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Resistance Exercise for Cardiac Rehabilitation

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Abstract

Lean mass abnormalities are highly prevalent in patients referred for cardiac rehabilitation (CR). As such, current guidelines recommend incorporating resistance exercise (RE) into the exercise prescription of Phase II-IV CR. The effects of RE on health-related outcomes in patients with cardiovascular (CV) disease (CVD) have not been extensively investigated in comparison to aerobic exercise, the traditional modality of exercise implemented in CR. The purpose of this review is to highlight the growing prevalence of lean mass abnormalities such as dynapenia and sarcopenia in CVD and briefly outline the contributing pathophysiology of these impairments as potential targets for RE training. An update on the current evidence pertaining to the effects of RE on exercise capacity, skeletal muscle strength, body composition, CV health, and quality of life in CR patient populations is provided. The current recommendations for RE training in CR are discussed. Future directions for research and clinical practice in this field are highlighted, and included the need to identify the most efficacious principles of resistance training for different health related outcomes in CVD, as well as the suggested drive towards a 'personalized medicine' approach to exercise prescription in CR.

Keywords

Cardiovascular Disease; Cardiac Rehabilitation; Resistance Training; Sarcopenia

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Conflict of Interest
None to declare

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INTRODUCTION

Cardiac rehabilitation (CR) is a sentinel and well-established aspect of standard of care in cardiology. Pioneered by Levine and Lown in the 1940's, and strongly opposed at the time, the movement away from bed rest to light intensity chair based activities following a cardiac event marked the beginnings of what we know as CR today[1]. Since then, the overwhelming evidence in favor of physical activity for improving clinical outcomes, prognosis, and quality of life (QoL) in patients with cardiovascular (CV) disease (CVD) has heralded CR and exercise training as a class 1 recommendation in cardiology clinical guidelines [2,3]. Subsequently, CR has evolved into a multidisciplinary practice that encompasses exercise training, nutrition intervention, smoking cessation, lifestyle behavior changes and psychological support for both primary and secondary prevention of CVD.

Exercise training remains the core component of CR. Scientific advances in the field of exercise physiology have led to the development of the exercise prescription, a combination of principles that include the frequency, intensity, duration and modality of exercise that will be most efficacious and improving a desired physiological outcome[4]. Based on the documented benefits of aerobic exercise on CV physiology and outcomes, a typical CR exercise prescription has previously been focused on implementing this modality of exercise[4]. In this regard, a large amount of research in the field has aimed at delineating the most superior aerobic strategy to improve outcomes in CR. Strategies have ranged from low intensity, long duration, high-calorie-expenditure interventions to short duration, high intensity interval training – a strategy that is covered in depth elsewhere in this issue[5]. However, in comparison the modality of resistance exercise (RE) has been less explored in the setting of CR.

Compared to aerobic exercise, RE provides a more powerful anabolic stimulus for muscle hypertrophy and increased muscle strength. Importantly, recent reviews from our group have highlighted the positive association between muscle wasting, dynapenia and the increased risk of CVD incidence and CVD related mortality [6,7]. In this respect, muscle strength is now emerging as a modifiable CVD risk factor. Furthermore, peripheral skeletal muscle quantity and quality is a definitive determinate of cardiorespiratory fitness (CRF), playing a fundamental role in the arterial-venous oxygen (a-v O_2) difference of the Fick equation. Notably, in some CVD populations skeletal muscle impairments have now been identified as major contributors to exercise intolerance, a paradigm shift away from the heart as the sole determinant of reduced CRF in these patients [8,9]. There is therefore a strong physiological rationale for resistance training to be routinely incorporated into CR.

The purpose of this review is to briefly highlight the pathophysiology of skeletal muscle abnormalities associated with CVD that could be targeted with RE to improve clinical and functional outcomes. An overview of studies investigating the effects of RE in CVD patient populations is presented as well as discussion pertaining to future directions for both scientific research and clinical practice as they relate to CR.

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THE HEART-SKELETAL MUSCLE AXIS

Loss of skeletal muscle strength, mass, and functionality, together defined as sarcopenia, are consistently reported in CVD populations such as in patients with heart failure (HF) and coronary artery disease (CAD) [6,7]. The loss in skeletal muscle strength, mass and functionality are noteworthy as they have a detrimental impact on QoL and are independent predictors of mortality in patients with CVD. Importantly, more than 50% of CR patients report musculoskeletal abnormalities that have a substantial impact on strength and exercise capacity [10]. The pathophysiology of skeletal muscle abnormalities is complex and multifaceted (Figure 1). The detailed pathophysiology of skeletal muscle abnormalities in CVD are beyond the scope of this review and readers are directed to extensive reviews recently published on this topic [6,7,11]. Briefly, endocrine abnormalities such as multihormone deficiency syndrome including a perturbed IGF-1/GH axis and insulin resistance that is common in CVD patients promote catabolism and prevent anabolism [12,13]. In addition, the presence of oxidative stress and chronic low-grade systemic inflammation prevent protein turnover and subsequently hamper anabolism [14]. Iron deficiencies evident in many CVD have shown to lead to more pronounced metabolic acidosis during activity and impaired skeletal muscle mitochondrial oxidative capacity, both of which are implicated in skeletal muscle dystrophy [15]. Mitochondrial dysfunction is consistently reported in CVD [16] and been implicated in myocyte dysfunction and viability, therefore playing a large role in the development of sarcopenia [17]. Certainly, impairments in skeletal muscle mitochondrial density, oxidative capacity, morphology and dynamics have all been reported in CVD populations[6]. Furthermore, in the presence of increased circulating free fatty acids, incomplete fatty acid oxidation and insulin resistance, an impairment in mitochondrial oxidative capacity could result in substrate overload with subsequent accumulation of lipid intermediates in the muscle, culminating in augmented deterioration of muscle quality. Superimposed on these pathophysiological processes of skeletal muscle wasting in CVD, disuse atrophy secondary to a sedentary life further exacerbates skeletal muscle impairments[18]. Herein commences a vicious cycle whereby CVD is exacerbated secondary to disuse and skeletal muscle atrophy (Figure 1). In this respect, impaired skeletal muscle quality and function could contribute to the abnormal exercise pressor response observed in this patient population, subsequently leading to detriments in neurocirculatory control that augment CVD progression[19,20].

PRINCIPLES OF RE TRAINING

The predominant trainable characteristics that can be obtained through RE include muscle strength, power, hypertrophy, and muscle endurance[21]. For optimal physiological adaptations pertaining to these characteristics, progressive training models should be implemented with appropriate manipulation of program variables including 1) choice of resistance 2) exercise selection 3) order and number of sets and repetitions 4) rest period length between sets 5) frequency of training per day and week[21]. Therefore, components of RE prescription will vary depending on the desired outcome. For example, where muscle hypertrophy is the primary objective, multiple sets of moderate to high intensity exercises are recommended with each set consisting of 8-12 slow to moderate repetitions with 1-2 minutes between sets[21]. Alternatively, where muscle endurance is the primary objective,

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multiple sets of light intensity exercises are recommended with each set consisting of 10-25 fast repetitions with <90 seconds between sets[21]. Progressive overload is sentinel to optimizing training adaptations and is typically achieved through increasing exercise intensity or load for given exercises, increasing repetitions, increasing repetitions speed, shortening rest periods, and increasing total training volume[21].

While progression models for resistance training have been established in the general population[22], there is less evidence for the optimal RE prescription in CR patients. Most of the work in this area has been carried out to address the safety concerns associated with the acute hemodynamic responses to RE. In this respect, in a group of men with CAD, there was a progressive cardiac drift of heart rate (HR), cardiac output and blood pressure (BP) across both concentric and eccentric RE types[23]. This drift was more pronounced when the repetitions were slow and the rest period between sets was short[23]. In a follow-up study, the hemodynamic response to low intensity, high repetition (4 sets of 17 reps at 40% 1RM) program was compared with a high intensity, low repetition (4 sets of 10 reps at 70% 1RM) program[24]. This study showed a transient increase in HR and BP with exercise, peaking at the last set in both models[24]. BP increased simultaneously with exercise intensity; however, significantly higher BP were recorded during sets with higher repetitions[24]. Finally, a 1-minute rest period between sets was insufficient to return HR and BP values to resting values[24]. Taken together, these findings suggest that for optimal hemodynamic stability during exercise in patients with CAD, resistance training protocols should consist of 8-10 repetitions per set with higher intensity exercise recommended over longer duration in terms of progressive overload. Also, rest periods should be longer that 1 minute to allow for full recovery or HR and BP.

Optimal progression models for hypertrophy, strength, power, and muscle endurance have not yet been delineated in the CR population and should be the focus of future investigations in this area. Until this information is available, health care providers can follow the American Heart Association guidelines for resistance training in cardiac patients[25]. Alternatively, the American College of Sport Medicine guidelines for progressive resistance training models in older adults can also be followed, making appropriate adaptations for patient co-morbidities[21]. These guidelines are detailed later in this review in the “clinical recommendations” section and in Table 1.

EFFECTS OF RE TRAINING ON HEALTH REALATED OUTCOMES IN CR PATIENT POPULATIONS

Exercise Capacity

Cardiorespiratory adaptations to CR, collectively reported as improvements in peak oxygen consumption (VO_{2peak}), are clinically important in CR patients as they predict long term survival[26]. Meta-analyses comparing RE training to usual care have shown RE to be efficacious at improving VO_{2peak} in CAD [27] and HF (1.4 [−0.3-3.1]) patient populations [28]. However, most studies suggest that aerobic exercise is a superior modality of exercise to improve CRF, with larger increases on VO_{2peak} following aerobic training compared to RE training alone [29,30]. A recent meta-analysis comparing RE training with aerobic

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training in CR patients showed no effect in favor of either type of training with regards to improvements in VO_{2peak}, however, the studies included in the analysis were reported as 'low quality' and should therefore be interpreted with caution [31]. Most studies in this area have compared combined aerobic and RE training regimens (hereon referred to as combined training) with aerobic training alone or usual care. The majority of meta-analyses data from CR, CAD and HF patients, report combined training to be superior to aerobic training at improving VO_{2peak} and exercise time[10,31,32]. In contrast, one meta-analyses in HF patients showed greater improvements in VO_{2peak} following aerobic training compared to combined training interventions [28]. In CR patients, greater increases in VO_{2peak} are observed following higher intensity combined training interventions of longer durations, indicating a dose response relationship for these exercise prescriptions[31]. As RE training does not appear to chronically alter resting or exercising cardiac output in CVD populations[29,33], it is inferred that the increases in VO_{2peak} associated with resistance training (whether alone or combined with aerobic training) are largely due to peripheral adaptations that increase oxygen extraction and utilization.

In addition to the noted benefits of RE training on VO_{2peak}, a small number of studies have shown greater improvements in VO_2 at the anaerobic threshold following combined training compared to aerobic training alone [10]. This has noteworthy implications on QoL and maintaining independence as it allows patients to complete activities of daily living and leisure time activities at a lower relative percentage of their maximal capacity.

Muscle Strength

As previously mentioned, diminished muscle strength has emerged as a modifiable contributor to morbidity and mortality in CVD [7]. There is strong evidence in favor of RE as the predominant exercise modality to increase muscle strength in CVD. Both RE and combined training programs result in increases in upper and lower body strength in CAD patients that supersede strength gains from aerobic training [10,27]. In contrast, an outlier study comprised of only women participating in CR showed that strength gains following 6 months of aerobic training were no different from those observed after the equivalent duration of combined training [34]. This could be suggestive of potential sex differences in strength adaptations to RE training, with women undergoing CR demonstrating an attenuated response. However, it is important to note that QoL assessment performed in these patients 1 year after completing CR showed that those who participated in combined training self-reported a better physical QoL compared to those who participated in aerobic training only[34]. This is noteworthy as women often tend to be widowed at the time of their CVD event and therefore maintaining their functional capacity is an important component of sustained independence and enhanced QoL[34].

The most efficacious RE for increasing muscle strength in CR has not yet been determined. However, in comparison to middle-aged patients, older adult patients (>65 years) may require RE prescriptions of higher intensity (with appropriate safety precautions implemented to avoid the Valsalva maneuver) and longer duration to elicit optimal gains in strength[27].

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Body Composition

Few studies have investigated the effects of resistance training on body composition in CR patients, which is somewhat surprising based on the proverbial hypertrophic effects of RE on skeletal muscle. With the incidence and clinical importance of cardiac sarcopenia and cachexia coming to light[6,9,11], RE may play an important role in increasing lean mass in CR patients, an outcome for which there are currently no efficacious pharmacological therapies for. Three studies included in a meta-analyses of individuals with CAD that included body composition measured by dual-energy X-ray absorptiometry (DEXA) reported significant increases in fat-free mass (that were directly correlated to increases in strength[35]), significant declines in percentage fat mass and improvements in trunk fat mass following combined training in comparison to aerobic training[10]. These studies all employed resistance training interventions ranging from light to high intensity[35-37]. Typically, high intensity, progressive protocols are deemed most efficacious at eliciting an anabolic effect[38]. One study in CAD patients showed significant increases in appendicular lean mass (i.e., lean mass of extremities) following resistance training incorporating multiple sets vs. single sets[36]. Aside from this study, the optimal RE prescription for altering body composition is yet to be determined for CR patients.

CV Function

Vascular endothelial dysfunction is characteristic of CVD and plays a large role in the pathophysiology of atherosclerosis, impaired vascular tone, platelet aggregation and an abnormal coagulant balance that culminates in the development of thrombosis [39]. In both HF and CAD patients, improvements in vascular endothelial function assessed by flow mediated dilation have been reported following RE training and combined exercise training [33,40,41]. These findings are supported by decreases in von Willebrand factor level observed following both resistance and combined training in these patients [41]. Future studies investigating the effects of RE training on mediators of endothelial function such as oxidative stress and inflammation as well as vasoactive molecules such as nitric oxide and endothelin-1 would provide a clearer insight into the effect of this type of training on vascular function.

Aberrant arterial hemodynamics and increased arterial stiffness also play a central role in the development and progression of HF in addition to end organ damage that leads to co-morbidities such as chronic kidney disease and dementia. The effects of RE training on arterial stiffness and central hemodynamics remain somewhat controversial in the general population, with increases in carotid compliance and carotid intima-media thickness reported [42,43]. In individuals with CVD, RE has been shown to significantly decrease aortic systolic and diastolic pressures in a similar manner to aerobic training [33]. The aforementioned improvements in endothelial function following RE training are speculated to contribute to decreases in central pressures [33]. With regards to arterial stiffness, no changes appear to be evident following RE in CVD patients [33]. This is in contrast to the effects of aerobic exercise where decreases in arterial stiffness have been reported following traditional CR[44].

Few studies have examined the effect of RE on cardiac function in CR patients. One study in HF patients with reduced ejection fraction that compared 12 weeks of moderate intensity

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RE training with aerobic training and a control group showed that whilst aerobic training appeared to be efficacious at improving cardiac diastolic function, resistance training had no effect on cardiac parameters assessed by echocardiography [45]. In line with this study, other findings have showed increases in resting and exercising cardiac output following aerobic and combined training, with RE alone having no effect on cardiac output [29,33]. Based on the currently available evidence, it appears that in patients with CVD, aerobic exercise is a more efficacious type of exercise of cardiac/central contributions to exercise capacity in comparison to RE.

With respect to cardiac autonomic regulation, combined training that include low intensity, high repetition RE has been shown to enhance parasympathetic cardiac modulation during exercise compared to aerobic exercise training[46,47]. Improvements in HR variability following this modality of training are speculated to be a result of reduced cardiac sympathetic modulation[47]. The reported improvements in cardiac autonomic regulation following combined training are suggested to be a result of improved skeletal muscle quality that subsequently alter the exercise pressor response [47]. Further evidence is warranted to confirm that these proposed physiological mechanisms are responsible for adaptations in autonomic function following resistance training.

Quality of Life

RE has a beneficial effect on self-reported QoL in patients with CVD, particularly in patients with HF[28,32]. In patients with CAD, combined training is superior to aerobic training alone at improving both physical and emotional components of QoL[10]. A large contributor to these observed improvements in QoL with RE appears to be an increase in self efficacy, defined as a patient's perceived ability to perform their normal activities[28,48]. This is aligned with objective measures of improved physical function, such as an increase in six minute walk test distance, that are reported following combined training[28]. This is particularly evident in women participating in CR, who report greater increases in self-efficacy for stair climbing, lifting and walking following combined training compared to aerobic training alone[34]. A meta-analyses in HF patients reported no effect of RE on sleep quality and depression, both of which could contribute to QoL[28].

CLINICAL RECOMMENDATIONS AND FUTURE DIRECTIONS

There is a sufficient body of evidence in favor of adding RE training to cardiac rehabilitation to increase exercise capacity and muscle strength. Current guidelines from the American College of Sport Medicine [4] recommend starting 2-3 days of RE per week performed on non-consecutive days in Phase II CR. Each session should implement 8-10 different exercises that focus on major muscle groups using equipment that is safe and comfortable for the patient to use. Multiple sets (1-3) of 8-10 repetitions should be performed at a moderate intensity (40%-60% of 1RM or 11-13 on Borg's rating of perceived exertion scale) for each exercise. Interventions should provide progressive overload for maximal adaptations. Resistance training may be particularly beneficial and indicated for CR patients with musculoskeletal abnormalities, patients that have a frail phenotype, female patients and patients aged >65 years.

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With regards to modality of resistance training, recent work in the area has started to investigate the effects of inspiratory muscle training (IMT) in CR patients. This type of training incorporated in phase I and II CR has been shown to improve pulmonary function, exercise capacity and QoL and reduce the length of hospital stay after cardiac surgery[49]. In addition, studies that incorporate IMT into combined training programs augment exercise capacity and QoL adaptations in CR patients[50,51]. IMT can be considered as an additional intervention to potentiate the benefits of combined training in CR[50].

Future studies need to establish the most efficacious principles of resistance training in CR. In addition, given the current focus on lean mass abnormalities and the prevalence of sarcopenia and cachexia in CVD patients more studies investigating the effects of RT on the intermediate physiological modulators of skeletal muscle abnormalities, in addition to nutritional endpoints (such as changes in body composition) are needed. Finally, it is our opinion that CR should move away from a 'one intervention fits all' model and towards a more individually tailored, 'personalized medicine' approach to exercise prescription. In this respect, with the use of cardiopulmonary exercise testing coupled with modern techniques to non-invasively measure cardiac output (e.g. inert gas rebreathing, impudence cardiography, cardiac magnetic resonance imaging) and a-v O_2 difference (e.g. magnetic resonance imaging or near infrared spectroscopy) it is becoming easier to gain a more comprehensive mechanistic insight into whether exercise capacity is limited by central (i.e., cardiac) or peripheral factors. Based on the current evidence, aerobic exercise would appear to be the most efficacious exercise prescription to address patients primarily limited by cardiac limitations whereas a focus on addition resistance training as part of a combined intervention may be more effective in those with peripheral abnormalities. Future research focused on personalizing the exercise prescription in CR has the potential to elicit more robust training adaptations and beneficial health related outcomes. Moreover, particularly in the setting of a virtually delivered CR program, identifying modalities of resistance training that are feasible, safe and effective is of utmost importance and we advocate for such studies to be conducted.

UNDERSTUDIED CLINICAL POPULATIONS

Overall, despite the potential beneficial effects of CR, and particularly of resistance training described above, there is a lack of data in specific cardiac populations, that urgently require more evidence. For instance, although resistance training in the setting of CR is likely beneficial in patients with heart failure, very little is known on the effects of this strategy in patients with advanced heart failure, particularly in those with left ventricular assist device (LVAD). Recent recommendations suggest that resistance training in this population can be indicated, however, the level of evidence remains low[52]. A randomized trial, although limited by the small sample size, has shown that CR is effective on improving CRF, functional capacity, muscle strength and patient-reported quality of life compared to standard of care[53], however, resistance training was not included in the exercise prescription. A 12-week randomized, controlled trial investigating the effects of exercise training including a resistance training combined with endurance training prescription in patients with LVAD is currently ongoing, and it will provide insights on the potential benefits as well as safety of this intervention[54].

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Considering the protective prognostic role of CRF in patients with LVAD, we could speculate that by increasing resistance training, patients might experience improvements in CRF and therefore in long-term prognosis. Importantly, muscle strength predicts patient-reported quality of life and length of stay in LVAD-recipients and considering the beneficial effects of resistance training on muscle strength, we could speculate that such an intervention would be beneficial in this population.

Similar to patients with LVAD, patients with spontaneous coronary artery dissection (SCAD) also represent a largely under investigated population with regards to the role of resistance training on its prognosis[55]. SCAD is typically defined as an epicardial coronary artery dissection that is not associated with atherosclerosis or trauma and not iatrogenic[56]. SCAD which can lead to sudden death and acute myocardial infarction among others, and portends a poor prognosis[56]. This highlights the need to investigate non-pharmacologic therapies as a means to reduce morbidity and mortality in this population. Preliminary studies suggest that CR is safe and is associated with favorable changes on CRF, body composition as well as mental health[57-59]. To support this evidence, current recommendations recommend referring patients with acute coronary syndrome due to SCAD to CR, however, no specific CR programs exist for patients with SCAD[60]. This is not ideal, as often patients with SCAD are younger than their counterpart with acute coronary syndrome, but without SCAD, therefore likely to be able to tolerate different volume and intensity of CR.

With regards to resistance training, however, the evidence remains highly limited in patients with SCAD. In this population, in fact, due to the complexity of the pathophysiology of the disease, weightlifting above 20 lbs, which would be often recommended in a typical resistance training session in adults, have been associated with a SCAD-related event[58]. The evidence on the ideal weight to utilize in the setting of resistance training remains conflicting, with other studies suggesting that women should not use more than 30 lbs and men no more than 50 lbs[60,61]. These conflicting reports clearly highlight the need for more studies to finally and unequivocally identify the safety and efficacy of resistance training in patients with SCAD.

SUMMARY AND CONCLUSIONS

With strong evidence pertaining to the adverse health related outcomes associated with lean mass abnormalities associated with CVD, there has been a paradigm shift towards developing therapeutic strategies loss in skeletal muscle mass, strength, and functionality in this patient population. As a result, RE is now becoming an important focus of standard of care CR. Current evidence in CR patient populations shows that RE significantly improves VO_{2peak}, an important predictor of prognosis and survival, and with augmented increases observed with resistance training is added to traditionally prescribed aerobic exercise. RE is a superior modality of exercise for increasing muscle strength compared to aerobic exercise, a finding that has considerable implications for rehabilitation programs including frail, elderly and women CR patients. Despite being an equivocal topic in the general population, chronic RE appears to be efficacious at improving vascular function in CR patients. However, beneficial cardiac adaptations are more pronounced following aerobic

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exercise in comparison to resistance training in these patients. RE significantly improves quality of life in CR patients. Increases in self-efficacy to perform activates of daily living and resume leisure activities contribute to the observed improvements in quality of life, particularly in women. More research is warranted to investigate the effects of resistance training on skeletal muscle hypertrophy to prevent and mitigate CVD related sarcopenia. In addition, future research studies in this area should focus on delineating resistance training patterns for different health related outcomes and in specific populations at high CV risk, as highlighted in this review. With more patient populations being referred for cardiac rehabilitation[60], individually tailored exercise prescriptions focused on personalized medicine are encouraged to elicit more robust training adaptations and beneficial health related outcomes following CR. Furthermore, considering the evolving field of telemedicine, which has been found to be central in the setting of a Pandemic, whether remote resistance training in the setting of CR is efficacious and can be conducted safely, remains largely unexplored, clearly requiring further study.

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Alphabetical List of Abbreviations:

BP	blood pressure
CAD	coronary artery disease
CR	cardiac rehabilitation
CRF	cardiorespiratory fitness
CV	cardiovascular
CVD	cardiovascular disease
DEXA	dual-energy X-ray absorptiometry
GH	growth hormone
HF	heart failure
HR	heart rate
IGF	insulin-like growth factor
LVAD	left ventricular assist device
QoL	quality of life
RE	resistance exercise

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SCAD	spontaneous coronary artery dissection
VO_{2peak}	peak oxygen consumption

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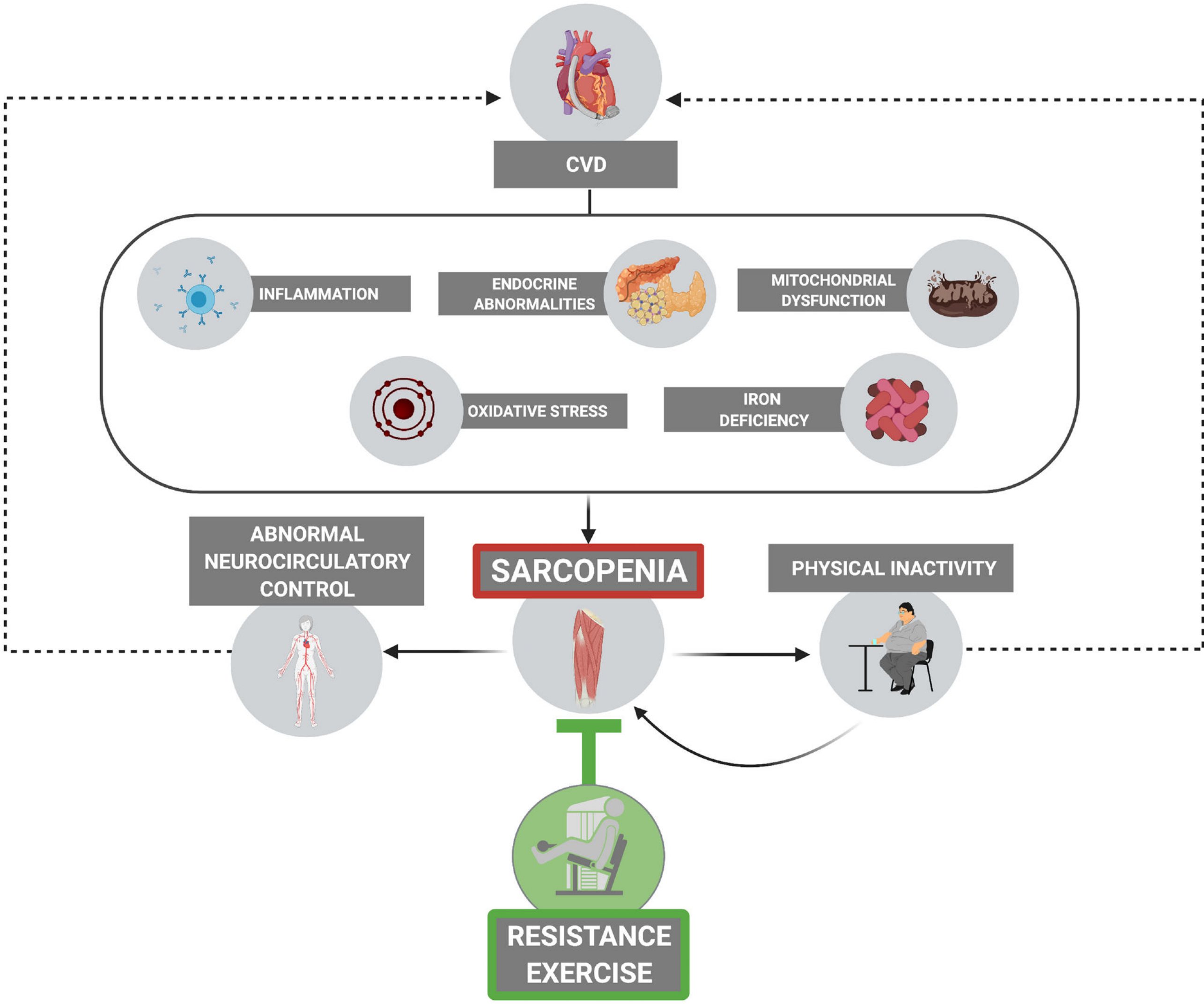

Figure 1.

Patients with cardiovascular disease (CVD) present with multifaceted pathophysiological contributors to lean mass abnormalities that are exacerbated by physical inactivity. The physiological consequences of sarcopenia in these patient populations augment the progressions of CVD, initiating a vicious cycle between lean mass abnormalities and CVD. Resistance exercise (RE) training implemented into CR as a therapeutic target to improve skeletal muscle health has the potential to reverse this cycle.

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Table 1.

Current resistance training guidelines for cardiac patients and older individuals.

	Population	Frequency	Intensity	Time	Type
ACSM [4]	Outpatient Cardiac Rehabilitation	2-3 nonconsecutive d • wk^{-1}	- RPE 11-13 on a 6-20 scale - 40%-60% 1RM	- 1-3 sets - 10-15 repetitions - 8-10 exercises	- Focused on major muscle groups - Select equipment that is safe and comfortable for the individual to use
ACSM [21]	Older Adults				
	For Strength & Hypertrophy	2-3 nonconsecutive d • wk^{-1}	- 60-80% 1RM - Slow-moderate lifting velocity	-1-3 sets - 8-12 repetitions -1-3 minutes rest between sets	- Multiple and single joint exercises - Free weights & machines
	For Power	2-3 nonconsecutive d • wk^{-1}	- 30-60% 1RM - High lifting velocity		
	For Muscular Endurance	2-3 nonconsecutive d • wk^{-1}	-Low-moderate intensity	-10-15 repetitions	
AHA [24]	Cardiac Patients	2-3 nonconsecutive d • wk^{-1}		- 1 set - 8-10 repetitions - 8-10 exercises	

ACSM, American College of Sports Medicine; AHA, American Heart Association; RM, repetition maximum; RPE, ratings of perceived exertion.