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Cardiac Rehabilitation in Older Adults: Apropos yet Significantly Underutilized

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Abstract

Cardiac Rehabilitation (CR) is a comprehensive disease management program that utilizes exercise training, behavioral modification, education, and psychosocial counseling to optimize outcomes and functionality in patients with cardiovascular disease (CVD)[1]. While CR was initially designed as an exercise training and fitness program for younger patients, usually men, after debilitating hospitalizations for myocardial infarction or cardiac surgery, evidence has expanded to also include other types of CVD in women as well as men, including heart failure, valvular disease, and peripheral arterial disease[2–4]. As the population of older adults continues to expand, age-related CVD is endemic and is commonly associated with exercise decline, diminished quality of life, and dependence. CR has the potential to counterbalance these patterns, and therefore stands out as a particularly important consideration for older adults with CVD. Nevertheless, CR remains highly underutilized[5,6]. Novel approaches to CR including home-based and hybrid CR programs show promise for enhanced outreach to patients who may not otherwise participate. This review summarizes the current data available regarding CR in older adults with CVD with a focus on geriatric-specific complexities, current barriers to utilization, and approaches to enhance participation and effectiveness.

Keywords

Cardiac rehabilitation; Older adults; Physical Function; Frailty; Adherence

Aging and Cardiovascular Disease (CVD)

Longevity has dramatically increased among the population of the United States, from a life expectancy of 50 years in the early 1900s to nearly 80 years in the present time[7,8]. With this increase in longevity, the population has seen a significant increase in the percentage of older adults, and by 2035, it is predicted that nearly a quarter of the entire

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population will be over age 65[9]. This demographic suffers from an increased burden of disease compared with younger adults. CVD remains the leading cause of mortality in older adults[10]. It is also the most common primary diagnosis for hospitalizations and nursing home admissions[11]. Moreover, disease burden compounds age-related functional declines, with greater risks regarding poor quality of life (QoL), increased healthcare utilization, and diminished independence.

Aging intrinsically predisposes to CVD, such that previously healthy adults become more likely to develop new onset of cardiovascular events and morbidity. Furthermore, even adults who develop CVD at a younger age are more likely to survive into old age[12] due to prevailing advances in pharmaco- and interventional therapies. Still, they are then more likely to become more vulnerable to recurrent events over time as well as to frailty, disability and diminished independence[13] due to insidious effects of CVD over time. CR is uniquely equipped to moderate and even avert these patterns.

Cardiac Rehabilitation (CR)

CR is a comprehensive disease management program that utilizes exercise training, behavioral modification, education, and psychosocial counseling to optimize outcomes and functionality in patients with CVD[8]. CR can be particularly useful in the critical period after a CVD event or hospitalization to allow for a supervised and structured (re)introduction to physical activity (PA) for patients suffering from significant physiological and psychological barriers to exercising, activity, and independent living. Additionally, as a disease management program, CR provides an opportunity for medication reconciliation and review, coordination of care, and more frequent evaluation of symptoms and health status[14]. While originally designed as a program for patients with acute myocardial infarction (MI) and coronary artery bypass grafting (CABG) surgery, eligibility now includes patients with stable coronary artery disease (CAD) or have had recent percutaneous coronary intervention (PCI) as well as patients with heart failure (HF) with reduced ejection fraction, valvular heart disease, and peripheral arterial disease[2–4].

CR is ideally suited to benefit older adults with CVD given that the pathobiology of aging and CVD are tightly linked, particularly with regards to inflammation[15]. CVD is more likely to have compounding effects to those with multimorbidity and geriatric syndromes (e.g., frailty, sarcopenia, and cognitive decline), and is often manifest in prolonged lengths of hospital stay, deconditioning, and to patterns of progressively sedentary behavior[16]. CR provides opportunities to address such issues in a longitudinal, multidimensional manner while also offering therapeutic facets to reduce other geriatric-specific intricacies. Table 1 summarizes the functional and clinical benefits of CR in older adults.

Aerobic Capacity

Cardiorespiratory fitness, also known as aerobic capacity, represents the highest volume of oxygen consumed per minute at peak PA (peak VO2)[17] and is a vital prognostic indicator for adults. While in younger adults aerobic capacity is reliably a true measure of cardiopulmonary function, in older adults it is often confounded by impaired cognition,

sarcopenia and musculoskeletal weakness, joint and mobility issues, and even sensory deficits in vision, hearing, and proprioception[16]. Aerobic capacity typically declines with age, by 8-10% per decade of life[18]. Accompanying this decline is a decline in ability to perform activities of daily living which can lead to a cycle of sedentary behavior, progressive disability and dependency, which may be further exacerbated by acute illness, hospitalization and deconditioning[19].

There is ample evidence that CR has efficacy for improving aerobic capacity in older adults. The first study looking at this measure, by Williams and colleagues in 1985, analyzed the effect of a 12-week exercise training program instituted for patients shortly after hospitalization for acute MI or CABG. The oldest group of patients, age 65 and older, experienced a 53% increase in metabolic equivalents (METs), considered a surrogate measure of aerobic capacity, after CR and had similar improvements in maximal heart rate and resting heart rate as younger patients[20]. Lavie and Milani found similar trends in a cohort of 199 patients age 65 and older enrolled in CR after acute coronary syndromes or CABG, with a notable 43% increase in METs after CR, which was statistically greater than the improvement seen in younger patients[21]. Similarly, in a cohort of 57 older adults (age >70) with CAD enrolled in CR, Lavie and Milani found that after completion, there were improvements in peak VO2 (+13%) and METs (+32%), although notably in this study improvements observed in older adults were lesser than those in the younger cohort[22]. More recently, Baldasseroni et al studied a cohort of 160 older adults over age 75 enrolled in a 4-week CR program after acute MI, PCI, CABG, or valve surgery. This group experienced a modest increase (+11%) in peak VO2, with the greatest gains noted in patients who had started from the poorest baseline[23]. Finally, a recent analysis of 1600 patients age 65 years and older enrolled in CR as part of the EU-CaRE study demonstrated that participation in CR was associated with improved peak VO2 regardless of training intensity. Interestingly on a program-level exercise intensity was not correlated to improvements in peak VO2 but on an individual level, increased exercise intensity was associated with greater improvement in peak VO2[24], which suggests that a more nuanced patient-specific approach may yield the best results. Overall, these data suggest CR is associated with improved aerobic capacity in older adults, and that gains for this population may even be proportionally greater than those for younger adults.

Strength and Balance

Strength and balance are components of physical function that are of particular importance in older adults as both disease (e.g., HF and chronic obstructive pulmonary disease) and age (frailty and sarcopenia) are associated with intrinsic muscle weakening. As muscle weakness limits aerobic capacity, strength is a prerequisite for effective aerobic exercise[25]. Muscle weakness may also contribute to imbalance, which is commonly further exacerbated in older adults by medication side effects, sensory deficits, neuropathy, and age-related decline in baroreceptor function. Furthermore, lower extremity weakness and gait and balance issues are risk factors for falling in older adults[26]. Falls are common in this population, with up to 30% of patients age 65 and older falling per year, and nearly 60% of people in retirement and nursing homes falling each year[26]. Approximately 1 in 5 falls lead to significant injury, and many will lead to hospitalization, pain syndromes, increased health care costs and

significant functional limitation[27]. Even in the absence of injury, a common consequence of falls in older adults often is fear of falling again which leads to lower mobility, worsening balance and cognition[28].

Exercise training is one of the best studied interventions for decreasing fall risk in older adults. Both supervised group exercise and home-based exercise programs have been shown to reduce risk of falls in older adults by 22-37%[29]. Tai Chi, an exercise program which includes multiple components focused on strength and balance training, has efficacy for improving balance and postural stability, mood and aerobic capacity, and seems to be the most effective exercise program at preventing falls[29,30]. Similar modifications have been incorporated into some CR programs. One study of 173 older adults 75 years and older who had recently undergone CABG found that the addition of resistance and balance training to standard CR resulted in improved measures of functional capacity (six-minute walk time, timed up-and-go (TUG), and relative workload) over standard CR alone[31]. Another small study of 26 older adults found that the addition of 20 minutes of stability and coordination training to standard CR improved balance scores and TUG[32]. Recently published results from the REHAB-HF trial, a RCT of 349 frail or pre-frail older adults with HF, showed that a progressive, tailored rehabilitation intervention initiated during or soon after HF hospitalization resulted in improved physical function compared to usual care[25]. Therefore, addition of specific strength and balance training may have synergistic benefits to CR for older adults, especially those at risk of falling.

Frailty

Frailty is generally defined as a state of diminished physiologic reserve that leads to increased vulnerability to acute stressors[33]. Frailty is highly prevalent amongst older adults with CVD, with estimates ranging from 10-60%[34] and prevalence further increases with age[35]. Physical frailty has been directly related to CVD, with underlying inflammation common to each. The presence of frailty additionally confers two- to threefold increased risk of morbidity and mortality in older adults with CVD, an effect independent of age and other comorbidities[34].

Although to date many interventions have been studied to reverse or improve frailty, few have demonstrated benefit. Of these interventions, exercise training has shown the most promise. One randomized controlled trial (RCT) of 100 frail older adults (median age 87) who resided in nursing homes demonstrated that high-intensity progressive resistance training improved muscle strength and gait speed[36]. Another RCT of mild to moderately frail community-dwelling older adults (median age 83) showed that a progressive exercise training program that began with flexibility, balance, and resistance training, and subsequently introduced endurance training, resulted in improved functional capacity compared to low intensity home exercise[37]. More recently, a study of 243 older Veterans with CVD, with 75 frail and 70 intermediate-frail (median age 68), demonstrated that CR has efficacy for improving several measures of physical function for frail and intermediate-frail patients. Additionally, more than one third of patents improved their frailty status after CR[38]. Although it is unclear whether these benefits are lasting over time, given the focus on improved self-efficacy and long-term behavioral change after CR,

it is feasible to expect long-term improvements in functional status for frail patients who maintain an active and healthier lifestyle after completion of CR. A key distinction of CR vs. exercise training alone is CR's broader programmatic integration of exercise training to behavior and lifestyle modification (diet, sleep, medication adherence) that are more likely to be durable over time.

Sarcopenia

Sarcopenia is defined as a generalized, progressive disorder of skeletal muscle leading to loss of muscle mass and function[39] and is associated with both aging and CVD[40]. While age-related inflammation has been implicated as a key etiological factor, the cause is likely multifactorial and also related to nutritional deficiencies, reductions in exercise, and changes in muscle fiber content and insulin-like growth factor 1[34]. Ultimately sarcopenia contributes to a broader composite of risks including frailty, functional declines, and falls[40].

Exercise training may moderate and even reverse sarcopenia in some instances by increasing muscle mass, strength and protein synthesis[41]. A small RCT of 93 older adults between 65-75 years old with sarcopenic obesity demonstrated that 8 weeks of either resistance training, aerobic training, or a combination resulted in improved muscle mass compared to controls, with resistance training resulting in greater improvements in strength compared to the other groups[41]. Additionally, resistance training has been shown to improve muscle mass, strength, endurance and physical function in older adults with HF and CAD and may be more effective at improving lower extremity strength when combined with aerobic training[42]. Various other studies of resistance training alone or combined resistance/aerobic training (with or without nutritional supplementation) in older adults have also shown improvements in muscle strength and/or muscle mass, although it is not clear which specific training regimens and/or nutritional supplementation are most effective[43]. Resistance training has even been shown to help institutionalized octogenarians and nonagenarians improve muscle strength and become more independent from assistive devices[44]. More recently, a retrospective study of 322 older adults enrolled in CR, 90 of whom had sarcopenia, found that participation in CR was associated with improvements in muscle mass, strength, and physical function for patients with and without sarcopenia, noting that exercise training was also associated with improvements in nutrition and caloric intake[45]. Thus, the exercise components of CR, in particular resistance training, may help counteract the deleterious effects of sarcopenia in older adults. If future studies demonstrate specific nutritional supplementation to be beneficial, it could be easily implemented through CR through dietary and medicine review and education.

Cognition and Socialization

Cognitive impairment and dementia are highly prevalent and morbid among older adults. Between 2.4 to 5.5 million Americans are estimated to have dementia, with an estimated prevalence of nearly a quarter of adults over age 80. Prevalence of mild cognitive impairment in adults over age 65 has been challenging to estimate, although estimates range from 3 to 42%[46]. The prevalence is likely higher among patients with CVD, as various conditions including CAD, cerebrovascular disease, HF, atrial fibrillation, and

possibly valvular disease are risk factors for cognitive impairment and dementia[47]. There is evidence from several prospective observational studies that exercise training and PA are associated with decreased risk of development of dementia. The same analysis found that multicomponent exercise regimens may have greater benefit for prevention of cognitive decline than aerobic exercise alone[48]. The multicomponent exercise intervention of CR may have a similar if not greater effect, as CR may further augment this effect through modification of medication regimens, sleep hygiene, and improved mood. Stanek and colleagues found that after completion of a 12-week CR program, older adults with CVD exhibited improvements in multiple cognitive domains[49], suggesting cognitive impairment may be modifiable, although it is unclear if these improvements last long-term.

Additionally, socialization is a critical component of center-based CR programs that may benefit older adults. The prevalence of loneliness and social isolation among older adults is high, previously estimated at 10-43% of community-dwelling older adults[50] prior to the COVID-19 pandemic. This has been greatly exacerbated during the past 18 months since the beginning of the COVID-19 pandemic[51]. Adults with CVD may be especially at risk for social isolation due to limiting symptoms such as dyspnea or angina, and even medication induced effects that make for difficulty in leaving home (i.e. diuretic therapy). Moreover, social isolation in older age is known to lead to declines in cognition, physical and mental health and has been associated with increased risk of CAD, HF, hospitalization and all-cause morbidity and mortality[52–54]. CR, especially center-based group programs, may serve as a source of socialization for older adults who otherwise may be limited in social options. One survey of adults 65 and older who completed CR found participants significantly valued the socialization aspect of CR and most preferred a larger role for socialization in CR[55], demonstrating utility of CR in offsetting the burden of social isolation.

Psychological Benefits

Depression is very common in older adults with CVD, and two-to-threefold more prevalent in patients with CVD than in the general population[56]The presence of depression in patients with CVD is associated with worsened health-related QoL (HRQoL), increased healthcare utilization and is an independent predictor of mortality[57–59]. A few studies in older adults have suggested CR is associated with improvements in depression. Milani and Lavie found that participation in phase II CR was associated with decreased prevalence and severity of depressive symptoms in adults 65 and older who experienced recent MI, PCI or CABG. Depressed patients also experienced greater improvements in quality of life compared to non-depressed[60]. A meta-analysis of 18 RCTs of home or community-based CR programs for adults 64 and older with CVD demonstrated improvements in depression post CR and that specifically tailored interventions for depression were likely more effective than usual care[61]. A meta-analysis of RCTs and cohort trials of older adults enrolled in CR also showed a trend that tailored psychological therapies in addition to standard CR may benefit depressive symptoms, although the analysis was limited by significant heterogeneity between the interventions[62]. More recently, a retrospective cohort study of 534 older adults 75 and older with CVD enrolled in a phase I CR program found that the addition of tailored psychological therapy was more beneficial for depression symptoms and associated with reduced hospital readmissions compared to standard CR[63].

These data suggest that CR may be efficacious for treating depression, and individualized approaches to depression therapy enhance efficacy. However, a recent meta-analysis of 17 studies including over 30,000 patients (mean age of 62) enrolled in CR showed that depressed patients are less likely to complete outpatient CR[64], highlighting the challenges pertinent to optimized care for depressed participants. Future studies are needed to determine if individually tailored depression therapies incorporated into CR can enhance completion rates in this population, and which therapies may be most efficacious.

Polypharmacy and Medication Adherence

Polypharmacy is common in older adults and associated with increased risk of iatrogenesis, falls, adverse effects, and even mortality[65]. Older patients are at especially high risk of adverse medication effects due to impaired hepatic and renal function, reduced lean body mass, and age-related sensory deficits[66]. Notably many medications with established benefit for CVD have adverse effects exacerbated by age-related physiology, such as urinary incontinence with diuretic therapy or orthostatic hypotension with beta blockers, angiotensin converting enzyme inhibitors, and angiotensin receptor blockers[67]. CR provides a unique opportunity for both medication reconciliation and direct observation of tolerance of medications during activity, allowing for a patient-centered approach to optimize medical therapy while reducing risks of adverse events, particularly falls, in older adults[68,69]. For example, this may be particularly helpful for older patients with HF, as the longitudinal structure of CR allows for easier titration of diuretic regimens and goal directed medical therapy, plus deprescribing of harmful or unnecessary medications[69].

Additionally, medication non-compliance remains a significant issue which contributes to hospitalization and death; medication adherence rates are a mere 50-60% in patients with chronic conditions including CVD[70]. CR may help with medication adherence through education and direct access to health care professionals who can address medication questions and concerns. One community study of 292 patients hospitalized with MI found that while over 50% of patients discontinued guideline-recommended medications within 3 years, participation in CR was the sole predictor of medication adherence post-MI and was associated with significant reductions in discontinuation of statins, beta blockers, angiotensin-converting enzyme inhibitors, and angiotensin receptor blockers[71]. Additionally, among nearly 12,000 adults older than 65 enrolled in the ACTION Registry-GWTG, participation in CR after MI was associated with improved adherence to secondary prevention medications with a dose-response effect between number of sessions attended, improved medication adherence, and resultant reductions in major adverse cardiac events and mortality[72]. Nonetheless, CR provides an important opportunity to longitudinally address medication tolerance, adherence, and safety in a vulnerable population to which the intricacies of medication management are critical.

Multimorbidity

Multimorbidity is defined as the presence of two or more co-existing diseases or medical conditions in one individual. Prevalence increases with age; over half of all adults over age 65 suffer from multimorbidity, with the highest prevalence in adults 85 years and older[73].

CVD is often accompanied by multimorbidity because of shared pathobiology with various other diseases that are also driven by inflammation, including type 2 diabetes mellitus, obesity, depression, stroke, frailty, sarcopenia, osteoporosis, peripheral vascular disease, and various types of cancer[73,74]. Furthermore, many risk factors for CVD are also risk factors for other diseases such as obesity (sedentary lifestyle), chronic obstructive pulmonary disease (smoking), and kidney disease (hypertension, diabetes mellitus). Multimorbidity is associated with worsened physical function, cognitive function, decreased QoL, and increased mortality[73].

Although CR was originally designed as an exercise program for patients with CAD, its evolution into a multidimensional longitudinal disease management program now makes it ideally suited for patients suffering from multimorbidity. Interval blood pressure and weight monitoring, medication reconciliation, lifestyle education, and cardiometabolic changes from aerobic and resistance training may help ease the burden of non-cardiac diseases, such as diabetes, hypertension, and obesity in addition to CVD. In the DANish StUdy of impaired glucose metabolism in the settings of cardiac rehabilitation (DANSUK), a small RCT of 104 patients with impaired glucose tolerance or type 2 diabetes, investigators found that a comprehensive CR program involving specific diabetic education resulted in improved glycemic and blood pressure control as compared to usual care[75]. CR participation is also associated with improvements in risk factors including smoking cessation and better lipid control[76,77]. Furthermore, CR presents an opportunity to address many atypical symptoms from multimorbidity that may confound or exacerbate cardiac symptoms and preclude patients from living a more active lifestyle.

Contemporary CR Models

CR programs have traditionally been center-based, usually at a hospital center or clinic, and span 36 weeks, with participants attending 2-3 sessions per week under direct supervision by exercise physiologists, with direct access to dieticians, social workers, psychologists, physicians, and/or nurses. While this traditional model has been most studied and allows for the greatest direct supervision of exercise, novel remote-based and hybrid models (combination of remote-based and center-based) have recently emerged as an attempt to increase reach to patients who have barriers to travelling to a hospital-based center frequently. Additionally, technologies including smartphone applications, telephonic monitoring, and internet-based interventions have potential for augmenting the benefit of CR and are increasingly accepted by older adults[78]. These novel models of CR may prove particularly useful given the COVID-19 pandemic has led to a significant increase in utilization of telemedicine and virtual provider interactions[79].

Although remote-based and hybrid models may increase access to CR, the particular value for older adults merits careful considerations. Prevailing concerns about age-related complexities, including frailty, sarcopenia, and cognitive impairment, may confound the conceptual advantages of remote-based CR. Table 2 lists some of the advantages and limitations of center- and remote-based CR for older populations.

There are promising, but limited, data on the use of remote-based CR in older adults. One RCT of with recent MI, two-thirds over age 65, found that home-based CR was just as efficacious as center-based at improving total work capacity and HRQoL, and just as safe[80], although notably many older patients were excluded due to severe cognitive impairment or mobility issues, or ejection fraction <35%. In a small RCT of older adults with CAD, Oerkild and colleagues found no difference in improvements in exercise capacity, risk factor reduction, and HRQoL between home-based and center-based CR[81]. A recent scientific statement from the AHA suggests that home-based CR is reasonable to consider for low- to moderate-risk patients who otherwise cannot attend traditional center-based CR[82], although this statement acknowledges that efficacy for adults who are frail, prone to falls, and/or cognitively impaired, is still uncertain.

Although there are few data on hybrid CR programs in older adults, the recently-initiated Modified Approach to CR in Older Adults (MACRO) trial is actively investigating hybrid and remote-based CR models specifically for older adults, pioneering novel approaches to CR in this population, including an individualized approach to each participant's needs[83].

Barriers to Utilization

Despite the beneficial effects of CR programs on clinical outcomes for patients with CVD, CR remains highly underutilized, with overall participation rates reported at less than 30% of all eligible patients[5,6]. Moreover, participation rates have an inverse relationship with age, with rates reported at <5% of those eligible among adults 85 and older[84]. This phenomenon is likely multifactorial, with both provider and patient-specific factors playing key roles.

Provider bias affects referral and participation patterns. Ades and colleagues found that among patients aged 62 and older with CAD, provider "strength" of recommendation was the strongest predictor of participation in CR[85]. This finding has been supported by additional studies analyzing physician factors affecting referral and enrollment in CR[86]. One possible explanation is that physicians may be more concerned about safety of CR in older adults, given the theoretical risk of cardiac complications. However, according to the American Heart Association, the risk of MI, death, or cardiac arrest during contemporary exercised-based CR is low at 1/200,000, 1/100,000, and 1/700,000 person hours of exercise respectively[87]. Although there are no large studies specifically evaluating safety in older adult populations, there is no evidence to suggest increased risk of adverse events in this population among patients who have been screened and enrolled in CR[88]. Additionally, physicians may be less inclined to refer older patients with greater comorbidities who are viewed to have a shorter life expectancy and thus less likely to benefit or meaningfully participate[89]. Finally, referral patterns differ per specialty-patients under the care of a cardiologist or cardiac surgeon while hospitalized or during follow up are more likely to be referred and enrolled than patients who follow up with a primary care doctor alone[86].

Older patients are not only less likely to be referred but are less likely to participate in CR once they have been referred[90]. Many older adults also suffer from comorbidities including pulmonary disease or orthopedic issues leading to symptoms that limit participation in exercise[91]. In addition, older patients who cannot drive or have limited ability to arrange

transportation are less likely to attend CR[85,91]. Farly et al also reported that 1 in 5 CR-nonattenders reported not wishing to attend due to not wanting to "dwell on the problem" or be "reminded of the hospital"[91]. Similarly, among older patients with CAD, patient's denial of severity of illness predicts CR non-attendance[85].

Finally, older women are less likely than their male counterparts to attend CR[5,92], and more likely to withdraw from CR than men[93]. A variety of factors, including lack of time (possibly due to greater caregiver responsibilities), reluctance to participate in group therapies where the majority of participants are male, and many of the same barriers previously discussed play a role[94]. Heath disparities related to race and socioeconomic status may further compound gender related disparities in participation as well[95–96].

Enhancing Utilization

There are many opportunities to address the significant underutilization of CR among older adults. First, education for referring providers including primary care physicians, geriatricians, cardiologists, cardiac surgeons specifically tailored to the safety and efficacy of CR for older adults, may increase referral rates. Additionally, remote-based and hybrid CR programs have promise for reaching older adults who otherwise would not participate in center-based CR. The rapid expansion of telehealth during the COVID-19 pandemic may help provide better infrastructure within the healthcare system to more effectively implement remote-based and hybrid CR programs, although notably, a significant remaining barrier is lack of coverage by health insurers. The Million Hearts Cardiac Rehabilitation Collaborative, recently developed in 2016 as part of a greater national initiative co-led by the Center for Disease Control and Prevention and the Centers for Medicare and Medicaid Services, has emphasized several system-wide changes to increase participation and adherence to CR, including automated referrals on hospital discharge, more flexible CR hours, minimizing CR co-pays, and home-based CR inclusion for participants who cannot participate in center-based CR[97]. An additional emphasis on outreach to geriatric patients and providers can help include older adults as part of these efforts.

Furthermore, modifications to CR that enhance efficacy may increase referral, participation, and adherence patterns if patients and providers see positive results. In older adults, individually tailored programs for specific types and combination of exercise (balance, resistance, aerobic), psychological treatment, and disease-specific education may increase efficacy. The ongoing MACRO trial should provide further insight into some of these strategies.

Conclusion:

CR is efficacious for older adults with CVD and may be particularly helpful with addressing various geriatric-specific complexities in this population. Although CR remains highly underutilized in older adults for various reasons, novel remote-based and hybrid models are promising alternatives to increase utilization and efficacy, especially given the additional telemedicine infrastructure developed during the COVID-19 pandemic. Further research

studying the efficacy of these models and refinements to individual components of CR will help expand and improve the benefits of CR for our aging population.

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Alphabetical list of abbreviations:

CABG	Coronary Artery Bypass Grafting
CR	Cardiac Rehabilitation
CVD	Cardiovascular Disease
CAD	Coronary Artery Disease
HF	Heart Failure
MI	Myocardial Infarction
PCI	Percutaneous Coronary Intervention
PA	Physical Activity
QoL	Quality of Life

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Table 1.

Conceptual* Benefits of CR and Theoretical Implications for Older Adults

Cardiac Rehabilitation Benefits	Clinical/Functional Implication
Improved exercise capacity	Improved quality of life, independence in ADLs, reduction in overall mortality
Reduced symptom burden (chest pain, dyspnea, claudication, palpitations)	Improved quality of life, reduction in anxiety and depression, increased exercise tolerance
Improved cardiovascular risk factors (hypertension, obesity, lipids, smoking cessation)	Reduced cardiovascular events and cardiovascular mortality
Improved management of noncardiac comorbidities (i.e. diabetes, COPD)	Reduced symptom burden Reduced morbidity Improved quality of life
Improved strength	Increased independence in ADLs Improved physical function
Improved balance	Decreased risk of falls
Improved mood (depression/anxiety)	Improved quality of life
Reduction in frailty burden	Increased independence and quality of life Reduction in morbidity and mortality
Reduction in sarcopenia	Increased muscle mass Reduced dependence on assistive devices
Improved cognition	Reduction in burden or delayed onset of memory loss, cognitive dysfunction
Increased self-efficacy	Improved quality of life and independence
Better medication monitoring	Decreased risk of adverse effects Better weight and blood pressure monitoring/control Reduction in symptom burden Improved exercise tolerance Improved adherence
Group socialization and support	Reduced loneliness and improved mental and physical health

ADLs- activities of daily living

Note: Table adapted from O'Neil Clin Geriatr Med 2019

*This remains conceptual as there is a paucity of pertinent data. Relevant research is ongoing.

Table 2.

Conceptual * Advantages and Disadvantages of Remote-Based CR Compared to Center-Based CR

Advantages	Disadvantages
Quicker enrollment	Less insurance coverage
Flexible scheduling, integration into home routines	Lower degree of accountability for patients
Increased accessibility	Less face-to-face monitoring
Minimal travel necessary	Increased safety concerns for higher risk patients
Increased privacy for patients	Decreased socialization/social support
More individualized exercise	Less intensive exercise
Lower risk for COVID-19 exposure *	Less evidenced-based standards
No mask-wearing requirement during exercise *	More difficult for blood pressure, weight, heart rate monitoring

* Depends on specific local and state regulations, vaccination and case rates during COVID-19 pandemic

Note: Table adapted from Thomas RJ et al Home-Based Cardiac Rehabilitation, Circulation 2019

* This remains conceptual as there is a paucity of pertinent data. Relevant research is ongoing.