Chapter

Exercise-Based Interventions as a Management of Frailty Syndrome in Older Populations: Design, Strategy, and Planning

Guilherme Furtado, Adriana Caldo, Rafael Rodrigues, Ana Pedrosa, Rafael Neves, Rubens Letieri, Eef Hogervrost, Ana Maria Teixeira and José Pedro Ferreira

Abstract

Exercise-based interventions emerged as the best alternative for treating frailty syndrome (FS). Recognized as a complex phenotype, the FS is a multifaceted aging expression determined by biologic, environment, and behaviors factors. The biological theories of human development perceive aging process as an accumulation of harmful biochemical changes, whose occurrence attends the course of life. The progressive losses of functional reserves that occur in the body systems are a hallmark of this negative process. Despite the biological effects of physical and cognitive decline, more contemporary studies have identified that the environmental and behavior factors such as malnutrition and negative psychological adjustment across the life span also contribute to the early appearance of FS. Notwithstanding the latest findings that consistently demonstrate an overall positive benefit of long-term-based exercise in the decrease and/or reversal of the FS with a substantial impact on their correlated outcomes, the focus of this chapter is to present strategies for designing exercise programs for this type of population, taking into account their practical application in the field.

Keywords: physical exercise, elderly-frail, program design, physical frailty, cognitive frailty

1. Introduction

Frailty syndrome (FS) is a complex aging expression determined by ontogenetic and phylogenetic factors [1]. Chronic stress has been shown to have immunosuppressive effects, to accelerate immunosenescence, and to cause cumulative disorders in many physiological systems, resulting in a frail state [2]. This phenotype, as thus treated by the specialists, had a strong influence on the biological theories of aging [3], which explains this process as an accumulation of harmful biochemical changes, whose occurrence accompanies the course of aging [4, 5]. The progressive losses of energy and functional reserves that occur in the body are a hallmark of this negative process [6]. The vulnerability induced by these losses can lead to a

weakening state, if he or she is exposed to more severe aggressions [2]. From a frail state, this individual tends to cycle through institutionalization, intensive care and hospitalization, often followed by early death [7].

Environmental factors such as malnutrition and negative psychological adjustment across the life span also contribute to an early appearance of frailty [8]. Nowadays, the scientific literature is identifying several sub-types of manifestation and classification of FS [9]. Fried et al. have developed a construct whose bases are the negative energy balance, low levels of physical activity, low gait speed, and hand grip strength performance called the physical frailty (PF) status [10]. Recently, some studies have identified cognitive frailty (CF) as a novel age-related concept [11], a form of pathological brain-aging, and a precursor to neurodegenerative processes, that is characterized by concurrent FS and potentially reversible cognitive impairment [12].

Despite the different frailty subtypes, there is a consensus about the sedentary lifestyle and the poor muscular resistance as powerful conditions linked to FS [13]. Regular exercise has been shown to have positive effects on several factors correlated to FS (e.g., immunity, musculoskeletal, cognitive abilities, and improve psychosocial domains) [14]. For this reason, a large number of the intervention studies with exercise in older individuals chose to investigate variables of physical, biological, and behavioral factors, also called frailty correlates [15]. These factors share biopsychological commonalities that can be explained by studying the exercise modulation simultaneous effect on some of these frailty related outcomes [16].

Evidence shows that immunological and hormonal parameters are able to mediate the effects of exercise on mucosal immunity, psychological stress, cognitive improvement, and risk of dementia in the elders who are regularly active [17]. Regular exercise may provide an effective strategy in the treatment and prevention of associated disorders due to its anti-inflammatory benefits [18] and also, in the reduction of stress and anxiety levels and on the risk of psychological diseases and emotional decline in the elders [19]. Currently, there is conflicting evidence concerning the efficacy and practicality of different types of exercise interventions to decrease FS. For this reason, some of the review articles published in the last decade, aimed to present a robust evidence supporting the use of exercise as a coadjutant treatment to frailty [20–22].

In this sense, the main purpose of the current chapter was to summarize the recent robust evidence regarding the impact of regular exercise in the decrease of several factors associated to the frailty syndrome. Specifically, our focus was to present strategies to design exercise programs for this population, taking into account their practical application in the field.

2. Benefits of exercise: recent evidences

An approach to the treatment, attenuation or reversal of the frail condition in older adults has gained some notoriety in recent years [23]. Much has been discussed about the efficacy of different physical exercise programs as an adjunct therapy capable of promoting a positive impact not only on the independent components of frailty but on their correlated domains [24]. Evidence indicates that PF-related and regular exercise research may be a 'key factor' in the study of these associations because of the important role played by regular physical exercise in neuroendocrine, immune, and hormonal modulation of several biochemical markers [25, 26]. The aging process does not affect the immune and neuroendocrine system uniformly, and there is a high degree of individual variability that may be

associated with confounding factors. These factors have the potential to either confound data interpretation or contribute to an interaction between different types of exercise and immune function, or both [27–30].

However, recent findings showed that participation in regular exercise may induce a "cascade" of cellular reactions, capable of promoting angiogenesis, neurogenesis, and synaptogenesis, and further delay immunosenescence [28, 31]. In addition, there is proven positive action in improving the quality of life related to emotional states, psychological well-being, and gains in autonomy to perform daily tasks [16]. However, scientific evidence points to different types of exercise causing distinct and specific responses in the different physiological systems in this type of population [32].

Current findings have demonstrated, for example, the beneficial effects of aerobic exercise on the increase of brain-derived neurotrophic factor (BDNF) in elderly people who practice regular exercise [33]. BDNF is an important mediator of brain neuroplasticity, differentiation, neuronal growth, learning, and memory [31]. Its unregulated expression is related to diseases such as Parkinson's, Alzheimer's, and mild cognitive impairment (MCI), a clinical condition evidenced through cognitive testing [34]. All these conditions or diseases can be diagnosed through easy-to-apply cognitive tests that are also valid and capable of revealing a possible decline in executive function and memory, among others [35]. However, MCI is often characterized as a condition or initial stage of more advanced cognitive impairments [36].

Recent findings consistently associate MCI with PF [34]. Exercise can act as a positive mediator of cognitive functioning in individuals suffering from early dementia and mental disorders, and these responses being attributed to a possible role of BDNF [12]. Cognitive functions sensitive to early dementia and mental disorders shown to undergo positive changes in response to the effects of exercise were attributed to a possible neurogenic effect of BNDF [33]. A possible regulatory effect of maintaining a satisfactory cognitive performance was also observed in studies with other markers such as testosterone and cortisol [37].

The efficacy of exercise in the prevention/attenuation of clinical manifestations of depression, stress, and chronic anxiety, whose evidences are supported by biochemical mechanisms of a similar nature was also shown [38]. In addition, the evidence that associates PF and CF with possible declines in the neuroendocrine system is increasingly robust [39]. A systematic review carried out by Hogervost et al. found that different types of exercise may affect different levels of cognition and dementia risk; aerobic programs seem to be particularly effective while there is little evidence that flexibility exercises, such as yoga, can help cognition [40].

Exercise could be a significant factor in ameliorating the deleterious effects of chronic stress but some indicators such as the type, intensity, and frequency of exercise should be controlled and defined clearly in order to effectively reduce the stress burden. However, other factors relevant to the participation of the elderly in systematic physical activity programs such as schedule, adherence strategies, health promotion and education, levels of physical function, personal wellness, and vocational dimension, should be taken in consideration when planning new successful community programs.

3. Exercise program design

An initial approach to the development of exercise programs for elderly people should include detailed description of the exercise program, as well as its information about intensity, volume, and resting intervals, taking into account the specificities of the population. Notwithstanding the influence of the fitness industry in the

offer of many types of activities, the development of new concepts and materials, and the disclosure of trends [41], the purpose of this chapter is to provide general strategies for implementation exercise program for senior populations, taking into account the current scientific evidence [42]. In this sense, a systematic search using key-terms related to the topic was conducted, and results were discussed with other exercise experts in order to prepare the final version of the exercise program. The main purpose of the systematic review was to verify the most recent scientific evidence and guidelines recommended for the type of exercise, the duration and frequency, and other elements which are crucial for an exercise program design and implementation. **Table 1** shows the examples of recommendations for the implementation of exercise programs, taking into account the duration of the exercise program.

Several books and guidelines related to exercise programs for elderly people highlight several important aspects of the program for this type of population. However, specific aspects, such as phases of implementation, schedule of activities, interruption of activities, the social calendar of the participants, and specificities of region, country, and target population are poorly referenced. The primarily relevant aspect for the development of any exercise program concerns the schedule of the program across the year. It is in this "time window" that we will organize activities, taking into account the social calendar. In sport science and exercise, this is a method called training periodization. Although it is premature to conclude that periodized exercise is superior to non-periodize exercise to increase health outcomes, periodization appears to be a feasible means of prescribing exercise to inactive adults within an intervention setting [44].

The physical activity recommendations for older adults describe the amount and type of systematic exercise that promote health and prevents, reduces or reverses the risk of getting some diseases or clinical conditions. The main benefits

Steps	General recommendations	Expected time
1	Pre-implementation	
	(a) Determine target population, program objectives, and fitness assessment model; (b) establish partnerships (i.e., schools, universities, and municipalities); (c) delimit the financial costs; (d) identifying appropriate facilities (accessibility); (e) selected sport and exercise specialists; (f) describe the types of activities, following the fitness assessment outputs	3–6 months
2	Implementation	
	(a) Organize a schedule in the periodization model, define key dates for physical-functional fitness assessment of the participants (2 or 3 times); (b) organize activities taking into account commemorative dates; (d) provide assessment, control, and feedback to the participants regarding the improvements in physical and global health	6–9 months
3	Post-implementation	
	(a) After the last moment of fitness assessment, close the season by organizing a special class; (b) communicate results and news for the next season; (c) look for some behavior indicators that provide important outcomes of improve exercise program (i.e., adherence, attractiveness by the activities and the teacher's style, motivating)	1–3 months

Note: Adapted from [24, 43].

Table 1.
Recommendations for the implementation of exercise programs in older adults.

of implementing exercise programs, not only in elderly people, but also in all other populations, is the improvement of health-related physical fitness, in its all five components (i.e., muscular endurance and strength, body composition, cardiovascular endurance, and flexibility) and others integrated physical qualities (such as balance, coordination, and reaction time), that tends to deteriorate across the aging process. In one of your innumerous paper, the American College of Sports Medicine (ACSM) makes clear the type of training and its degree of evidence in relation to its effectiveness for some markers of global health [45].

In this sense, training for cardiorespiratory fitness, muscle strength and endurance training, flexibility, and multicomponent exercise programs are strongly recommended for the improvement of different health indicators in older adults. In the next topic, these aspects will be discussed in further detail focusing on the specificity of each type of exercise and the degree of evidence for the different health-related indicators.

3.1 Participants

Frailty is considered by many authors to be a subcategory of the aging process, taking into account the level of physical functions that allow them to perform activities of daily living. This participants cannot perform several tasks evolving strength (i.e., carrying shopping bags, carrying out small tasks like sweeping or cleaning the floor) as they are unable to stand for long periods [46]. In terms of physical condition, the main characteristics of this group are the low muscular strength and cardiovascular endurance and the poor levels of dynamic and static balance [8]. This population may have a debilitating disease or condition that physically challenges them in their daily life. However, the recently created concept of frailty – decreased resistance to biological stressors [47], has been reported to modulate the risk of several types of dementia and cognitive impairment (CI) [48]. Since physical and cognitive decline have a similar outcome, a physical exercise program must take into account other methodological specificities. In this sense, chair assisted-exercise appears to be a good integrated method to promote exercise for this population [49], considering that integrated methodologies seem to be the best option for this type of population.

3.2 Physical-functional fitness assessment

There are numerous isolated tests and test batteries that can be used to assess the physical and functional capacities of the elderly [50]. Based on the assumption that exercise programs need to regularly monitor using quick, valid, and reliable tests, some test batteries such as the Short Physical Performance Battery [51] and the Senior Fitness Test Battery [52] seem to be great options to assess this population as they evaluate different components of the physical-functional and health-related fitness with low cost materials and still have numerous studies that support its use.

Although the most functional fitness tests for old adults are quite simple to use, careful planning is required including adequate use of specific strategies to overcome some critical phases that may appear during application. Thus, it is important to consider the following steps before assessment: (a) technicians team training; (b) screening of participants; (c) informed consent/assumption of liability; (d) subject some program participants to a pre-test familiarization; (e) testing equipment/supplies; (f) data recording (scorecards); (g) testing order; (h) environmental conditions; (i) observation/monitoring of signs of overextension in the participants during the tests. Considering these steps when planning the assessment

is very important to assure the participant safety, testing efficacy, and to obtain a good accuracy of the measurements [52].

As a rule, it is suggested that exercise program participants should be evaluated twice, in a pre and a post exercise intervention moment, during the same season. In long-term programs (6 months and more), it is recommended to carry out an intermediate evaluation moment, since this can provide relevant information and evidence for the hypothetical changes caused by the exercise program and about the direction of those changes, that is, if they reveal a positive or a negative progress. Many studies in the literature indicate that exercise programs with a duration between 8 and 12 weeks, in average, tend to evidence positive changes in the various components of physical fitness, although it is known that the number of weekly sessions and the participant's initial state of physical fitness are factors that will influence these variables [53].

3.3 Type of activities

The following guidelines are based on land-based group class exercise programs, which seems to be the type of format that gathers more evidence regarding its effectiveness and taking into account its epidemiological impact [43]; relatively lower costs when compared to the other types of exercise and therapies, such as water-based exercise [54]; the effect of the group environment to motivate the participants, the psychosocial needs of the group in relation to building bonds of friendship preventing social isolation and encouraging people to engage in activities and maintain an active and healthy lifestyle [55].

However, our focus is on developing specific methodologies to be used with the population affected by frailty syndrome. **Table 2** presents a set of recommendations for old adults and describes the amount and type of systematic physical activity needed to promote an improvement of general health in frail individuals. These recommendations apply to all adults aged 65+ years and to adults aged 50–64 with significant clinical chronic conditions or functional limitations that affect movement ability, functional status, and/or levels of physical activity.

Type of activities	Dose
Aerobic activity or cardiovascular Exercises	Moderate-intensity aerobic physical activity for a minimum of 30 minutes on 5 days each week or vigorous-intensity aerobic activity for a minimum of 20 minutes on 3 days each week [43]
Muscle strength and resistance	Moderate intensity for maintaining or increasing muscular strength and endurance for a minimum of 2 days each week. It is recommended that 8–10 exercises (10–20 repetitions) be performed on two or more non-consecutive days per week using the major muscle groups [53]
Type-flexibility activities	Low to moderate isolated type flexibility exercises on at least 2 days each week for at least 10 minutes each day or integrated exercises 2–3 times per week [43]
Multicomponent activities	Long-term intervention (≥5 months) performed for a minimum three times per week, for 30–45 minutes per session [24]
Body and mind interventions (BMI)	After 12 weeks and frequency of 2–3 times weekly 45–60 minutes per session, BMI interventions (i.e., Yoga, Taiichi) improve cognition related to motor tasks and functioning [56].
Balance exercises protocol	Greater effects seen from long-term exercise programs (≥6 months) that challenged balance and involved more than 3 hours/week [57].

Table 2.
Exercise recommendation statement for old adults.

3.4 Exercise class format

Several formats can be effective for senior classes. The standard format includes 45–60 minutes comprising 5–10 minutes of warm-up, 30–35 minutes of fundamental part (core of the exercise session), and 5 minutes of cooldown. Classes for beginners will have a longer warm-up and cooldown phases, but the fundamental phase must be shorter. As participants adapt and adjust to their own level of effort, classes become more regular and the duration of the fundamental phase may increase progressively, becoming closer to the main specificities and characteristics usually found in many exercise prescription manuals for older participants [43] (**Table 3**).

In order to develop a progressive exercise program aiming to improve physical fitness, in elderly participants, each exercise will be planned and performed with a specific number of sets, repetitions per set, time rest intervals, and other variables relevant to the type of exercise program. In the case of the elderly frail population, it is recommended to use an integrative approach due to the current literature which has been shown that mixed or combined training methodologies can provide improvements to one or more physical health problems that accompany these individuals.

An example of a muscle-strength exercise session with elastic resistance bands created especially for old participants with frail condition is presented below (see **Figure 1**). The use of elastic bands (EB) is an alternative method to traditional muscle strength exercise devices which reduces the risk of injury, which is cheaper and easily accessible [58], and allows individuals to perform a range of ergonomic movements and easily adjusts the training intensity to the rate of perceived exertion [59]. According to the ACSM evidence-based statement position, the systematic

Chair muscle-strength exercise group class			**Total time: 50 minutes**		
				5 minutes	
Phase 1 Warming-up: Body mobilization and dynamic flexibility exercises	**Sets***	**Reps**	**Cadence**	**Rest**	**PSE**
	2	6	1:2	20”	1–3
Phase 2 Muscle-strengthening activity: Elastic-band exercises compound (bi-sets) protocol				**30 minutes**	
Sequence of exercise*					
1. Front squat (stand or chair)	1–3	10–15	2:3	30–45”	3–5
2. Leg press with chair	1–3	10–15	2:3	30–45”	3–5
3. The calf press with chair	1–3	10–15	2:3	30–45”	3–5
4. Chest press (stand or chair)	1–3	10–15	2:3	30–45”	3–5
5. Seated row	1–3	10–15	2:3	30–45”	3–5
6. Lateral raiser with chair (or stand)	1–3	10–15	2:3	30–45”	3–5
7. The triceps press	1–3	10–15	2:3	30–45”	3–5
8. The biceps curl	1–3	10–15	2:3	30–45”	3–5
Phase 3 Cool-down: Body mobilization and static flexibility exercises				**5 minutes**	
	1	10	2:1	10”	1–2

Table 3.
Overview of single session chair elastic-band muscle resistance exercises program.

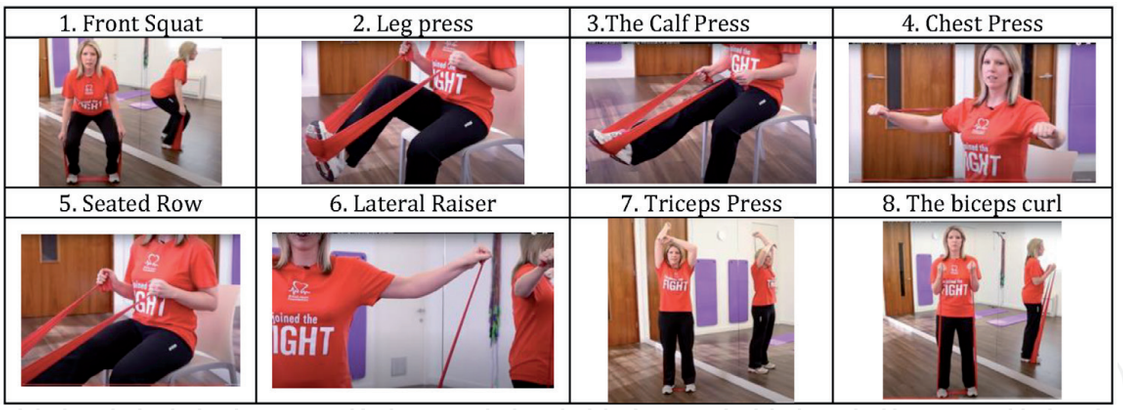

Figure 1.
Illustration of each elastic band exercise of the single session elastic-band muscle resistance exercises program, authorized by British Heart Foundation (adapted from: https://www.youtube.com/watch?v=mka5ZLE2RI0).

muscle-strength exercise has an evidence category A. The materials used in EB exercise programs are relatively inexpensive and provide a practical form of strength training that could be considered in exercise programs designed for older adults with mobility limitations [60].

3.5 Control of exercise effort

Some methods can be used by exercise participants to check their own response to intensity. A target heart rate range to be achieved and maintained during aerobic exercise can be calculated for monitoring the heart rate response to exercise. Karvonen's formula is an example of how to calculate an age-specific target heart rate zone [61]. The Borg Rating of Perceived Exertion Scale (PSE), which consists of a 10-point category/proportion scale, is another method used to monitor exercise intensity [62]. It is a subjective method that allows exercise participants to assess how well they are working during the exercise.

Stress assessment can be a primary way of measuring exercise intensity when a patient is not experiencing typical heart rate responses to exercise. On a scale of 0–10, patients assess how they are feeling while exercising, in terms of body fatigue and how they are feeling physically and mentally. In addition to the Borg Scale, other methods using scales are widely used, for example, the OMNI scale (OMNI-S) during resistance exercise [63].

In the case of the EB exercise program, intensity was measured through the OMINI-S that consists of an arbitrary scale ranging from 0 to 10 points, with identical intervals and with reference to the quality of effort: (PSE = 0) extremely easy; (PSE = 1–2) easy; (PSE = 3–4) somewhat easy; (PSE = 5–6) somewhat hard; (PSE = 7–8) hard; (PSE = 9–10) extremely hard [63].

In terms of periodization, considerate is suggested that these programs may last 9 months. During the first 12 weeks of periodization, participants will develop their stabilization and implement their endurance strength training program using an intensity somewhat easy [PSE = 3–4]. For this effect, the level one (yellow color) of EB was used. In the next 12 weeks, participants were encouraged to develop their resistance strength level, increasing their intensity load perception level to somewhat hard (PSE = 5–6).

They were also induced to change the elastic-band levels for 2 and 3 (red and green color). In the last 12 weeks, participants were stimulated for training their resistance and muscular strength level and increasing their intensity load (PSE = 7–8) [49]. In this way, we have a periodization divided into 3 periods (mesocycles), determined by controlling the intensity of the training over a season.

3.6 Music and materials

According to the current evidence, music plays a significant role in the success of an exercise class. Exercise with music increases participation in the class, when compared to the controls without music [64]. Exercise combined with music helps to determine and maintain the rhythm of the motor tasks and the dual-tasks involving upper and lower limbs and to improve balance [65]. Music can also match or transmit vibrations, rhythms, and vocalizations consistent with the different moments of the class. After moderate exercise (cooldown), listening to a favorite piece of music might decrease the influence of stress caused by fatigue thus increasing the level of "comfort" to perform the exercise [66]. Besides that, music plus exercise appears to maintain older participants' positive moods, motivate them to exercise, and help them to continue high involvement [67]. Over time music may encourage participants to realize a more challenge exercises.

Considering that the classic format of an exercise group class presents three parts (warming-up, fundamental part of class, and cooling down), specific songs should be selected to help us to create an adequate environment to those three moments. When choosing the type of music, professionals should take into account some cultural aspects of the group or try to identify the musical preference of the participants. According to experts, the ideal number of beats per minute (bpm) used in exercise programs for the elderly should vary between 100 and 140 bpm, and for muscle strength and endurance training between 120 and 140 bpm. For relaxation (or cooldown), music close to 100 bpm recommended [68]. However, pay attention for some specific aspects, such as: (a) choose distinct music without over powering vocals; (b) consider the appropriate volume of the music taking into account that some of the participants may have some level of hearing impairment.

3.7 Quality of fitness instructors

Fitness instructors play an important role in helping their participants to acquire and maintain a healthy lifestyle [69]. Exercise leaders must give safety and high priority as well as to be able to match exercise programming to physical fitness and functional abilities. Generally, these professionals have degrees in physical education and sports, with extra training in specific fitness activities for each type of population. For example, the laws in some European countries require that professionals, in addition to specific fitness courses, present additional cardiopulmonary and basic or intermediate first aid certification.

In some countries, researcher surveys show that instructors usually stay in continuous training education, combined with their work routine [70]. However, it is still unclear how they impart practical knowledge based on scientific evidence to their students and this needs to be improved. The senior exercise certifications offer extensive information on special conditions and clinical settings and circumstances relevant to conduct exercise programs for old people. It is recommended that the professional is constantly undergoing in training and updating, as knowledge about the benefits of exercise for health and well-being is evolving exponentially and participants can highly benefit from this [69].

4. Conclusions

The growth of the physically and cognitively elderly frail population leads to the creation of specific guidelines for the prescription of exercise programs aiming to target this audience. Nowadays, the knowledge base of research and practice is

growing; however, more information is needed to provide adequate exercise programming for this populations, and this is a challenging task. Some factors such as motivation, global health status, and other psychosocial aspects can influence the participant adherence. In this sense, the organization of the program and the quality of the professionals involved may be one of the determining factors for the involvement and regular participation of the elderly. Currently, exercise science seeks what is the best type of exercise to prevent, mitigate, and to a certain extent, reverse this condition, taking into account the close relationship between physical and cognitive decline.

Cognitive frailty represents a great challenge for public health. Recent findings support causal evidence of regular exercise effects in older frail individuals not only in motor skills, but in others important CS, such as visuospatial function, executive function, and memory. In this sense, maintaining an active, healthy lifestyle and including a regular exercise program in everyday life habits can have protective and lasting effects on physical and mental health. For this reason, to meet the specifics of this elderly sub-clinical population, professionals need specific education training and reviewing research in the area to be able to provide adequate answers to the needs of those looking for this specific type of service.

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Author details

Guilherme Furtado[1*], Adriana Caldo[1], Rafael Rodrigues[1], Ana Pedrosa[1], Rafael Neves[1], Rubens Letieri[2], Eef Hogervrost[3], Ana Maria Teixeira[1] and José Pedro Ferreira[1]

1 University of Coimbra and Research Unit of Physical Activity and Sport at Faculty of Sport Sciences and Physical Education (CIDAF, UID/PDT/04213/2019), Portugal

2 Multidisciplinary Research Nucleus in Physical Education (NIMEF) - Federal University of Tocantins – UFT, Brazil

3 National Center of Sport and Exercise Medicine – Applied Cognitive Research, Group at School of Sport, Exercise and Health Sciences, Loughborough University, United Kingdom

*Address all correspondence to: furts2001@yahoo.com.br

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