of tissue with functional alterations[29]. Considering this specific aspect, in particular, of the effect triggered by eccentric exercises, in which a rupture of the myofibrillar structure can occur, fundamentally of the Z bands of the sarcomeres, and as well as cell membrane damage, the muscle of older adults is less efficient in creating new muscle tissue, though it retains a good capacity for the proliferation and fusion of myoblasts[29]. Beyond the extrinsic factors that are involved in the process, the intrinsic factors of the skeletal muscle, such as the variations of the extracellular matrix, vascularisation, expression of growth factors and, in particular, of the receptors of satellite cells, may also favour the less efficient regeneration seen in older adults[13].

Figure 2 displays the changes in the structure and the function of the skeletal muscle that propitiate the loss of functionality and its subsequent implications.

Functional capacity in older adults

Ageing has been referred to as a process, or a collection of processes, inherent in all living beings, that is expressed through the loss of the capacity to adapt to the environment and the reduction in functionality[30, 31]. When discussing functional capacity we refer to a multidimensional quality, however, for the particular aspect of physical functionality, diverse authors consider it to be the physiological and/or physical capacity to perform everyday activities safely and autonomously, without reaching exhaustion[32]. When referring to functionality, we associate the theoretical concept that defines it as the capacity to

Figure 2. Implications of the biological ageing of the skeletal muscle.



CSA: cross-sectional area; LTMU: low-threshold motor units; LIF: leukaemia inhibitor factor; FGF: fibroblast growth factor; IGF-1: Type 1 insulin growth factor; NGF: nervous growth factor. The ↓ symbol represents the reduction or maintenance of the function, level or magnitude of the variable. The ↑ symbol represents the increase or progress of the function, level or magnitude of the variable.

Table 1. Adaptations provided by different strength training modalities.

Author	Year	Subjects	Modality	Training features	Adaptations
Sousa, *et al.*	2011	10 men (average age: 73±6 years).	CST	12 weeks of training, frequency of 3 weekly sessions with intensities of 50 to 80% of 1MR, 7 exercises of 2 to 3 S X 12 reps.	Increase in the maximum strength of the four extremities. Greater adaptation in upper extremities.
Rebolledo-Cobos, *et al.*	2014	25 women (average age: 63±5 years).	CST	12 weeks of training, frequency of 3 weekly sessions with intensities of 70% of 1MR, 8 exercises with volumes of 1 or 3 S X 15 reps	Increase in maximum strength, muscle quality and the anatomic cross-sectional area. No functional adaptations recorded.
Miszko, *et al.*	2003	28 men and women (average age: 72.5±6.3 years).	CST and RST	Two groups with different training sessions, 16 weeks in a row with 3 weekly sessions, 6 exercises, 3S X 10 reps.	Adaptations in the maximum strength in older people in the CST group. More significant functional adaptations in the RST group.
Fielding, *et al.*	2002	30 women (average age: 70.1±1 years).	CST and RST	16 weeks of training, two groups with different contraction speeds. 3 weekly sessions, only exercises for knee extensors 3S X 10 reps.	Increases in the peaks of maximum strength in older people in the CST group. Functional adaptations related to the performance of RST.
Henwood, *et al.*	2008	67 men and women (average age: 74.5±1 years).	CST and RST	24 weeks of training, two groups with different contraction speeds. 2 weekly sessions, 6 exercises at 75% 1MR, 3S X 8 reps.	Similar increases in the maximum strength in both groups. More significant functional adaptations related to the performance of RST.
de Vos, *et al.*	2005	112 men and women (average age: 69±6 years).	RST	From 8 to 12 weeks of training, with 3 groups of different intensities (20, 50, 80% 1 MR), 2 sessions a week, 3S X 8 reps.	The different training intensities revealed similar adaptations in general muscle performance, however at a greater intensity it was more likely to achieve simultaneous improvements in muscle strength, power and resistance.
Caserotti, *et al.*	2008	54 women (average age: 70±1 years)	APT	12 weeks of training, 2 sessions a week, intensities between 70 to 80% of 1|MR	Increase in explosive strength and in functional capacity. Greater adaptations in adults over 80 years.
Laroche, *et al.*	2008	24 women (73.2±1 years)	APT	8 weeks of isokinetic training, 3 sessions a week at 80% of the MVC.	Significant increases in maximum strength. No considerable changes in explosive strength, muscle reaction time and contractibility.
Correa, *et al.*	2012	58 women (average age: 67±5 years)	CST, RST and APT	12 weeks of training, 3 different modalities, 2 weekly sessions.	Increase in the maximum strength and muscle performance. More important functional adaptations in the group with APT.

MR: maximum repetition; S: sets; reps: repetitions; X: times; MVC: maximum voluntary contraction; CST: conventional strength training; RST: rapid strength training; APT: adapted plyometric training.

perform activities or tasks required in every day life and to withstand them independently[33, 34, 31].

Associating physical inactivity or sedentary behaviours as an aggrieving factor to the phenomena described in the previous sections, and knowing that with it comes the much quicker loss of functional capacity is hugely relevant[35]. A lack of muscle activation induces the progressive de-conditioning of skeletal muscle and cardio-metabolic aptitudes, favouring the fragility of bone structures and the loss of muscle reaction speed, as well as favouring the appearance of heart disease, which in turn predisposes falls which can lead to fractures and catastrophic heart episodes. Given the functional, emotional and quality of life implications triggered by orthopaedic or non-transmittable chronic alterations, older adult physical inactivity can be associated with a transcendental factor in the loss of physical independence[25].

Health science professionals in the field of older adult health should intervene directly in their patients' lifestyles to encourage them to perform regular planned physical activity, thus boosting the main non-pharmacological strategy that impacts the physical well-being of human beings, promoting functionality, mobility and autonomy. Considering the functional deficit of older adults as a public health problem favours the increase of life expectancy in the different communities, due to the fact that it can have a positive impact on the quality of life of this demographic and on the years lived without incapacitating disorders25. To perform different everyday, work or leisure activities, older adults need enough muscle strength, the essential mechanism developed through the constant performance of physical exercise, which is particularly effective if it is governed by a competent specialised professional[30, 25, 35].

Physiological and functional implications of the different modalities of ST on older adults

The different muscle strength training (ST) modalities display different adaptations to the muscle tissue, such as the development of maximum strength, power or reactive strength (Table 1). Included within the types of ST are the following: conventional strength training systems (CST), rapid strength training (RST) and reactive strength through adapted polymeric training systems (APT), which include the lengthening and shortening period[12]. The ability to produce strength quickly requires the intensive intervention of type IIX muscle fibres, a capacity that is often reduced in older adults. Rapid strength is hugely important, both for men and women of any age, given that it enables us to perform activities that require the intense yet short application of strength[17]. Prescribing the ST type that best influences the maintenance of functional capacity is key to physical autonomy and a good quality of life in older adults[16].

Conventional muscle strength training - CST

CST uses machines and free weights with controlled contraction speed (both concentric and eccentric), in which the main objective is to build maximum dynamic strength and muscle thickness, reducing the process of sarcopenia in older adults[16].

The adaptation of a systematic and frequent CST programme prevents the appearance of chronic illnesses and, therefore, also reduces the cost of medical procedures[29]. In CST, older adults display increases in muscle tone and strength[36]. Particularly when they perform exercises with intensity between 70% and 90% of a maximum repetition (1MR), significant increases have been shown in muscle strength, muscle quality and therefore significant increases in muscle mass[37]. These increases are more linked to the high intensity when performing the exercises, around 100% of 1MR, with a training volume of between 1 and 3 sets per exercise[37], and a weekly frequency of at least twice, using machines and free weights[20].

Rapid strength training - RST

The RST used in the majority of the studies is based on the adaptation of CST, with the main difference being the execution of a concentric phase at maximum contraction speed[31,38,39]. Performing rapid contractions is influenced by neuro-muscular factors associated with the trigger rate of the motor units, the number of innervated muscle fibres and tiredness[41].

Whilst CST is shown to be effective in the progress of maximum strength, in lesser measure in muscle power, the effect of RST on functional abilities is shown to have a greater impact due to the effect on the rapid production of muscle strength[10, 38-40]. In RST, aside from promoting effective adaptations similar to those in CST in maximum strength, there are better results in functional assessments, achieving an excellent impact on functional capacity, performing EDA and a leading a more autonomous lifestyle[23,41,42].

Older adults that require assistance in performing activities such as walking, climbing stairs or standing up from a chair have between 42% and 54% less muscle strength in the extensor muscles of the knees compared to older adults that do not need assistance[42]. The reduction of muscle strength is directly related to an increase in the risk of falls, which is why strength training modalities with rapid contractions significantly favour the functionality and physical independence of older adults due to the positive adaptations that they provide in contractibility and skeletal muscle power[20].

Adapted Plyometric Training (reactive training) - APT

The capacity to generate muscle strength is influenced by two essential factors: the morphology of the tissue (angle of pennation, physiological cross-sectional area, length and type of fibres) and the neuro-muscular activation properties[20]. In older adults, a decline in the capacity to activate motor units has been revealed, associated mainly with sarcopenia[3, 22]. Meanwhile, when older adults undergo a strength training programme, these damaging effects of ageing are considered to be counteracted, indicating that large parts of the mechanism related to the loss of muscle mass and strength are derived from physical inactivity[43, 44].

There is evidence indicating the benefits of performing APT in older adult populations, especially related to improvements in muscle activation and response. As such, the application of explosive strength training with lengthening-shortening cycles that increase the production of strength have been protected, considering that there is a more significant loss in the capacity to produce explosive strength than in isometric strength in older adults. However, it is less common to find studies that perform APT programmes on older adults compared to CST and RST[12].

In 2008 one of the findings of Caserotti *et al.* proved the increase in explosive strength in the extensor knee muscles in older adults, aged around 60 and 80 years, after 12 weeks of APT (twice a week with an intensity of 70% to 80% of 1MR)[45]. In turn, it was shown that low frequency training with adequate loads was able to optimise the explosive strength production capacity of older adults. Another result of the study revealed a greater increase in the muscle strength of subjects over 80 years of age in comparison to those aged between 60 and 70 years[45]. This study conclusion backs up the idea that despite having greater functional deficits related to dynapenia, older adults aged 80 years have higher muscle training capacity.

In terms of loss of strength between men and women, it appears that female subjects may display greater losses of explosive strength in the lower limbs, linking this situation to the lower amount of muscle mass, supporting the notion that sedentary older women have a greater risk of falling than men of the same age and characteristics[46,47].

The reaction and activation time of the ankle and knee muscles in older adult women is much less in comparison to younger women, considering that the muscle groups of these joints are essential for keeping balance following a change of posture, and are also used during walking[47], as shown in the findings of Laroche *et al*. in 2008 when they revealed that even though weeks of APT in older adult women[8] are not enough to obtain significant adaptations in muscle power or reaction time, it is enough time to reduce the antagonistic co-activation that modulates the increase in maximum strength and functional capacity, especially in the muscles of the lower limbs[46].

Continuing with the comparison between both sexes, in 2008 Caserotti *et al.* assessed the possible differences in the precise elements of muscle strength during the concentric and eccentric phases in executing a jump with counter movement in older adults. The authors were able to observe that men present a greater peak in muscle power in the concentric phase compared to women of the same age, as well as discovering that older adult women present greater efficiency at the end of the concentric phase in the jumps than men, which was shown by the reduction between the speed of the time the foot lost contact with the floor and the maximum concentric speed, resulting in a minimum height achieved by women[48]. In alignment with the authors, the lower speed achieved by the women allowed for the consideration that the reduction in muscle mechanic performance during the intense concentric contractions that promote rapid movements would be a responsible factor for the greater handling of time in reacquiring balance after losing it, which could also be expressed as a greater rate of falls suffered in relation with older adult males.

Therefore APT could be considered to be an important yet little explored strategy in increasing muscle power in older adults, especially in reducing the consequences of the mortal effects of ageing[12], such as the loss of strength, the reduction of the neuro-muscular activation/response, with this being the result of the sarcopenia and the de-innervation of rapid muscle fibres, which are the main cause of falls in older adults[49].

Discussion

Based on the findings obtained in the previous sections, it is important to elucidate which are the physiological effects provided by the different ST modalities in sustaining strength, promoting muscular hypertrophy and optimising functional capacity in older adults. For this reason, it was essential to discover the changes in the skeletal muscle characteristics (morphological, neuromuscular, metabolic and myogenic) endured in biological ageing.

The lack of strength, mainly of the dorsiflexor muscles, can reduce the capacity of older adults to overcome difficulties, thus increasing the frequency of trips. Aside from these events, less stiffness in the tendons, which affects the transmission of strength for the muscle, the reduction of calcium release for the sarcoplasmatic reticulum, and extrinsic factors such as depression, lack of sleep, arthritis and hypertension can increase the risk of falls in older adults[46]. It is an undeniable reality that older adults with physically inactive lifestyles tend to experience an accelerated morphological and physiological deterioration of the skeletal muscle, and parallel to this, the risk of falling and more serious injuries increases. Older adults with a history of an active life have a greater capacity to incorporate motor units in circumstances that require a rapid muscle response, such as a trip[47].

Adaptations of maximum strength and in the resistant strength of the skeletal muscle provided by some ST modalities are an important component in limiting the muscular deterioration endured in biological ageing. However, to have a positive impact on the functional capacity and the life quality and expectancy of people, the training systems should provide adaptations that do not just focus on strength, but that also achieve a more powerful rapid neuromuscular response, and with it, functional adaptations that promote the physical independence of the subject[50,24].

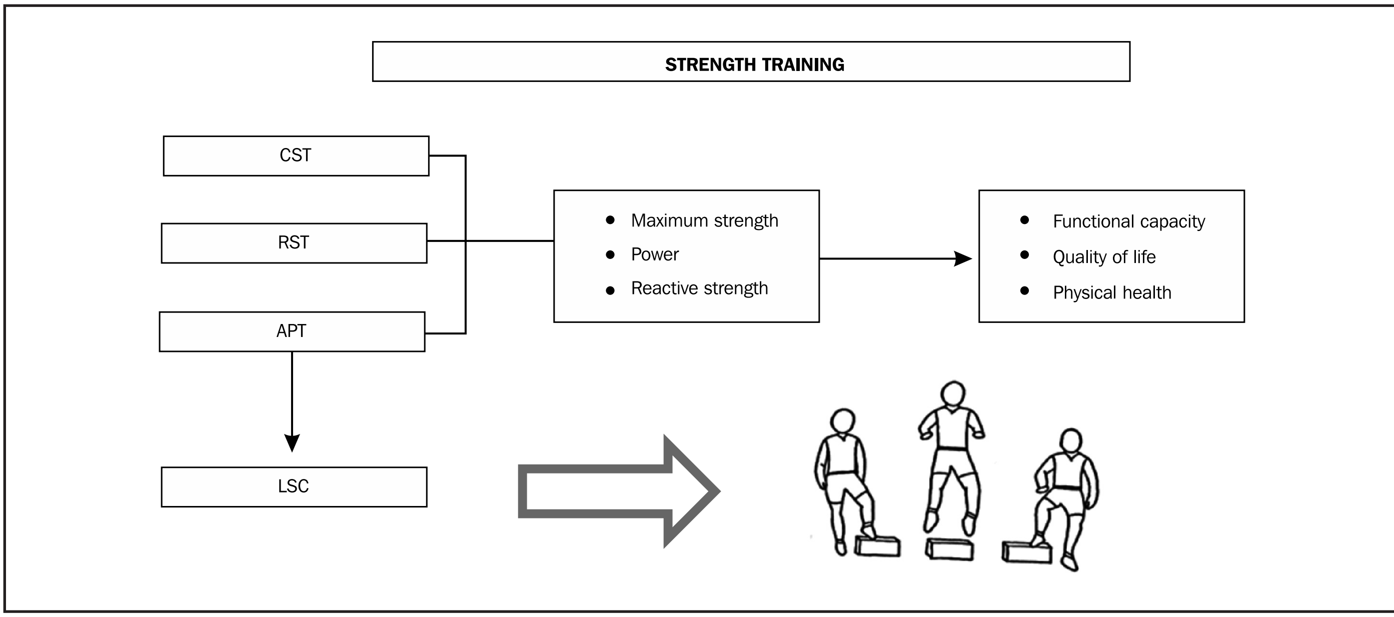
Despite the physiological responses that arise from the regular performance of CST and RST in older adults generally converging in the increase of the morphological and neuronal conditions of the muscle, the magnitudes of these adaptations depend greatly on two factors: the intrinsic characteristics of the subject that will be trained, and the specifications of the training system.

Biological age, sex, the presence of systemic pathologies, the dimension of the physical and cognitive deterioration, and the behavioural characteristics of the older adult play a large role in the changes that can be offered through the regular performance of physical exercise. Before being able to perform parallels for the applicability of any intervention mechanism based on a published study aimed at this demographic, it is necessary to verify the characteristics of the demographic that was studied and the subject that will be the object of the intervention, given that often co-morbidities held by older adults influence the obtaining of similar results and can bias the application of an already trialled intervention. Likewise, through the desire to compare the different training modalities against resistance in general, the specifications of the systematisation, periodisation, volume, intensity, muscle groups involved, contraction speed, recovery time, type of external resistance, among other factors framed within the structure of the training programme will be elements to take into consideration, as they will determine the subsequent metabolic, morphological and physiological response.

Deciding which ST modality to perform on a group or individual is still initially circumstantial to the physical and mental state of the older person, followed by sensitivity and tolerance to the effort provided, due to the high physical demands that some types of ST require. The authors recommend that the application of RST and APT should be preceded by general physical preparation, proven by Correa *et al.* (2012), whereby before implementing RST and APT in older adults, an initial 6-week period of preparation was performed with CST, with the aim of ensuring the adequate performance of the movements and limiting adverse events that may arise[12].

APT seems to be an effective strategy in developing capacities from muscle well-being and the increase of performance for functional tests[12]. Today it is necessary to expand evidence regarding the training systems that involve the skeletal muscle lengthening-shortening period, as their implementation has revealed positive results in the performance of activities that require the reactive strength of the lower limbs, essential components for the good execution and maintenance of functional capacity, motor health and consequent quality of life in older adults[12,47,49] (Figure 3).

Figure 3. Scheme of the three specific strength training types; CST: conventional strength training; RST: rapid strength training; APT: adapted polymeric training; and LSC: lengthening-shortening cycle. The three modalities prove to be efficient in improving the expressions of muscle strength and functional capacity, promoting health, physical independence and an optimum quality of life.



Conclusions

The deterioration of the systematic functions brought about by the ageing process leads to a series of alterations in the skeletal muscle function. Sarcopenia and the reduction in neuromuscular innervation bring about negative implications on the quality of life of the older adult, due to the reduction in functional capacity and physical independence. Physical inactivity and sedentary habits are catalysing factors in these phenomena.

Functional deficiencies lead to falls and fractures in older adults, therefore health science professionals that belong to this field of physical health in this demographic should encourage the use of strategies that limit the decay of the skeletal muscle system, such as ST. The scientific proof mentioned in the previous sections defends the performance of muscle strengthening programmes, given that they provide extensive benefits to the physical health and physical autonomy of the older adult, promoting well-being and quality of life.

Despite APT being shown to be the training method with the optimum functional results, it should be highlighted that its implementation requires screening by professionals in the field of prescribing exercise and physical conditioning, given its methodology and physical demands. However, due to the variety in the biological repercussions of ageing from person to person, performing the different ST strategies also revealed positive results in the varied signs of strength, promoting the reduction of motor deterioration and optimising the functional capacity of the older adult.

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