Exercise Prescription Methods

POINT: Is it Time to Rethink Aerobic Exercise Prescription Methods?

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ABSTRACT

Exercise prescription is complex and can vary greatly. As well, methods have their own advantages and disadvantages. The purpose of this discussion is to consider if some of these methods should be modified. We look at the concept of the heart rate and oxygen intake reserve because it is recommended by the American College of Sports Medicine. *Journal of Clinical Exercise Physiology*. 2021;10(3):94–96.

INTRODUCTION

It is useful and appropriate to ask whether we should rethink aerobic exercise prescription methods. However, because there are many ways to prescribe exercise and many reasons for prescribing exercise (e.g., health, fitness, and performance), it is a complex task. No prescription method is perfect for all persons or even for the same person over time, as his or her interests, needs, goals, health, or fitness change.

This discussion focuses on methods based on exercise testing. When variables are estimated, there is so much variation that results may be useful to estimate a group average, but they cannot predict an individual's value. For example, Sarzynski et al. (1) compared maximal heart rate (HR_{max}) measured on 762 men and women aged 17 to 65 y in the HERITAGE study with 2 age-based estimates (Fox et al. (2) and Tanaka et al. (3)) and found that the standard error of estimate was 12.4 and 11.4 b·min^{-1} respectively; this is too large to be useful.

The factor with most variability when prescribing exercise is *intensity*. Absolute intensity (e.g., power output [PO], speed, kcal·min^{-1}) can be the same for everyone, but how it relates to a maximal (e.g., $\dot{V}o_2max$) or submaximal (e.g., lactate threshold) anchor point can vary. When intensity is a percentage of a maximal anchor, there is wide variation in how that relates to a submaximal anchor and vice versa. Complicating the situation is that there is little agreement on which anchor points are best and in which situations (4).

Rather than comparing anchor points or relative exercise intensities or determining which are best, we will discuss some facts and problems with several methods so readers can decide if modifications are warranted.

One method of determining exercise intensity is based on HR at a given PO or $\dot{V}o_2$. People who exercise at a HR associated with the same $\%\dot{V}o_2max$ can vary substantially in training PO, rate of increase in PO over time, and improvement in $\dot{V}o_2max$ (5). Nevertheless, training does not affect the HR-$\dot{V}o_2$ relationship. While HR at the same PO decreased after training, HR at the same $\%\dot{V}o_2max$ did not change in more than 700 men and women, blacks and whites, aged 17 to 65 y with different initial $\dot{V}o_2max$ values and different responses to training. Thus, frequent testing is not necessary to adjust exercise prescriptions once HR has been determined relative to a person's $\dot{V}o_2max$.

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Swain et al. (6) suggested that the relationship between %$\dot{V}o_2$max and %HR_{max} might be affected by individual differences in maximal and/or resting values. One attempt to correct for this is the Karvonen formula (7), also known as HR reserve (HRR), which considers the range from resting to maximal HR. This same reserve concept was applied to $\dot{V}o_2$ by Swain and Leutholz (8).

There have been many studies looking at the relationships among %$\dot{V}o_2$max, %HR_{max}, %HRR, and %$\dot{V}o_2$R in different populations, and there is evidence for (8–14) and against (9,13,15–20) the validity of the reserve concept (which assumes that %HRR and %$\dot{V}o_2$R are equal) for prescribing exercise intensity.

Recently, Ferri Marini et al. (21) assessed the %HRR-%$\dot{V}o_2$R relationship using more than 400 maximal exercise tests performed by sedentary subjects in the HERITAGE study. They found that (a) the relationship was not 1:1 and (b) %HRR was higher than %$\dot{V}o_2$R at 30% to 90% $\dot{V}o_2$R, suggesting that actual metabolic demands are different than those expected with exercise intensities commonly recommended for healthy individuals and various clinical groups.

Although individual linear regressions between %HRR and %$\dot{V}o_2$R were very strong, high interindividual variability in slope and intercept was observed (21). This implies that a single population equation to predict HR or $\dot{V}o_2$ for an individual may be inaccurate.

Another consideration is that the transferability and validity of HR-$\dot{V}o_2$ relationships found during incremental exercise to prolonged exercise has been debated (22,23). Although transferability and validity may improve with specific exercise protocols (24,25), several time-dependent adjustments (e.g., cardiovascular drift and $\dot{V}o_2$ slow component, which induce increases in HR and $\dot{V}o_2$ over time (26)) occur during prolonged exercise and may alter the HR-$\dot{V}o_2$ relations.

In an unpublished study, Ferri Marini et al. studied 8 active males during randomly assigned exercise bouts (15 min at 60%HRR, 15 min at 80%HRR, 45 min at 60%HRR, and 45 min at 80%HRR). As expected, treadmill speeds decreased to maintain a constant target HR. Reductions were similar during the 15- and 45-minute bouts at the same intensity but greater at 80%HRR. The %HRR-%$\dot{V}o_2$R relationship was affected by exercise duration, and the 1:1 relationship was not present during longer exercise bouts. Thus, HR-$\dot{V}o_2$ relationships derived from incremental exercise tests may not be transferred to prolonged, constant-intensity exercise.

The American College of Sports Medicine (ACSM) recommends using either %$\dot{V}o_2$R or %HRR to establish intensity (27) because of their assumed 1:1 relationship during incremental exercise. The ACSM guidelines state that exercise intensity should be 55/65–90% HR_{max} or 40/50–85% $\dot{V}o_2$R or HRR. The lower number reflects the suggestion that "quite unfit" people should start at lower intensities.

TABLE. Approximate mean ventilatory threshold and 40% $\dot{V}o_2$ reserve in 183 HERITAGE subjects with low levels of maximal oxygen intake ($\dot{V}o_2$max).

	$\dot{V}o_2$max ($mL \cdot kg^{-1} \cdot min^{-1}$)			
	30	25	20	15
Ventilatory threshold				
$\dot{V}o_2$ ($mL \cdot kg^{-1} \cdot min^{-1}$)	16.8	14.8	12.4	9.8
%$\dot{V}o_2$max	56	59	62	65
40% $\dot{V}o_2$ reserve				
$\dot{V}o_2$ ($mL \cdot kg^{-1} \cdot min^{-1}$)	14.1	12.1	10	8.3
%$\dot{V}o_2$max	47	48.4	50	53.3

This range of intensities corresponds well with mean $\dot{V}o_2$ at ventilatory threshold ($\dot{V}o_2$vt) relative to $\dot{V}o_2$max (VT%$\dot{V}o_2$max), which ranges from 52% in sedentary individuals to 85% in well-trained endurance athletes (28). However, ACSM guidelines did not consider the wide variance in VT%$\dot{V}o_2$max. As an example, mean VT%$\dot{V}o_2$max of 432 sedentary subjects in HERITAGE was 55% (range: 34%–83%).

Unpublished data from 183 HERITAGE subjects with low initial $\dot{V}o_2$max (15–30 $mL \cdot kg^{-1} \cdot min^{-1}$) show that less fit subjects had lower $\dot{V}o_2$vt values that tended to level off at ~10–14 $mL \cdot kg^{-1} \cdot min^{-1}$ (~3–4 Metabolic equivalents or METs). Interestingly, this is about the same level that Shephard (29) says is associated with activities of daily living. Because absolute values level off, while $\dot{V}o_2$max decreases in less fit people, the relative values (VT%$\dot{V}o_2$max) increase (see Table). Because "unfit" people already were doing enough to maintain VT at >50% $\dot{V}o_2$max and because the 40% $\dot{V}o_2$R values are less than their VT, it is uncertain whether lower intensities should be prescribed. For example, these HERITAGE subjects began training for 30 minutes at 50% $\dot{V}o_2$max and had no problems.

Further complicating the discussion is the fact that genetics plays a role in determining how people respond to the same or different exercise programs (30). There are high, average, and low responders to training and no difference associated with sex, race (blacks and whites), age (17–65 y), or initial $\dot{V}o_2$max (31). Thus, it is difficult to compare prescription methods.

Therefore, should we rethink how to prescribe exercise? As mentioned earlier, there is no perfect method and many factors to consider. Therefore, modify methods only if new information suggests that we should.

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