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PERSPECTIVES

Exercise and trainability: contexts and consequences

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Systematic and regular changes in physical activity – known as exercise training – evoke a host of short- and long-term physiological adaptations (Hawley *et al.* 2014). Casual observations of humans who participate in sports training (or physically demanding occupations) demonstrate that the magnitude of these adaptations shows marked inter-individual variability. This variability has been confirmed in countless training studies and has led to the concept of 'trainability'. Individuals who show robust increases in physiological capacity in response to training are said to be highly trainable, while those with more modest responses are said to be less trainable. These concepts are most notable in their application to endurance exercise training and also strength training.

Interest in trainability comes from several angles. First, less trainable people might miss out on some of the health benefits of exercise. Second, understanding the molecular and signaling mechanisms that explain differences in trainability could provide 'mechanistic' insight into the health benefits of exercise and even lead to things like drug targets or compounds for the prevention and treatment of diseases and conditions that are modified by training (Garatachea *et al.* 2015). At a speculative level it might be possible to devise exercise training programmes matched to some marker or markers of trainability to maximize a given individual's responses to training. Such markers – if found, replicated and confirmed – might also be used to identify extreme responders to training and identify individuals with a higher than average likelihood of success in sports (Pitsiladis *et al.* 2016).

In the landmark HERITGE study that trained a large number of people for 20 weeks using an endurance exercise programme consistent with public health guidelines, at least some people showed little or no increase in maximal oxygen uptake (Bouchard *et al.* 1999; CDC, 2015). This observation has led to the concept that perhaps 20% of individuals do not respond to endurance exercise training with the anticipated increase in cardiorespiratory fitness. Such individuals are said to have extremely low or even to lack trainability. Others have argued via smaller training studies and at least one meta-analysis that this apparent lack of trainability is *context specific*, and that with some combination of more prolonged and/or intense training marked responses can be seen in essentially all otherwise healthy individuals (Bacon *et al.* 2013; Howden *et al.* 2015).

How to resolve this controversy?

In this issue of *The Journal of Physiology*, Montero and Lundby (2017) subjected a large number of healthy young men ($n = 78$) to an intense programme of endurance training. The subjects were divided into five groups and trained one, two, three, four or five days per week for 6 weeks. On retesting, all of the subjects who trained four or five days per week showed measurable increases in peak workload and/or maximal oxygen uptake. While many of the subjects who trained one to three days per week showed increases in peak workload and maximal oxygen uptake, some did not. When two exercise sessions per week were added to the training load of the 'non-responders' for an additional 6 weeks, they essentially all became responders. Thus while a range of trainability was observed, the authors concluded that 'individual CRF (cardiorespiratory fitness) non-response is abolished by increasing the dose of exercise'.

These observations have several important *consequences*. First, cardiorespiratory fitness is perhaps the most powerful predictor of both cardiovascular and all-cause mortality in middle aged and older adults (Lavie *et al.* 2015; McAuley *et al.* 2016). Individuals with high levels of fitness have a much lower risk of death over epochs ranging from years to decades. These effects on mortality are also partially independent of traditional risk factors like blood lipids, hypertension and obesity. Along these lines, the data from Montero and Lundby suggest that the vast majority of humans could reap the health and mortality benefits outlined above. This is especially true in the context of the impressive protection provided by a peak exercise capacity of '10 mets', a value that is likely to be within reach of many or even most middle aged humans (Barnes & Joyner, 2013). Second, from a physiological perspective the vast majority of the individual differences in peak exercise capacity, maximal oxygen uptake and the responses of these variables to training are explained by some combination of increased cardiac stroke volume, cardiac output, total body haemoglobin, and blood volume (Lundby *et al.* 2017). These concepts were further confirmed by Montero and Lundby. Importantly, at this time the molecular signals identified and associated with trainability seem to be remote or even disconnected from these physiological fundamentals (Sarzynski *et al.* 2017). While some have argued for a hypothesis-neutral approach in the reductionist search for the molecular and signalling mechanisms that might explain differences in cardiorespiratory trainability, would it make more sense to focus on explaining the mechanisms underpinning these deterministic physiological pathways?

While the points made above are clearly interesting, one argument is that it is unrealistic, on a population basis, to get most people to do the sort of exercise required to ensure that their cardiorespiratory fitness increases. Thus studies focused on guideline-based exercise recommendations are highly relevant and the concept of non-responders remains valid. A counter to this argument is that fitness promotion via guideline-based training on an individual basis is challenging and has been largely unable to combat high and increasing rates of physical inactivity in many countries (GBD Risk Factors Collaborators, 2016).

Noncompliance with exercise and activity guidelines is perhaps similar in some ways to the noncompliance seen for many drugs used to combat chronic diseases (Conn *et al.* 2015). Thus, like drug therapy, perhaps greater focus should be placed on so-called 'low agency' and other approaches to promote more exercise and physical activity for most people on most days (Adams *et al.* 2016; Flint & Cummins, 2016). In the final analysis, any and all biological insights related to trainability need to be leveraged by effective public policy responses to the inactivity epidemic.

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Additional information

Competing interests

None declared.