ABSTRACT

HVAM, J. A. Metabolic cost of exercising on the HealthRider in females. MS in Adult Fitness/Cardiac Rehabilitation, December 1996, 44pp. (J. Porcari)

The study compared the physiological responses between HealthRider exercise and treadmill walking/running. Ten volunteer female students (mean age = 24 ± 3.2) served as Ss. On the first day, Ss completed a maximal treadmill test. The subsequent two days involved 6 submaximal exercise bouts on the HealthRider, utilizing a combination of three different arm/leg positions (LLRA = lower leg rear arm, LLFA = lower leg front arm, and ULFA = upper leg front arm), performed at an elevated and nonelevated position (elevated position is defined as placing a 6" riser under the front end of the HealthRider). Each bout lasted 5 minutes with a 5-minute rest period between each exercise bout. There was a significant ($p < .05$) main effect for position, with the LLFA position producing significantly lower HR, VO_2, and RPE values than either LLRA or ULFA. Results were consistent for both the no elevation and elevated positions. On average, Ss exercised at 71% of HRmax and 52% of VO_2max, at an average RPE of 12. For all positions, the predicted VO_2 that would have been elicited on the treadmill at a same HR from the HealthRider was higher than that achieved on the HealthRider. However only the ULFA, LLRAE, LLFAE, and ULFAE positions were significantly ($p < .05$) different. The results of this study indicate HealthRider exercise is capable of providing only a relatively low intensity aerobic workout and furthermore, the HR/VO_2 relationship during HealthRider exercise is different than that of treadmill exercise.

METABOLIC COST OF EXERCISING ON
THE HEALTHRIDER IN FEMALES

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Metabolic Cost of Exercising on the HealthRider in Females

INTRODUCTION

The current trend in the fitness industry centers around total body fitness, with the health benefits of aerobic and resistance training being clearly documented (1). Despite the overwhelming evidence related to the benefits of these modalities, only 22% of the adult population exercises frequently enough to improve their health (11). There are many reasons people give for not exercising. These include work and family commitments, inconvenience, fatigue, and most frequently lack of time (4). Manufacturers have developed equipment appealing to individuals who claim they do not have the time to workout. Manufacturers are marketing home equipment that supposedly combines both aerobic and strength training benefits. The major question is: Is it possible to receive aerobic and strength training benefits from one workout simultaneously?

Aerobic or cardiorespiratory endurance refers to the body's ability to sustain prolonged rhythmical exercise, which is related to the body's ability to deliver sufficient oxygen to meet the needs of the active tissues. Aerobic activities involve large muscle groups in the performance of low-resistance, high-repetition exercises (running and cycling) to induce increases in VO_2max (5). During aerobic training, heart rate (HR) is a good indicator of how hard an individual is working.

Strength, on the other hand, is defined as the ability of muscles to exert force. Strength training uses different muscle fibers (fast twitch fibers) and different energy sources of aerobic training (15). This type of exercise also engages large muscle groups; however, it is different from aerobic training in that it utilizes high-resistance, low-repetition activities to increase maximal force output of the skeletal muscles (5). Resistance training often elicits a much higher HR than that which is elicited during aerobic training at similar levels of oxygen consumption.

In order to produce a cardiovascular training effect it has been recommended by the American College of Sports Medicine (ACSM) that an exercise intensity should be at least 50% of maximal heart rate reserve or VO_2max, or 60% of heart rate maximum (HRmax) (1). Following aerobic training, research indicates that increases in VO_2max will occur if training heart rates fall within these guidelines. In several strength training studies, however, heart rates have exceeded these recommended rates without resulting in a substantial increase in VO_2max (7). In other words, strength training is not an effective way to improve one's VO_2max even though the HR may reach an intensity above the aerobic threshold recommended by ACSM. A possible reason is that the HR/VO_2 relationship during resistance training and aerobic exercise are very different. With aerobic exercise the HR increases proportionately to the oxygen cost of the exercise while during resistance training the HR increases disproportionately to the oxygen cost of the exercise due to a phenomenon called the pressor response (10,12).

It has been suggested that exercise which produces occlusion of the circulation in the exercising muscles, such as during resistance training, may stimulate a "pressor response". A pressor response is considered to be an exaggerated HR and blood pressure response to exercise. As the body tries to overcome the mechanical compression on the blood vessels to provide oxygen to the working muscles, HR and blood pressure become greatly elevated, secondary to an increase in catecholamine levels and a decreased stroke volume (10,12,13). The HealthRider is a relatively new product on the market which purports to provide an aerobic and strength workout in one session. The exercise movement on the HealthRider is similar to that of rowing; it consists of pulling with your arms while simultaneously pushing with your legs, thus moving your own body weight against gravity. The individual controls the speed and, therefore, the intensity of the workout.

The purpose of this study was to first determine whether or not an individual is able to obtain an aerobic training threshold during HealthRider exercise. A second purpose is to determine the HR/VO_2 relationship during exercise on the HealthRider compared to that of treadmill exercise.

METHODS

Subjects

Ten females between the ages of 20 and 29 served as voluntary subjects. They were recruited from the University of Wisconsin-La Crosse campus. Consistent with guidelines established by the University's Institutional Review Board (IRB), each subject was given a full explanation of all testing procedures (previously approved by the IRB) and signed an informed consent prior to any participation in the study.

Physiological Testing Protocols

Each subject was required to complete 3 days of testing. On the first day each subject performed a maximal treadmill test and on the second and third days of testing subjects performed a series of submaximal exercise bouts on the HealthRider. Prior to undergoing any testing, each subject was required to complete a training phase.

Training Phase

The training phase was held in the Human Performance Laboratory in Mitchell Hall at UW-La Crosse and was designed to allow subjects as much time as needed to become familiar with walking on the treadmill and exercising on the HealthRider. Subjects attended as many sessions as necessary in order to become proficient on the HealthRider. Subjects also practiced breathing into the mouthpiece and wearing the head gear required for measurement of VO_2.

Testing Phase

The testing phase included three sessions, each conducted on a separate day. During each session the subjects wore a Polar Vantage XL heart monitor (Polar USA, Inc., Stamford, CT.). Expired gas volumes and concentrations were measured in order to calculate the metabolic responses during the treadmill VO_2max test and the two submaximal sessions on the HealthRider using the Quinton Q Plex I metabolic cart (Quinton Instruments Co., Seattle, WA.). Prior to testing, the gas analyzers and pneumotachometer on the Q-Plex were calibrated according to standard protocols. Ratings of perceived exertion (RPE) were also assessed using the 6-20 Borg Scale (3).

All subjects returned within 2 weeks after the laboratory practice sessions for testing. Each subject was asked to wear appropriate clothing for exercise, drink plenty of fluids 24 hours prior to testing, and to avoid food, alcohol, tobacco, and caffeine 3 hours prior to testing. The subjects were also asked to refrain from strenuous physical activity the days of testing and encouraged to get an adequate amount of sleep (6 to 8 hours) the night before the test (1).

Session 1

During the first session subjects performed a maximal treadmill test utilizing the Bruce protocol (1). Prior to performing the test each subject was encouraged to warm up at a self-selected pace for 3 minutes. During the test HR, VO_2, and RPE were measured at the end of every stage and at maximal exertion. The submaximal HR and VO_2 data were used to develop a regression equation for each subject, which described the HR/VO_2 relationship for the treadmill exercise.

Sessions 2 and 3

During the second and third sessions, subjects exercised at six different positions on the HealthRider. The positions were as follows: lower leg rear arm (LLRA), lower leg front arm (LLFA), upper leg front arm (ULFA), lower leg rear arm elevated (LLRAE), lower leg front arm elevated (LLFAE), and upper leg front arm elevated (ULFAE). Exercise at each of the level positions was completed on one day and all elevated conditions were completed on a separate day. Elevated positions were obtained by placing a 6-inch riser under the front of the HealthRider. All cadences were self-selected for each position on the first day then maintained on the second day. The order of level and elevated conditions and the order of positions within each day, were randomized for each subject.

Each exercise bout (position) was 5 minutes in duration, with a rest period of 5 minutes between each bout. The cadence was maintained by the use of a metronome set at a self-selected pace by each subject. During each position HR, VO_2, and RPE were obtained every minute. Upon completion of the test, subjects were encouraged to cool down by continuing to exercise on the HealthRider at a slower cadence until the HR was at or below 100 bpm. If necessary, subjects were encouraged to walk around the laboratory until they felt completely cooled down.

Statistical Analyses

Standard descriptive statistics were used to categorize the pretest population and to summarize the responses to the various conditions. Differences between position and elevation/no elevation were analyzed using a two-way ANOVA with repeated measures. If a significant F-ratio was obtained, a Tukey's post-hoc test was used to detect pairwise differences.

Individual regression equations were calculated from the treadmill test data to compare the HR/VO_2 relationship of exercising on the HealthRider to that of treadmill walking/running. The number of data points from each subject's maximal treadmill test varied from either 4 or 5. HR was chosen as the independent variable to predict VO_2. A steady state was achieved during each exercise bout and the heart rates from that point were averaged (the last 2 minutes of each stage). The mean HR (for each position) on the HealthRider was inserted into each respective individual regression equation to yield a predicted VO_2. The predicted values were compared to the actual VO_2 values obtained during the exercise bouts on the HealthRider using paired t-tests. A probability level of .05 was selected for significance for all analyses.

RESULTS

Selected demographic characteristics of the subjects are presented in Table 1. All subjects were apparently healthy females who exercised recreationally.

Table 1. Demographic statistics of the subject population. N = 10.

Variable	Mean ± SD	Range
Age (yrs)	24.5 ± 3.2	20.0 - 29.0
Height (cm)	166.1 ± 4.7	160.0 - 175.3
Weight (kg)	59.9 ± 7.0	51.1 - 75.6
HRmax (bpm)	194 ± 1.9	191 - 197.0
VO_2max (ml/kg/min)	48.6 ± 3.1	44.4 - 55.0

Note. VO_2max and HRmax were obtained from the treadmill test.

The physiological responses to exercising on the HealthRider at the different positions are shown in Table 2. There was a significant ($p < .05$) main effect for position, with the LLFA position producing significantly lower HR and VO_2 values than either LLRA or ULFA. Results were consistent for both no elevation and elevated conditions.

Table 2. Physiological responses among the different positions on the HealthRider. N = 10.

Positions	HR	%HRmax	VO_2	%VO_2max	RPE
LLRA	138 ± 12.4	71 ± 6.4	27.0 ± 2.6	55 ± 5.6	11 ± 1.1
LLFA	126 ± 8.8*	65 ± 4.6*	22.5 ± 1.9*	46 ± 4.6*	11 ± 1.9
ULFA	137 ± 17.5	70 ± 8.9	25.1 ± 4.1	52 ± 10.6	13 ± 1.3
LLRAE	148 ± 17.7	76 ± 9.4	28.5 ± 2.9	58 ± 7.6	12 ± 1.3
LLFAE	137 ± 17.4	70 ± 9.2	23.8 ± 3.1	49 ± 7.8	11 ± 1.5
ULFAE	141 ± 21.2	72 ± 11.3	24.6 ± 3.4	51 ± 9.0	13 ± 2.0
Mean	138 ± 15.8	71 ± 8.3	25.3 ± 3.0	52 ± 7.5	12 ± 1.5

All values represent mean ± standard deviation.

There was not a significant ($p > .05$) main effect for elevation, indicating that elevation had no effect on HR, VO_2, and RPE at any position.

The HR and VO_2 data were represented as a percentage of HRmax and VO_2max. On average, subjects exercised at 71% of HRmax and 52% of VO_2max, with an average RPE of 12. Overall, across positions, subjects on average exercised at a cadence of 48 strokes per minute (SPM). For each position, average cadences were as follows: LLRA elicited 52 SPM, LLFA 53 SPM, and ULFA 40 SPM.

Table 3 lists the individual regression equations for each subject. These equations were calculated for each subject from the treadmill test data.

Table 3. Individual regression equations

Ss	N	Individual Regression Equations
1	4	-30.095 + .39883 * X
2	5	-26.944 + .47324 * X
3	4	-34.264 + .45607 * X
4	4	-29.656 + .42487 * X
5	4	-23.048 + .39706 * X
6	4	-45.952 + .49080 * X
7	4	-34.270 + .43852 * X
8	4	-30.589 + .45350 * X
9	5	-31.778 + .42085 * X
10	5	-39.455 + .46770 * X

X = actual HR

Table 4 presents data comparing the actual VO_2 achieved at a given HR on the HealthRider to the predicted VO_2 that would have been elicited on the treadmill at that same HR. For all positions, predicted VO_2 was higher than the actual VO_2. However, the pairwise comparison was significantly different ($p < .05$) for the ULFA, LLRAE, LLFAE, and ULFAE positions.

Table 4. Comparison of actual versus predicted VO_2 at a given HR. N = 10.

Positions	HR	Actual VO_2	Predicted VO_2
LLRA	138 ± 12.4	27.0 ± 2.6	29.7
LLFA	126 ± 8.8	22.5 ± 1.9	24.1
ULFA	137 ± 17.5	25.1 ± 4.1	29.4*
LLRAE	148 ± 17.7	28.5 ± 2.9	33.8*
LLFAE	140 ± 21.2	23.8 ± 3.1	28.8*
ULFAE	141 ± 21.2	24.6 ± 3.4	30.5*

* significantly different ($p < .05$) from the actual VO_2.

DISCUSSION

The ACSM (1) recommends that individuals should perform regular aerobic exercise for the development of cardiorespiratory endurance. Running, walking, and swimming are all documented as good aerobic activities; however, limited information is available regarding the physiological responses to exercise on other modalities such as the HealthRider.

The first purpose of this study was to determine whether or not an individual could obtain an aerobic training threshold on the HealthRider. Results indicated that subjects achieved a mean VO_2 of 25.2 ml/kg/min (7 METs) at an average HR of 138 bpm. This represents a relative intensity for all positions of 52% of VO_2max and 71% HRmax. The results of this study are similar to those reported by Hooker et al. (6) who found that subjects exercised at 63% HR_{peak} and 46% VO_{2peak} at cadences ranging from 30-60 SPM which were similar to those used in the present study (40-53 SPM). Kravitz and Heyward (8) also found similar results in a study which investigated the physiological responses to exercising on six different exercise modalities, including the HealthRider. Their study found that exercising on the HealthRider elicited 47% of VO_2max and 70% of HRmax at an average RPE of 12.6 in both men and women.

The ACSM recommends exercising at 60-90% of HRmax or 50-85% of VO_2max for "healthy" adults. Furthermore, exercise intensities as low as 40% of VO_2 max have been found to elicit health benefits in "unfit" adults (1).

The present study found that relatively active females exercising on the HealthRider may not improve their maximal oxygen consumption because the elicited level of VO_2 represented only 52% of the subjects' VO_2max. However, it may help maintain their current fitness level. Females who are sedentary or have a low fitness level may see improvements in their VO_2max.

It was found that the LLFA position produced a significantly lower HR and VO_2 than either the LLRA or ULFA positions. This was consistent for both the no-elevation and elevated positions. This may be due to the nature of the position which allows the work to be spread more evenly between the upper-body and legs. In the LLRA position work is mainly produced from the legs, while in the ULFA position work is mainly produced from the upper-body. Isolation of the workload to a smaller muscle mass may be the cause for the differences in the HR and RPE.

These findings are not consistent with the results of a study conducted by Meyer et al. (9). Results of their study indicated a significant difference in VO_2 at 40 SPM, across positions as well as increases with elevation. An increase of 18% in oxygen consumption was found when the front end of the HealthRider was elevated.

Differences between studies may be, in part, due to the fact that we did not keep the stroke length consistent throughout testing. This may have been a problem when subjects became fatigued and they used a shorter stroke movement to maintain the cadence, thereby decreasing VO_2.

The second purpose of the study was to investigate the HR/VO_2 relationship during exercise on the HealthRider compared to that of walking/running on the treadmill. Frequently, the intensity of a workout is judged by the percentage of HRmax. This concept is based on the assumption that HR increases proportional to increases in VO_2. This relationship is linear and proportionate during aerobic type activities but is not during strength or resistance type training. This is seen in a classic study by Hurley et al. (7) who studied the effects of strength training on cardiovascular function. Thirteen healthy, untrained males were put on a 16-week high intensity, variable resistance strength training program. Results showed a 44% increase in muscular strength but there was no effect on the subjects' maximal oxygen consumption even though subjects moved as quickly as possible between exercises keeping their heart rates high.

The investigators next had subjects walk on the treadmill at the same VO_2 elicited during the circuit training program (18 ml/kg/min) when HR was 155 bpm. When the subjects walked on the treadmill at this VO_2, a HR of 115 bpm was attained. The exaggerated HR response elicited during the circuit program represented 80% of their maximal values, but the oxygen consumption was only 45% of the subjects' maximum values which is not sufficient to improve cardiovascular function. Results of that study indicated that because there was a disproportionate increase in HR compared to the oxygen cost, resistance training is not a good form of exercise to improve cardiovascular function (7).

The results of the present study indicate that there was a significant difference between the actual VO_2 obtained on the HealthRider compared to the predicted VO_2 calculated from the treadmill data. The predicted VO_2 was higher than actual VO_2 for all conditions with the ULFA, LLRAE, LLFAE, and ULFAE positions achieving significance. This indicates that the HR/VO_2 relationship during HealthRider exercise compared to treadmill exercise is different, with exercising on the HealthRider eliciting an exaggerated HR response in comparison to the oxygen cost of the exercise.

A study conducted by Shephard et al. (14) may help to explain this disproportionate elevation in HR in comparison to the oxygen cost of the exercise. Shephard found that arm-cranking activity elicits an elevated HR relative to the oxygen cost of the exercise. This supports the notion that the upper-body resistive movement of the HealthRider may cause a disproportionate increase in HR relative to the actual VO_2 obtained, possibly due to an increase in sympathetic nervous system activity.

Another possible explanation for the elevated HR may be due to the tight hold or hand grip needed when exercising on the HealthRider. Due to inherent gender differences, smaller muscle mass and less upper-body strength may require women to grip tighter, especially when fatigued. A study conducted by Auble et al. (2) found exaggerated hemodynamic responses to excessive hand gripping, which indicates the occurrence of a pressor response.

In summary, based on the results of this study it is concluded that for relatively active females, exercising on the HealthRider may not provide a sufficient stimulus for improving maximal oxygen consumption. This mode of exercise may be appropriate for those females with a low level of fitness. Accordingly, the HealthRider is capable of providing only a relatively low intensity aerobic workout. Furthermore, the HR/VO_2 relationship during HealthRider exercise is different than that of treadmill exercise. HR is elevated disproportionate to VO_2, indicating that the pressor response may be occurring. Further research is needed in the area of exercise modalities which claim to produce both aerobic and strength training benefits simultaneously. Also research needs to be conducted on females only. Current literature focuses either on males or on males and females together.

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APPENDIX A

INFORMED CONSENT

INFORMED CONSENT

METABOLIC COST OF EXERCISING ON THE HEALTHRIDER IN FEMALES

I,______________, volunteer to be a subject in a research study to determine the physiological responses to exercising on the HealthRider. I understand that I will be required to participate in three exercise sessions. One session will involve completing a maximal treadmill test and the other two sessions will involve performing a series of submaximal exercise bouts on the HealthRider exercise machine.

The maximal treadmill test will involve walking and/or running on a treadmill until I no longer can continue. The speed and grade of the treadmill will be increased every 3 minutes until the test is terminated.

The other two days will involve six submaximal exercise bouts on the HealthRider, utilizing a combination of three different arm/leg positions recommended by the manufacturer. Each bout will last for 5 minutes and there will be a 5 minute rest period between each bout.

During all tests my heart rate will be monitored continuously with a Heart Rate Monitor strapped to my chest. I will also breathe room air through a mouthpiece so that my exhaled air can be collected and analyzed.

I realize that I can stop the testing any time I wish. As with any exercise there exists the possibility of adverse changes occurring (i.e. dizziness, difficulty in breathing, etc.) during the test. If any abnormal observations are noted at any time, the test will be immediately terminated. In addition, I will probably feel tired at the end of the test and may experience some muscle soreness.

All testing sessions will be scheduled at my convenience and will be conducted by trained graduate students under the supervision of John P. Porcari, Ph.D.

I consider myself to be in good health and to my knowledge I am not infected with a contagious disease or have any limiting physical condition or disability, especially related to my heart, that would preclude my participation in the tests described above. I have read the foregoing and I understand what is expected of me. Any questions which I may have had have been answered to my complete satisfaction. I, therefore, voluntarily consent to be a subject in this study. Furthermore, I know that I may withdraw at any time without any type of penalty.

Signed:________________________________ Date:________________

Witness:_______________________________ Date:________________

APPENDIX B

REVIEW OF RELATED LITERATURE

This review of literature concentrates on the documented research in aerobic and resistance training. The focus primarily involves the cardiorespiratory and physiological effects in both trained and untrained individuals. Secondly, the HR/VO_2 relationship elicited during these two separate training modes is addressed, in addition to the factors that may alter this relationship. Lastly, the few published studies completed on HealthRider exercise are reviewed.

Cardiorespiratory endurance refers to the ability of the body to utilize oxygen efficiently. It is measured by assessing one's VO_2max, which is directly related to the frequency, duration, and intensity of exercise (2). The American College of Sports Medicine (ACSM) recommends that to improve one's cardiovascular endurance, the exercise needs to be rhythmic in nature, utilize large muscle groups, be 20-30 minutes in duration, and be performed 3-5 days per week. Furthermore, the exercise intensity should be 50-85% of VO_2max or 60-90% of HRmax (1). In addition to aerobic training, it is recommended that resistance training be performed at least 2 days per week, performing a minimum of 8-10 separate exercises, utilizing the major muscle groups of the body. Each exercise ought to include one set of 8-12 repetitions to the point of volitional fatigue.

Aerobic Training

Improvements in VO_2max are directly related to the frequency, intensity, and duration of training, with improvements ranging from 5-30% as a result of training (2). Traditional aerobic activities include walking, running, machine-based stairclimbing, swimming, and cycling to name a few.

Kearney et al. (13) conducted a study on 27 sedentary, college-aged women. Subjects trained on the treadmill 3 times per week over a 9 week period. They exercised at a HR of either 50 or 65% of the HR reserve, with the duration of each session limited to the time required to elicit 1,000 beats above the resting value. The treadmill speed was adjusted to maintain this exercise HR. A comparison of the pre- and posttraining results revealed that both training intensities resulted in significant increases in VO_2max. A training effect was demonstrated for both intensities even though the mean exercise HR was only 134 bpm for the 50% group and 155 bpm for the 65% group. There was not a significant difference between groups, yet those subjects who exercised at 50% of HR reserve improved their VO_2max by

16% and those who exercised at 65% of HR reserve improved their VO_2max by 24%.

Duncan et al. (7) conducted a study on 102 sedentary women. The study consisted of one control group and three walking groups (strollers, brisk walkers, and aerobic walkers). The aerobic walkers exercised at 86% of their HRmax while strollers and brisk walkers exercised at 67 and 56% of their HRmax, respectively. The aerobic walkers increased their VO_2max by 16%, the brisk walkers increased it by 9%, and the strollers had a minimal increase of 4%, as compared to the control group who elicited a negative 6% of their VO_2max (meaning there was a decline in their VO_2max).

Santiago et al. (20) investigated the physiological responses to a 20 week conditioning program of walking and jogging. Subjects were randomly assigned to walking, jogging, and control groups. The initial training intensity was 71% of HRmax for the walkers and 84% of HRmax for the joggers. This intensity was increased by one MET at the midpoint of training. VO_2max significantly increased by 21% for walkers and 31% for the joggers.

Another form of exercise which enhances cardiorespiratory endurance is bicycle ergometery. Burke and Franks (4) conducted a study on 16 high school nonathlete males who were randomly assigned to 1 of 3 training groups or a control group. The training groups trained 3 days per week on bicycle ergometers at 3 different intensities (65, 75, and 85% of VO_2max) with all groups doing the same mechanical work. This study revealed a significant difference in VO_2max between the groups. Significant differences were found between both the 75 and 85% groups and the control group, but no significant difference between the 65% group and the control group. The mean increases in VO_2 for both exercise intensities (75 and 85%) group were 8.7 and 9.4% respectively, with the 65% of VO_2max group eliciting only a 3% increase. They found that when exercising on the bicycle ergometer an intensity of 75-85% of VO_2max should be achieved in order for a "training effect" to occur. The study concluded that while holding mechanical work constant it is necessary to work at a minimum of 75% of HRmax to elicit significant changes in VO_2max.

Overall, it is well documented that activities such as walking, running, and cycling enhance cardiorespiratory endurance (1). However, studies do not necessarily agree on the prescribed intensity to elicit improvements, especially when considering different exercise modalities (4,12,21).

Resistance Training

In the most recent position statement released by ACSM (2), recommendations for enhancing muscular strength and endurance were included. The recognized need for a more well rounded program that exercises all the major muscle groups of the body prompted this addition. Thus, the inclusion of strength training in fitness programs is thought to be effective in the development and maintenance of fat free weight. As with any exercise, specificity can also be applied to strength training. The effect of resistance training is specific to that area of the body being trained (2).

Muscular strength and endurance can be achieved by either static or dynamic exercise. Dynamic resistance training is recommended for healthy adults; however both types of training have both benefits and drawbacks. Resistance training should be rhythmical, performed at a fairly slow speed and move through a full range of motion (2). Heavy resistance exercises may cause an extreme acute increase in both systolic and diastolic blood pressures (15). In regard to health and performance, the importance of strength is often underestimated. Strength training helps to protect the joints that the trained muscles cross and it also increases the strength of the tendons and ligaments, which in turn helps to prevent injuries (23).

Strength gains are expected and well-documented from resistance training programs; however, it is difficult to assess the expected improvement due to the individual's initial strength level and their potential for improvement (2).

A study conducted by Hurley et al. (10) found that following a 16 week high intensity, variable resistance, Nautilus strength training program, subjects' strength increased on average by 44%. Fat-free weight also significantly increased from 66.9 to 68.8 kg.

Fleck and Kraemer (8), in review of 13 research studies representing various forms of weight training, showed that subjects on average improved by 23.3% in bench press strength and 26.6% in leg strength.

Another study conducted by Braith et al. (3) compared resistance training 2 days per week with 3 days per week for 18 weeks. The 2 days per week group showed a 21% increase in strength compared to a 28% increase in the 3 days per week group. In other words, the 2 days per week group elicited 75% of what could be attained 3 days per week.

Weight training is able to elicit strength improvements with minimal amount of time expended.

Despite the short time needed to elicit strength training benefits, circuit weight training was developed. Circuit weight training is used to enhance both cardiovascular endurance and strength simultaneously. Furthermore, many use it as a combined workout to shorten the total workout time.

Circuit weight training typically entails small muscle mass exercises, high repetitions, fairly light weights, and short rest periods between sets, in attempt to increase metabolic rate during the training period. By placing weight training into a circuit training format, research demonstrates gains in lean body weight, flexibility, strength, and cardiovascular endurance, and losses in relative body fat (25).

A study conducted by Dohmeier et al. (6) found by using timed interval squats at 60% body weight, the exercise could elicit 56% of subjects' treadmill VO_2max. The timed interval squats were performed at a rate of 1 repetition every 4 seconds lasting a total duration of 20 minutes. This represented an aerobic intensity sufficient to elicit an aerobic training stimulus.

In conclusion, increases in muscular strength have been universally reported following mild to moderate isotonic, isokinetic, and circuit resistive exercise training in healthy subjects (24,25). Greater improvements in strength have been reported following even higher intensity programs using workloads up to 80% of 1 RM (10).

HR/VO_2 Relationship

During aerobic exercise there is a linear relationship between HR and VO_2 as the energy demands of exercise increase. Accordingly, this allows HR to be a good indicator of how hard an individual is working. Aerobic endurance depends on the ability to deliver sufficient oxygen to meet the increased metabolic needs of the active muscles (25). The degree of metabolic overload on the cardiorespiratory system provides the stimulus to improve aerobic endurance, expressed as VO_2max (19).

In contrast, during resistance training HR is elevated disproportionately relative to oxygen consumption. At any given level of oxygen consumption, HR is much higher for resistance training than for aerobic training. Even though HR is elevated, the oxygen consumption is not elevated to the same degree. This means that resistance training may not sufficiently overload the body's system to enhance VO_2max.

A classic study by Hurley et al. (10) demonstrates this concept. In this study a group of 13 untrained males completed a 16-week, high-intensity strength training program using Nautilus exercise machines. The subjects exercised 3-4 days per week performing a total of 14 upper and lower body exercises. Overall the subjects had a 44% increase in strength, however, VO_2max remained unchanged. This occurred despite the fact that subjects moved as quickly as possible between stations, maintaining a relatively high HR. To help explain these results, researchers had the subjects walk on a treadmill at the same VO_2 (18 ml/kg/min) elicited during the resistance training exercises. In comparing HR, the treadmill exercise elicited only 115 bmp while the resistance training exercise elicited a HR of 155 bpm. The resistance training program elicited 80% of HRmax, but only 45% of VO_2max, which according to ACSM is too low to improve VO_2max.

A study by Collins et al. (5) was conducted to define the relation between HR and VO_2 during weight lifting at four different percentages of subjects one-repetition maximum. The study found weight lifting exercise elicits a

60-80% treadmill determined HRmax and 33-47% treadmill determined VO_2max. The study concluded that when HR and VO_2 are expressed as percentages of treadmill-determined maximum values, the slope of the linear regression equation predicting %VO_2max from %HRmax is approximately half that reported for dynamic low-resistance exercise (aerobic type activities). These data are in agreement with the conclusions from prior studies. When using the HR/VO_2 relationship based on treadmill or cycling data to prescribe intensity for weight lifting, a lower absolute or relative level of aerobic metabolism will be elicited than would occur during low resistance exercise (5).

The Pressor Response

To explain the factors that limit improvements in VO_2max as a result of resistance or strength training, one must understand the phenomenon called the pressor response. The pressor response is defined as the cardiovascular changes (i.e., HR and blood pressure) that occur as a result of muscular contraction. The pressor response will make it easier to understand the elevated HR response elicited during resistance training (17,19).

There are three main factors defining the intensity of the pressor response. These factors are responsible for the differences in the hemodynamic responses to resistance as compared to aerobic exercise. These are as follows: (1) the level of central command, (2) intramuscular compression within the working muscles, and, (3) vasoconstriction in the nonworking muscles (17,19).

Stimulation of the cardiovascular center in the brain is noted as the central command. This stimulation is based on the amount of skeletal muscle activity. The brain sends impulses to the working muscles and to the cardiovascular center to drive HR and blood pressure in proportion to that of the working muscles.

The magnitude of the response is proportional to the percent of maximal strength (%MVC) to which the muscles are contracting, and not necessarily proportional to the amount of muscle mass being used nor to the metabolic needs of muscles. High resistance strength training requires a large number of muscle fibers which results in a high degree of central command, causing an elevated HR and blood pressure response (17,19).

The second factor that affects the pressor response is intramuscular compression within the working muscles. This response occurs during any type of lifting activity. When an individual contracts his/her muscle it causes a mechanical compression upon the vessels within those muscles. This in turn limits the flow of fresh blood into the tissue and also impedes the removal of waste products resulting from muscular work (17,19).

Increasing concentrations of waste products stimulate afferent endings located within these working muscles. These signals stimulate the cardiovascular center in the brain causing an alteration of hemodynamic responses. In other words, the elevated HR and blood pressure response are due, in part, to the build up of waste products in the working muscles rather than in response to the metabolic needs of the muscles (19).

Vasoconstriction in the nonworking muscles is the third factor which contributes to the pressor response. As an individual exercises, vessels within the working muscles vasodilate, to provide these muscles with an adequate blood supply. The vessels within the nonworking muscles reflexively vasoconstrict, thus shunting more blood to the working muscles. This causes an elevated HR and blood pressure response. Since resistance training taxes a smaller muscle mass than aerobic training, there is a larger muscle mass being vasoconstricted than vasodilated thus causing an increased resistance the heart must pump against.

This increases HR so that the cardiac output is able to be maintained (17,19).

HealthRider

Today the fitness industry is being inundated with a wide variety of new equipment. The aim seems to be on increasing cardiovascular and strength training simultaneously. Therefore, manufacturers have developed equipment that incorporates upper and lower body exercise hoping to elicit aerobic and resistance training benefits concurrently.

The HealthRider was developed to provide both an aerobic training stimulus and a resistance training effect. The goal of concurrent resistance and aerobic training is to decrease total workout time while creating a total body training effect.

There is very little published research available on the physiological responses to exercising on the HealthRider. Pinachio et al. (18) found that the average amount of oxygen consumed while performing the most strenuous work on the HealthRider was 67% of the amount consumed while on the treadmill. Their study inferred that while exercising on the HealthRider an individual would burn about 25% fewer calories than on the treadmill. The study also found that the more fit women did not outperform the less fit females when exercising on the HealthRider at the most difficult level. They concluded that once an individual has reached a higher level of fitness, they may not be able to get a sufficiently strenuous enough workout on the HealthRider to positively improve cardiorespiratory endurance.

Another study by Kravitz and Heyward (14) found that exercising on the HealthRider elicited 70% of HRmax and 47% of VO_2max. HR fell within the guidelines recommended by the ACSM, while VO_2 did not.

A previous study by Shephard (22) may help to explain this disproportionate increase in HR relative to VO_2. His study found that during arm-cranking activity, HR was disproportionately elevated relative to VO_2. The upper-body movement during the HealthRider exercise probably evokes this disproportionate elevation of HR compared to actual oxygen consumption. This occurrence is attributable to the increased sympathetic nervous activity (14).

Johnson et al. (11) conducted a study on 15 healthy males and females performing a submaximal test on the HealthRider. The protocol consisted of a 5-minute warm-up followed by 3 minutes of exercise at 30, 40, 50, and 60 cycles per minute (CPM). The average metabolic responses for all CPM ranged from 3.8-6.9 METS. They concluded that a fitness program consisting of aerobic "riding" will present sufficient metabolic challenge to evoke health-related benefits (probably not fitness benefits) and is therefore an effective form of exercise.

On the other hand, a study conducted by Hooker et al. (9) found results suggesting that HealthRider exercise at cadences of 40, 50, and 60 rpm is of mild-moderate intensity for young, healthy adults. Levels of %HRmax and %VO_2max attained fell within ACSM guidelines for cardiorespiratory endurance exercise training.

In addition, a study conducted by Meyer et al. (16) concentrated on numerous modifications to the standard exercise "riding" positions (SRP). The purpose of their study was to compare the metabolic effects of: (1) external resistance, (2) secondary handlebar position, (3) secondary foot position, and (4) front-end elevation. The standardized cadence was 40 CPM.

It was found that the metabolic rate increased by 1.6% for every additional 1% of body weight added. Secondary handlebar and foot position increased metabolic rate by 30 and 50%, respectively. Front end elevation resulted in an overall increase in metabolic rate of 18% (16).

In summary, the correct combination of frequency, intensity, and duration for chronic exercise is found to elicit a sufficient training stimulus. Due to specificity of training and the importance of muscular strength and endurance, a well rounded program which includes resistance training is recommended for all adults. Combining strength and aerobic training in one workout seems to be a perfect way to cut workout time in half while reaping the benefits of both workouts. However, research is still inconclusive as to whether exercising on the HealthRider can provide these benefits.

The HealthRider may provide a sufficient aerobic stimulus, especially for the "unfit" population but it should not be prescribed for most as an exercise modality to enhance VO_2max. Research seems to indicate that while exercising on the HealthRider, the HR/VO_2 relationships are different and because they are different, HR is not a good indicator of an aerobic training stimulus for the HealthRider.

In order to achieve both strength and aerobic training benefits it may be best to divide the workout into two separate segments, following ACSM guidelines (19).

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