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Training Program for Presarcopenic Elderly Patients

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Abstract

Purpose: Our aim was to test a training program designed to decrease/reverse the deleterious effects of sarcopenia: a generalized and progressive loss of muscle mass and muscle strength and function. *Materials and methods*: An intervention group of 9 participants and a control group of 7 participants took part in the pilot study, aged 65+, and former patients of the Szent Rókus Hospital. We measured grip strength, functional capacity with the Timed Up and Go test, and the presence and severity of sarcopenia with the SARC-F questionnaire. A two-month training period followed, with biweekly workouts. After which we reassessed and used a paired samples T-Test in JASP 0.16.4.0.. A focus group interview was used to collect participants' thoughts and feelings regarding the training period. *Results:* The intervention group showed a positive, nonsignificant change in their SARC-F scores (p=0.080). Their functional capacity improved significantly (p=0.033). Their muscle strength also improved significantly (p=0.006). The control group's SARC-F scores decreased, (p=0.423), performed the TUG test slower (p=0.114) and their grip strength decreased (p=0.477). We received unanimously positive answers at the focus group interview. *Conclusion:* The exercise program improved the functional capacity and muscle strength of the participants; thus, it would be worthwhile for physiotherapists working with older people to familiarize themselves with principles used here and to utilize a similar program.

Introduction

Sarcopenia definition

Sarcopenia was first defined in 1980 as an age-related loss of muscle mass, mobility and self-care, and in 2010 the European Working Group on Sarcopenia (EWGSOP) added the loss of muscle function to the definition (Cruz-Jentoft & Sayer, 2019). In 2019, the EWGSOP updated the definition again, which was finally defined as follows: "sarcopenia is a progressive and generalized muscle disorder involving an accelerated deterioration of muscle volume and muscle quality, with an increased incidence of adverse events such as falls, stumbling and mortality" (Cruz-Jentoft et al., 2019). Although the focus of this paper is on skeletal muscle, sarcopenia affects not only skeletal muscle but also the heart and diaphragm, as it is a systemic disease (Pár et al., 2021).

In 2016, it was given a separate ICD code: M62. 84, classified as a muscle disease (Anker et al., 2016).

Sarcopenia should be distinguished from other similar conditions. These are cachexia, malnutrition and malaise, which may also contribute to lower muscle mass and muscle quality. According to the newer EWGSOP2 definition, which focuses on muscle function, reduced muscle mass but preserved muscle function may be associated with malnutrition, and reduced muscle mass also associated with reduced function may be associated with sarcopenia. Frailty is an age-related condition with increased vulnerability due to reduced performance (Chen et al., 2014). As it is a whole-body chronic inflammatory condition, such as sarcopenia, sarcopenia can be treated as a building block of frailty syndrome (Cruz-Jentoft & Sayer, 2019).

Basic training theory concepts

The essential building blocks of any effective resistance training program are specificity, progressive overload, and variation (Kraemer & Ratamess, 2004).

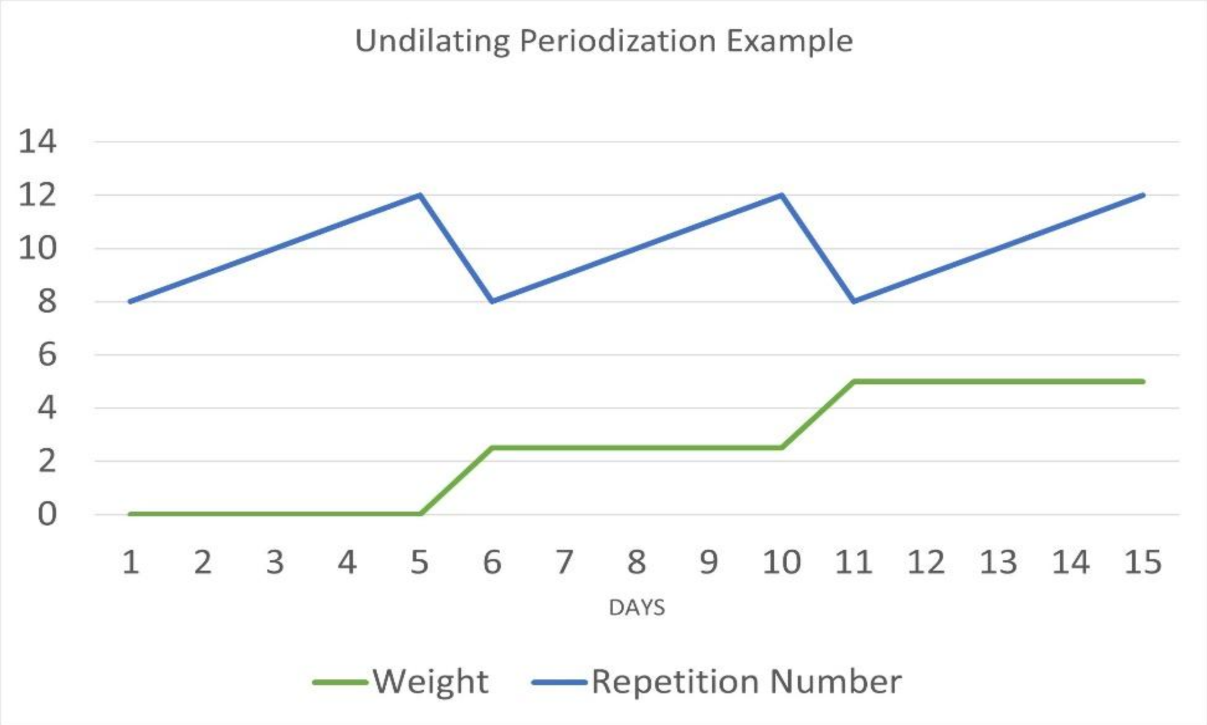
Specificity: training adaptations correspond to the stimuli that elicit them, so that the specific stimuli that are applied in a training program determine the adaptations that we can expect and obtain. At the same time, if non-specific stimuli are applied in training, the training may even be counterproductive, i.e. the qualities to be increased may either not be increased or, in worse cases, can even regress (Sale & MacDougall, 1981). These adaptations may be developments in muscle size, muscle strength, changes in energy systems (anaerobic-aerobic), improvements in range of motion (ROM) or changes in the speed of a movement's execution. While it is conceivable that there is some carry-over between adaptations, i.e. general fitness and performance can improve with almost any training modality, outstanding progression in specific domains can only be achieved with the right stimuli (American College of Sports Medicine [ACSM], 2009). However, specificity does not mean that only one domain can be developed, qualities considered to be in conflict with each other, such as maximal strength and endurance, cannot be developed simultaneously. In 1980, it was found that simultaneous strength and endurance development had a negative effect on strength development, reducing its effectiveness through the so-called "interference effect" (Hickson, 1980). Recent research, however, has shown that several domains can be developed simultaneously, as long as a well-designed and separated training program develops the two domains separately, in which case the principle of specificity is not compromised (Schumann et al., 2022).

Progressive overload: Progressive overload is a process whereby the body is subjected to progressively greater and greater loads. As the capacity of the individual increases, i.e. as tissues, organs and organ systems adapt to the stressors and stimuli they are exposed to (which in the case of this study, if we look only at the musculoskeletal system, is contraction against varying degrees of resistance, with a fixed number of sets and repetitions), an increasing amount of stimulus is required to reach the next capacity step. Put differently, if the body is only required to overcome the same amount of resistance continuously, then after a while that resistance becomes easy, but beyond a certain point no adaptation occurs. However, progressive overload can be enforced not only by increasing the resistance, i.e. the intensity, but also by increasing the number of repetitions for a given intensity, by determining the speed at which repetitions are performed, and by shortening the rest period between sets (ACSM, 2009).

Variation: variation in the context of exercise theory can be a variation of a particular exercise (bench press with a barbell vs. bench press with one-handed dumbbells) to achieve variations in ROM, relative and absolute intensity, or to focus on different muscles, and can also be a process of systematically changing the variables that build up the program (weight, number of repetitions, number of sets, rest time). As mentioned in the case of continuous overload, the body adapts to a certain type of stimulus, but it is not feasible to increase the weight alone each time, as this can quickly reach the individual's limit of development. By not changing the weight (or even decreasing it) but increasing the number of repetitions, a novel training stimulus can still be administered and the body can develop. Even without changing the weight or the number of repetitions, variation can be introduced by adding one more set to the previous number of sets. The proper use of variation is essential to trigger continuous adaptations during prolonged training periods. The second definition of variation in training design is periodization (ACSM, 2009; Stone et al., 2000).

Periodization: as mentioned in the section about variation; in order to maintain the adaptive response to training, changes can be made to the parameters that make up the training plan. Most often, the training volume (total work done, i.e. intensity x total number of repetitions (number of sets x number of repetitions); 100 kg 3x10 = 3000 kg), whether it is just the volume of a single training session, the volume of a micro- or macro-cycle, and the intensity are varied. There are several types of periodization, but since the study used "undulating periodization", we will only discuss it and the classical periodization. In classical periodization, also referred to in the literature as linear periodization, the initial high volume in the training program is accompanied by a lower intensity, and then as the volume decreases steadily, the intensity increases (Fleck, 1999). This type of periodization is very effective for the initial development of movement learning and for the initial development of core physical abilities that determine performance, such as endurance, strength-endurance and general strength (ACSM, 2009). This paper uses undulating periodization, i.e., fluctuating periodization. Undulating periodization, also referred to in the literature as non-linear periodization, uses more frequent changes in the composition of the load, which can occur on a daily, weekly or even bi-weekly basis. This means that the relationship between volume and intensity is constant for one day, one week or the desired duration, and changes occur thereafter (Evans, 2019). Taking the sit-to stand exercise as an example: in the first few sessions, only the patients' bodyweight was used as resistance, with the number of repetitions increasing every session. Then, after the first instance of external weight was introduced (in our case a 2,5 liter water bottle, weighing roughly 2,5 kilograms) the repetitions were decreased before a subsequent gradual increase. Again, as more external weight (a DIY sandbag weighing roughly 5 kilograms) was introduced, the repetitions were again lowered.

1. Figure Undilating Periodization Example



Research comparing exercise programs that use periodization and those that do not, has found that periodization is more effective in terms of the extent of adaptations induced. When comparing undulating periodization and classical periodization, undulating periodization has been shown to elicit better results, i.e. greater adaptation, than classical, linear periodization (Evans, 2019; Peterson et al., 2008; Stone et al., 2000). Moreover, given the limited resources at our disposal, a constant increase in weight (i.e. intensity) with a constant decrease in volume, would not have been possible. This adhering to undulating periodization is also a necessity.

Materials and methods

Participants

The initial survey was carried out at the St. Rokus Hospital, 2 Gyulai Pál Street, Budapest, and 16 people attended. A brief presentation was given on the nature of the pre-intervention surveys, followed by an introduction to the design, purpose and process of the research itself. A printed version of the patient information and consent form was then distributed. During recruitment and selection, any neurological condition requiring special treatment, i.e. recent brain event or disruption of temporal and spatial orientation, recent surgery, recent (within 6 weeks) hip/spinal prosthesis implantation, was considered as an exclusion criterion. Cardiovascular diseases such as hypertension, anaemia and diabetes were not considered as exclusion criteria. After reading the document and giving their informed consent, surveys were conducted and then participants were divided into intervention and control groups according to their time schedule and motivation. After the allocation, an intervention group of 9 participants and a control group of 7 participants were formed. Of the 9 intervention group, 2 did not complete the training program and 1 did not show up to be tested again, thus after the two-month training period, 6 participants were retested. Out of the control group of 7, 2 persons disappeared from the register, 1 person could not be contacted for an appointment, 1 person did not respond to enquiries, and so 3 persons could be re-surveyed.

Data Collection

SARC-F questionnaire: the SARC-F Questionnaire, developed to assess the risk of sarcopenia, includes questions such as "How much difficulty do you have lifting and carrying a package weighing about five kilograms?" or "How many times have you fallen in the past year?", with three possible answers: no difficulty - 0 points, moderate difficulty - 1 point and great difficulty/unable to - 2 points (Vereckei et al., 2019). The cut-off point was 4 points or more. The mean score on the SARC-F questionnaire of the 16 subjects who appeared at the initial survey was 2.3 points, which was the same as the mean score of the 6 intervention group members who participated in the initial and subsequent measurements.

Timed up and Go walk test: in the TUG walk test, the participant sits on a chair, stands up on cue, walks 3 meters, turns around and sits back down again. Performance is timed in seconds, starting at the signal and stopping when the participant's back is again against the backrest. The participant is instructed to complete the walk as fast as he/she feels safe (Podsiadlo & Richardson, 1991). According to the European sarcopenia working group recommendation, 20 seconds is the threshold above which sarcopenia can be assumed to occur (Cruz-Jentoft & Sayer, 2019). The mean time for the 16 participants who attended the initial survey was 8.20 seconds, and the mean time of the participants who attended the sessions and were retested was 7.73 seconds.

Grip force measurement: manual grip force, is an effective measure of total body strength and indirectly, muscle mass (Wind et al., 2010). Measurements were performed using a CAMRY EH101 model. With the dominant side, elbow extended, and arm hanging next to the body, participants held the equipment in a pronation-supination mid-position. Two squeezes were performed and the higher value was recorded. The European sarcopenia working group gave 16kg as a range value, with results below this value suggesting sarcopenia (Cruz-Jentoft

& Sayer, 2019). The mean value of the 16 participants who attended the initial survey was 23.69kg, and the mean value of the participants who attended the sessions and were retested was 23.37kg.

Based on these results, the participants were considered presarcopenic.

Description of Interventions

Structure of the training program

A common denominator of intensity in exercise science is #RM, where RM stands for resistance maximum, and the number corresponds to the maximum number of repetitions performed. 1RM means one repetition maximum that is the highest amount of weight that is able to be performed once. Thus, 2-4-5 RMs show weights that can be lifted 2-4-5 times.

With respect to intensity, in previously untrained individuals, even very low intensities of 45-50% 1RM have been shown to induce muscle strength gains, but as individuals become stronger, higher intensities are required. It can be concluded that for beginners, an intensity of 50-60% is an optimal starting point, suitable to master the technique of performing the exercises and to get used to the specific form of training (ACSM, 2009). In terms of the number of sets of a given exercise, it can be said that training program using two, three, four, five and more than six sets are effective. Exercise programs using three sets were found to be more effective than programs using one or two sets (Schoenfeld & Grgic, 2018). For postmenopausal women, exercise programs using multiple sets were found to be more effective than those using one set. The former showed a strength increase of 3.5%-5.5%, while the latter showed a strength decrease of -1%-2% (Kemmler et al., 2004). In terms of weekly frequency, 2 to 3 training sessions per week is effective and necessary in the beginning to trigger adaptations, but in the later stages, 1 to 2 sessions may be sufficient to maintain the level. Although 3 training sessions per week show better results than 2 sessions per week, if the total volume is the same, similar levels of adaptations can be observed (ACSM, 2009).

An important consideration when sequencing exercises is that exercises that involve more joints, such as squats, push-ups, deadlifts, are more effective in eliciting adaptations in muscle strength, but also more fatiguing, Therefore, it is advisable to start with the most difficult, complex and fatiguing exercises, because if they are added later in the training session, the person will not be able to perform as well as at the beginning (Simão et al., 2007; Spreuwenberg et al., 2006).

Thus following the guidelines of the NSCA and the above mentioned rationales the training program had the following characteristics: Twice a week, 30-40 minutes in duration, 1-2 multi joint exercises per major muscle group with the most fatiguing at the beginning, 2-3 sets per exercise, adhering to progressive overload and at the correct intensity (65-85% 1RM, that is one repetition maximum, the highest weight a person can lift for one rep) (Fragala et al., 2019).

RESULTS

Intervention group (N = 6)

1. Table Results (Intervention group)

Paired Samples T-Test

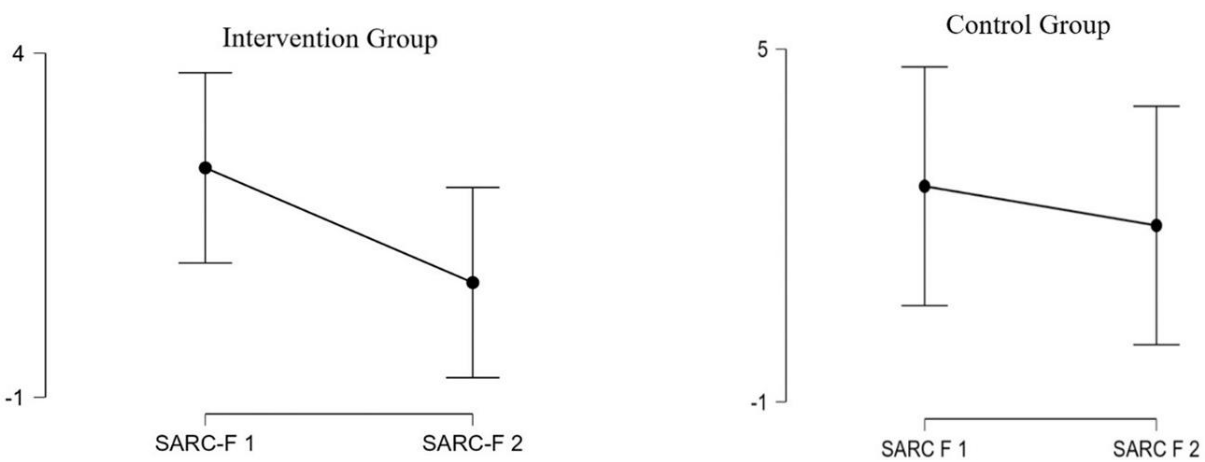
Measure 1		Measure 2	t	df	p	Cohen's d	SE Cohen's d
SARC-F 1	-	SARC-F 2	2.193	5	0.080	0.895	0.514
TUG 1	-	TUG 2	2.915	5	0.033	1.190	0.283
Grip 1	-	Grip 2	-4.563	5	0.006	-1.863	0.218

Descriptives

	N	Mean	SD	SE	Coefficient of variation
SARC-F 1	6	2.333	2.066	0.843	0.885
SARC-F 2	6	0.667	0.816	0.333	1.225
TUG 1	6	7.727	1.989	0.812	0.257
TUG 2	6	6.433	1.325	0.541	0.206
Grip 1	6	23.367	3.638	1.485	0.156
Grip 2	6	25.800	4.046	1.652	0.157

SARC-F questionnaire:

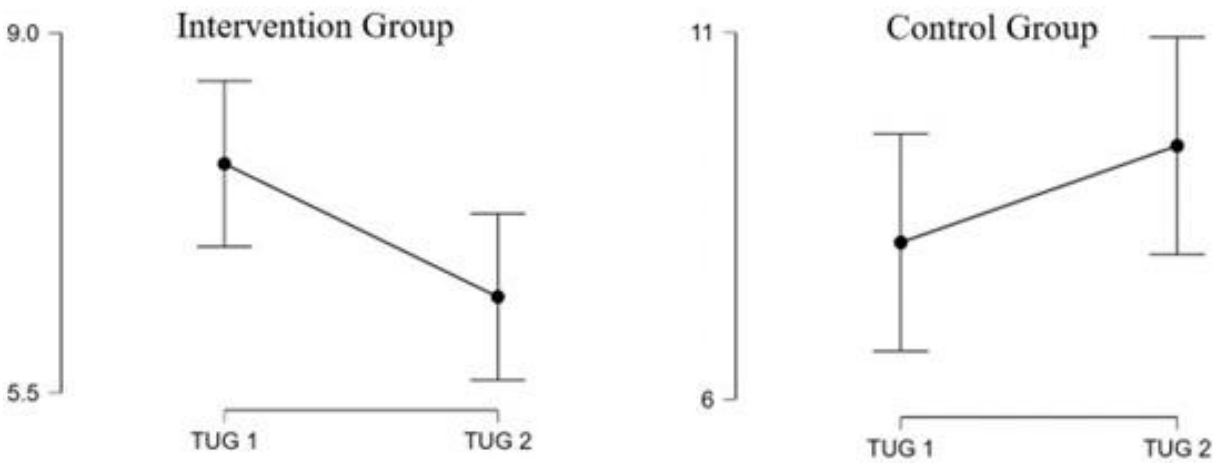
2. Figure Sarcopenia questionnaire data, showing points achieved in the questionnaire



The mean score on the SARC-F questionnaire for the 6 participants who took part in the intervention and were measured back was 2.333 (SD = 2.066) at baseline and 0.667 (SD = 0.816) at follow-up p = 0. 080.This p value does not show significance, but it does show a trend, and it is likely that the result would be significant with a higher number of participants.

Timed up and go test:

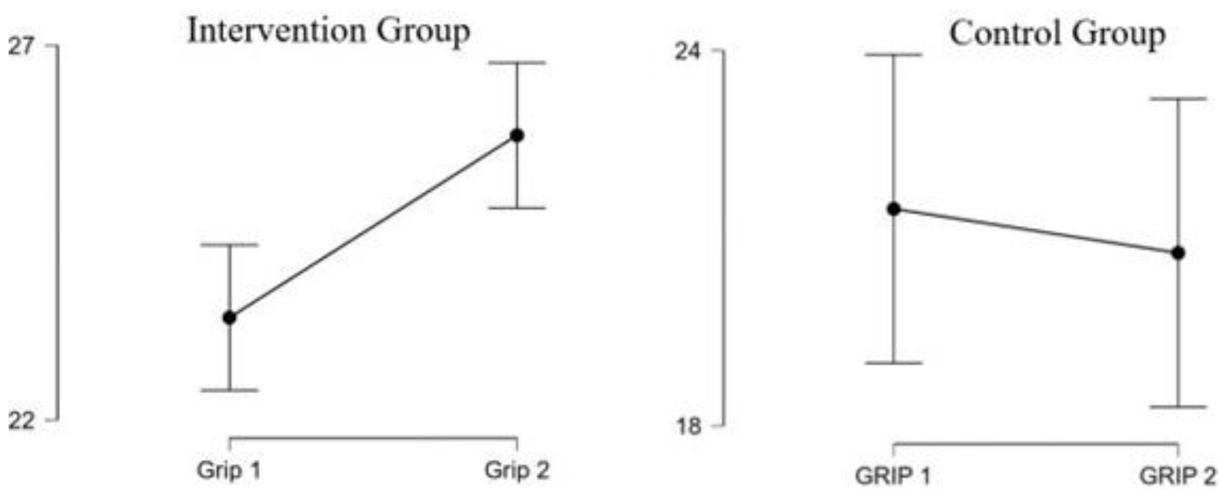
3. Figure Timed Up and Go test data, in seconds



The timed up and go test was completed in an average of 7.727 seconds (SD = 1.989) by the 6 intervention and 6.433 seconds (SD = 1.325) by the 6 intervention and retest participants, respectively, at baseline and retest, p = 0.033, indicating significance.

Grip strength:

4. Figure Grip strength data, in kilograms



On the manual clamp force measurement, the 6 intervention and back-measured participants averaged 23,367 (SD = 3,638) kilograms at baseline and 25,800 (SD = 4,046) kilograms at back-measurement, p = 0.006 indicating high significance.

Control group (N = 3):

2. Table Result (Control group)

Paired Samples T-Test

Measure 1		Measure 2	t	df	p	Cohen's d	SE Cohen's d
SARC F 1	-	SARC F 2	1.000	2	0.423	0.577	0.000
TUG 1	-	TUG 2	-2.708	2	0.114	-1.563	0.512
GRIP 1	-	GRIP 2	0.869	2	0.477	0.502	0.092

Descriptives

	N	Mean	SD	SE	Coefficient of variation
SARC F 1	3	2.667	0.577	0.333	0.217
SARC F 2	3	2.000	1.732	1.000	0.866
TUG 1	3	8.137	1.096	0.633	0.135
TUG 2	3	9.453	0.335	0.193	0.035
GRIP 1	3	21.467	1.901	1.097	0.089
GRIP 2	3	20.763	3.253	1.878	0.157

SARC-F questionnaire:

The mean score on the SARC-F questionnaire for the 3 control participants was 2.667 (SD = 0.577) at baseline and 2.000 (SD = 1.732) at follow-up p = 0.423.

Timed up and go test:

The timed up and go test was completed by the 3 control participants in an average of 8.137 seconds (SD = 1.096) on the initial assessment and 9.453 (SD = 0.335) seconds on the retest, p = 0.114.

Grip strength:

On the manual grip strength measurement, the 3 control participants averaged 21.467 (SD = 1.901) kilograms at baseline, compared to 20.763 (SD = 3.253 kilograms, p = 0.477) at remeasurement.

Discussion and conclusions

The results suggest that resistance training is an effective antidote to sarcopenia and should be included in institutions' toolbox. Since the control group either stagnated or showed worse results in the follow-up retest, it can be assumed that the training programme triggered positive adaptations. The increased muscle strength (and potential subsequent muscle mass gain) compensates for the muscle loss during sarcopenia and the imbalance in muscle protein synthesis and catabolism during anabolic resistance. The undesirable consequences of sarcopenia, such as reduced self-sufficiency and restricted living space, can also be overcome as the functional abilities of the participants in the training programme improved, as shown by the improvement in the timed up and go walking test. As there were no injuries during the 8-week training period, we can state that it is a safe way to improve strength in the geriatric population. It can be safely used in any environment.

It must be noted that very little, if any muscle tissue adaptations occurred during the two-month period, as these changes require more time. However, since the rate of muscle adaptation is similar to that of neurological changes (i.e. increases in strength performance); and those did occur, an assumption can be made that if the program would have continued, detectable muscle mass adaptations would have occurred.

Resistance training is an effective way to increase muscle strength and muscle mass, the two physical characteristics that are most impaired in the elderly with scrapie. Our aim in this research was to put together an effective training programme that requires few tools, is consistent with exercise theory principles and is effective in protecting against sarcopenia.

During the training programme, a group of 6 women aged 65 and over trained twice a week for 30-40 minutes for 8 weeks. Before and after the training period, their muscular strength was assessed using a manual grip strength test, their functional status using the timed up and go walking test, and the extent of any sarcopenia using the SARC-F questionnaire. The same tests were also performed on a control group. A pooled samples T-test was performed on the data and analysed using JASP 0.16.4.0. A significant difference was $p<0.05$.

In conclusion, the 8-week training period was effective in increasing participants' muscle strength, muscle mass and functional capacity: they increased their grip strength, scored better on the SARC-F test and completed the walking test in less time.

Ethical approval: This study was conducted in accordance with the 2008 revision of the 1975 Declaration of Helsinki.

Authors' Contribution: MR performed the literature search and analysis, compiled the testing methods, wrote the training program and supervised every training session, carried out the statistical analysis conducted the initial and follow-up tests with the help of ML and LP. GD provided consultation throughout the study period.

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