CHAPTER 9

Resistance Exercise to Prevent and Manage Sarcopenia and Dynapenia

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ABSTRACT

For well over 20 centuries, the muscle wasting (sarcopenia) and weakness (dynapenia) that occurs with old age has been a predominant concern for mankind. Exercise has long been suggested as a treatment to combat sarcopenia and dynapenia, as it exerts effects on both the nervous and muscular systems that are critical to positive physiological and functional adaptations (e.g., enhanced muscle strength). For more than two decades, scientists have recognized the profound role that progressive resistance exercise training (RET) can have on increasing muscle strength, muscle size, and functional capacity in older adults. In this review article, we discuss how RET can be used in the management and prevention of sarcopenia and dynapenia. We first provide an overview of the evidence for this notion and highlight certain critical factors—namely, exercise intensity, volume, and progression—that are key to optimizing the resistance exercise prescription. We then highlight how many, if not most, of the commonly prescribed exercise programs for seniors are not the "best practices" and subsequently present easy-to-read guidelines for a well-rounded RET program designed for the management and prevention of sarcopenia and dynapenia, including example training programs for the beginner through programs for the advanced senior resistance exerciser. These guidelines have been written for the academician as well as the student and health-care provider across a variety of disciplines, including those in the long-term care industry, such as wellness instructors or activity directors.

http://dx.doi.org/10.1891/0198-8794.36.205

INTRODUCTION

For well over 20 centuries, the muscle wasting and weakness that occurs with old age has been a predominant concern of mankind. As eloquently reviewed by Narici and Maffulli (Narici & Maffulli, 2010), the Classical Greeks (4th and 5th centuries BC) detested the degrading effects of aging on their bodies and considered it a chronic, incurable, and progressive disease. However, by the 1st century BC and the 1st century AD, the perspective on physical frailty and aging started to change as Cicero and others began to view aging not as an irreversible illness but rather a modifiable condition. In fact, in his “Essay on Old Age” in 44 BC, Cicero argues that “it is our duty . . . to resist old age, to compensate for its defects, to fight against it as we would fight a disease; to adopt a regimen of health; to practice moderate exercise; and to take just enough food and drink to restore our strength.” While Cicero’s suggestion to use exercise to combat muscle wasting and weakness was logical, it did not truly gain steam in the scientific and medical communities until the latter part of the 20th century. In particular, a series of landmark studies published in the early 1990s by Fiatarone and colleagues in the *Journal of the American Medical Association* (Fiatarone et al., 1990) and the *New England Journal of Medicine* (Fiatarone et al., 1994) highlighted the profound role that progressive resistance exercise training[1] (RET) can have on increasing muscle strength, muscle size, and functional capacity in older adults. For instance, the first of these studies demonstrated that institutionalized nonagenarians (i.e., individuals 90–99 years old) were able to increase their muscle strength, on average, an astounding 174%, their mid-thigh muscle area 9.0%, and their gait speed 48% with 8 weeks of high-intensity progressive RET (Fiatarone et al., 1990). By the start of the 21st century, we knew that muscle fiber types of older adults were able to hypertrophy (~30% increase in size with 16 weeks of high-intensity RET), could transition the fiber type (from type IIX fibers to IIA), and had the capacity to incorporate new nuclei into the fibers (Hikida et al., 2000). These adaptations are comparable to what is observed in younger individuals, suggesting that the muscle of older adults is not limited in its ability to adapt. Some two decades later, there is now evidence indicating that high-intensity RET, when coupled with other targeted multidisciplinary interventions, results in lower mortality, nursing home admissions, and disability compared with usual care after hip fracture (Singh et al., 2012).

With the demographic profile of the United States, and the world for that matter, changing (e.g., more than 14% of the entire U.S population is now greater than 65 years [United States Census Bureau, 2015]), there is a continued and growing interest in developing effective interventional strategies to combat muscle wasting and weakness associated with aging. To date, scientific evidence suggests that high-intensity, progressive RET (also commonly referred to as "strength training") is one of, if not the most, effective interventional strategies to enhance muscle size and strength in the elderly (Bird, Hill, Ball, & Williams, 2009; Chale et al., 2013; Charette et al., 1991; Fiatarone et al., 1990, 1994; Hikida et al., 2000; Kalapotharakos, Diamantopoulos, & Tokmakidis, 2010; Liu & Latham, 2009; Manini et al., 2007; Sylliaas, Brovold, Wyller, & Bergland, 2011; Van Roie, Delecluse, Coudyzer, Boonen, & Bautmans, 2013). Accordingly, in this chapter, we briefly review the current literature regarding the use of RET to prevent and manage sarcopenia and dynapenia, and provide pragmatic advice for patients and practitioners on the resistance exercise prescription for older adults. First, however, we discuss sarcopenia and dynapenia with special attention to their operational definitions.

Sarcopenia is a term, originally proposed by Rosenberg in 1989 (Rosenberg, 1989), specifically referring to the loss of muscle mass associated with aging. However, the meaning of this term has often been extended to the age-related loss of muscle strength and/or physical function. Although sarcopenia is certainly a contributor to muscle weakness, it has been argued that these two terms should not be used interchangeably since this would imply a direct proportionality between the two (Clark & Manini, 2008; Manini & Clark, 2011; Manini, Russ, & Clark, 2012; Narici & Maffulli, 2010; Visser & Schaap, 2011), which is not the case as a variety of other neural and muscular factors contribute to force output that are independent of muscle mass (for review, see Clark & Manini, 2008; Duchateau & Enoka, 2002; Manini & Clark, 2011; Manini et al., 2012; Narici & Maffulli, 2010). Accordingly, the term *dynapenia* was proposed by Clark and Manini in 2008 to specifically refer to the loss of muscle strength and power associated with aging (Clark & Manini, 2008).

While there are semantic debates in the literature, there is progress toward developing criteria/criterion for the diagnosis of clinically significant sarcopenia and/or dynapenia in recent years. For example, the European Working Group on Sarcopenia in Older People incorporates aspects of (a) physical function (i.e., gait speed), (b) muscle strength, and (c) muscle mass into a singular diagnosis of sarcopenia (Cruz-Jentoft et al., 2010). Other criteria, namely, those by the Foundation for the National Institutes of Health's Sarcopenia Working Group, attempted to define low muscle mass and muscle weakness independently using a data-driven approach in a pooled sample of 26,635 older adults (Studenski et al., 2014). While there are significant efforts being put forth by both researchers and practitioners in the development of diagnostic criteria, it is important to note there are no established agreed-upon definition for these common conditions at this time.

RET AND THE MANAGEMENT AND PREVENTION OF MUSCLE WASTING AND WEAKNESS

While sarcopenia and dynapenia are realized to be major clinical problems for older adults, until recently, there has been little widespread support for ways to combat these debilitating conditions. However, research on the effects of exercise and nutrition on sarcopenia and dynapenia has rapidly expanded in the past one to two decades (Sayer et al., 2013). Today, there is still limited evidence suggesting that pharmacologic interventions effectively ameliorate sarcopenia and/or dynapenia. However, there is strong and growing evidence that progressive RET can combat both sarcopenia *and* dynapenia (Burton & Sumukadas, 2010), as RET has a profound effect on virtually all of the physiological mechanisms in the nervous system and the muscular system known to influence strength (Duchateau & Enoka, 2002; Russ, Gregg-Cornell, Conaway, & Clark, 2012). For instance, maximal motor unit discharge rates, a key "neural factor" involved in muscle strength, increased 49% in older adults following only 6 weeks of high-intensity progressive RET (Kamen & Knight, 2004). Non-mass-dependent muscular factors, such as muscle fiber fascicle length and tendon stiffness, have also been observed to increase (10% and 64%, respectively) following RET in older adults (Reeves, Maganaris, & Narici, 2003). Additionally, RET is also a powerful stimulus for inducing muscle hypertrophy as illustrated by 24 weeks of RET, when coupled with modest protein supplementation, increasing thigh muscle cross-sectional area 4.6% in mobility-limited older adults (Chale et al., 2013). Given that there exists widespread evidence that inactivity, which is prevalent in the elderly (Troiano et al., 2008), leads to loss of muscle mass and strength (Clark, 2009), findings of this nature would (or should) lead all scientists and clinicians to support the use of RET for treating, slowing, and/or preventing sarcopenia and dynapenia.

Indeed, the extant literature supports this notion. For instance, a 2009 Cochrane review of 121 trials including over 6,700 participants concluded that "progressive resistance training is an effective intervention for improving physical functioning in older people, including improving strength and the performance of some simple and complex activities" (Liu & Latham, 2009). Most of the trials reviewed involved high-intensity training two to three times per week. Benefits included large positive effects on both muscle mass (hypertrophy) and strength (Liu & Latham, 2009). A functional assessment of gait speed showed a modest improvement, and a strong effect was observed on the ability to rise from a chair (Liu & Latham, 2009).

It is well recognized that the effectiveness of RET for strength and muscle mass improvement is variable across studies, and recent meta-analyses by Peterson and colleagues attempted to identify critical aspects of RET programs, which promote strength adaptation (e.g., the frequency of exercise training, the duration of exercise training, the intensity of exercise training, and the volume of exercise training; Peterson, Rhea, Sen, & Gordon, 2010; Peterson, Sen, & Gordon, 2011). These studies revealed two critical aspects for positive adaptations associated with progressive RET. First, higher intensity RET is associated with greater improvements in muscle strength. Specifically, with each incremental increase in exercise intensity from low intensity (<60% of 1 repetition maximum or 1RM), low/moderate intensity (60%–69% of 1RM), and moderate/high intensity (70%–79% of 1RM) to high intensity (≥80% of 1RM), the average percent change in strength was 5.3%, as shown in Figure 9.1A (Peterson et al., 2010). Second, higher RET volume, defined as the total number of exercise sets performed per session, is associated with greater improvements in lean body mass (LBM) after controlling for a variety of confounders (e.g., age, study duration, gender, training intensity and frequency, etc.), as shown in Figure 9.1B (Peterson et al., 2011). This finding suggests that for every additional 10 sets of exercise performed per session, one can expect, on average, a 0.5 kg increase in LBM (Peterson et al., 2011). It should be noted that this study reported that older individuals experienced a lesser increase in LBM with RET (Peterson et al., 2011). Some scientists have suggested that there are "nonresponders" to progressive RET (Bamman, Petrella, Kim, Mayhew, & Cross, 2007); however, a recent retrospective analysis revealed that while there is a large heterogeneity in the adaptive response to prolonged RET as it relates to changes in strength and mass, the level of responsiveness was strongly affected by the duration of the exercise intervention, with more positive responses following more prolonged exercise training (Churchward-Venne et al., 2015). Accordingly, these findings suggest that there are no true "nonresponders" to the benefits of RET among the elderly and that it should be promoted without restriction to prevent and manage sarcopenia and dynapenia. In Figure 9.2, we present conceptual interactions between physical activity, sarcopenia, dynapenia, fatigability, exercise tolerance, and physical function (Figure 9.2A) and demonstrate how progressive RET can modulate these various phenotypic factors (Figure 9.2B).

THE COMMON PRACTICES ARE NOT THE BEST PRACTICES

Unfortunately, many older people are unable or unwilling to embark on strenuous exercise training programs, and, despite a call from the American Academy of Family Physicians (Physicians, 2015), many seniors are often prescribed "low-dose" resistance exercise programs that are physiologically inadequate to increase gains in muscle mass and strength. In 2004, the National Council on Aging (NCOA) Center for Healthy Aging released a guide entitled *Best Practices*

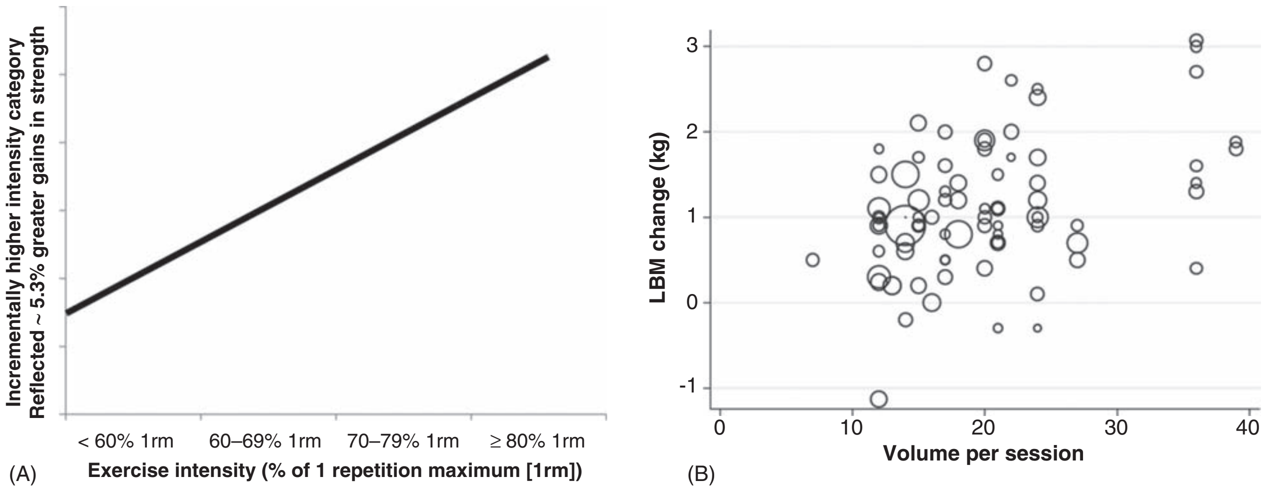

FIGURE 9.1 Higher intensity resistance exercise training is associated with greater improvements in muscle strength (A), and higher volume resistance exercise training is associated with greater improvements in lean body mass (LBM) (B). (A) Peterson et al. (2010) reported in a meta-analysis that with each incremental increase in exercise intensity from low-intensity (<60% of 1RM), low-/moderate-intensity (60%–69% of 1RM), and moderate-/high-intensity (70%–79% of 1RM) to high-intensity (≥80% of 1RM) training, the average percent change in strength was 5.3%. Created from data presented in Peterson et al. (2010). (B) LBM change by training volume (defined as sets per session) when weighted by the number of subjects in a given study using a meta-analytical approach. Reprinted with permission from Peterson et al. (2011).

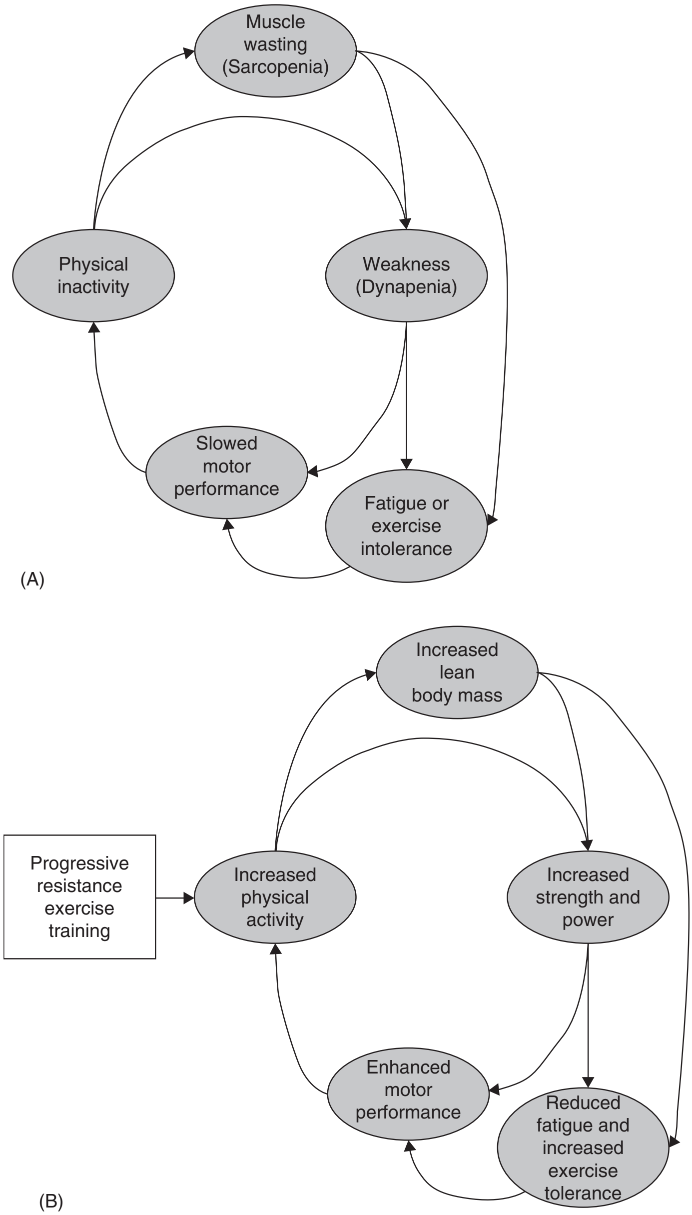

FIGURE 9.2 Conceptual interactions between physical activity, sarcopenia, dynapenia, fatigability, exercise tolerance, and physical function (A) and how progressive resistance exercise training can modulate these various phenotypic factors (B). *Note:* Other influences, such as nutritional, cognitive, and psychological factors, are not shown for clarity. Adapted with permission from Liu and Fielding (2011).

in Physical Activity in order to disseminate information to the public regarding the best practice and evidence-based models that were being employed at a community level (local public or nonprofit organizations) to facilitate older adults in achieving and maintaining functional independence and vitality (NCOA, 2004). A team of experts developed best practice criteria based on expert opinion and findings from the literature and identified 10 community-based programs as national best practice programs. In 2009, Hughes et al. assessed the impact of these 10 best practice physical activity programs for older adults in terms of health-related outcomes (Hughes, Seymour, Campbell, Whitelaw, & Bazzarre, 2009). Not surprisingly, these community-based physical activity programs, which utilized multiple-component physical activity interventions, measurably improved aspects of physical function that are risk factors for disability among older adults. Unfortunately, our anecdotal observation is that there is a large degree of variability in the implementation of physical activity programs in the community-based setting. Common barriers to implementation and participation in community-based exercise programs are program costs, lack of transportation/accessibility, lack of necessary time commitment, unsupportive physical environments, psychological barriers with regard to negative connotations of exercising in the older adults, as well as lack of expertise (Boyette et al., 2002; Mathews et al., 2010; Schutzer et al., 2004). In 2009, Cress et al. identified the key components of best practice physical activity programs for older adult populations as being (a) muscular strength and endurance, (b) balance, (c) cardiovascular endurance, and (d) flexibility (Cress et al., 2005). While many of the existing best practice community programs incorporate these components into their physical activity interventions, very few have adopted the American College of Sports Medicine (ACSM) guidelines for progressive high-intensity RET to promote muscle hypertrophy, strength, and power (ACSM, 2009). An example of one such program is the Go4Life program by the National Institute on Aging (2015). While this program encourages older adults to create personal physical activity programs incorporating all four of these key components, the examples provided for muscular strength training/resistance exercises on the Go4Life website are exercises of very low to moderate intensity for most seniors and are difficult to progress as they utilize wrist weights, TheraBand™, small hand weights, and gravity-reduced body weight resistance exercises. Similarly, our observations indicate that many rehabilitation facilities (including hospitals and short- and long-term stay facilities) have not adopted high-intensity progressive RET into their standard protocol for the prefrail and frail elderly client/patient populations. While many of these facilities offer 60 minutes of therapy twice per day, they commonly use low-intensity exercise (e.g., seated in a wheelchair performing knee extension exercises with ankle weights) in conjunction with some functional training (i.e., wheelchair transfers) and aerobic activity. While the types of exercises mentioned earlier present adequate entry-level exercises for seniors, they are not likely a sufficient stimulus to promote positive muscle growth and adaptation. Accordingly, in the following section, we attempt to provide pragmatic resistance exercise advice for patients and practitioners.

PRAGMATIC RESISTANCE EXERCISE ADVICE FOR PATIENTS AND THE PRACTITIONER

When developing RET programs for older adults, it is important to consider all of the various training-related variables such as frequency, duration, exercises, sets, intensity, repetitions, and progression. Also, many older adults often have existing health issues (e.g., orthopedic limitations and cardiovascular disease) that require special consideration. Therefore, it is highly recommended that older adults who are at risk for RET-induced adverse events receive prior approval from their physician before participating in RET (note: the Physical Activity Readiness Questionnaire [PAR-Q] is a common questionnaire utilized to determine whether an individual should consult a physician before starting a physical activity program). Further, it is suggested that older adults who are beginning a RET program receive proper instruction and supervision by an appropriately trained exercise professional such as a physical therapist or an exercise physiologist.

RET Frequency

Exercise frequency refers to the number of exercise sessions per week. With regard to older adults performing RET, 2–4 days per week are commonly recommended, with training typically being performed on alternating days (e.g., Monday, Wednesday and Friday; Willoughby, 2015). The most common approach for someone beginning a RET program is to perform a "total body" exercise routine whereby all of the major muscle groups are exercised at each exercise session with the "total body" routine being performed 2–3 times per week. An alternative approach, which is more commonly used in more advanced RET programs involves exercising selected muscle groups on 1 or 2 days per week while the remaining are exercised on a separate 1 or 2 days per week (e.g., chest, back, and upper legs on Monday; arms, shoulders, and lower legs on Tuesday; chest, back, and upper legs on Thursday; and arms, shoulders, and lower legs on Friday).

RET Duration

Duration describes the length of each training session. The total duration of RET programs is highly variable and not commonly studied per se as there are many extraneous factors that contribute to duration (e.g., rest time between sets). In general, however, most RET sessions should be able to be completed in 30 minutes to an hour (at an advanced level, more time may be required). The amount of rest taken between sets is a highly influential variable that affects the total duration (alongside the number of sets, exercises, etc.). With respect to between-set rest interval, the ACSM currently recommends rest intervals of 1–2 minutes for training programs designed to stimulate muscular hypertrophy in novice and intermediate healthy resistance exercisers (ACSM, 2009). With this said, many authors have proposed that rest intervals of 30–60 seconds are optimal because they result in the greatest exercise-induced elevations in selected anabolic hormones, notably growth hormones (de Salles et al., 2009; Willardson, 2006). The current literature does not support this notion per se (Henselmans & Schoenfeld, 2014); however, many experienced practitioners anecdotally report more hypertrophic gains with shorter rest intervals.

RET Exercises

Exercises are commonly categorized as either multijoint or unijoint. Multijoint exercises are those in which more than one joint is involved in the exercise, such as the chest press and leg press. Unijoint exercises are those where only one joint is involved, such as bicep curls and leg extensions. For older adults, multijoint exercises should be encouraged (due to their functional relevance) (Willoughby, 2015), although unijoint exercises should not necessarily be discouraged. Additionally, resistance exercise machines (e.g., leg press machines) are recommended for the beginner over free weights (i.e., barbells and dumbbells) as less skill is required when using machines, and the movement restrictions of the machines provide greater safety for the user. As an individual progresses, however, free-weight exercises appropriate for level of skill, training status, and functional capacity are reasonable.

The specific exercises to perform can be highly variable depending on the availability of equipment, but a well-rounded RET program should include exercises that involve all of the “major muscle groups.” These muscle groups are commonly defined as the chest, back, arms, shoulders, upper legs (quadriceps, hamstrings, and gluteals), and lower legs (calves). Examples of different exercises for each of these major muscle groups are provided in Table 9.1. One to two exercises per muscle group is adequate for the beginner and intermediate exerciser (Willoughby, 2015), and it should be noted that performing multijoint exercises

TABLE 9.1
Example Exercises for the Major Muscle Groups

Muscle Group	Exercises
Chest	Flat chest press (machine*, barbell**, or dumbbell**)
	Chest flyes (machine*, flat dumbbell flyes**, incline or decline flyes***)
	Incline or decline chest press (machine**, barbell***, or dumbbell***)
	Push-ups (modified with knees on ground** or unmodified with feet on ground***)
Back	Pull-downs or seated cable rows (machine*)
	Chest-supported rows (machine**, barbell***, dumbbell***)
	Pull-ups (with machine body weight assist** or no body weight assist***)
	Shrugs (machine**, barbell***, dumbbell***)
Arms	Seated curls (machine*, barbell**, or dumbbell**)
	Hammer or preacher curls (dumbbell**)
	Triceps extension (machine*, cable press-down*, or prone barbell or dumbbell***)
	Bent-over triceps extension “kickbacks” (dumbbell**)
Shoulders	Overhead press (machine*, barbell***, or dumbbell***)
	Upright rows (machine**, barbell***, or dumbbell***)
	Lateral raises (machine*, barbell***, or cable***)
	Rear deltoid rows/flyes (machine**, barbell***, or dumbbell***)
Upper legs	Leg press (machine*)
	Leg extensions (quadriceps) and curls (hamstrings) (machine*)
	Lunges (no weight**, barbell*** , or dumbbell***)
	Machine squat***
Lower legs	Standing calf raises (no weights*, with additional weight via machine or dumbbells***)
	Seated calf raises (machine*)

Note: Exercises recommended for *the beginner, **an intermediate level, and ***an advanced level. Resistance exercise machines are recommended for the beginner over free weights. As an individual progresses, however, free-weight exercises appropriate for the level of skill, training status, and functional capacity are reasonable. Additionally, multijoint exercises are recommended, as these frequently have higher functional relevance and also result in more than one muscle group being exercised.

results in multiple muscle groups being exercised (e.g., chest press exercises not only the chest [pectoralis] muscles, but also the triceps and the anterior compartment of the shoulder). In general, it is recommended that multijoint exercises be performed before unijoint exercises for a particular muscle group and that within each session, the larger muscle groups be exercised before the smaller muscle groups (Willoughby, 2015).

RET Sets

Significant improvements in muscle strength and size have been observed with the number of sets ranging between one and three (Starkey et al., 1996). We recommend that an individual start with a familiarization period that lasts 1–2 weeks where one set of each exercise is performed with heavy emphasis placed on safety and form. Next, depending on individual need, progression up to three sets in the beginner phase is reasonable when deemed appropriate. With progression to an intermediate and advanced stage, additional sets or additional exercises can be added to increase the overall volume of training (total number of sets per session), which, as illustrated in Figure 9.2B, is critical for hypertrophic gains. Also, as mentioned previously, the interset rest interval is important to consider, and sufficient rest should be taken to avoid excessive fatigue (i.e., enough rest so that the remaining sets can be performed with the appropriate form), but an excessively long rest period should be avoided.

RET Intensity

Intensity refers to the relative amount of weight being lifted (i.e., the percentage of maximum). As illustrated in Figure 9.1A, the RET intensity is a critical factor in determining the amount of neuromuscular adaptation induced via training. Numerous studies have now illustrated that high-intensity RET (e.g., 80+% of 1RM) is tolerated in older adults (Chale et al., 2013; Fiatarone et al., 1994; Reeves et al., 2003; Singh et al., 2012). Accordingly, we suggest that RET intensity should be progressed to “high intensity” as permitted. However, it should be noted that studies have shown intensities ranging from 65% to 75% of maximum will increase strength, and some authors suggest these intensities should be utilized as an attempt to decrease the risk of musculoskeletal injury (Willoughby, 2015).

RET Repetitions

Repetitions refer to the number of times an individual performs a complete movement of a given exercise. The number of repetitions that one can perform is inversely related to the exercise intensity (i.e., the higher the intensity, the fewer repetitions that can be performed). As illustrated in Figure 9.3, if an individual is exercising at 60% of his/her maximum strength, he/she will likely be able to perform between 18 and 32 repetitions to “task failure” using free weights. At 80% of the individual’s maximum strength, the number of repetitions to failure is generally between 8 and 15, and at 90%, it is 4–12 repetitions with free weights. The number of repetitions to failure for machines is, generally speaking, slightly higher than with free weights (Figure 9.3) presumably due to free weights requiring more muscles for stabilization and balance compared to a fixed-path machine-lifting task. Understanding these relationships is important, as it provides a mechanism for a trial-and-error approach to be utilized to prescribe the appropriate training load without having to actually test muscle strength (e.g., performing the exercise to task failure within 10–15 repetitions would likely indicate that an individual is exercising at an intensity in the 70%–85% of maximum strength range).

RET Progression

The concept of “progression” refers to gradually overloading, or increasing the stress, placed on the body during exercise. The human body will only respond if it is continually required to exert a greater magnitude of force (or higher volume) to meet higher physiological demands. Thus, in order to continually enjoy improvements in mass, strength, and functional capacity, it is important to consistently incorporate progression and variation into the RET program. There are an ample number of ways to progress a RET program. For instance, one can make adjustments by increasing the frequency, duration, exercises performed, number of exercises for each muscle group, sets, and repetitions. Progression should be a gradual process with adjustments made on a monthly basis commonly recommended (Willoughby, 2015). During progression, it is important for the exercise professional to be aware of the patient’s medical limitations and for progression to occur via adjustments in the most appropriate training variables on a case-by-case basis.

In Tables 9.2 to 9.5, we present an example progressive RET program. This program is designed for an older adult without any contraindications for RET training. Modifications would need to be made if certain musculoskeletal, neurological, or mobility limitations precluded an individual from safely performing the program. This program is designed on the assumption that access to typical machine and free-weight resistance exercise equipment is available, but it could be modified as needed based on equipment availability. Additionally, progression could be varied (sped up or slowed down) depending on individual adaptation.

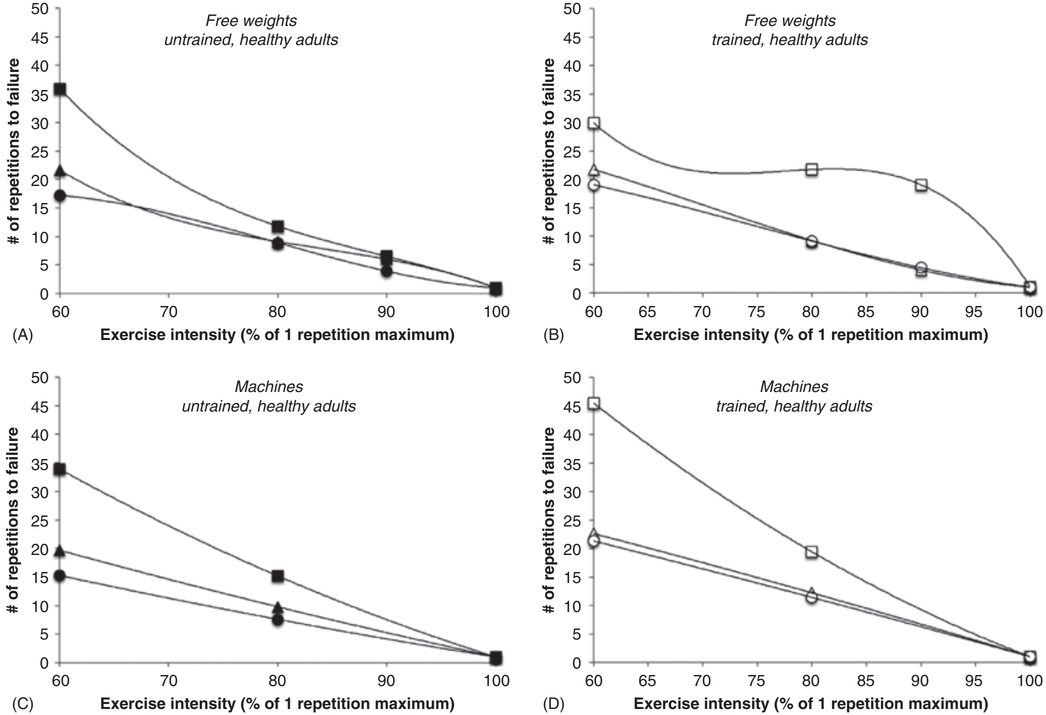

FIGURE 9.3 Relationship between the number of repetitions untrained (A) and trained (B) healthy adults were able to perform *using free weights* at four different resistance exercise intensities (60%, 80%, and 90% of 1RM) for the squat (square), bench press (triangle), and arm curl (circle). Created from data presented in Shimano et al. (2006). Relationship between the number of repetitions untrained (C) and trained (D) healthy adults were able to perform using resistance exercise machines at three different resistance exercise intensities (60%, 80%, and 1RM) for the leg press (square), chest press (triangle), and arm curl (circle). Data represent the mean response for each exercise and intensity, respectively. Created from data presented on Hoeger et al. (1990).

TABLE 9.2
Example Beginner Progressive Resistance Exercise Training Program (Weeks 1–8)

Body Part	Exercise	Sets × Reps
Beginner, Phase I: 50%–60% of 1RM; 2×/Week; 1–2 Weeks; Familiarization Phase		
Chest	Chest press (machine: seated or lying)	1 × 15–20
Back	Seated cable row	1 × 15–20
	Seated cable pull-down	1 × 15–20
Arms	Biceps curl (seated machine)	1 × 15–20
	Triceps extension (seated machine)	1 × 15–20
Shoulders	Overhead press (seated machine)	1 × 15–20
Upper legs	Leg extensions (seated machine)	1 × 15–20
	Leg curl (seated machine)	1 × 15–20
Lower legs	Calf raise (seated machine)	1 × 15–20
	Calf raise (standing)	1 × 15–20
	Rest between sets: 2 minutes (as needed)	**Total sets: 10**
Beginner, Phase II: 60%–69% of 1RM; 2×/Week; 3–8 Weeks		
Chest	Chest press (machine: seated or lying)	1 × 12–18
	Wall push-ups	1 × 12–18
Back	Seated cable row	1 × 12–18
	Seated cable pull-down	1 × 12–18
Arms	Biceps curl (seated machine)	1 × 12–18
	Triceps extension (seated machine)	1 × 12–18
Shoulders	Overhead press (seated machine)	1 × 12–18
Upper legs	Leg extensions (seated machine)	1 × 12–18
	Leg curl (seated machine)	1 × 12–18
Lower legs	Calf raise (seated machine)	1 × 12–18
	Calf raise (standing)	1 × 12–18
	Rest between sets: 90 seconds	**Total sets: 11**

Note: It is suggested that the exercise is performed to, or near, task failure in the range of repetitions provided.

1RM = 1 repetition maximum.

TABLE 9.3

Example Intermediate Progressive Resistance Exercise Training Program (Weeks 9–24)

Body Part	Exercise	Sets × Reps
Intermediate, Phase I: 60%–69% of 1RM; 2×/Week; 9–16 Weeks		
Chest	Chest press (machine: seated or lying)	2 × 12–18
	Wall push-ups	2 × 12–18
	Chest flyes (machine)	2 × 12–18
Back	Seated cable row	2 × 12–18
	Seated cable pull-down	2 × 12–18
Arms	Biceps curl (seated machine)	2 × 12–18
	Triceps extension (seated machine)	2 × 12–18
Shoulders	Overhead press (seated machine)	2 × 12–18
	Lateral raises (seated machine)	2 × 12–18
Upper legs	Leg press (machine)	2 × 12–18
	Leg extensions (seated machine)	2 × 12–18
	Leg curl (seated machine)	2 x 12–18
Lower legs	Calf raise (seated machine)	2 x 12–18
	Calf raise (standing)	2 x 12–18
	Rest between sets: 90 seconds	**Total sets: 28**

Body Part	Exercise	Sets × Reps
Intermediate, Phase II: 70%–79% of 1RM; 3×/Week; 17–24 Weeks		
Chest	Chest press (barbell)	2 × 10–15
	Chest flyes (lying with dumbbells)	2 × 10–15
	Push-ups (knees down)	2 × 10–15
Back	Chest-supported rows (machine)	2 × 10–15
	Pull-ups (machine with body weight assist)	2 × 10–15
Arms	Biceps curl (seated dumbbell)	2 × 10–15
	Triceps extension (cable press-down)	2 × 10–15
	Triceps kickbacks (dumbbells)	2 × 10–15
Shoulders	Overhead press (seated machine)	2 × 10–15
	Lateral raises (seated machine)	2 × 10–15
	Upright rows (barbell or dumbbells)	2 × 10–15

(*Continued*)

TABLE 9.3
Example Intermediate Progressive Resistance Exercise Training Program (Weeks 9–24) (Continued)

Body Part	Exercise	Sets × Reps
Intermediate, Phase II: 70%–79% of 1RM; 3×/Week; 17–24 Weeks		
Upper legs	Leg press (machine)	2 × 10–15
	Leg Extensions (seated machine)	2 × 10–15
	Lunges (no weight)	2 × 10–15
	Leg curl (seated machine)	2 × 10–15
Lower legs	Calf raise (seated machine)	2 × 10–15
	Calf raise (standing)	2 × 10–15
	Rest between sets: 90 seconds	**Total sets: 34**

Note: It is suggested that the exercise is performed to, or near, task failure in the range of repetitions provided.

1RM = 1 repetition maximum.

TABLE 9.4
Example Advanced Phase I Progressive Resistance Exercise Training Program (Weeks 25–32)

Body Part	Exercise	Sets × Reps
Advanced, Phase I: >80% of 1RM; 3×/Week; 25–32 Weeks		
Chest	Chest press (barbell)	2 × 8–12
	Chest flyes (lying with dumbbells)	2 × 8–12
	Incline chest press (machine)	2 × 8–12
	Push-ups (knees down)	2 × 8–12
Back	Chest-supported rows (machine)	2 × 8–12
	Pull-ups (machine with body weight assist)	2 × 8–12
	Shoulder shrugs (machine)	2 × 8–12
Arms	Biceps curl (seated dumbbell)	2 × 8–12
	Hammer curls (seated dumbbell)	2 × 8–12
	Triceps extension (cable press-down)	2 × 8–12
	Triceps kickbacks (dumbbells)	2 × 8–12
Shoulders	Overhead press (seated machine)	2 × 8–12
	Lateral raises (seated machine)	2 × 8–12

(*Continued*)

TABLE 9.4

Example Advanced Phase I Progressive Resistance Exercise Training Program (Weeks 25–32) (Continued)

Body Part	Exercise	Sets × Reps
	Rear deltoid flyes (machine or dumbbells)	2 × 8–12
	Upright rows (barbell or dumbbells)	2 × 8–12
Upper legs	Leg press (machine)	2 × 8–12
	Leg extensions (seated machine)	2 × 8–12
	Lunges (no weight)	2 × 8–12
	Leg curl (seated machine)	2 × 8–12
Lower legs	Calf raise (seated machine)	2 × 8–12
	Calf raise (standing)	2 × 8–12
	Rest between sets: 60–90 seconds	**Total sets: 42**

Note: It is suggested that the exercise is performed to, or near, task failure in the range of repetitions provided.

1RM = 1 repetition maximum.

TABLE 9.5

Example Advanced Phase II Progressive Resistance Exercise Training Program (32+ Weeks)

Body Part	Exercise	Sets × Reps
Advanced, Phase II: >80% of 1RM; 4×/Week Split; 32+ Weeks; Monday and Thursday		
Chest	Chest press (barbell or dumbbell)	3 × 6–10
	Incline or decline chest press (barbell or dumbbell)	3 × 6–10
	Chest flyes (lying with dumbbells)	3 × 6–10
	Push-ups	3 × 6–10
Back	Chest-supported rows (barbell or dumbbell)	3 × 6–10
	Pull-ups (with or without assist)	3 × 6–10
	Shoulder shrugs (barbell or dumbbell)	3 × 6–10
Upper legs	Squat (machine)	3 × 6–10
	Leg extensions (seated machine)	3 × 6–10
	Leg curl (seated machine)	3 × 6–10
	Lunges (dumbbell)	3 × 6–10

(*Continued*)

TABLE 9.5
Example Advanced Phase II Progressive Resistance Exercise Training Program (32+ Weeks) (Continued)

Body Part	Exercise	Sets × Reps
Tuesday and Friday		
Arms	Biceps curl (standing barbell)	3 × 6–10
	Biceps curl (seated dumbbell)	3 × 6–10
	Hammer or preacher curls (seated dumbbell)	3 × 6–10
	Triceps extension (lying with barbell or dumbbell)	3 × 6–10
	Triceps kickbacks (dumbbells)	3 × 6–10
Shoulders	Overhead press (barbell or dumbbell)	3 × 6–10
	Lateral raises (dumbbell or cable)	3 × 6–10
	Rear deltoid flyes (machine or dumbbells)	3 × 6–10
	Upright rows (barbell or dumbbells)	3 × 6–10
Lower legs	Calf raise (seated machine)	3 × 6–10
	Calf raise (standing)	3 × 6–10
	Rest between sets: 60 seconds	**Total sets: 33 sets/day**

Note: This phase goes to four times per week with a "split routine." It is suggested that the exercise is performed to, or near, task failure in the range of repetitions provided.

1RM = 1 repetition maximum.

CONCLUSIONS

A well-designed, progressive RET program is well known to exert positive effects on both the nervous and muscular systems and, ultimately, results in profound enhancements in muscle mass and muscle strength. Accordingly, RET should be considered a first-line treatment strategy for managing and preventing both sarcopenia and dynapenia. While there are many components to an optimal resistance exercise prescription, exercise intensity, exercise volume, and progression are critical factors that deserve strong consideration as this relates to following best practice guidelines. We hope the example RET program presented herein is useful for academicians, students, and healthcare providers across a variety of disciplines, including those in the long-term care industry.

NOTE

1. Progressive RET involves increasing the number of repetitions at a constant load until exceeding an established repetition range (e.g., 12 repetitions). Subsequently, the load is increased and the exercise is performed at the new load until again exceeding the repetition range.

ACKNOWLEDGMENTS

We would like to thank Robert S. Staron, PhD (Ohio University), for his thoughtful critique and input on a draft of this manuscript. This work was supported in part by the following grants from the National Institutes of Health to Brian C. Clark: R01AG044424 from the National Institute on Aging, R01AT006978 from the National Center for Complementary and Integrative Health, and R21AR063909 from the National Institute of Arthritis and Musculoskeletal and Skin Diseases.

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