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Commentary

THE ACSM EXERCISE INTENSITY GUIDELINES FOR CARDIORESPIRATORY FITNESS: WHY THE MISUSE?

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ABSTRACT

Dalleck LC, Dalleck AM. The ACSM Exercise Intensity Guidelines for Cardiorespiratory Fitness: Why The Misuse? ***JEPonline*** 2008;11(4):1-11. The purpose of this study was to quantify the misapplication and misinterpretation of the current American College of Sports Medicine (ACSM) exercise intensity guidelines for cardiorespiratory fitness. A literature review (January 2000 to January 2007) was completed identifying studies conducted on the effects of aerobic exercise training on cardiorespiratory fitness in healthy adults. Studies (*N*=15) were identified in which exercise intensity was prescribed by a percentage of maximal oxygen uptake (%VO_2max) rather than a percentage of oxygen uptake reserve (%VO_2R) (a misapplication). Eight instances of misinterpretation were identified; referencing the current ACSM guidelines, but citing intensity in terms of %VO_2max. Recent research demonstrating that percentage of heart rate reserve (%HRR) is more closely aligned to %VO_2R, not %VO_2max, prompted a change in the ACSM exercise intensity guidelines in 1998. Despite the ACSM's recommendation of the use of %VO_2R, present findings suggests the frequent use of %VO_2max (misapplication) in the methodology of aerobic training studies. The ACSM exercise prescription recommendations are the most recognizable guidelines for exercise professionals, and it is the responsibility of authors and reviewers to ensure correct interpretation and reporting in future publications. Continued use of exercise intensity prescribed by %VO_2max perpetuates an out-of-date recommendation and results in unequal training stimuli for individuals with dissimilar fitness levels. We recommend exercise professionals integrate the current intensity guidelines into both research and practice.

Key Words: Aerobic Fitness, Exercise Training, Maximal Oxygen Uptake, %VO_2max.

INTRODUCTION

Cardiorespiratory fitness, typically determined by maximal oxygen uptake (VO_2max), is a fundamental measurement for the exercise physiologist. VO_2max refers to the highest rate at which oxygen can be taken up and consumed by the body during intense exercise (1). Traditionally, the magnitude of an individual's cardiorespiratory fitness has been viewed as both a characteristic of endurance athletes and a symbol of overall health. Elevated VO_2max has long been considered an essential attribute required for success in endurance-related events. A landmark study conducted at Ball State University in the 1960's confirmed the importance of cardiorespiratory fitness to endurance performance, with findings demonstrating a strong correlation between VO_2max values and 10-mile run times (2). Additionally, studies have consistently demonstrated an inverse relationship between VO_2max values and risk of cardiovascular disease and all-cause mortality (3-4). In fact, Franklin has recently suggested that cardiorespiratory fitness should be employed as the ultimate marker for risk stratification and health outcomes (5).

Given its relationship to enhanced athletic performance and positive health, the parameters of an exercise program required to improve cardiorespiratory fitness have been studied extensively, and subsequently well-defined guidelines have been published (6). The American College of Sports Medicine (ACSM) currently recommends 20-60 minutes of aerobic exercise 3-5 days/week at an intensity of 64/70-94% of heart rate maximum, and 40/50-85% of heart rate reserve (HRR) or oxygen uptake reserve (VO_2R). Exercise intensity is arguably the most critical component of the exercise prescription model. Failure to meet minimal threshold values may result in lack of a training effect, while too high of intensity could lead to over-training and negatively impact adherence to an exercise program (5).

In a classic study 50 years ago on exercise prescription guidelines, Karvonen and colleagues (7) introduced the concept of HRR (the difference between maximal and rest heart rate) and noted a threshold intensity existed for the improvement of cardiorespiratory fitness. Historically, exercise intensity prescription by oxygen uptake (VO_2) has been based on a straight percentage of VO_2max (8). The relationship between %HRR and %VO_2max has been inconsistently reported in the literature. In the 1978 Position Stand *Recommended Quantity and Quality of Exercise for Developing and Maintaining Cardiorespiratory Fitness in Healthy Adults*, the ACSM recommends a minimum training threshold of 60% HRR or 50% VO_2max (9). The citation for this recommendation is the work by Karvonen et al. (7), although VO_2 was not actually measured in that study. The revised 1990 Position Stand *Recommended Quantity and Quality of Exercise for Developing and Maintaining Cardiorespiratory and Muscular Fitness in Healthy Adults* again cites Karvonen et al. (7), however in this report %VO_2max is considered equivalent to %HRR, and recommended an intensity threshold for improving cardiorespiratory fitness of 50 %HRR or %VO_2max (10). In contrast to the 1990 Position Stand, findings reported in several papers from the 1980's and 1990's suggest a discrepancy between %HRR and %VO_2max (11-13). These inconsistencies prompted Swain and colleagues (14-15) to address the issue in the mid-1990's at the Wellness Institute and Research Center at Old Dominion University.

Swain and Leutholtz (14) noted that at rest an individual would be at 0% of HRR, but at a finite value above 0% VO_2max depending on the fitness level of the individual. It was hypothesized that %HRR would be more equivalent to %VO_2R (difference between maximal oxygen uptake and resting oxygen uptake) compared to %VO_2max, due to the fact that at rest an individual would be at both 0% HRR and 0% VO_2R. Swain and Leutholtz (14) were able to confirm this hypothesis with data illustrating that %HRR is equivalent to %VO_2R, and not %VO_2max, during cycling exercise in healthy, young males and females. Likewise, these findings were corroborated by Swain et al. (15) during treadmill

exercise in a young, healthy population, although the regression between %HRR and %VO_2R differed statistically from the line of identity. Accordingly, in the ACSM 1998 position stand on the *Recommended Quantity and Quality of Exercise for Developing and Maintaining Cardiorespiratory and Muscular Fitness, and Flexibility in Healthy Adults* (16) and subsequent editions of the *ACSM's Guidelines for Exercise Testing and Prescription* (6,8), exercise intensity prescription by VO_2 has since been expressed as a percentage of VO_2R. Since the pioneering work by Swain et al. (14-15), more recent research in both young, healthy populations (17-18) and older, diseased populations (19-20) has consistently demonstrated that %HRR is more clearly aligned with %VO_2R, rather than %VO_2max.

In a recent edition of *Medicine and Science in Sports and Exercise*, Pintar et al. (21) reported that the components of a walking program should be consistent with the American College of Sports Medicine (ACSM) guidelines for exercise prescription. These authors went on to state that according to the *ACSM's Guidelines for Exercise Testing and Prescription* (8), the exercise intensity should range between 50 and 85% of maximal oxygen uptake (VO_2max). In fact, this statement is a misinterpretation of the current above-mentioned ACSM exercise guidelines. The 6th edition of *ACSM's Guidelines for Exercise Testing and Prescription* (8), along with the most recent edition (6), both state that the exercise intensity should be between 40 and 85% of oxygen uptake reserve (VO_2R), not %VO_2max. Upon reading the misinterpretation of the ACSM exercise intensity guidelines by Pintar et al. (21), the present authors entertained the question of whether the error was an isolated incident, or conversely, whether there was a more widespread misunderstanding of the current guidelines. A brief review of the literature indeed revealed several additional instances of the ACSM guidelines being misinterpreted (22-24). Additionally, aerobic training studies since publication of the ACSM position stand have continued to prescribe exercise intensity according to %VO_2max, not %VO_2R (22,25). Despite the shift in the ACSM guidelines from prescribing exercise in terms of %VO_2max to %VO_2R nearly 10 years ago, there appears to be inconsistency in the literature regarding accurate interpretation and application of the current guidelines. Because the ACSM exercise prescription recommendations are the most recognizable guidelines for exercise professionals, there clearly is a need to better understand the magnitude of this concern. The purpose of this study was to quantify the misapplication and misinterpretation of the current ACSM exercise intensity guidelines, based on exercise prescription in terms of %VO_2max rather than %HRR or %VO_2R. A secondary purpose was to quantify the exercise intensity prescription method applied to all training studies published in *Medicine and Science in Sports and Exercise* from January 2001 to January 2007; and to categorize the findings into methods recommended by ACSM (%HRmax, %HRR, %VO_2R, RPE) and that not recommended by ACSM (%VO_2max).

METHODS

A comprehensive literature review using MEDLINE was performed to identify research studies conducted on the effects of exercise training on cardiorespiratory fitness (VO_2max) in healthy adults from January 2000 to January 2007. Because the exercise intensity guidelines shifted from %VO_2max to %VO_2R in 1998 (16), we postulated that studies published from 1998-1999 might have been designed prior to the Position Stand. Only those studies at least 10 weeks in length, in which cardiorespiratory fitness was one of the main health outcomes, were included in the analysis. Others (14-15,18) have demonstrated that the disparity between %HRR and %VO_2max is non-significant at intensities greater than 75%, therefore only those studies in which the exercise training intensity was below (or partially below) 75% HRR or VO_2max in at least one training group were included. The following search terms were used: exercise, training, cardiovascular endurance, aerobic fitness, cardiorespiratory fitness, maximum oxygen consumption, %VO_2max, %VO_2R, oxygen uptake

reserve, heart rate reserve. Lastly, the references from research articles obtained were cross-referenced for additional studies.

The aim of the literature review was three-fold: 1) to identify studies that misinterpreted the current ACSM exercise intensity guidelines; 2) to identify examples of the ACSM exercise intensity guidelines being misapplied; and 3) to identify the exercise intensity prescription method applied to all training studies published in *Medicine and Science in Sports and Exercise* from January 2000 to January 2007. We defined misinterpretation as papers that referenced the current ACSM exercise intensity guidelines (6,8,16), but incorrectly cited intensity in terms of %VO_2max, not the correct %VO_2R. An additional step to identify sources of misinterpretation was to review popular Exercise Physiology- and Kinesiology-related textbooks used for undergraduate instruction at our own institution. Misapplication was defined as prescribing exercise intensity as part of the intervention in terms of %VO_2max. We also perused the literature for studies that established exercise intensity in correct terms that are in agreement with the current ACSM exercise intensity guidelines (%HRR or %VO_2R). The final step of our literature review was to hand-search all *Medicine and Science in Sports and Exercise* volumes and issues from January 2000 to January 2007 for all exercise training studies. We divided the obtained list into two groups based on the method of establishing training intensity: recommended by ACSM (%HRmax, %HRR, %VO_2R, RPE) and not recommended by ACSM (%VO_2max).

RESULTS

Table 1. Sources (*N* = 8) misinterpreting the ACSM exercise intensity guidelines.

Authors	*Year*	*Publication*
Branch et al. (23)	2000	Journal of Women's Health & Gender-Based Medicine
Asikainen et al. (22)	2002	British Journal of Sports Medicine
Teh & Aziz (26)	2002	Medicine & Science in Sports & Exercise
Asikainen et al. (27)	2003	Scandinavian Journal of Medicine & Science in Sports
Mackinnon et al. (28)	2003	Exercise Management Textbook
Morss et al. (24)	2004	Medicine & Science in Sports & Exercise
Pintar et al. (21)	2006	Medicine & Science in Sports & Exercise
McArdle, Katch, & Katch (29)	2007	Exercise Physiology Textbook (6th ed)

Table 1 lists studies (*N* = 6) and textbooks (*N* = 2) misinterpreting the current ACSM exercise intensity guidelines. In these sources, the authors cite the current guidelines by referencing either the 1998 Position Stand (16) or 6th edition (8) of *ACSM's Guidelines for Exercise Testing and Prescription*, yet incorrectly refer to the current guidelines in terms of %VO_2max. Table 2 lists exercise training studies (*N* = 20) in which there is both a correct application, as well as misapplication, of the current ACSM exercise intensity guidelines. An examination of Table 2 reveals that only 5 out of 20 studies (25%) used %HRR or %VO_2R to establish exercise intensity. The remaining studies (75%) established exercise intensity in terms of %VO_2max rather than the ACSM recommended %HRR or %VO_2R.

Figure 1 summarizes the method of exercise intensity used for all training studies (*N* = 33) published between January 2001 and January 2007 in *Medicine and Science in Sports and Exercise*. Those studies incorporating an exercise intensity method recommended by the ACSM included: HRmax (*N* = 7), (47-53) and %HRR (*N* = 7), (37,54-59). Those studies not incorporating an exercise intensity

method recommended by the ACSM included: %VO_2max (*N* = 19), (24,32,36,41,60-71). No studies were identified that prescribed exercise intensity in terms of %VO_2R.

Table 2. Summary of sources correctly applying (*N* = 5) and misapplying (*N* = 15) the ACSM exercise intensity guidelines.

Study	*Year*	*Age*	*Length*	*Gender*	*Mode*	*Intensity Method*	*Exercise Intensity*
Asikainen et al. (22)	2002	48-63	24 wk	F	Walk	%VO_2max	45%
	2002	48-63	24 wk	F	Walk	%VO_2max	55%
Asikainen et al. (30)	2002	48-63	15 wk	F	Walk	%VO_2max	65%
Kraus et al. (31)	2002	40-65	8 mo	M/F	Walk, Cycle, Elliptical	%VO_2max	40-55%
	2002	40-65	8 mo	M/F	Walk, Cycle, Elliptical	%VO_2max	65-80%
Morris et al. (32)	2002	63.0±1.0	10 wk	M	Cycle	%VO_2max	70-75%
Okazaki et al. (33)	2002	58-72	18 wk	M	Cycle	%VO_2max	50-80%
Asikainen et al. (27)	2003	48-63	15-24 wk	F	Walk	%VO_2max	45-65%
Okura et al. (34)	2003	34-66	14 wk	F	Walk	%VO_2max	40-50%
	2003	34-66	14 wk	F	Aerobic Dance	%VO_2max	70-85%
Park et al. (35)	2003	62.6±2.2	36 wk	F	Walk, Running, Cycle	%HRR	50-60%
Gass et al. (36)	2004	65-75	12 wk	M	Cycle	%VO_2max	50%
	2004	65-75	12 wk	M	Cycle	%VO_2max	70%
Glowacki et al. (37)	2004	18-40	12 wk	M	Running	%HRR	65-80%
Shields et al. (38)	2004	24.0±6.5	12 wk	M	Cycle, Walk	%VO_2R	50%
Duncan et al. (39)	2005	30-69	24 mo	M/F	Walk	%HRR	45-55%
	2005	30-69	24 mo	M/F	Walk	%HRR	65-75%
Duscha et al. (25)	2005	40-65	7-9 mo	M/F	Walk, Cycle, Elliptical	%VO_2max	40-55%
	2005	40-65	7-9 mo	M/F	Walk, Cycle, Elliptical	%VO_2max	65-80%
O'Donovan et al. (40)	2005	30-45	24 wk	M	Cycle	%VO_2max	60%
	2005	30-45	24 wk	M	Cycle	%VO_2max	80%
Coker et al. (41)	2006	65-90	12 wk	M/F	Cycle	%VO_2max	50%
	2006	65-90	12 wk	M/F	Cycle	%VO_2max	75%
DiPietro et al. (42)	2006	73.0±10	9 mo	F	Walk	%VO_2max	50%
	2006	73.0±10	9 mo	F	Walk	%VO_2max	65%
	2006	73.0±10	9 mo	F	Walk	%VO_2max	80%
Ring-Dimitriou et al.(43)	2006	40-60	24 mo	M/F	Cycle	%VO_2max	50-65%
Sarsan et al. (44)	2006	20-60	12 wk	F	Walk, Cycle	%HRR	50-85%
Church et al. (45)	2007	45-75	6 mo	F	Walk, Cycle	%VO_2max	50%
Stephens et al. (46)	2007	30-45	10 wk	F	Walk, Cycle, Air Dyne	%VO_2max	70%

DISCUSSION

The main finding of the present study is that based on the review of many research studies, there is considerable misapplication and misinterpretation of the current ACSM exercise intensity guidelines in the literature. Despite the ACSM's shift in recommending the use of %VO_2R in place of %VO_2max, there continues to be erroneous representation of the guidelines in the literature (Table 1), as well as the frequent use of %VO_2max in the methodology of aerobic training studies (Table 2). Furthermore, the majority of exercise intervention studies published in the ACSM's journal (*Medicine and Science in Sports and Exercise*) have continued to use an outdated method for prescribing exercise intensity,

rather than one of the current methods recommended by the most recent published guidelines (Figure 1).

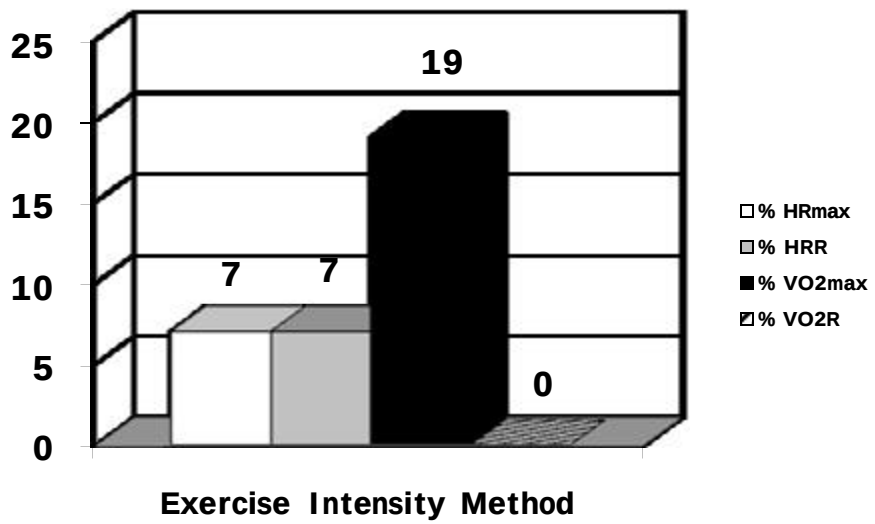

Figure 1. Exercise training studies published in *Medicine and Science in Sports and Exercise* between January 2001 to January 2007 and the various exercise intensity methods applied.

Swain introduced the VO_2R concept 10 yrs ago and postulated that %HRR would be more closely aligned with the new term compared to $\%VO_2max$ (14). Subsequent research by Swain et al. (14-15) and others (17-20) has substantiated this idea and, consequently, the ACSM changed its exercise intensity recommendation to reflect the closer relationship between %HRR and $\%VO_2R$. According to Swain et al. (15) one of the major advantages of prescribing exercise intensity based on $\%VO_2R$, rather than $\%VO_2max$, is that it provides an equivalent relative intensity for individuals of different fitness levels. Consider the following example of two individuals with VO_2max values of 25 and 50 $mL \cdot kg^{-1} \cdot min^{-1}$, respectively. At rest, the 25 $mL \cdot kg^{-1} \cdot min^{-1}$ individual is at 14% VO_2max, while the 50 $mL \cdot kg^{-1} \cdot min^{-1}$ individual is at 7% VO_2max. If the intensity of the exercise prescription is set at 50% VO_2max, the 25 $mL \cdot kg^{-1} \cdot min^{-1}$ individual increases by 36%, compared to the 50 $mL \cdot kg^{-1} \cdot min^{-1}$ individual who increases by 43%, in terms of $\%VO_2max$. The discrepancy in relative adjustments in training intensity in the above example may result in disparate training effects between the two individuals. Conversely, if the $\%VO_2R$ method were used, the individuals would both increase by identical adjustments in relative intensity (15). The continued use of $\%VO_2max$ in some training studies raises the question of whether or not exercise intensities are truly being controlled among subjects in these investigations (Table 2).

In 2002, Swain and Franklin (75) reviewed exercise training studies in an effort to identify the minimal threshold intensity required to improve cardiorespiratory fitness in terms of $\%VO_2R$. It was concluded that individuals with initial VO_2max values less than 40 $mL \cdot kg^{-1} \cdot min^{-1}$ may experience a training effect at intensity levels as low as 30% VO_2R, while those individuals with baseline VO_2max values greater than 40 $mL \cdot kg^{-1} \cdot min^{-1}$ may need to exceed a training threshold greater than 45% VO_2R. Given the importance of cardiorespiratory fitness to overall health, these findings provided the exercise professional with important information regarding the minimal training intensity requirements for the exercise program of their clientele. However, the authors (75) cautioned that a limitation to the analysis was the translation of $\%VO_2max$ to $\%VO_2R$ exercise intensity using group mean values. They went on to say that their findings should be considered preliminary until confirmed or refuted by

future studies establishing exercise intensity in %VO_2R terms. According to our findings, this very important recommendation has failed to be examined further by researchers. We feel this is unfortunate given the importance of understanding the dose response relationship between exercise intensity and cardiorespiratory fitness, along with the minimal training threshold necessary for yielding positive changes to this critical health outcome.

The continued use of an outdated exercise recommendation (%VO_2max) highlights a problem brought to the attention of our field nearly 30 years ago. In the 1978 Position Stand *Recommended Quantity and Quality of Exercise for Developing and Maintaining Fitness in Healthy Adults* (9), it was noted that although much research has been done pertaining to exercise training and the human organism, a lack of standardization in training methodology made interpretation difficult. Similar comments were also published in both the 1990 and 1998 Position Stands (10-11). If it is indeed true that establishing exercise intensity in %VO_2max terms places individuals with different fitness levels at different training stimuli as claimed by Swain et al. (15), then many important research questions continue to remain fully understood. For example, research aimed at identifying the minimal dose ($kcal^{-1} \cdot wk^{-1}$) of exercise required to elicit positive changes to cardiorespiratory fitness must control exercise intensity (22). If exercise intensity is prescribed in terms of %VO_2max to a population with heterogeneous initial VO_2max values, individuals make dissimilar adjustments from rest to exercise VO_2, and consequently exercise intensity has become a confounding variable and a considerable limitation to the study. Likewise, research intended to elucidate the genetic contribution to the trainability of cardiorespiratory fitness would control exercise intensity (70). Once again, exercise prescription by %VO_2max will result in dissimilar training intensities for individuals with un-equivalent baseline VO_2max values, potentially resulting in different training effects.

We identified two undergraduate textbooks in which the exercise intensity guidelines were misinterpreted by the authors (28-29). This finding is particularly disconcerting given the fact that these textbooks serve as important resources for future professionals in our field. If the current exercise intensity guidelines are not being properly presented in the academic setting, then it becomes increasingly likely that their misinterpretation and misapplication will continue to be perpetuated in the future. Furthermore, the general public looks to exercise professionals for guidance in their individual pursuits of health and fitness. Inconsistency in both the literature and among exercise professionals concerning the appropriate exercise intensity guidelines may lead to confusion for clientele, which may negatively impact adherence and effectiveness of an exercise program. Ultimately, the misinterpretation of the current exercise intensity guidelines reflects poorly on our profession.

CONCLUSIONS

Based on the present findings, we conclude that there is considerable misinterpretation and misapplication of the current ACSM exercise intensity guidelines. Despite the ACSM's shift in recommending the use of %VO_2R in place of %VO_2max, there continues to be erroneous interpretation of the guidelines in the literature (Table 1), as well as the frequent use of %VO_2max in the methodology of aerobic training studies (Table 2). Because the ACSM exercise prescription recommendations are the most recognizable guidelines for exercise professionals, it would seem responsible for both authors and reviewers to take care that they are correctly interpreted and reported in future publications. What is the genetic contribution of cardiorespiratory fitness? What is the minimal threshold intensity for improving cardiorespiratory fitness? What is the dose response relationship between exercise amount and cardiorespiratory fitness? These very important questions, and others, will remain to be completely understood until exercise intensity is standardized in the methodologies across studies. In agreement with the ACSM guidelines and others (6,8,14-16,75), we

recommend that future studies prescribe exercise intensity using %HRR or %VO_2R, rather than %VO_2max, to ensure all subjects are exercising at similar relative intensity levels. Additionally, we recommend that exercise professionals familiarize themselves with the current exercise intensity guidelines for cardiorespiratory fitness.

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