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COMMENTARIES

Body Composition Matters When Designing and Prescribing HIIT Protocols to Individuals for Health Promotion

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Many experimental studies use the quantification of aerobic and anaerobic ability as performance indicators and as injury rehabilitative measures. The measurement of aerobic performance can be quantified by the volume of oxygen consumed while exercising sub-maximally or at maximum capacity or intensity. Recently, high intensity interval training (HIIT) has emerged as a sustainable and effective method for improving cardiorespiratory fitness (CRF). HIIT has been proven to produce equal or greater improvements in cardio respiratory fitness (CRF) when compared to moderate intensity continuous exercise. HIIT has been described as an intermittent exercise period of short intense training bouts interspersed by different recovery periods. Whether using continuous aerobic or intermittent anaerobic training protocols to develop increased exercise capacity, the quantification of the active muscle mass contributing to the measurement outcome is important. Here we suggest that outcome measures should be based on lean tissue mass and not total body composition when examining individual responses to aerobic and anaerobic training protocols.

Keywords: High-intensity interval training; Aerobic ability; Cardiorespiratory fitness; Body composition; Health

Many experimental studies use the quantification of aerobic ability/cardiorespiratory fitness as an indicator of the health status of individuals (Ingle et al. 2020). Aerobic ability and capacity have also been used as a rehabilitative measure for cardiac event patients (Chirico et al. 2020), and as a method of relaxation training for cancer survivors (Cohen et al. 2020). The measurement of aerobic performance can be quantified by the volume of oxygen consumed while exercising sub-maximally or at maximum capacity or intensity. VO_{2max} is defined as the maximum amount of oxygen in millilitres, used in one minute per kilogram of body weight. Aerobic ability and capacity is a primary factor for most types of sports and is powerfully correlated and related to the health status of individuals. Recently, high intensity interval training (HIIT) has emerged as a sustainable and effective method for improving cardiorespiratory fitness (CRF) in adolescents. HIIT has been proven to produce equal or greater improvements in CRF when compared to moderate intensity continuous exercise (Martin et al. 2020). HIIT has been described as an intermittent exercise period of short intense training bouts interspersed by different recovery periods. Two main forms of HIIT exist, and are collectively referred to as 'high-intensity training (HIT)' and 'sprint interval training (SIT), respectively. HIT incorporates bouts of close to maximum intensity exercise performed between one to several minutes at between >80% peak oxygen uptake (or VO_{2peak}) to <100% VO_{2peak}, with several minutes of low-intensity recovery observed between sets (Wun et al. 2020). A typical example of the traditional SIT exercise protocol employs the Wingate anaerobic cycle ergometer test (WAnT) which consists of one or more 30-s or 10-s bouts of 'all-out' or supramaximal efforts (>100% VO_{2peak}). The WAnT has also been classified as the 'gold standard' in the assessment of anaerobic power and capacity (Inbar et al. 1996). In relation to this, we read with interest the technical report by Savonen et al. (2012) published in the International Journal of Obesity, and were particularly interested in the section which stated that cardiorespiratory fitness is currently estimated by dividing maximal oxygen consumption (VO_{2max}) by body weight (per-weight standard). The paper further suggested that the statistically correct way to neutralize the effect of weight on VO_{2max} in each population was to perform an adjustment for body weight using regression techniques (adjusted standard). The paper also stated that the objective of the study was to quantify the bias introduced by the per-weight standard in a population distributed across different categories of body mass. The paper concluded that in comparisons across different categories of body mass, the per-weight standard systematically underestimated cardiorespiratory fitness in obese subjects. Use of the per-weight standard was seen to markedly inflate associations between poor fitness and co-morbidities of obesity. Further to this, Welshman et al. (2019) investigated the treadmill determined peak oxygen uptake data to examine whether traditional per body mass (ratio) scaling appropriately controls for body size differences in youth. Using simple methods based on correlation and regression analysis, they observed that the statistical relationship, which is assumed in ratio scaling, is not met in groups of similar aged young people. Their findings demonstrate how sample size and composition can influence relationships between body mass and peak oxygen uptake and show that mass exponent derived from log-linear regression effectively remove the effect of body mass. Because of the spurious conclusions based on the assessment of aerobic performance using different experimental and statistical methodologies, we would like to comment on the measurement of anaerobic ability in overweight and obese subjects. This is particularly relevant today and because of the popularity of high intensity exercise protocols has implications for obese populations and for populations with underlying co-morbidities. We feel that correct exercise prescription and assessment of anaerobic performance is as important as aerobic quantification and is relevant in relation to the study of exercise responses in the obese and overweight. This is particularly true if we are to effectively combat the current obesity epidemic. We also feel that valid and reliable measures are crucial for diagnostic credibility when evaluating success in training programme design in relation to related blood biochemistry and subsequent post exercise performance and evaluation.

High-intensity cycle ergometry has been widely employed previously to assess indices of muscle performance during maximal exercise. Traditionally, the resistive force established for such a test is determined for the WAnT using resistive forces calculated from total body mass (TBM) multiplied by a ratio standard, e.g.: 75g.kg^{-1} × TBM.

McInnis and Balady (1999) observed that individuals who weigh the same might have very different body compositions that include variations in lean body mass and fat content. Van mil et al. (1996) recommended that optimal performance during high intensity cycle ergometry was highly related to an individual's fat-free mass (FFM), or to the mass of the muscles that are contributing to the test. Inbar et al. (1996) have suggested that FFM or active muscle mass may provide a more realistic assessment of anaerobic ability during high intensity exercise performance. These statements agree with the earlier suggestions of Wilkie (1960) who stated that resistive forces used during cycle ergometry should be matched as closely as possible to active muscle output.

Body mass and not the composition is the frequently used index to determine resistive force selection during high-intensity cycle ergometer exercise, and because power is the product of both resistive force and velocity, over- or under-estimations in power performance and assessment may occur. This may be particularly pronounced in overweight populations where resistive forces based on TBM may overestimate the capacity of the active muscle mass that contributes to the performance of the test.

Baker and Davies (2006) investigated the anaerobic potential of an overweight and obese population using two resistive force selection procedures namely, TBM and FFM. The TBM resistive force protocol was inclusive of the fat component of body composition, whereas the FFM protocol was not. The study examined maximal exercise performance during friction broken cycle ergometry of 10 s duration. Subjects were assigned in a random fashion to either the TBM or FFM experimental protocol. Eleven apparently healthy male university students (age: 22.3 ± 2 yrs; % body fat: 27.1 ± 2 %; determined hydrostatically) participated in the study (see **Tables 1** and **2**). A large significant difference ($P < 0.01$) in peak power output (PPO) was recorded between the TBM and FFM experimental conditions (1029 ± 98 W in TBM

Table 1: Age and anthropometric characteristics of subjects (N = 11).

	Means ± SD
Age (yrs)	22.3 ± 2
Stature (cms)	188.5 ± 7
TBM (kg)	100 ± 5
% Fat	27.1 ± 2
FFM (kg)	73.2 ± 5

Table 2: Descriptive analysis of cycle ergometer test results (N = 11).

	TBM Means ± SD	FFM Means ± SD	P value
PPO (W)	1029 ± 98	1397 ± 146	< 0.01
T to PPO (s)	4 ± 1.4	2 ± 1	< 0.01
R/f (kg)	7.5 ± 0.4	5.5 ± 0.4	< 0.01
P/revs (rpm)	98 ± 8	139 ± 6	< 0.01
HR (bpm) pre	68 ± 10	66 ± 11	> 0.05
HR (bpm) post	167 ± 8	165 ± 8	> 0.05

vs. 1397 ± 146 W in FFM). The findings of the study indicated that greater peak power outputs were obtainable when resistive forces reflected FFM as opposed to TBM. These results have implications similar to those of Savonen et al. (2012) and indicate that the assessment of exercise performance should relate to the active muscle tissues performing the task. This finding is extremely important to accurately assess effective exercise prescription, diagnostic capacity, clinical examination, and associated biochemistry in overweight and obese individuals. The findings also suggest that resistive force selection methods used in the assessment of anaerobic performance need to be reconsidered in obese and healthy populations, when anaerobic ability is the diagnostic measure of interest.

In summary, to achieve more effective and reliable exercise treatment effects, more scientific consideration needs to be implemented in relation to body composition when designing HIIT exercise programs and prescribing relevant exercise protocols. This is particularly important and necessary, especially when targeting overweight and obese individuals as experimental subjects.

Key

PPO	Peak power output
T to PPO	Time to peak power output
R/f	Resistive force
P/revs	Pedal revolutions
HR	Heart Rate

Competing Interests

The authors have no competing interests to declare.

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