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Comparison of Perceived Exertion While Exercising at the Same Intensity on Land and Aquatic Treadmills

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Honors Project

The University of Akron

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Abstract

The purpose of this study was to determine if at the same intensity, two separate modalities of exercise could be perceived to have different difficulties. The modalities chosen for this study were underwater treadmill versus land treadmill. It was hypothesized that at the same sub maximal protocol, the underwater treadmill would be perceived as easier than the land treadmill. Both an objective measure, heart rate, and a subjective measure, a 10-point Borg rate of perceived exertion (RPE) scale (Borg, 1982), were used. Ten healthy University of Akron students from the ages 19-23 were used for this study. The students did two separate trials, one land and one underwater, one week apart. Some were selected to do the underwater treadmill first while others did the land treadmill first. The students participated in a 7 stage, 14-minute protocol while wearing a heart rate monitor and sharing their perceived exertion on a 10-point scale after every stage. The results found that the heart rates at all stages were not significantly different between the land treadmill and underwater treadmill. This indicates that the intensity of the protocol was relatively the same. The RPE measurements of the participants were also found to not be significantly different between the land and underwater treadmill. This suggests that both protocols were perceived to have similar intensities. It was concluded that the protocols both objectively and subjectively had similar intensities.

Keywords: rate of perceived exertion, treadmill, heart rate, aquatic, land, exercise

Introduction

One of the most difficult aspects of starting an exercise program is how well the individual adheres to the program. In 2012, approximately 69% of American adults were overweight, and lack of physical activity is one of the leading causes of this. Studies have found that overweight adults are less likely to participate in physical activity compared to normal weight adults. Fewer than 20% of overweight adults meet recommended exercise guidelines of expending 1000-2000 kcals/week through exercise. This expenditure is approximately equivalent to 150-300 min/week of moderate intensity exercise, which is defined as 64%-75% of maximal heart rate (HR). Researchers suggest that exercise adherence is largely linked to intensity, and people would be more likely to adhere to self-paced programs instead of a moderate intensity. People also do not like to participate in behaviors that “do not feel good” and prefer activities that “feel good” (Williams, Dunsiger, Emerson, Gwaltney, Monti, and Miranda, 2012). Other factors such as lack of time, schedule, and unfamiliarity with exercise contribute to lack of adherence. Different modalities of exercise can elicit different rates of perceived exertion (RPE), in other words, how tired an individual feels. If an individual can elicit the same metabolic response but feel less tired with one modality over another then they might be more likely to adhere to an exercise program.

In the study conducted in Wake Forest University, the researchers determined the cardiorespiratory responses and the RPE during a matched underwater and a land treadmill protocol. The study was comprised of 11 athletes who both randomly completed both treadmill protocols on different days. The Borg 6-20 RPE scale was used, and the RPE was assessed every minute during the testing protocol. The results showed that the cardiorespiratory responses between two matched submaximal workloads and the RPE were not significantly different (Brubaker, Ozemek, Gonzalez, Wiley & Collins, 2011)

The aim with this current study was to compare the RPE in two different exercise settings with the same physical demands. Both the underwater treadmill and land treadmill will elicit the same metabolic response through each stage of exercise. The underwater treadmill reduces the stress on the joints and is said to yield improvements in cardiovascular fitness without the ground-reaction of a land treadmill (Brubaker et al, 2011).

It was hypothesized that the higher impact of running on a hard surface as opposed to running in water will cause the participants to believe that running underwater is less intense and hence result in a lower number on the RPE scale. This is important to investigate because it is a challenge to get people to maintain and adhere to an exercise protocol. Many people are more likely to follow through with a program if it is not perceived as overly difficult. Understanding how people perceive exercise intensities may lead to better workout plans being developed and better exercise adherence.

The population used for this study were undergraduate students at a large Midwestern university. Our rationale for using this population was that there was not a lot of literature on healthy college students and whether or not aquatic treadmills yield the same benefits as those of a regular treadmill. Additionally, the use of aquatic treadmills is associated with conditioning of college athletes. In a study done by Rutledge, Silvers, Browder, and Dolny, (2007) it was shown that underwater treadmill running that combines high speeds and resistance jets produced similar peak cardiorespiratory responses as those that occurred on land-based treadmills. The problem with land treadmills is weight-bearing impact on the joints may lead to difficulties and injuries such as stress fractures, Achilles tendonitis, patellar tendonitis, “runner’s knee”, iliotibial band syndrome and muscle pulls. The buoyancy of the underwater treadmill can provide people with an increase in mileage needed during conditioning season without the incurring stress on the joints.

Methods

Participants

The participants consisted of 10 recreationally active undergraduate students (5 men, 5 women; see Table 1) aged between 19 and 23 from a large Midwestern university. All participants were considered recreationally active engaging in moderate amount of physical activity every week. This was defined by American College of Sports Medicine as participating in physical activity 30 minutes a day, ≥5 days/week (Pescatello, 2014). Participants completed a PAR-Q & YOU as their health history to ensure they were healthy and cleared to exercise. They also completed an informed consent waiver consistent with the policies regarding the use of human participants and written informed consent as approved by the university’s Institutional Review Board. Individuals who were pregnant, suffering from musculoskeletal injury, currently smoke, had a phobia of water, or presented cardiovascular or respiratory conditions were deemed ineligible due to health risks and conditions to participate in this study.

Equipment

The underwater treadmill used throughout the study was a HydroWorx 1200 (HydroWorx, Middletown, PA) that consisted of a 6′ wide by 9’6″ long footprint with a treadmill built into it. Water jets were located at the front of the treadmill and the adjustable speed of the jets provided the different water resistances needed for the different stages of our protocol. The land treadmill used was a Welch Allyn model number TMX425 (Full Vision Inc, Newton, KS). For both modalities the participants were connected to a metabolic cart that analyzed the oxygen consumption and energy expenditure, ParvoMedics TrueOne 2400 Metabolic Measurement System (Sandy, UT). The participant's maximal oxygen consumption (VO2), metabolic equivalent (METs), fraction of expired oxygen (FEO2), respiratory exchange ratio (RER), Kilocalories burned and VE were measured every 15 seconds. Before the start of the test, gas meter and flow meter were calibrated to ensure accurate results. Water-resistant chest-strap heart rate monitors (Polar, USA) were used to measure participant's heart rates at the end of every stage. Ratings of perceived exertion were also measured after every stage using the 10-point Borg scale (Borg, 1982), 1 being 'not tired at all' and 10 being 'extremely tired'.

Protocol

All participants took part in two trials, which consisted of a land-based treadmill session on the Welch Allyn model number TMX425, and an underwater treadmill session in the HydroWorx 1200 (HydroWorx, Middletown, PA). Published testing protocols of Brubaker et al (2011) were adapted for this study. These sessions were randomized so not every participant started with the same modality. Two days prior to the participants coming into the lab they were emailed and asked to refrain from eating or drinking 3 hours prior to testing and to avoid strenuous activity within 24 hours of all testing (Brubaker et al, 2011). Before starting the experiment, the participants arrived 15 minutes prior for a familiarization session in which they signed the informed consent form, were reminded about the voluntary nature of the study and how they could discontinue participation at any time. Instructions of methods were given at this time. When all paperwork was complete, participants' resting vitals and demographics were obtained, including resting heart rate and blood pressure, age, weight, gender, and height. Testing procedures were consistent for each participant and all participants were instructed to wear a swimsuit or compression for the underwater treadmill, which includes swimming trunks/compression shorts for males and a one-piece swimming suit/compression shorts and sports bra for females. The warm-up consisted of standing in place for five minutes and allowing an oxygen exchange mask collect data. Following the warm-up, participants began walking on the treadmill at 1.5mph. From this point on participants' heart rate was measured using a Polar Heart Rate monitor (Polar, USA), RPE using a 10-point Borg scale (Borg, 1982) at the end of every stage. Oxygen consumption and energy expenditure was measured using a ParvoMedics TrueOne 2400 Metabolic Measurement System (Sandy, UT) every 15 seconds. The variables measured were VO2, METs, FEO2, Respiratory exchange ratio, Kcals burned and VE. Participants walked at this speed for two minutes and then the treadmill speed was increased to 3.0 mph. After two minutes had been completed the treadmill speed was increased to 4.5 mph and participants completed two minutes at this speed. After two minutes was completed, the treadmill speed was increased to 6.0 mph. Participants completed two minutes at this speed. After two minutes the treadmill speed remained at 6.0 mph, but a 1.5% incline was implemented. After two minutes was completed, the treadmill incline was increased to 2%. When two minutes had been completed, the treadmill incline was increased to 4% incline (Table 2). When two minutes had been completed at this incline, a cool-down began. The cool-down consisted of having participants walk at 1.5 mph until their heart rate was within or under 100 beats per minute. A rest period of at least 48 hours took place before participants reported back to the Exercise Physiology laboratory to do their second session. The underwater treadmill trial went as follows. A weighted belt was placed on the participant to avoid excessive buoyancy while running on the underwater treadmill. Participants aquajogged in the water. To begin, the participant warmed up by standing at rest for five minutes in the water and during this time the water level of the pool was adjusted to their Xiphoid process. An oxygen exchange mask was used to take their initial readings during this time. After five minutes the underwater treadmill was turned on to 1.5 mph. Following the warm-up the same procedures used during the land-based treadmill was used for the underwater treadmill sessions, except instead of using incline during the last three stages at 6.0 mph water jets were turned on to 30%, 40%, and 50% resistance following two minute increments (2011) (Table 3).

Table 1 Descriptive Statistics of Participants, M (SD)

	Age, years	Weight, kg	Height, cm	Resting heart rate, bpm	Resting systolic blood pressure, mmHg	Resting diastolic blood pressure, mmHg
Women, n=4	21.25 (1.71)	64.3 (6.88)	168.68 (1.26)	78 (9.38)	118 (4.43)	71 (6.83)
Men, n=6	20.83 (1.33)	77.13 (7.16)	181.18 (3.46)	67 (9.27)	113 (12.81)	73 (15.27)
Total, N=10	21 (1.41)	75.6 (9.39)	179.51 (6.99)	70 (10.36)	112 (10.20)	73 (12.07)

Table 2 Land Treadmill Protocol

Stage	Duration, min	Speed, mph	Incline, %
REST	5	0	0
1	2	1.5	0
2	2	3	0
3	2	4.5	0
4	2	6	0
5	2	6	1.5
6	2	6	2
7	2	6	4
8	Until HR drops below 100	1.5	0

Table 3 Underwater Treadmill Protocol

Stage	Duration, min	Speed, mph	Jet Resistance, %
REST	5	0	0
1	2	1.5	0
2	2	3	0
3	2	4.5	0
4	2	6	0
5	2	6	30
6	2	6	40
7	2	6	50
8	Until HR drops below 100	1.5	0

Results

All participants were able to complete the underwater and land trials without discontinuing the experiment at any moment.

The physical characteristics of the students including age, height, body weight, resting heart rate and resting blood pressure are shown in Table 1.

Table 2 and 3 provide the protocols for land treadmill and underwater treadmill respectively.

Table 4 provides the average RPE at the end of each stage for the land treadmill protocol and table 5 provides the average RPE at the end of each stage for the underwater treadmill protocol.

Table 6 provides the comparison of RPE measured during land treadmill and underwater treadmill at matched submaximal workloads. There were no significant differences shown for any stage of the protocol. The mean RPE of the final stage of the land treadmill was 4.9 $\pm$ 1.45, and the RPE of the final stage of the underwater treadmill was 4.7 $\pm$ 1.7. The average RPE of the water treadmill is slightly lower than the RPE of the land treadmill. A two-tailed t test revealed a p value of 0.89, which means the data is not significant. This study suggests that the perceived exertion between the underwater treadmill and lead treadmill is not different. At no stage was the p value $\geq$ 0.05 when comparing the RPEs of the land and water treadmills. Because the p value $\geq$ 0.05, these results do not support our hypothesis that the underwater treadmill would be perceived as easier. Graph 1 represents the data shown in Table 6.

Tables 7 and 8 compare the RPE between females and males in land and underwater treadmill, respectively. When comparing genders, the RPEs between men and women are not significantly different despite the women on average reporting higher RPEs throughout all stages of both the land and underwater trials. For the final stage of the land treadmill, women reported an average RPE of 5.75 $\pm$ 1.71 and men reported an average RPE of 4.33 $\pm$ 1.03, and the p value for these averages was 0.08 (not significantly different). For the final stage of the underwater treadmill, women reported an average RPE of 4.75 $\pm$ 2.06 and men reported an average RPE of 3.83 $\pm$ 1.94, and the p value for these averages was 0.49 (not significantly different). The graphs corresponding to the data in Tables 7 and 8, are Graphs 2 and 3 respectively.

As an objective measure, heart rate was used to compare the intensities. Tables 9 and 10 show the average HR at the end of each stage for the land and underwater treadmills respectively. Table 11 shows the comparison of average HR between land treadmill and underwater treadmill. The mean HR of the final stage of the land water treadmill was 187 $\pm$ 16.9, and the HR of the final stage of the underwater treadmill was 153 $\pm$ 11.8. A two-tailed t test revealed a p value of 0.91, which means the data is not significant. Even though the land treadmill had a higher HR than the underwater treadmill, the data in every stage was not statistically significant which suggests the protocols were of similar intensities. Graph 4 represents the data in Table 11.

Tables 12 and 13 show the comparison of HR between females and males in land and underwater treadmills. For the final stage of the land treadmill, women reported an average HR of 187 $\pm$ 16.90 and men reported an average HR of 169 $\pm$ 17.78, and the p value for these averages was 0.15 (not significantly different). For the final stage of the underwater treadmill, women reported an average HR of 154 ± 9.19 and men reported an average HR of 152 ± 12.74, and the p value for these averages was 0.90 (not significantly different). Even though females reported a higher average HR in every stage for both the land and underwater treadmill, the data was not statistically significant as all the p-values in every stage except for one was > 0.05. In stage 3 during the land treadmill there was a significant difference between females and males' HRs (p-value < 0.05). The graphs corresponding to the data in Tables 12 and 13, are Graphs 5 and 6 respectively.

Table 4 Ratings of Perceived Exertion (Borg Units) for Land Treadmill Trials, *M (SD)*

Stage	1	2	3	4	5	6	7
Women	1 (0)	1.75 (0.96)	2.75 (2.22)	3.5 (1.73)	4.25 (1.26)	5 (1.41)	5.75 (1.71)
Men	1 (0)	1.17 (0.41)	2 (1.10)	2.83 (1.17)	3.33 (1.03)	4 (1.10)	4.33 (1.03)
Total	1 (0)	1.4 (0.70)	2.3 (1.57)	3.1 (1.37)	3.7 (1.16)	4.4 (1.26)	4.9 (1.45)

Table 5 Ratings of Perceived Exertion (Borg Units) for Underwater Treadmill Trials, *M (SD)*

Stage	1	2	3	4	5	6	7
Women	1 (0)	1.75 (0.5)	3.25 (0.96)	4 (1.15)	4.75 (1.50)	4.75 (2.06)	5.25 (1.5)

Men	1 (0)	1.5 (0.55)	2.5 (1.38)	3.17 (1.60)	3.5 (1.52)	3.83 (1.94)	4.33 1.86)
Total	1 (0)	1.6 (0.52)	2.8 (1.22)	3.5 (1.43)	4 (1.56)	4.2 (1.93)	4.7 (1.7)

Table 6 Comparison of Rate of Perceived Exertion between LT and UT

Stage	Mean RPE Treadmill	SD RPE	Mean RPE Underwater	SD RPE	**p***
1	1	0	1	0	**0**
2	1.4	0.70	1.6	0.52	**0.28**
3	2.3	1.57	2.8	1.22	**0.26**
4	3.1	1.37	3.5	1.43	**0.32**
5	3.7	1.16	4	1.56	**0.51**
6	4.4	1.26	4.2	1.93	**0.89**
7	4.9	1.45	4.7	1.70	**0.89**

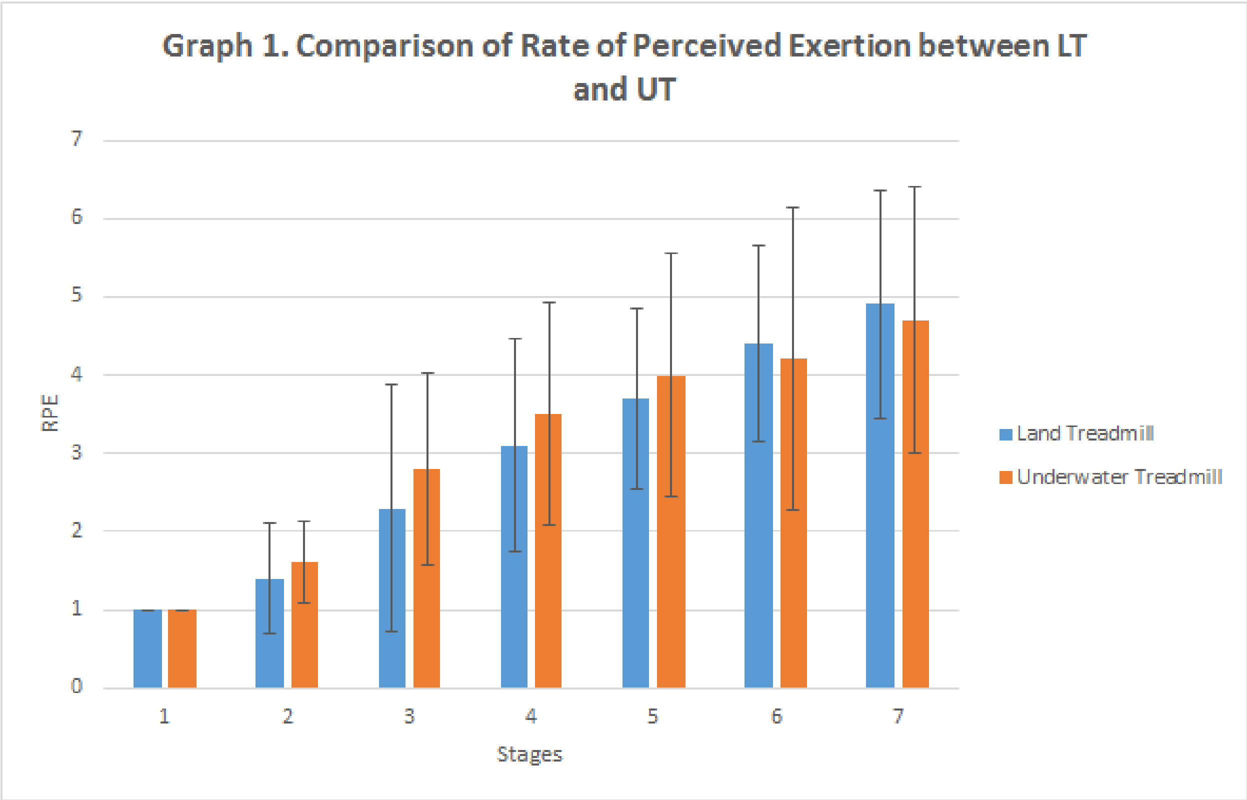


Table 7 Comparison of Rate of Perceived Exertion between Females and Males using the Land Treadmill

Stage	Female (n=4)		Male (n=6)		
	Mean	SD	Mean	SD	**p***
1	1	0	1	0	**0**
2	1.75	0.96	1.17	0.41	**0.08**
3	2.75	2.22	2	1.10	**0.27**

4	3.5	1.73	2.83	1.17	**0.21**
5	4.25	1.26	3.33	1.03	**0.12**
6	5	1.41	4	1.10	**0.12**
7	5.75	1.71	4.33	1.03	**0.08**

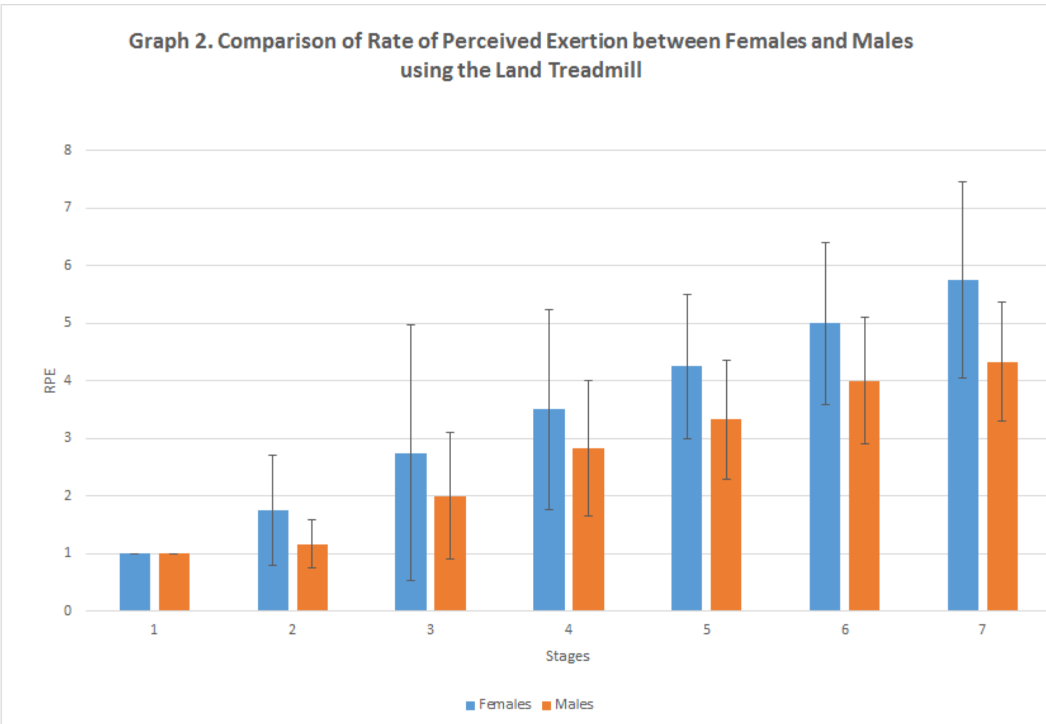


Table 8 Comparison of Rate of Perceived Exertion between Females and Males using the Underwater Treadmill

Stage	Females (n=4)		Males (n=6)		
	Mean	SD	Mean	SD	p*
1	1	0	1	0	0
2	1.75	0.5	1.5	0.55	0.49
3	3.25	0.96	2.5	1.38	0.37
4	4	1.15	3.17	1.60	0.39
5	4.75	1.50	3.5	1.52	0.23
6	4.75	2.06	3.83	1.94	0.49
7	5.25	1.5	4.33	1.86	**0.43**

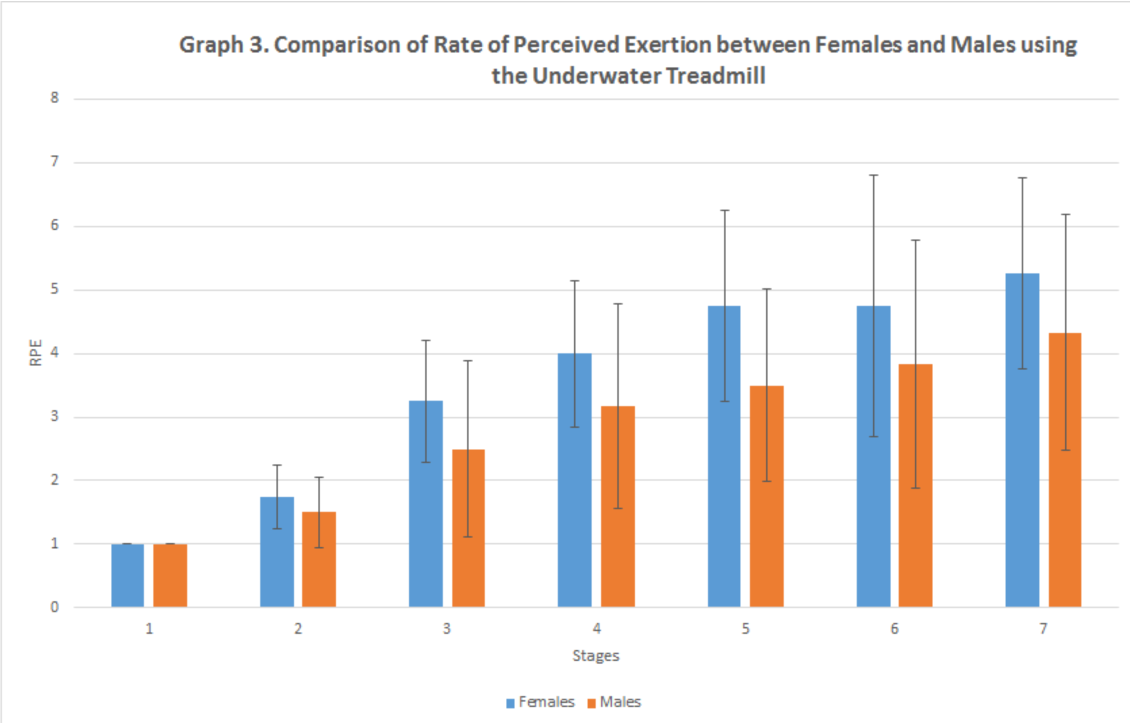


Table 9 Heart Rate (bpm) for Land Treadmill Trials, *M (SD)*

Stage	1	2	3	4	5	6	7
Women	102 (20.20)	111 (20.25)	159 (12.47)	169 (18.52)	175 (18.26)	181 (16.78)	187 (16.90)
Men	87 (7.63)	101 (9.09)	127 (19.81)	149 (18.29)	157 (20.23)	163 (19.84)	169 (17.78)
Total	93 (15.26)	105 (14.56)	140 (23.15)	157 (20.13)	164 (20.48)	170 (19.83)	176 (18.86)

Table 10 Heart Rate (bpm) for Underwater Treadmill Trials, *M (SD)*

Stage	1	2	3	4	5	6	7
Women	95 (14.73)	109 (8.72)	112 (20.60)	132 (36.77)	138 (31.11)	155 (9.19)	154 (9.19)
Men	89 (8.08)	106 (13.60)	119 (11.15)	137 (14.88)	139 (14.33)	148 (12.69)	152 (13.74)
Total	91 (10.18)	107 (11.00)	117 (14.09)	136 (19.47)	139 (16.89)	150 (11.47)	153 (11.84)

Table 11 Comparison of Heart Rate between LT and UT

Stage	Mean HR Treadmill	SD HR	Mean HR Underwater	SD RPE	**p***
1	93	15.26	91	10.18	0.45
2	105	14.56	107	11.00	0.77
3	140	23.15	117	14.09	0.48
4	157	20.13	136	19.47	0.79
5	164	20.48	139	16.89	0.93
6	170	19.83	150	11.47	0.55

7	176	18.86	153	11.84	0.91

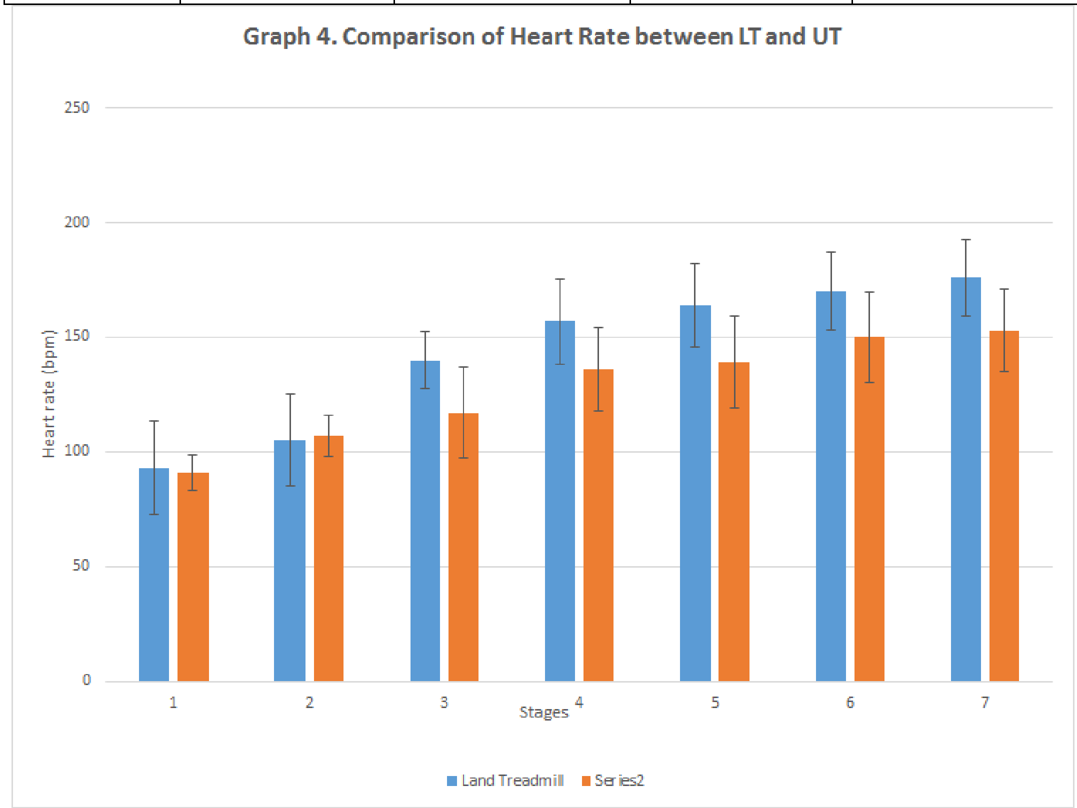


Table 12 Comparison of Heart Rate between Females and Males using the Land Treadmill

Stage	Female (n=4)		Male (n=6)		
	Mean	SD	Mean	SD	p*
1	102	20.20	87	7.63	0.12
2	111	20.25	101	9.09	0.29

3	159	12.47	127	19.81	**0.02***
4	169	18.52	149	18.29	0.13
5	175	18.26	157	20.23	0.20
6	181	16.78	163	19.84	0.19
7	187	16.90	169	17.78	0.15

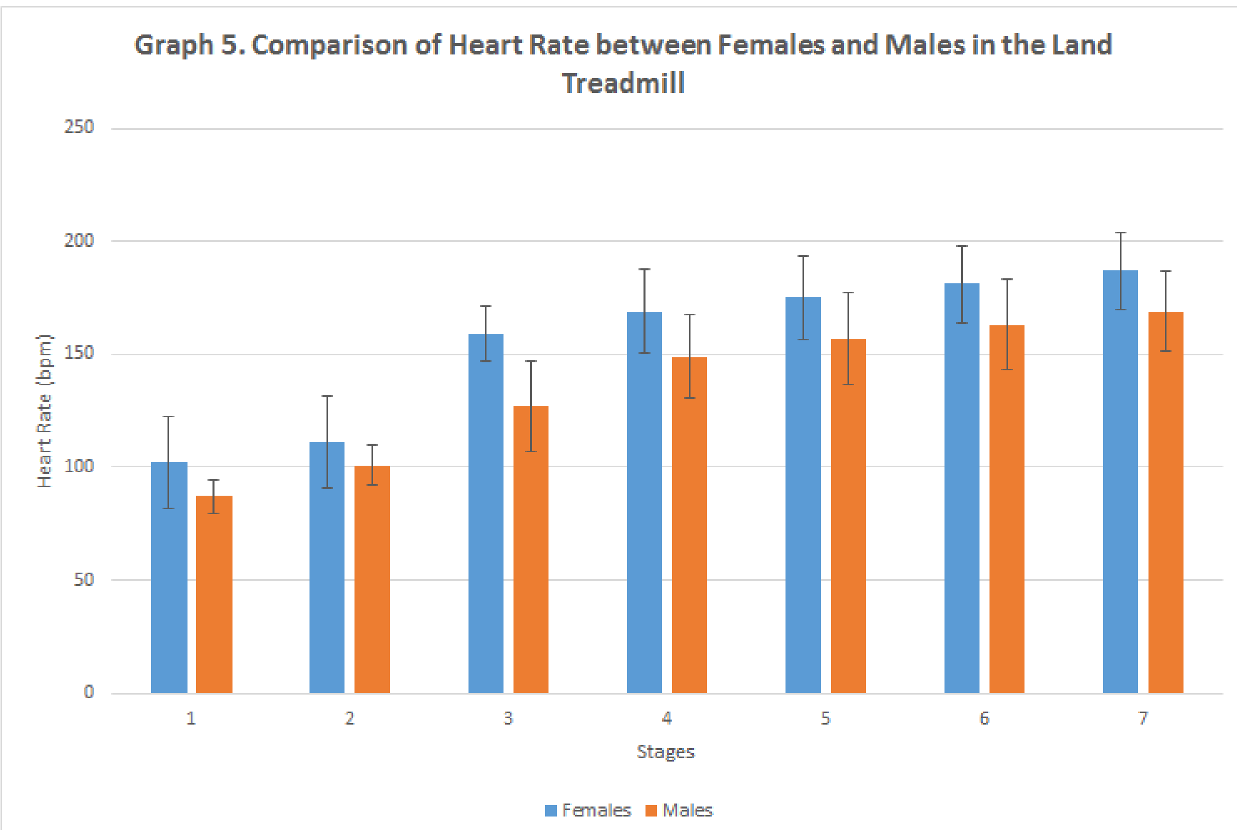
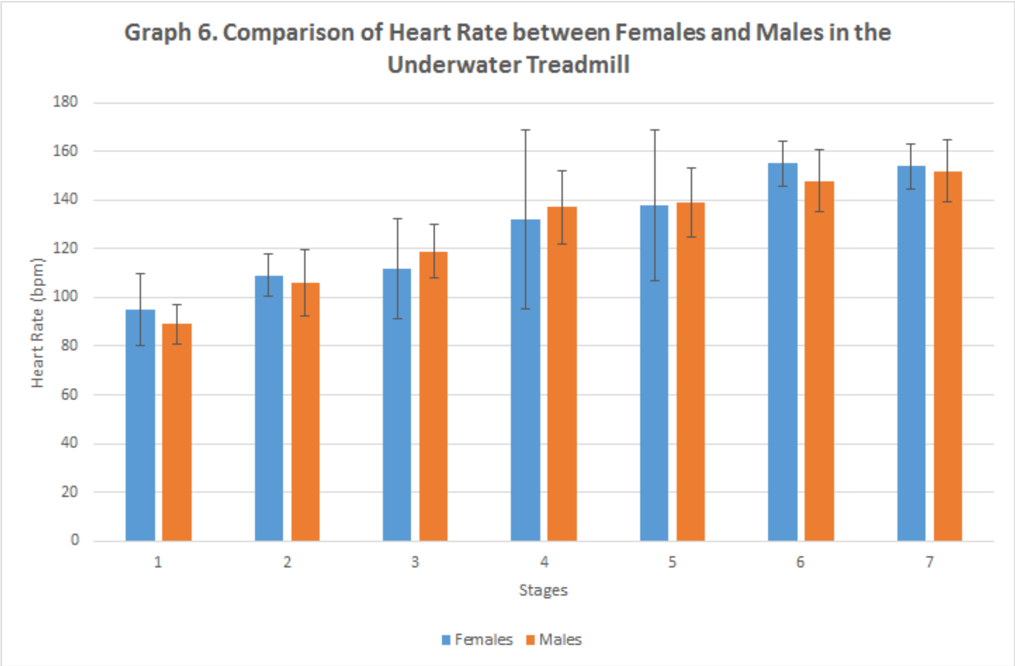


Table 13 Comparison of Heart Rate between Females and Males using the Underwater Treadmill

Stage	Female (n=4)		Male (n=6)		
	Mean	SD	Mean	SD	p*
1	95	14.73	89	8.08	0.45
2	109	8.72	106	13.6	0.77
3	112	20.6	119	11.15	0.48
4	132	36.77	137	14.88	0.79
5	138	31.11	139	14.33	0.93
6	155	9.19	148	12.69	0.55
7	154	9.19	152	12.74	0.9



Discussion

Exercise adherence is a challenge to those implementing an exercise program for various reasons such as injury, perceived difficulty of the exercise, or pain associated with the exercise. Both land and aquatic treadmills provide their own therapeutic benefits to those exercising. Previous studies show that an aquatic treadmill can provide the same cardiovascular benefits as a land treadmill without providing the same stress on the body as a land treadmill (Brubaker et al, 2011). Because of this, we felt that participants doing both a land and underwater treadmill at the same intensity would find the underwater treadmill to be easier. A 10 point Borg scale (Borg, 1982) was used to measure the perceived difficulty of each exercise. The purpose of this study is to see if two different exercises at the same intensities could be perceived differently. This study sought to investigate the idea that if one exercise seems easier because people would be more likely to adhere to the “easier” mode of exercise. It was hypothesized that the underwater treadmill would be perceived as easier compared to a land treadmill due to the reduced stress on the joints. Our overall findings concluded that two different exercise modalities with similar workloads did not yield statistically different RPEs to support our hypothesis. When analyzing the data and comparing females and males, it was found that the average RPE and HR at the end of every stage for both land and underwater treadmill was higher for females, however the p-values show that these differences aren’t statistically significant. The only piece of significant data in this study was seen in stage 3 of the land treadmill protocol when comparing the average HR between males and females. The p-value noted was 0.02 which is $p < 0.05$ making it statistically significant.

This study had several limitations, primarily the small sample size (n=10) and exclusive sample, healthy college students, does not accurately represent the general population. All the participants were free from any diseases/ailments, were a healthy weight, and moderately active. Much of the general population suffers from being overweight or having diseases such as arthritis. Testing this population may provide different results. Another limitation is that the heart rate monitor was unable to pick up some of the heart rates during the underwater trial. A disturbance was likely created due to the water separating the monitor and the watch used to read the monitor. This limitation made us unable to see if the heart rates at all stages were not significantly different. A third limitation is that we did not have an objective measure to reveal which test the participants preferred. Even if the RPEs were similar, exercise in the land treadmill and underwater treadmill is a vastly different experience (despite similar cardiovascular demands), but we were unable to measure that.

Further studies should be done to measure the difference in enjoyment level between the land and underwater treadmill. After completing their trials, participants discussed which trial they preferred and why. Doing a study to objectively measure their enjoyment could contribute the information that promotes exercise adherence. The PACES scale, used in the study by Garcia et al. (2008), could be used to objectively measure and compare the enjoyment between the land and underwater treadmill.

Conclusion:

In conclusion, the study suggests that for healthy college aged students, the perceived exertion of an underwater treadmill and land treadmill at the same intensity is not significantly different. The study also suggests that a two separate protocols on two separate modalities (land and underwater treadmill) can produce similar cardiovascular effects.

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