Post-COVID era: Time to re-introduce "cardiorespiratory fitness" as a vital sign

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With the acute burden of novel coronavirus 2019 (COVID-19) winding down in many parts of the world, there is an increased appreciation for those living with COVID-19 sequelae. Clavario and colleagues[1] found almost a third of COVID-19 survivors with functional limitations identified from cardiopulmonary exercise testing (CPX). This illustrates the role of CPX in identifying symptoms of long COVID. Keeping in mind that the acute phase of COVID-19 could also be asymptomatic, the true incidence and prevalence of long COVID is currently unclear. Evidence indicates that the acute pathophysiologic cascade triggered by COVID-19 infection can lead to chronic symptoms.[2] This long term-sequelae of COVID-19 supports the evaluation of cardiorespiratory fitness (CRF) to identify compromised exercise tolerance.

Considering CRF a vital sign was recommended by the American Heart Association (AHA) in 2016, specifically stating: "*all adults should have CRF estimated each year*".[3] Integration into clinical services, however, requires that the methods to evaluate CRF be readily available and accessible. Therefore, a key question remains: is it universally feasible to consider CRF a vital sign in the post-COVID era?

CRF is reflective of the integrated physiology of several systems, from the cardiopulmonary system to the cellular level, that allows an individual to perform physical work.[3] At the genetic level, particular genes related to CRF (e.g., WNT3, MAPT, LRRC37A2, CRHR1) have recently been identified through genome-wide association studies.[4] These genes were also found to have a shared genetic susceptibility for chronic disease, thus making CRF a potentially important index for chronic disease prognostication. At the cellular level, mitochondria play a vital role in an individuals' ability to extract oxygen and perform exercise and at the system level, CRF reflects the strong interplay between the cardiovascular and respiratory systems.[3] In fact, CRF is a more powerful predictor of adverse health outcomes than traditional risk factors in many studies, which underscores its recognition as an essential vital sign.[3]

CRF is most accurately determined from a maximal exercise test using either a treadmill or bicycle ergometer with the need for measurement of heart rate and exercise workload, at minimum, for the estimation of peak oxygen consumption (peakVO_2). However, the cost of CPX systems as well as the advanced training of personnel needed to operate these systems is not feasible across all health care settings.[5] Thus, there is a need for other approaches, such as walk tests like the six minute walk test, shuttle walk test or self-paced walking test.[5] The requirement for supervision is dependent on the clinical condition of the patient and could in most circumstances be supervised by an appropriately trained non-physician healthcare professional.[3] This makes these tests easy to administer in clinical settings. Recently, the use of estimated CRF (eCRF) has gained popularity and utilises easily available non-exercise data in a multivariable score (such as sex, age, body mass index, waist circumference, resting heart rate, smoking status and physical activity). When compared directly with the Framingham risk score, the area under the curve was slightly higher (c-statistic = 0.7987; 95% CI 0.7813, 0.8161) when compared to the Framingham risk score alone (c-statistic = 0.7972; 95% CI 0.7798, 0.8146), with no statistically significant difference in predictive power between the two.[6] This and other studies[3] suggest the benefit of adding eCRF to existing clinical assessments for predicting outcomes related to cardiovascular disease.

With variations existing in health care systems around the world, flexibility is needed to implement a CRF assessment. Table 1 illustrates a list of recommendations for the evaluation of CRF, including required human resources and infrastructure across these settings and systems. These recommendations provide the minimum requirements that should be available in different settings and regions and propose building on the various CRF evaluation methods. With the need to promote healthy lifestyle across all strata of society and to ensure "health equity", an important starting point is the evaluation of CRF. Without this initial step, the efforts and

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Setting	Equipment Needs for the Evaluation of CRF		Human resources	
	Required	**Optional**	**Required**	**Optional**
Low resource setting **Primary/Secondary health care centre**	Field tests[a] Non-exercise equations	Treadmill tests/ Cycle ergometry with or without integrated ventilatory expired gas analysis and ECG systems	Non-physician health care professional	Non-physician healthcare professional or Physician specialised in exercise science or integrative physiology or clinical cardiology
High resource setting **Tertiary health care centre**	Field tests[a] Non-exercise equations Treadmill tests/ Cycle ergometry with or without integrated ventilatory expired gas analysis and ECG systems	Exercise echocardiography Invasive cardiopulmonary exercise testing	Non-physician health care professional trained in exercise science	Physician specialised in exercise science or integrative physiology or clinical cardiology

Table 1: Recommendations for methods to evaluate CRF across settings.
[a] These will include walk/run tests or step tests.

strategies of public health initiatives and policies to promote healthy lifestyles are merely "castles in the sand".

Given the relevance of CRF in both assessing long-COVID and its impact on chronic disease, the need for it to be a vital sign could not come at a more opportune time.

Contributors

ASB drafted the manuscript; RA and JM provided intellectual input; ASB, RA and JM all revised the manuscript and approved the final version.

Declaration of interests

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