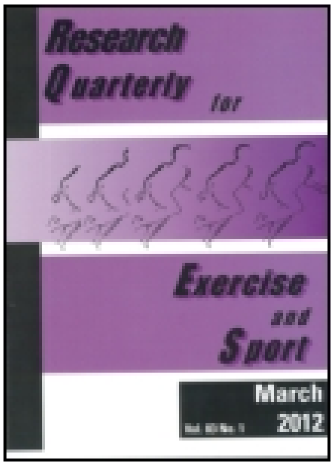

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Ratings of Perceived Exertion of ACSM Exercise Guidelines in Individuals Varying in Aerobic Fitness

Christopher Kaufman, Kris Berg, John Noble, and James Thomas

The physiological responses of high (HF) and low fit (LF) individuals at given perceived exercise intensities were compared to ranges provided by the American College of Sports Medicine (ACSM). Participants were 7 LF and 8 HF men between the ages of 22 and 26 years. All participants performed a maximum oxygen uptake and lactate threshold test and two 15-min experimental runs in which they exercised at a constant perceived exercise intensity (RPE 13 and 17). The LF group exhibited significantly greater maximum oxygen uptake reserve (%VO_2R; $p < .05$) and velocity of lactate threshold ($p < .01$) values than HF at RPE 13 and 17. Both groups had significantly greater %VO_2R and maximum heart rate values at RPE 13 in comparison with the ACSM ranges, using the highest value for the given range ($p \leq .001$).

Key words: blood lactate concentration, oxygen consumption, psychobiology, running

Physical activity has been found to be beneficial in preventing and/or treating coronary artery disease, cancer, Type 2 diabetes, obesity, osteoporosis, hypertension (Franklin, 2000), and Parkinson's disease (Reuter & Engelhardt, 2002). To achieve cardiopulmonary benefits, it is necessary to engage in the proper amount and intensity of physical activity. To this end, the American College of Sports Medicine (ACSM, 1998) published recommended guidelines for the quantity and quality of exercise to achieve and maintain cardiorespiratory fitness. The ACSM recommended 20–60 min of continuous or intermittent exercise, 3–5 days/week at an intensity of 55/65–90% of maximum heart rate (HRmax), or 40/50–85% of maximum oxygen uptake reserve (VO_2R; the maximum oxygen uptake [VO_2] attained minus the resting VO_2) or heart rate reserve (HRR; ACSM, 1998). For unfit individuals, the recommended intensities for improving maximal aerobic capacity (VO_2max) are at the lower end of these ranges, 40–49% of VO_2R or HRR and 55–64% of HRmax, respectively. For fit individuals, the recommended intensities are greater and lie in the middle to upper portions of the ranges.

When considering individuals' fitness levels, research has moderately supported using RPE to prescribe exercise intensity. A study done by Felts, Crouse, and Brunetz (1988) indicated no relationship between fitness level and RPE in college-age women at exercise intensities of 30% and 60% of VO_2max. In another study, low-active women did not differ significantly at a given RPE value from high-active women in their percentage of VO_2max (Parfitt, Eston, & Connolly, 1996). Thus, these studies supported use of the ACSM recommendations for individuals of high and low aerobic fitness.

However, other research showed that fitness level may affect RPE. Studies have shown that high and low fit individuals reported significantly different RPE at various percentages of VO_2max, indicating that untrained individuals rate their perception of effort at a given relative exercise intensity as more intense or harder than trained

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individuals at the same relative intensity (Demello, Cureton, Boineau, Singh, 1987; Sylva, Byrd, Magnum, 1990). Another study indicated that sedentary individuals, whether cycling or running, reported a greater perception of exertion than trained cyclists and runners at the same relative work rates (Hassmen, 1990). It was suggested that the primary mechanism responsible for the difference in RPE was the greater initial blood lactate accumulation (BLA), followed by a greater BLA rate for the sedentary group. It is also possible that highly trained individuals' enhanced ability to clear lactate aided in this difference in BLA and, subsequently, the difference in RPE.

Despite this conflicting research, the ACSM (1998) recommendations assigned certain RPE ranges to associated relative exercise intensities. For example, the RPE assigned to the intensity classified as "moderate," 40–59% of VO_2R or HRR, is 12–13 (somewhat hard) using the Borg 6–20 scale. Intensities classified as "very hard" represent RPE of 17–19 and are categorized as ≥ 85% of VO_2R or HRR (ACSM, 1998).

To the authors' knowledge, no published studies directly examined the ACSM (1998) recommendations for RPE and exercise intensity in individuals of varying fitness levels using a production protocol design (controlling RPE rather than VO_2 or HR). This design tests application of the ACSM guidelines, as it commonly occurs in clinical and recreational settings (i.e., assigning a given RPE level assuming the desired VO_2 and HRR are elicited). This study compared the physiologic response (i.e.,%VO_2R, blood lactate concentration, %LT, and %HRmax) in high fit/active (HF) and low fit/inactive (LF) men exercising at two levels of RPE (13 = somewhat hard and 17 = very hard) via a production protocol. The study also examined the ACSM recommendations by comparing %VO_2R and %HRmax in HF and LF men at these RPE values.

Method

Participants

Prior studies of the effect of aerobic fitness level on RPE have typically used participants of one gender. This was most likely because gender has been shown to influence subjective rating of effort (Grant et al., 2002; Travlos & Marisi, 1996; Winborn, Meyers, & Mulling, 1998). Because of potential intraparticipant variability on RPE due to menstrual cycle influence, women were not used as participants. Therefore, male volunteers from Omaha, NE, were recruited via fliers outlining the specific participant characteristics (e.g., men who exercised at a high intensity ≥ 3 days/week or at low intensity ≤ 1 days/week) and the study requirements (maximal exercise test, lactate threshold test, and two additional exercise sessions). Most participants were students at the University of Nebraska at Omaha. The age range was limited to 19–39 years. Potential participants completed a medical history form and brief exercise history form to determine study eligibility. All were free of any health contraindications for maximal exercise testing (Franklin, 2000), such as pain or chest discomfort due to ischemia, palpitations or tachycardia, or shortness of breath at rest or with mild exertion. Each participant read a complete description of the testing protocols and the associated risks and then provided written informed consent.

Participants who exercised aerobically ≥ 3 days/week at an estimated intensity of ≥ 10 metabolic equivalents (METS) in the previous 4 months were placed in the HF group. Participants who exercised ≤ 1 day/week at an estimated intensity of ≤ 10 METS for 30 min in the previous 4 months were placed in the LF group. If a participant indicated he exercised < 1 day per week for 30 min or less in the previous 4 months, a total cholesterol blood test was performed in the laboratory per recommendation of the University of Nebraska Institutional Review Board. The participant's total cholesterol level had to be less than 200 mg/dL to meet inclusion criteria. The grouping of participants was validated after the first visit, when they performed a maximal treadmill test to determine VO_2max. Five participants were not included for analysis, because their VO_2max values did not meet inclusion criteria. Therefore, a final sample of 15 participants was included for analyses.

To demonstrate that groups were significantly different in training and aerobic capacity, independent t tests were performed for weight, HRmax, VO_2max, VO_2R, lactate threshold (LT), and velocity of LT (vLT; see Tables 1 and 2). Significant differences between HF and LF were found for weight, $t(13) = 2.76$, $p < .05$; VO_2max, $t(13) = 5.53$, $p < .001$; VO_2R, $t(13) = 5.53$, $p < .001$, and vLT, $t(13) = 4.26$, $p < .001$.

The participants were divided into two groups: (a) high in aerobic fitness and active (VO_2max of 50–75 ml/kg/min), and (b) low in aerobic fitness and inactive (VO_2max of 35–45 ml/kg/min). Activity level was determined through a brief exercise history form completed by participants. The VO_2max values used to validate group status were chosen, because they fell in the upper and lower quintiles of percentile ranking for maximal aerobic power: > 85th (50 ml/kg/min) and < 50th (45 ml/kg/min) percentiles, respectively (Franklin, 2000).

Design

The study involved four testing sessions conducted on different days with at least 48 hr between visits to ensure the participants were rested. The participants were instructed not to consume food 4 hr prior to testing or exercise earlier that day. Furthermore, participants were told not to consume caffeine 8 hr prior to testing, as it has been shown caffeine may affect RPE (McArdle, Katch, & Katch, 2001). If participants chose to exercise on the day before a visit, they were instructed to perform "easy" exercise sessions. Verification of adherence to the above-mentioned study requirements was obtained prior to each testing session. If a participant did not adhere to the requirements, the visit was rescheduled. All participants adhered to the requirements for all visits, and, therefore, no visits were rescheduled.

To limit the potential influence of the researcher's body language on the participant's report of RPE, the researcher positioned himself outside the participant's view. In addition, the participant was required to indicate RPE every time he heard a beeping noise produced by a tape-recorder. This was done to eliminate the potential bias of the researcher's verbal tone.

Peak Oxygen Uptake Test

Each participant listened to the following instructions prerecorded by the investigator. In addition, the participant received a written copy of the verbal instructions, which were adapted from Borg (Pollock & Wilmore, 1990):

> During the exercise session we want you to rate your perception of exertion, meaning the total amount of exertion and physical fatigue. Don't concern yourself with any one factor, such as leg pain or shortness of breath, but try to concentrate on your total inner feeling of exertion. We want you to use this scale, where 6 means no exertion at all and 20 means maximal exertion; 9 is very light exercise; 13 on the scale is somewhat heavy exercise, but it still feels fine, and you should not have any problems to continue exercising; 17 is very hard, it is really very strenuous, and you have to push yourself very much; 19 on the scale is an extremely strenuous exercise. For most people, this is an exercise as strenuous as they have ever experienced before. Therefore, when you are exercising, you will be required several times to provide the number from the scale that corresponds to your feeling of exertion and physical fatigue. You will report this number to the investigator when you hear the following beep noise [beep].

On confirming the participant's understanding of the RPE instructions, the participant's height (cm), weight (kg), resting heart rate (bpm) and blood pressure (mmHg) were measured and recorded. Participants performed a maximal treadmill test to determine their VO_2max. The test began with a familiarization stage and warm-up, which was set at 53.6 m/min for 2 min and 80.4 m/min for 2 min. Following the warm-up, the work rate was continually increased 26.8 m/min every 2 min until the participant's respiratory exchange ratio (RER) reached 0.91–.094. At this point, the speed remained constant, while the grade increased 1% each minute. The test was terminated once the participant was unable to continue at the given incline and speed. Collected expired air was analyzed every 30 s using a metabolic cart (Sensor Medics Vmax Series, Yorba Linda, CA). RPEs were collected in the last 15 s of each

Table 1. Characteristics of the high fit group (n = 8)

Variable	*M*	*SD*	Minimum	Maximum
Age (years)	23.9	1.3	22	26
Weight (kg)	76.6*	14.2	55.9	96.8
HRmax (bpm)	190.6	6.2	182	204
VO_2max (ml/kg/min)	59.2**	8.4	51.2	72.9
VO_2R (ml/kg/min)	55.7**	8.4	47.7	69.4
LT (mmol/L)	5.1	1.5	2.6	6.6
vLT (m/min)	225.1**	1.9	182.2	305.5

Note. M = mean; *SD* = standard deviation; HRmax = maximum heart rate; VO_2max = maximal aerobic capacity; VO_2R = maximum oxygen uptake reserve; LT = lactate threshold; vLT = velocity of LT; significance indicates difference from the low fit group.
*$p < .05$.
**$p < .001$.

Table 2. Characteristics of the low fit group (n = 7)

Variable	*M*	*SD*	Minimum	Maximum
Age (years)	24.1	1.6	22	26
Weight (kg)	93.4*	7.9	82.7	103.2
HRmax (bpm)	194.6	3.3	188	198
VO_2max (ml/kg/min)	40.1**	3.0	36.1	44.4
VO_2R (ml/kg/min)	36.6**	3.0	32.6	40.9
LT (mmol/L)	5.2	1.5	2.9	7.9
vLT (m/min)	150.1**	0.7	126.0	176.9

Note. M = mean; *SD* = standard deviation; HRmax = maximum heart rate; VO_2max = maximal aerobic capacity; VO_2R = maximum oxygen uptake reserve; LT = lactate threshold; vLT = velocity of LT; significance indicates difference from the high fit group.
*$p < .05$.
**$p < .001$.

stage. RPE data from this visit and the subsequent visit were not used for analysis, but rather allowed the participant to become familiar with the Borg 6–20 RPE scale and how to use it appropriately for the experimental visits. To ensure a valid VO_2max test, three of the following four criteria were required: RER > 1.10, max HR within 10 bpm of age-predicted max HR, RPE ≥ 19, and a failure to increase VO_2 by 150 ml/min with increased workload (plateau of VO_2). All VO_2max tests met this criterion and, consequently, were considered valid.

Lactate Threshold Test

On their second visit, participants' LT and velocity of LT (vLT) were obtained. They performed the LT test on a treadmill. At the beginning of each LT protocol session, the participant reviewed the tape-recorded and written instructions for the appropriate use of the Borg 6–20 RPE scale. The protocol for each LT test was based on the participant's VO_2max test. Therefore, the protocol relied on the concept that aerobically fit, trained individuals typically exhibit LT at 80–85% of VO_2max, and aerobically unfit, untrained individuals display LT at 50–60% of VO_2max (McArdle et al., 2001). The assumed vLT occurred just prior to the third blood sample. Thus, two blood samples were obtained below LT and two to three samples were above LT. This allowed for an accurate acquirement of the LT via the Dmax method, which consisted of plotting velocity on the x-axis and blood lactate concentration (BLC) on the y-axis, as outlined by Cheng et al. (1992), who found no statistical differences between this method and the conventional linear regression method. Because BLC varies for LT (McArdle, 2001), the Cheng et al. (Dmax) method appears to be more valid in identifying each individual's LT. Consequently, the Dmax method allowed the researcher to individualize the lactate response during exercise. Therefore, its primary advantage over conventional methods was that it provided an objective and reliable method for determining threshold.

The test protocol began with a warm-up stage in which the participant walked at 53.6 m/min for 2 min followed by 80.4 m/min for 3 min. Following warm-up, each stage was 5 min. RPE and heart rate were obtained 15 s prior to the end of each 5-min stage. After each 5-min stage, the treadmill was slowed to a stop, and blood samples were taken. The participant's finger was first cleansed with an alcohol swab, wiped with a cotton ball, and then stuck with a sterilized lancet to draw blood for immediate BLC analysis using an Accusport blood lactate analyzer (Total Performance, Inc., Mansfield, OH). After the approximate 1-min blood draw period, the participant stepped onto the treadmill for another 5 min of running at an increased speed of 16.1 m/min. The 5:1 run-to-rest cycle continued until the participant reached volitional fatigue. If a participant stopped during a stage, the treadmill was slowed to a stop and one last blood sample was taken for a final blood lactate reading. The participant was allowed to cool down on the treadmill at a self-selected pace. BLCs obtained from the test were used to determine LT and vLT.

Experimental Runs

The format for both experimental runs required participants to exercise on a treadmill for 15 min at an intensity specific to the experimental condition (RPE 13 and 17 on the Borg 6–20 scale). The sessions were set at 15 min, primarily because of the feasibility for LF participants to exercise at high intensity (RPE 17). It was believed that asking LF participants to exercise at such an intensity longer than 15 min would create inaccuracies in the data obtained at the later stages of the protocol (e.g., beyond 15 min). Pilot experiments with 2 moderate-to-low fit individuals indicated they had difficulty maintaining exercise due to extreme fatigue beyond 15 min. If the duration of the exercise protocols were compromised due to inability to complete the experimental condition, the comparisons of physiological responses between conditions would be severely limited. The low-intensity exercise condition was chosen to be RPE of 13 instead of 12, as it is the value on the Borg 6–20 RPE scale with the verbal indicator of physical effort, "somewhat hard." Using 12 could be potentially problematic, as it does not have a verbal indicator and, thus, might be difficult for a participant to correctly identify the desired level of physical effort. Consequently, the 15-min time period and exercise intensities of RPE 13 and 17 for the experimental session appeared justified and feasible to all study participants.

The protocol required participants to work at a given perceived intensity. Each participant informed the researcher to increase or decrease the treadmill speed so that he felt he was always exercising at that intensity. Furthermore, the participants were unaware of the speed at which they were exercising. This was done to minimize participants' previous treadmill experience. A 5-min warm-up stage began the session with the participant walking at 53.6 m/min for 2 min and 80.4 m/min for 3 min. This was followed with a 15-min exercise session in which the participant wore a mask connected to a metabolic cart to collect VO_2. The participant could inform the researcher to change the velocity at any time during the exercise bout. Every minute, the participant was queried to ensure he was exercising at the given RPE level and determine whether the intensity needed to be adjusted. Any change in work rate (treadmill speed) was recorded along with the time the work rate changed. Heart rate data were collected every minute. VO_2 data were collected every 30 s. In addition, the treadmill was stopped momentarily after the 5th, 10th, and 15th min, to obtain blood samples, after which the treadmill was started again and adjusted to the participant's preference for the condition.

The fourth and final visit followed the same protocol and data collection procedures of Visit 3, except the alternate exercise intensity condition was used. On completing the exercise session and cool down, the participant was informed of his VO_2max and LT and how those measures could aid him in beginning or continuing his exercise program.

Data Analysis

A series of two-sided independent *t* tests were performed for %HRmax, %VO_2R, BLC, %LT and %vLT to compare HF and LF at RPE 13 and 17. The ACSM (1998) values of %VO_2R and %HRmax for a RPE of 13 are provided in a range, 40–59 %VO_2R and 55–69% HRmax, and, consequently, analyses were performed on the highest value of the range (59% VO_2R and 69% HRmax). Therefore, a correlated *t* test was performed for the mean difference of the participants' %VO_2R and %HRmax to that of the ACSM value. In addition, to compare ACSM ranges of %VO_2R at RPE 13 and 17, sensitivity measures were calculated to identify the percentage of participants (both HF and LF) who had %VO_2R and %HRmax values within the ACSM ranges. The alpha level for all statistical procedures was set at .05. An a priori power calculation was not obtained for the study; however, post hoc power calculations are presented with the results of the study.

Results

RPE 13 Condition

The results indicated a significant difference between groups for %VO_2R at RPE 13, $t(13) = 2.86$, $p = .013$. This was an unexpected finding in that the LF participants' %VO_2 was greater than their HF counterparts. However, no difference in %HRmax was found between HF and LF participants at the RPE 13. No significant differences were found between groups at RPE 13 for %LT, $t(13) = 1.80$, $p = .096$. Moreover, no significant differences were found between groups for BLC at RPE 13, $t(13) = 1.76$, $p = .10$. Table 3 displays the means of all variables compared for fitness level and perceived intensity.

RPE 17 Condition

The results indicated no differences between HF and LF participants in %HRmax, %LT, and BLC at RPE 17. However, a significant difference was found for %VO_2R, $t(13) = 2.30$, $p = .042$. This result indicated that LF participants were using a greater proportion of VO_2R than the HF participants. A significant difference between groups was found for %vLT in both exercise intensity conditions, $t(13) = 3.68$, $p = .003$ (RPE 13) and $t(13) = 3.87$, $p = .002$ (RPE 17). This indicated that the LF participants ran at a greater percentage of their vLT than the HF participants for both RPE levels. Post hoc power calculations for %VO_2R and %vLT indicated the study had 77% and 91% power to detect differences between groups.

As indicated in Tables 1 and 2, the HF and LF groups differed significantly in weight ($p < .05$). A 2 x 2 analysis of covariance performed a posteriori with weight (kg) as a covariate revealed no change in the results.

Comparison With ACSM Recommendations

A one-sample *t* test indicated that the LF participants' mean %VO_2R (78.0 ± 3.9 %) was significantly higher than the ACSM (1998) values at RPE 13, $t(6) = 12.7$, $p < .001$.

Table 3. Physiologic response of high fit and low fit participants at varying perceived intensities

	High fit (n = 8)				Low fit (n = 7)			
	RPE 13		RPE 17		RPE 13		RPE 17	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
%VO_2R	70.5*	5.9	86.8*	3.5	78.0*	3.9	91.3*	4.2
%HRmax	81.4	4.7	91.5	4.2	81.4	4.0	91.0	3.0
%LT	80.9	21.4	189.7	76.9	105.8	31.9	194.6	51.4
BLC (mmol/L)	3.9	1.4	8.7	2.6	5.4	2.0	10.5	3.3
%vLT	87.6**	7.2	108**	8.6	103**	9.4	129**	11.9

Note. RPE = perceived exercise intensity; *M* = mean; *SD* = standard deviation; VO_2R = maximum oxygen uptake reserve; HRmax = maximum heart rate; LT = lactate threshold; BLC = blood lactate concentration; vLT = velocity of LT; asterisk indicates significant difference between high fit and low fit at the same RPE.
rating.
*$p < 0.05$.
**$p < 0.01$.

HF participants' mean %VO_2R (70.5 ± 5.9 %) was significantly higher than the ACSM values at RPE 13, $t(7) = 5.56$, $p < .001$. Again, these statistics were calculated using the ACSM's highest value within the given range (59 %VO_2R).

Similar to the results regarding the ACSM (1998) %VO_2R values, significant differences were found when comparing the %HRmax values of all participants and ACSM values for %HRmax at RPE 13. The results indicate that HF participants' mean %HRmax values (81.4 ± 4.7 %) were significantly higher than ACSM values at RPE 13, $t(7) = 7.43$, $p < .001$. In addition, mean %HRmax values (81.4 ± 4.0 %) for LF participants were significantly higher than ACSM values at RPE 13, $t(6) = 8.27$, $p < .001$. These statistics were calculated using the ACSM's highest value within the given range (69% HRmax).

Sensitivity is the percentage of individuals correctly identified within a range for a given dependent variable. When sensitivity is high, individuals are correctly identified as having values within the range. In the context of this study, sensitivity was calculated to show how many participants were accurately classified using the classification ranges of ACSM (1998) values for %VO_2R and %HRmax at RPE 13 and 17. The results indicated that for RPE 13 no participants were within the given ACSM ranges for %VO_2R. This further supports the finding that both HF and LF participants were using a greater percentage of their VO_2R than that indicated by the ACSM, when participants exercised at a perceived intensity of somewhat hard (RPE 13). Conversely, the results indicated that 100% of the LF participants and 75% of the 8 HF participants were within the ACSM range for RPE 17.

Similar to the results indicated, prior comparison via sensitivity analysis of the classification ranges of ACSM (1998) values for %HRmax to actual %HRmax values in HF and LF indicated no participants were appropriately classified using the ACSM range at RPE 13. However, at RPE 17, 75% of HF and 71.4% of LF participants were appropriately classified within the ACSM ranges.

Discussion

RPE 13 Condition

The most significant finding of the RPE 13 condition was that the LF participants used a greater percentage of VO_2R than the HF participants (see Figure 1). A possible mechanism contributing to this finding might be explained in part by examining the participants' %LT values. Figure 2 shows the relative response of %VO_2R and %LT in HF and LF across time at RPE 13. It clearly indicates the relatively constant response of the HF participants for both variables. However, it is interesting to note the rise in %LT for the LF group. For the last 10 min of the run, the LF participants consistently ran at an intensity above their LT. The mean value for the entire run for this group was 105.8 ± 31.9 %LT, whereas the HF participants consistently ran below their LT (80.9 ± 21.4 %). The large standard deviations suggest a large amount of variability in response and may explain why no significant differences were found between the two groups for this variable. However, 5 of the 7 LF participants were at or above LT during the 15-min run. Thus, as these participants exercised at intensities above their LT, the slow component of VO_2 would be influential (Saunders et al., 2000).

Briefly, the slow component of VO_2 causes an increase in oxygen cost when individuals exercise above LT. The mechanism has been suggested to occur due to increased use of additional muscle fibers, specifically type II muscle fibers (Saunders et al., 2000). Consequently, as the LF participants worked above LT, the slow component in theory would be expected to escalate the oxygen cost, which might account for the significantly higher values of %VO_2R compared to the HF group. The HF group ran at a rate less than their LT throughout the 15-min run, and, therefore, their data were probably not affected by the slow component. Perhaps the role of the

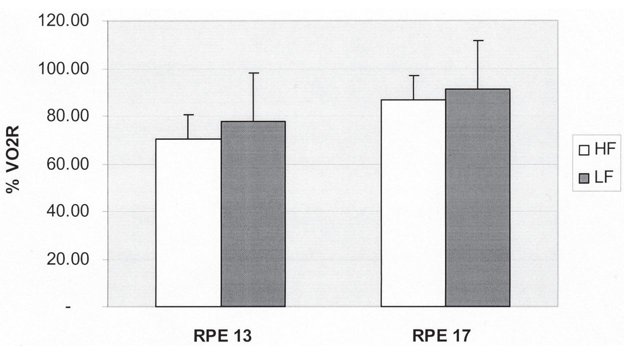

Figure 1. High fit (HF) and low fit (LF) maximum oxygen uptake reserve (% VO_2R) values at perceived exercise intensity (RPE) 13 and RPE 17.

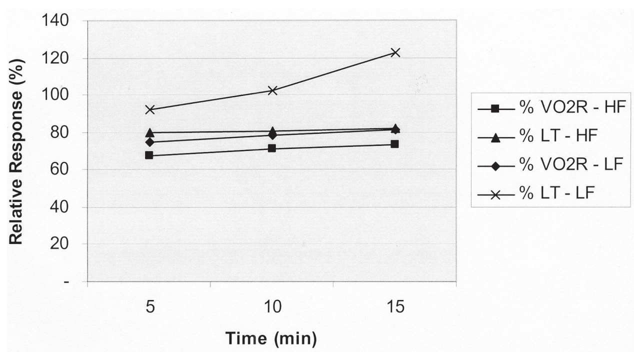

Figure 2. Physiological responses of groups at perceived exercise intensity (RPE) 13 across time (VO_2R = maximum oxygen uptake reserve; LT – low fit; HF = high fit).

slow component explains much of the variance seen between the two groups in %VO_2R at RPE 13.

The impact of the slow component on %VO_2R might best explain why the results are contrary to prior findings. Prior research suggested that at comparable relative exercise intensities low fit/untrained individuals rated their perception of effort greater than high fit/trained individuals (Demello et al., 1987; Hassmen, 1990; Travlos & Marisi, 1996). Travlos and Marisi (1996) had male participants of high (VO_2max > 56 ml/kg/min) and low fitness (VO_2max < 46 ml/kg/min) cycle at various relative exercise intensities (40–80 %VO_2max) and collected reports of perceived exertion for each intensity. The results indicated that when controlling for VO_2max values, HF men reported significantly lower RPE than LF men. In the context of the present study, the results of these studies suggest the LF individuals would work at lesser relative oxygen costs than HF individuals, when the RPE is controlled. As mentioned, this did not occur. Other studies have indicated that differences are not apparent in individuals varying in fitness level (Felts, Crouse, & Brunetz, 1988; Parfitt, Eston, & Connolly, 1996). Because prior studies investigating the effect of fitness level on RPE have not used designs that measured LT, their findings could not address the influence of the slow component. Therefore, a potential explanation for the present study's contradiction with previous research resides in the role of the VO_2 slow component.

RPE 17 Condition

Previous research has suggested that differences in perceived exertion in HF and LF individuals are least apparent at less strenuous exercise intensities but most evident at higher exercise intensities (Demello et al., 1987; Hassmen, 1990; Travlos & Marisi, 1996). Of the variables measured, the RPE 17 condition revealed significant differences between HF and LF only for %VO_2R and %vLT. The LF individuals ran at a greater percentage of vLT than HF individuals. Despite this difference, no significant differences were apparent between groups in BLC and %LT. This appears paradoxical, as one would assume a group running at a greater percentage of vLT would use a greater percentage of LT. The most evident explanation for the lack of significance in %LT lies in the large amount of variability within the groups (LF = 194.6 $\pm$ 51.4%, HF = 189.7 $\pm$ 76.9%).

The lack of difference in BLC between groups supports previous findings (Seip, Snead, Pierce, Stein, & Weltman, 1991) and disputes other research (Demello et al., 1987; Hassmen, 1990). Seip et al. (1991) investigated the effect of training state in men on RPE obtained at LT and fixed BLC of 2.0, 2.5, and 4.0 mM. These authors found no differences between groups in RPE at all BLC conditions. In the present study, HF and LF showed no difference in BLC response at RPE 13 and 17. Consequently, the results of the Seip et al. study corroborate the findings of the present study in that blood lactate response is similar between groups varying in training status at a given RPE. Therefore, it appears that blood lactate as a potential physiologic mediator of perceived exertion is similar in LF and HF participants.

Comparison With ACSM Recommendations

Another pertinent finding of this study, in relation to the RPE 13 condition, is the lack of sensitivity of the ACSM (1998) classification ranges for %VO_2R and %HRmax. All participants, when asked to exercise at a perceived intensity of somewhat hard (RPE 13), used a higher percentage of VO_2R and HRmax than the highest value within the ACSM's range. Examining the sources cited to justify the ACSM ranges indicates the results of the present study are contrary to them (Borg, 1982; Pollock & Wilmore, 1990; Robertson & Noble, 1997). Their research imparts correlation evidence of RPE with relative oxygen consumption and heart rate. It is important to note that these studies all used protocols in which oxygen consumption (% VO_2max) or heart rate (%HRmax) were controlled, thereby allowing the researchers to correlate the RPE given during the experimental bout at a selected %VO_2R with the RPE given from a prior baseline test. However, in a graded protocol, each stage influences the RPE and physiological responses of succeeding stages. Consequently, the correlation of RPE and physiological data are influenced. The present design can test the degree at which the VO_2 and HR responses will fall within a specified range, when people exercise at a given RPE. In support of this notion, to the authors' knowledge, no studies have directly examined the ACSM ranges using the design and types of participants researched here. Consequently, the current study has no research against which to directly compare its findings. The results suggest that the classification scheme is not without error.

A study by Kohrt, Spina, Holloszy, and Ehsani (1998) indicated similar contradictions to ACSM's (1998) classification of perceived exercise intensities in elderly women (*M* age = 66 year, *SD* = 4). These authors investigated how the declination of VO_2 and HR seen in aging might affect the applicability of the ACSM's guidelines for exercise prescription. The results applicable to the present study indicated the elderly participants perceived exercise intensities of 64% and 70% HRmax as 9 and 11 on the Borg 6–20 RPE scale, respectively. However, the ACSM's guidelines indicated the RPE associated with these relative exercise intensities should be 12 or 13. Despite differences in the samples studied (elderly women vs. young men), these findings support the present study's results in that they strengthen the notion the ACSM's guidelines might not accurately classify all persons.

Overall, the findings of this study indicate the presence of greater variability in the physiological response at RPE 13 than what was suggested (ACSM, 1998). Pollock and Wilmore (1990) noted the imperfection of using the RPE scale in prescribing exercise for all individuals: "…it (Borg 6–20 RPE scale) should not be used or interpreted in a vacuum. It is not a perfect scale and should be used in conjunction with common sense and other pertinent clinical, psychological, and physiological information." (p. 293). In light of these comments, the results of this study could be interpreted as evidence of the large amount of variability within individuals when using the RPE scale for prescribing aerobic training exercise.

Limitations

The relatively homogenous (college-age men) and small sample size reduce the ability to generalize the results and, therefore, are limitations of the study. Further investigations in low and high fit women are needed. However, the results reveal the potential for interindividual differences to influence the ability of the ACSM (1998) guidelines to classify these individuals accurately. In addition, the somewhat intermittent nature of the experimental protocols (1-min breaks for blood draw) may have had an unknown effect on the participants' RPE and, thus, should be considered a potential limitation to this study's methodology. Another limitation is that the study did not account for dispositional (i.e., personality, self-efficacy) and psychological factors (i.e., expected duration, self-presentation) within the participants. Prior research has suggested these variables may serve a significant role in perception of effort (Noble & Noble, 2000). It is possible that not accounting for a factor such as self-presentation, which asserts that individuals in a social situation will want to present themselves in a socially acceptable manner by appearing competent and honest, could have skewed the results of both perceived exercise intensity conditions (Baumeister, 1982; Sylva et al., 1990). Therefore, these potential limitations should be considered when interpreting the results of the study.

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Authors' Notes

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