Canadian Journal of Cardiology 35 (2019) 1275–1277

Editorial

Sustaining Improvements in Cardiorespiratory Fitness and Muscular Strength in Cardiac Rehabilitation

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See article by Pryzbek et al., pages 1359–1365 of this issue.

Despite the fact that the American Heart Association, American College of Cardiology, and American College of Sports Medicine, among numerous leading medical organizations, have emphasized physical inactivity (PI) and sedentary behavior (SB) as major modifiable risk factors for cardiovascular disease (CVD), a sizable percentage of the population in the United States, Canada, and worldwide still have low levels of physical activity (PA) and high levels of PI/SB.[1-6] Recently, major efforts have been made to make health promotion a priority, including promoting PA/exercise training to improve levels of cardiorespiratory fitness (CRF) in the United States and worldwide in the primary and secondary prevention of CVD.[2] Among patients with established CVD, especially coronary heart disease (CHD), but also heart failure (HF) and even congenital heart disease, formal cardiac rehabilitation and exercise training (CRET) programs have considerable evidence for improving CHD risk factors, psychological risk factors, quality of life, and CRF levels, as well as reducing major CVD morbidity and mortality.[2,7-13]

Currently, all major PA/exercise guidelines have also emphasized resistance exercise (RE) or strength training to improve muscular strength (MusS) and prognosis.[14] Recently, we demonstrated that RE was associated with improved survival independent of levels of CRF,[15] and MusS was associated with better CVD prognosis and reductions in the incidence of type 2 diabetes mellitus, a strong risk factor for CHD/CVD.[16,17]

In the current issue of the *Journal*, Pryzbek and colleagues[18] report data on 160 men (average age 64 years) who enrolled in $\geq$ 1 year of maintenance CRET programs and who completed 2 or more exercise tests. They found that CRF increased nonlinearly up to 3 years and then declined nonlinearly up to 5 years. MusS as assessed by chest press and seated row slowly declined by $<$ 1% per year over 10 years, whereas knee extension increased nonlinearly for 4 years and then declined nonlinearly up to 10 years of follow-up. Although all of the initial benefits were not maintained for the full follow-up (5.5 years for CRF and 10 years for MusS), the maintenance CRET programs were still associated with fairly marked long-term benefits in this CHD cohort.

Although the study by Pryzbek and colleagues[18] demonstrates an initial increase followed by a progressive decline in CRF as assessed by peak oxygen consumption (VO_2), Belardinelli et al.[19] previously found an initial VO_2 increase ($\sim$16.5 mL/kg/min to $\sim$19 mL/kg/min after 1 year) in response to aerobic exercise training 2 times weekly at 60% of peak VO_2, which was maintained over a 10-year period in patients with HF. Therefore, in the study by Pryzbek and colleagues,[18] it is unclear if the decline in peak VO_2 after 3 years was due to age-associated declines or changes in exercise volumes. Future studies are needed to quantitate the volumes of exercise being performed in maintenance CRET programs to elucidate contributing factors that dictate VO_2 peak response over time. Certainly, understanding the determinants of CRF declines (reduced cardiac reserve vs pulmonary vs skeletal muscle) is important in HF and CHD.[20,21] Particularly, understanding the determinants responsible for the CRF decline would potentially allow for targeted strategies to prevent such declines, potentially with nonpharmacologic or even pharmacologic therapies. In fact, if the CRF decline is driven by cardiac impairments, proven cardioprotective agents, such as angiotensin blockers and β-adrenergic receptor blockers, but also those currently under investigation, such as coenzyme Q10, omega-3 fatty acids, and interleukin-1 blockers, in addition to exercise training, could be implemented; on the other hand, if CRF decline is, for instance, only driven by noncardiac abnormalities, exercise training and increased PA would remain, to date, the only proven tools shown to improve skeletal muscle dysfunction. Clearly, as we have recently demonstrated, high responders to improvements in CRF in CRET programs have considerably better survival

Received for publication May 31, 2019. Accepted June 10, 2019.

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See page 1276 for disclosure information.

https://doi.org/10.1016/j.cjca.2019.06.008

than lower responders and, especially, than nonresponders.[22] Also, although the improvements in CRF in the current study began to decline after 3 years,[18] the benefits on mortality as demonstrated in our study persisted for many years after the 3-month, 36-session CRET program.[21] Therefore, the mortality benefits persist for many years after current formal Phase II CRET programs. In addition, reducing PI/SB and increasing PA and the use of high-intensity interval training may be needed to further improve levels of CRF in CRET programs.[1-6,23,24]

As mentioned earlier, the combination of aerobic and RE or strength training across populations has been endorsed by all major health organizations, including the recent PA guidelines.[1-6,14-18] Although there are no studies to date that have endorsed the effects of long-term (eg, > 5 years) combined exercise training in patients with CHD, previous meta-analyses have shown that combined exercise training is superior to aerobic training alone for patients with CHD,[25] although this may not necessarily be the case in patients with HF.[26] In fact, a meta-analysis by Jewiss and colleagues[26] highlighted the fact that aerobic and RE performed in isolation significantly improved peak VO_2 compared with controls without exercise training, but there was no significant effect of combined therapy compared with aerobic training alone. Nevertheless, RE will also improve MusS, which also appears to be an important predictor of prognosis.[15-17] Therefore, future studies are needed not only to increase these observation times but also to compare responses between populations, including for major clinical CVD events.

Finally, as recently discussed in other publications,[1-3,8,9,27] greater efforts are needed to increase attendance and completion of regular CRET programs, much less maintenance programs, in the United States and across the globe. Clearly, the current CRET model is limited by long commutes, transportation times, and specific circumstances in various cultures, countries, ages, and genders. The "one size fits all" standard CRET model has limitations, is outdated, is not working well now, and will be even less effective in the future. Certainly, more comprehensive remote CRET modalities, including home-based, community-based, and internet-based programs, are needed to "re-brand and reinvigorate" the entire CRET field.

In conclusion, we applaud Pryzbek and colleagues[18] for their success in 160 men with CHD in maintenance CRET programs;[18] however, greater efforts throughout the field of CVD and all of medicine to better promote PA and exercise training to improve both CRF and MusS throughout the healthcare system and in society are desperately needed.

Funding Sources

Dr Carbone is supported by a Career Development Award 19CDA34660318 from the American Heart Association.

Disclosures

The authors have no conflicts of interest to disclose.

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