VARIATIONS IN HEART RATE AND PERCEPTION OF EFFORT DURING LAND AND WATER AEROBICS IN OLDER WOMEN

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ABSTRACT

VARIATIONS IN HEART RATE AND PERCEPTION OF EFFORT DURING LAND AND WATER AEROBICS IN OLDER WOMEN. Kelly Heithold And Stephen C. Glass. JEPonline. 2002;5(4):22-28. The purpose of this study was to compare heart rate and perceptual responses in healthy, active women while performing the same aerobic exercise routine on land and in the water at a self-selected intensity level. Seven subjects (mean age= 61±3.2 yr) performed an aerobic exercise routine on land and in the water on two consecutive occasions. The exercise routine consisted of 3 minutes above the shoulder arm exercise, three minutes leg exercise, 3 minutes below the shoulder arm exercise, 3 min total body exercise and was performed twice for a total of 24 minutes of aerobic exercise. All exercise was performed at each subject’s self-selected intensity level. Heart rate (HR) was recorded after each individual exercise and RPE was recorded every 3 min. Results showed that subjects exercised from 66-88% of their age predicted maximal HR. HRs were significantly higher on all land exercise (126±12.23 to 141.5±13.7 beats/min) compared to water exercise (105±5.72 to112.21±10.55 beats/min). RPE was not different between land exercise (13.5±1.29 to 14.64±1.52) and water exercise (12.14±1.73 to 14.29±2.10). Aerobic exercise at a self-selected intensity elicits higher heart rate responses on land compared to water. RPE was a consistent indicator of intensity levels and could be used in these differing exercise settings.

Key Words: Physical Activity, Disease, Prevention

INTRODUCTION

Aging produces many physiological changes in the body, as well as increasing the risk for disease (10,20). Hahn and associates (15) identified five risk factors, other than cigarette smoking, which carried the highest risk for mortality. They included obesity, a sedentary lifestyle, high cholesterol, hypertension and diabetes. Exercise has been found to slow these age-associated physiological declines as well as decrease the risk for disease, and is recommended for the majority of the population (4,22). When prescribing an exercise program,
there are four components to consider: mode, frequency, duration and intensity. A muscle strength/endurance program combined with an aerobic program produces the greatest benefits.

In exercise prescription, intensity may be the most important component to be manipulated, and this is especially true in older adults to avoid the possibility of muscle/joint injuries (1,10,11). In the normal exercise setting, there are three methods used to calculate or quantify intensity levels. Some research has found a percentage of the predicted maximal heart rate, or a percentage of the heart rate reserve combined with the rate of perceived exertion scale to be reliable indicators of exercise intensity (2,9,24). While others (14,18) have not found this relationship between RPE and heart rate to be true in all conditions.

Environment plays a large role in the physiological and psychological responses to exercise. At the same intensity level, higher heart rate responses have been seen in hot temperatures compared to cool or thermoneutral temperatures (14,18). In water, however, a number of factors such as water temperature, type of exercise, percentage of body fat, and intensity of exercise all affect the physiological responses and make it more difficult to compare responses. Heberlein et al. (16) compared responses of women with a mean age of 42.9 years while performing two identical dance routines, one in water and one on land. The exercise routine was held constant by using the same duration, music, and video sequence. Each subject performed a minimum of 8 min of steady state exercise in both environments. Significant differences were found in heart rate (170±6 beats/min on land compared to 143±2 beats/min in water) as well as in RPE (12.5±1 on land and 9.9±2 in water).

The purpose of this study was to compare cardiovascular and perceptual responses to self-selected intensity levels exercise in healthy, active women while performing the same aerobic exercise routine on land and in the water.

METHODS

Subjects

Subjects for the study were recruited from a College Senior Wellness population and the community. Seven women between the ages of 55-65 years completed the study. All were apparently healthy, active women. All regularly engaged in an exercise program two to seven days/week, ranging from 15-120 min/session. Two subjects regularly engaged in water aerobics, two participated in land aerobics or jazzercise, with the remaining three reporting walking, treadmill, or biking as the main modes of exercise. Subjects reported for a preliminary session and completed health history and informed consent forms. Exclusion criteria included chronic disabling arthritis or neuromuscular disease or pain, progressive neurological diseases, current use of blood pressure or heart rate regulating medications, history of stroke or previous cardiac, pulmonary or orthopedic condition that would hinder participation. Resting heart rate (RHR) was monitored and recorded with a telemetry heart rate monitor (Polar, Beat Heart Rate). Resting blood pressure (BP) was obtained using a standard cuff placed over the brachial artery while auscultation was done using a standard stethoscope. Height was measured using a stadiometer and weight measurements were obtained using a digital scale (Befour Inc.). The exercise practice session and exercise test sessions were explained to the subjects. The RPE 6-20 scale was also explained to each subject.

Procedures

A practice session and two test sessions were held on three consecutive evenings between the hours of 5 to 7 p.m. The practice session was held to familiarize subjects to the routine and acquaint them to it in both environments. This practice consisted of the warm-up/stretching and performing the aerobic routine once on land (12 min), then moving to the pool and performing the same routine again in the water (12 min), finishing with the cool-down/stretching in water.

For the exercise test, the same exercise routine was performed twice in the water the first evening and twice on land the next evening. Water temperature was approximately 28 °C. Subjects were immersed to shoulder level
in the water. Time was the constant factor rather than a specific workload or workrate. Each subject was encouraged to exercise at his or her own pace with the common factor of equal time allowed for each individual movement. (i.e. front kicks were performed for 30 s with each subject exercising at her own rate and completing as many kicks as she chose). The exercise routine consisted of a four-min warm-up and approximately five min stretching of all major muscle groups. Table 1 demonstrates the exercise routines completed. To avoid muscle fatigue, the above shoulder arm movements were changed every 15 s. The remaining exercise movements were changed every 30 s to allow for reduced speed of movement in the water. Each segment was performed for three min. The entire aerobic routine lasted 12 min and was performed twice for a total of 24 min of aerobic exercise. Approximately 10-15 s were allowed after each three-min segment to record RPE. A cool-down and a repeat of the stretches completed the workout.

### Table 1. The Exercise Routine

<table>
<thead>
<tr>
<th>Time (min)</th>
<th>Minute 1 - 3</th>
<th>Minute 3 - 6</th>
<th>Minute 6 - 9</th>
<th>Minute 9 - 12</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Arms - Above Shoulders</td>
<td>Legs only</td>
<td>Arms - Below Shoulders</td>
<td>Total Body</td>
</tr>
<tr>
<td>0:15</td>
<td>Window washer circles</td>
<td>Front kick</td>
<td>Cross-country ski - arms</td>
<td>Elbow/Knee touch- opposites</td>
</tr>
<tr>
<td>0:30</td>
<td>Clap hands over head</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0:45</td>
<td>Front punch - alternating</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1:00</td>
<td>Shoulder touch-simultaneous</td>
<td>March - high knees</td>
<td>Front punch - alternating</td>
<td>Lunge/twist &amp; lift arms opposite</td>
</tr>
<tr>
<td>1:15</td>
<td>Breaststroke circles</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1:30</td>
<td>Climb ladder</td>
<td>R &amp; L leg adductor/abductor</td>
<td>Cross punch - alternating</td>
<td>Forward kick/forward punch opp.</td>
</tr>
<tr>
<td>1:45</td>
<td>Reverse breaststroke circles</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2:00</td>
<td>Cross punch</td>
<td>Can-can kick (no jumps on land)</td>
<td>Breaststroke circles</td>
<td>March w/breaststroke &amp; reverse</td>
</tr>
<tr>
<td>2:15</td>
<td>Chest (taffy) pulls</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2:30</td>
<td>Cheerleader to L &amp; R</td>
<td>Step/slide/step/sidekick &amp; back</td>
<td>Speed bag punches</td>
<td>Charleston w/front punch</td>
</tr>
<tr>
<td>2:45</td>
<td>Reach to side/cross &amp; pull</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3:00</td>
<td>Speed bag punches</td>
<td>Hamstring curl</td>
<td>Reverse breaststroke circles</td>
<td>Twist</td>
</tr>
</tbody>
</table>

An exercise science student recorder was assigned to each subject. Heart rate was monitored with the Polar Beat Heart Rate monitor and recorded every 15 s during the above shoulder arm exercises and every 30 s during the legs only, arms below shoulder, and total body exercise (after each individual exercise). Subjects reported an RPE rating to this recorder after each three-min exercise segment in order to minimize subjects influencing each other’s perceptual ratings.

**Statistical Analyses**

Subject characteristics were quantified using descriptive statistics. Comparisons between water and land exercise for heart rate and RPE were made using dependent means t-tests. Age predicted maximal heart rates were computed using the traditional 220– age equation. Research has shown correlations of 0.84-0.89 between actual and predicted maximal heart rate with error margins up to 15 beats/min (17). Significance was set at p<0.05.
RESULTS

Data of the subject characteristics are presented in Table 2. Figure 1 shows the HR responses to the same exercises performed on land and in the water. HR was significantly higher for all land exercises compared to water exercise. Leg exercise and total body exercise elicited virtually the same responses as well as the greatest overall HR responses, both on land and in the water. Land HR response to above the shoulder arm exercise and below the shoulder arm exercise was virtually the same, as was arm exercise above and below the shoulder in water, but HR responses to arm exercises were lower in water than on land.

Figure 2 demonstrates the RPE response to the various exercises. There were no differences in RPE ratings. Figure 3 shows the percent of age predicted maximal heart rate (%APHRmax) achieved. Land exercises all produced a significantly greater %APHRmax than the same exercise in water. Once again, leg exercises produced the same intensity as total body exercise and both were higher than arm exercise alone. Arm exercises elicited the same %APHRmax whether performed above or below the shoulder in water or on land.

Table 2. Subject Data

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean±SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yr)</td>
<td>61.0±3.2</td>
</tr>
<tr>
<td>Resting HR (bpm)</td>
<td>76.1±5.9</td>
</tr>
<tr>
<td>Resting systolic BP</td>
<td>129.0±14.02</td>
</tr>
<tr>
<td>Resting diastolic BP</td>
<td>77.7±7.7</td>
</tr>
<tr>
<td>Body Mass Index</td>
<td>26.5±4.7</td>
</tr>
</tbody>
</table>

![Figure 1](image1.png)

**Figure 1.** The differences in heart rates between exercise conditions during different components of the aerobics session.

![Figure 2](image2.png)

**Figure 2.** The differences in heart rates between exercise conditions during different components of the aerobics session.

![Figure 3](image3.png)

**Figure 3.** The differences in percentage of the age predicted maximal heart rate (%APMHR) between exercise conditions during different components of the aerobics session.
DISCUSSION

Heart rate was significantly higher during all land exercise compared to all water exercise with no difference in RPE. There are several factors that may account for this HR difference. The body’s thermoregulatory response to exercise in various temperatures is an important factor. During exercise, the core temperature rises due to metabolic heat, which is a by-product of the added metabolism used to fuel skeletal muscle contraction. In cool conditions, the skin-to-ambient temperature gradient facilitates heat loss. In hot air environments, the body must rely more on evaporative cooling (25). As the body’s core temperature rises, so does the heart rate. However, in cool water, the body can more readily lose this added heat via conduction and convection, thereby decreasing this heat induced rise in heart rate.

In addition to the thermoregulatory response to water, there are also cardiovascular adaptations. Immersion in water produces several hemodynamic responses at rest, and these responses seem to be more pronounced in cooler water. The increased water pressure as well as the vasoconstriction evoked by low skin temperature in cool water causes a redistribution of blood volume from the periphery to the core (3). This in turn, increases the preload or blood volume returning to the heart and results in a larger stroke volume. Park and associates (23) found a significant increase in stroke volume (108.9±9 mL vs. 64±5 mL) when comparing resting values in water (30 °C) and on land (26±1 °C). Park et al. as well as other studies (6,20) have also found a larger cardiac output due to a larger stroke volume during water immersion. Heart rate variations seem to be dependent upon water temperature. While Park et al. found a 10 beats/min decrease in resting HR between air temperature of 26 °C and 30 °C water temperature, there was no change between air and 34.5 °C water temperature. Arborelius et al. (3) also found this to be true when comparing resting heart rate values in 28 °C air and 35 °C water, as did McArdle and associates (20) when subjects exercised in 25-27 °C air temperature and 18, 25, and 33 °C water temperatures. McArdle et al. found responses to be relatively similar between air exercise and 33 °C water exercise. However, when comparing responses at a given VO$_2$ in air or 33 °C water with exercise in 25 and 18 °C, heart rate was significantly lower (5 –15 beats/min) in 25 and 18 °C water, respectively. Water temperature in the present study was approximately 28 °C and so would have evoked these cardiovascular responses due to the cooler temperature.

Physiological responses to exercise in water seem to be comparatively similar to the resting values found in water. This study found heart rate values to be 20-29 beats/min lower during water exercise than land exercise. Other studies comparing identical or similar upright exercises in water and on land have also found heart rates to be lower in the water. Cassady et al. (7) found heart rate to be lower in 29.44 °C water than on land, Darby and associates (8) found heart rate to be 7-13 beats/min lower in 30 °C water, and Heberlein et al. (16) found a 27 beats/min decrease while exercising in water. However, in these studies exercise intensity was held constant with a selected cadence or constant sequence. The present study evaluated the intensity level at which women 55-65 years of age would exercise when encouraged to work at a self-selected pace, and how the heart rate intensity would relate to the subject’s perceived exertional level. ACSM recommends that healthy subjects exercise at 60-90% of the age-predicted maximal heart rate (2). All subjects were within this range both in water and on land. Land heart rate values were between 79-88% of age predicted maximal heart rate (APHRmax), and water values were between 66-70% of APHRmax

Rating of perceived exertion (RPE) has been proven a valid indicator of exercise intensity on land and in water (9,25,24). RPE integrates information received from peripheral working muscles and joints, from the central cardiovascular and respiratory function, and from the central nervous system (5). Some studies have found RPE values to be higher in water when subjects exercised at a pre-selected pace. Byrne et al. (6) and Svedenhag and associates (26) compared water treadmill/water running with dry land treadmill running and found water RPE ratings to be approximately two units higher than land RPE scores. However, Heberlein et al. (16) and the present study found very little difference in RPE ratings between upright land and water exercise, even though
Heart rate was significantly higher on land. This revealed that subjects did not perceive heart rate variations, and therefore heart rate did not have an effect on RPE ratings.

When comparing arm exercise above the shoulder to arm exercise below the shoulder on land, there was no difference in heart rate response or in perceived effort. This was also true for water exercise when comparing exercises above shoulder or below shoulder, but all water heart rate responses were lower than heart rate responses on land. It is also interesting to note that arm exercises above the shoulder were executed in air both on land and in the water routine, therefore there was no increased resistance from the water, and still heart rate was 22 beats/min lower in water. This response is in accordance with the body’s thermoregulatory reaction as well as the cardiovascular responses to water discussed earlier. Likewise, legs only exercise elicited the same heart rate and RPE response as total body (arms and legs combined), though both were lower in water than on land. It was thought that use of arm movement may actually counterbalance leg movement and so increase the comfort level of the exercise. However, leg exercise and total body exercise produced a higher heart rate response than arm exercise and was also perceived to be more intense. This is in agreement with a review of studies by Miles et al. (21) who found heart rates during upper body exercise to usually be 90-95% of those reported during lower body exercise. In addition, Franklin (12) reviewed peak heart rates during arm and leg ergometry in normal and cardiac men, and in normal women, and found maximal heart rates during arm ergometry to be approximately 93% of those obtained during leg ergometry. Researchers concluded that exercise prescription for arm training should be lowered approximately 10 beats/min than for leg training. The present study found heart rate during leg/total body exercise to be 10 beats/min higher in water and 13.5 beats/min higher on land than arm exercise.

In conclusion, the present study demonstrates that aerobic exercise at a self-selected intensity elicit higher heart rate responses on land compared to water. However, perception of effort is not different. When allowed to exercise at a self-selected intensity level, healthy active women chose an intensity level within ACSM training guidelines, 60-90% of age predicted maximal heart rate, which would improve aerobic fitness. In this study, adding arms to leg exercise did not increase the overall intensity level, but would be important in improving upper body muscle endurance. When prescribing exercise intensity, the environment must be taken into account. Prescribing intensity levels based on land heart rates would not be advisable for water exercise. Subjects given a land-based heart rate to attain during water exercise would have to work at a very high intensity, thereby causing undue risk and strain. In this study, use of RPE was a consistent indicator of intensity levels and could instead be used in these differing exercise settings.

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REFERENCES


