UNIVERSITY OF WISCONSIN – LA CROSSE

Graduate Studies

CARDIORESPIRATORY RESPONSES DURING AN AQUA CYCLING CLASS

A Manuscript Style Thesis Submitted in Partial Fulfillment of the Requirements for the Degree of Masters of Science in Clinical Exercise Physiology

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By Kathryn G. Johnson

We recommend acceptance of this thesis in partial fulfillment of the candidate's requirements for the degree of Masters of Science in Clinical Exercise Physiology

The candidate has completed the oral defense of the thesis.

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ABSTRACT

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The purpose of this study was to determine the relative exercise intensity and EE during an aqua cycling class and determine if aqua cycling meets ACSM guidelines for exercise prescription. Subjects completed an aqua cycling workout by following along to a pre-recorded video of an aqua cycling class. The total class was 50 minutes in length, including a 5-minute warm-up and a 5-minute cool-down. The average HR and %HRR were 115 $\pm$ 13.7 bpm and 49 $\pm$ 9.8%, respectively. The average VO_2 and $\%VO_2R$ were 20.3 $\pm$ 3.15 ml/kg/min and 47 $\pm$ 5.3%, respectively. The VO_2 corresponded to an average of 5.8 $\pm$ .90 METs. The average EE was 7.3 $\pm$ 1.31 kcal/min. The number of calories expended during the entire workout averaged 363 $\pm$ 65.5 kcals. The average RPE for the entire aqua cycling class was 11.0 $\pm$ .79. Excluding the warm-up and cool-down, the average RPE for just the 40-minute workout portion of the class was 12.2 $\pm$ .95. It was concluded that aqua cycling meets ACSM guidelines for improving cardiovascular endurance and controlling body composition and should be an enjoyable, low impact alternative for those individuals with orthopedic issues that make weight-bearing exercise problematic.

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INTRODUCTION

It is well known that exercise is important for overall health and disease prevention (Giacomini et al., 2009; ACSM, 2017). According to the current American College of Sports Medicine (ACSM) guidelines, it is recommended that individuals perform 30 minutes of moderate intensity aerobic exercise at least 5 days/week or 20 minutes of vigorous intensity aerobic exercise at least 3 days/week in order to achieve the health/fitness benefits of exercise (ACSM, 2017). As stated above, the intensity of exercise should be moderate to vigorous which ACSM defines as 64-95% of maximal heart rate (HR), 46-90% of maximal oxygen consumption (VO_2max), and 40-89% of heart rate reserve (HRR) or oxygen uptake reserve (VO_2R) (ACSM, 2017). However, many people do not meet these recommendations because they find exercise boring or claim exercise is not "fun." As a result, group exercise classes, such has spinning, boot camp, Zumba, Pilates, yoga, or high intensity interval training (HIIT) have been developed, providing a fun and social environment for people to work out in, in attempt to increase compliance with ACSM recommendations.

A relatively new group fitness class is aqua cycling. Aqua cycling is essentially a "spinning" class performed immersed in water, typically up to the xiphoid process. Cycling underwater provides a low impact environment and the resistance provided by the water allows for high levels of energy expenditure with little musculoskeletal strain on the body (Rebold, Kobak, & Otterstetter, 2013). Aqua cycling was originally used for the purpose of rehabilitation (Frangolias & Rhodes, 1996), but has now emerged as a unique fitness trend, appearing in fitness studios all over Europe and most recently in the United States. To date, studies have reported no adverse events related to aquatic cycling (Rewald et al., 2017).

When comparing cardiorespiratory responses between land and water-based exercise, research findings are inconsistent. There is a tendency for studies to find lower submaximal and maximal heart rates during water-based exercise compared to land-based exercise (Parfitt, Hensman, & Lucas, 2017; Barbosa et al., 2009; Rebold et al., 2013; Rewald et al., 2017; Kanitz et al., 2015; Frangolias & Rhodes, 1996). Studies have also found that submaximal and maximal VO_2 are similar during water and land-based exercises (Brubaker et al., 2011; Yazigi et al., 2013; Rewald et al., 2017; Frangolias & Rhodes, 1996; Greene, Greene, Carbuhn, Green, Crouse, 2011). Conversely, Garzon et al. (2015b) and Kanitz et al. (2015) found lower VO_2 during water-based exercises and attributed this finding to the fact that the increased buoyancy when exercising in the water required less muscle recruitment to execute the exercise.

When comparing land-based exercise to water-based exercise, the overall training effect has been shown to be greater in water than on land (Handa et al., 2016). The researchers observed that women in a water-based walking group were able to exercise at a higher metabolic rate compared to on land and attributed the differences to improved subjective feelings. This resulted in greater gains in physical fitness.

Rating of perceived exertion (RPE) is another way to quantify exercise intensity. Research supports the use of RPE as an effective indicator of intensity during land-based exercise and Alberton et al. (2016) found a similar relationship between RPE and underwater exercise intensity. Brubaker et al. (2011) also found similar RPE values during aquatic exercise compared to land-based exercise at the same exercise intensity. Conversely, Barbosa et al. (2009) observed higher RPE during water vs. land-based exercise. According to ACSM (2017), RPE should be between 12-17 (on the 6-20 Borg Scale) in order to elicit cardiorespiratory benefits.

To our knowledge, there is no data evaluating the physiological responses to an aqua cycling class. The purpose of this study was to assess HR, VO_2, RPE and energy expenditure during an aqua cycling class and determine if aqua cycling meets ACSM guidelines for exercise prescription. This investigation was part of a larger study which measured maximal HR and VO_2 responses during an incremented water-based cycling test. Data from that study allowed the data from this study to be converted to relative exercise intensity (e.g., %HRR and % VO_2R).

METHODS

Subjects

Sixteen apparently healthy volunteers from the University of Wisconsin – La Crosse participated in this study. Subjects ranged in age from 19-24 years of age and had no musculoskeletal or cardiovascular problems that would have been exacerbated while immersed in water or prevented them from exercising at various intensities. All subjects had basic familiarity with riding a stationary bike. Approval from the University of Wisconsin – La Crosse Institutional Review Board for the Protection of Human Subjects was obtained and written informed consent was provided by each subject prior to data collection.

Procedures

Subjects practiced cycling and performing various exercises using the Hydrorider Professional Bike (Biscayne Park, FL) to familiarize themselves with the activity of underwater cycling. Subjects practiced until deemed proficient by the principle investigator and then were allowed to complete an aqua cycling workout by following along to a pre-recorded video of an aqua cycling class played on a computer screen placed on the edge of the pool deck. The aqua cycling class was created by the investigators of this study and was based on workouts performed at aqua cycling studios around the country. The total class was 50 minutes in length, including a 5-minute warm-up and a 5-minute cool-down. The 40-minute workout portion of the class consisted of 4 sections: 1) Interval 1, 2) Arm, 3) Interval 2, and 4) Leg. There was a 2-minute recovery period (cycling against light resistance) after Interval 1 and after the Arm section. Interval 1 was 10 minutes in duration and was similar to a high intensity interval training pattern of 1 minute "on" or exercising at a high intensity, with 1 minute "off" or a recovery period. The Arm section was 6 minutes in duration and consisted of various arm strokes and movements in the water performed simultaneously with a comfortable baseline pedaling rate of 70 rpms. Interval 2 was a repeat of Interval 1. The Leg section was 10 minutes in duration and was a mixture of higher intensity pedaling and leg exercises that were done without the feet secured on the pedals.

All sessions took place in the swimming pool in Mitchell Hall on the University of Wisconsin – La Crosse campus. The seat height was adjusted so that each subject was submerged to their xiphoid process. Prior to the test, each subject sat quietly on the bike in the water for 10 minutes to determine resting HR. Upbeat music, similar to that played in typical land-based spinning classes, was played throughout the entire workout and the subjects were given encouragement periodically, especially during the more difficult portions of the workout, similar to what an instructor would give during a typical spinning class. Heart rate and VO_2 were measured continuously during the entire workout. Heart rate was recorded with a Polar HR monitor (Bethpage, NY) and VO_2 was measured using a Parvo Medics metabolic cart (Sandy, UT). Prior to each test, the metabolic system was calibrated with gases of known concentrations (15.98% O_2, 4.12% CO_2) and with room air (20.94% O_2 and 0.03% CO_2) as per the manufacture guidelines. Calibration of the pneumotachometer was done via a 3 Litre calibration syringe. Rating of perceived exertion was assessed at the end of each section of the workout using the 6-20 Borg Scale (Borg, 1982). Energy expenditure was calculated from the VO_2 data assuming a constant of 5 kcal per liter of oxygen consumed. Percentage of HRR was calculated using the subject's resting HR that was determined in the water. Percentage of VO_2R was calculated using a resting VO_2 of 3.5 ml/kg/min for all subjects.

Statistical Analysis

Standard descriptive statistics were used to characterize the subject population and to summarize the responses to the aqua cycling workout. All data are represented as mean ± standard deviation. Differences in demographic characteristics between males and females were compared using independent t-tests. Alpha was set at .05 to achieve statistical significance. Data were analyzed using SPSS version 25.0 (Chicago, IL).

RESULTS

Sixteen subjects completed the study. There were 8 females and 8 males ranging from 19-24 years of age. Descriptive characteristics of the subjects are presented in Table 1.

Table 1. Descriptive characteristics of subjects (N=16).

	Males (n=8)	Females (n=8)
Age (yr)	22.3 ± 1.75	21.1 ± 1.46
Height (cm)	176.8 ± 1.89*	168.9 ± 6.21
Weight (kg)	78.6 ± 8.24*	65.4 ± 9.53
HRmax (bpm)	165 ± 17.5	167 ± 10.7
VO_2max (ml/kg/min)	40.9 ± 8.89	37.8 ± 4.06

*Significantly different than females ($p<.05$).

Absolute and relative HR responses during the 50-minute aqua cycling class are presented in Figure 1 and 2, respectively. The average HR and %HRR were 115 ± 13.7 bpm and 49 ± 9.8%, respectively.

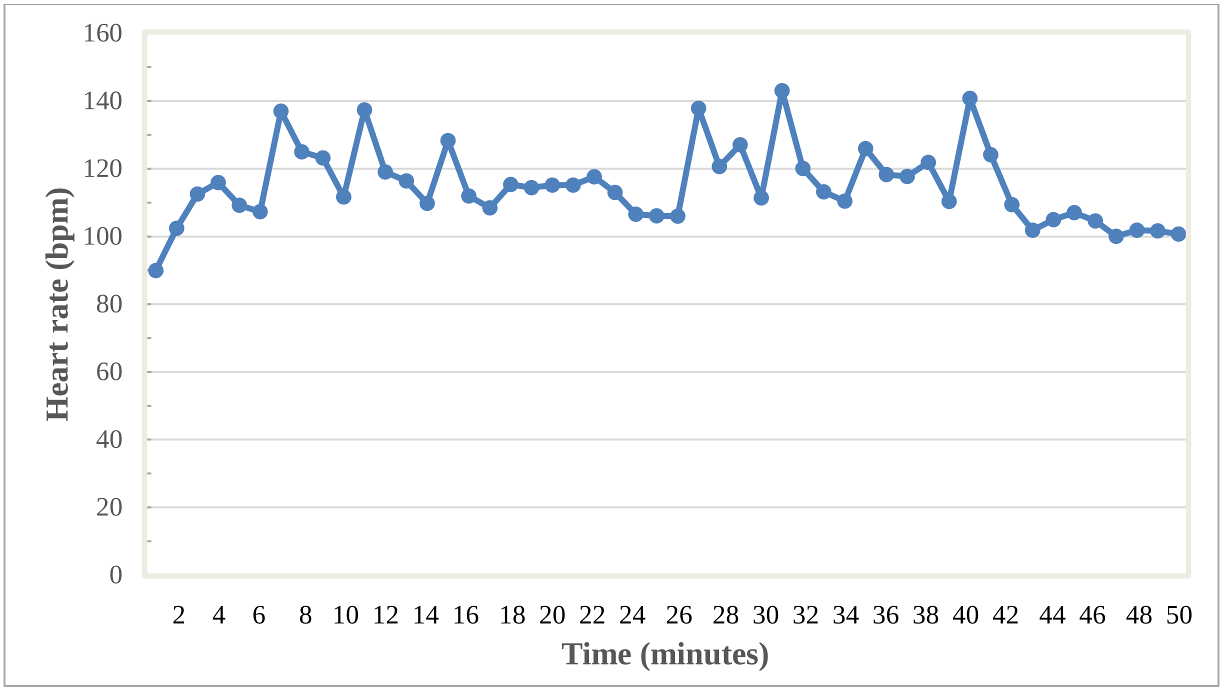


Figure 1. Average heart rate during the aqua cycling class.

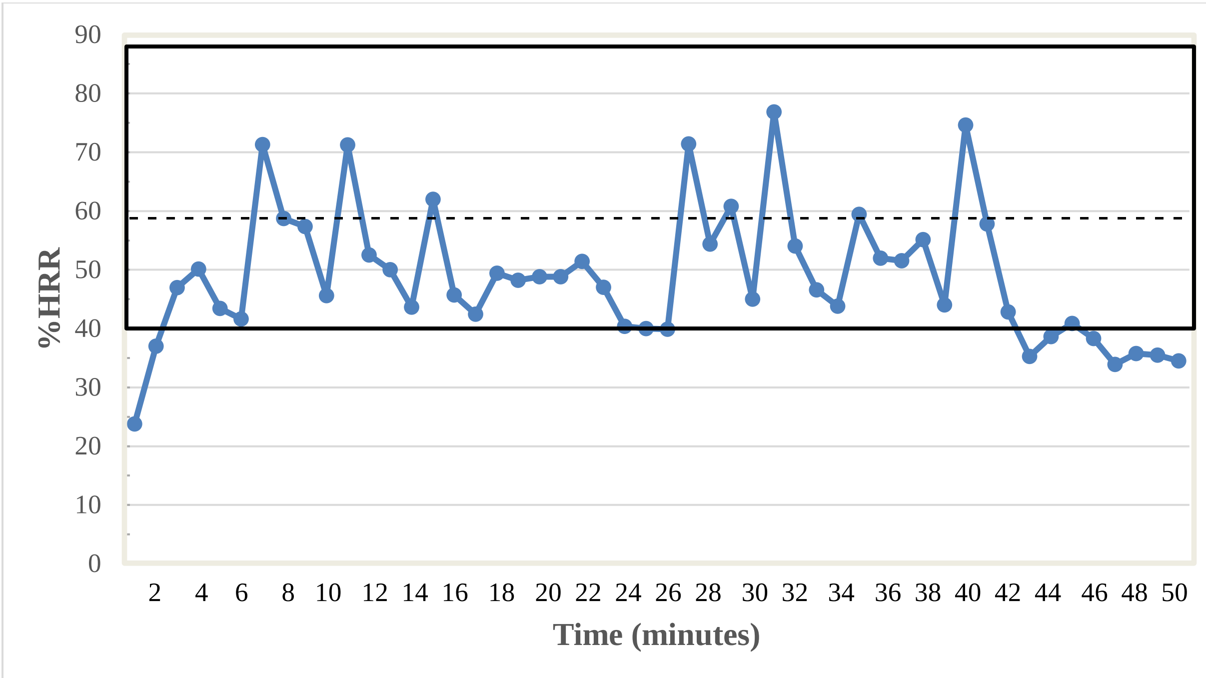


Figure 2. Average %HRR during the aqua cycling class. ACSM guidelines recommend exercising between 40-89% of HRR which is represented by the boxed area on the graph. The separation between moderate and vigorous intensity ranges within the guidelines is represented by the dotted line.

Average and relative VO_2 responses during the aqua cycling class are presented in Figure 3 and 4, respectively. The average VO_2 and $\%VO_2R$ were 20.3 $\pm$ 3.15 ml/kg/min and 47 $\pm$ 5.3%, respectively. The VO_2 corresponded to an average of 5.8 $\pm$ .90 metabolic equivalent units (METs).

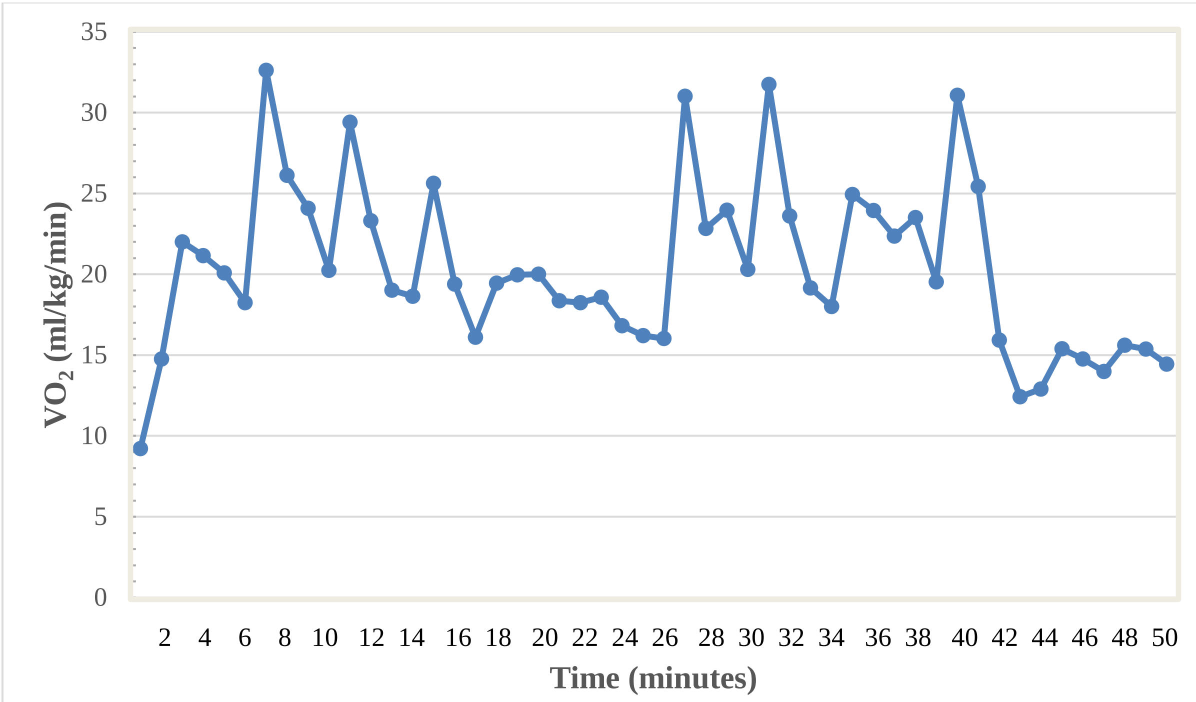


Figure 3. Average VO_2 during the aqua cycling class.

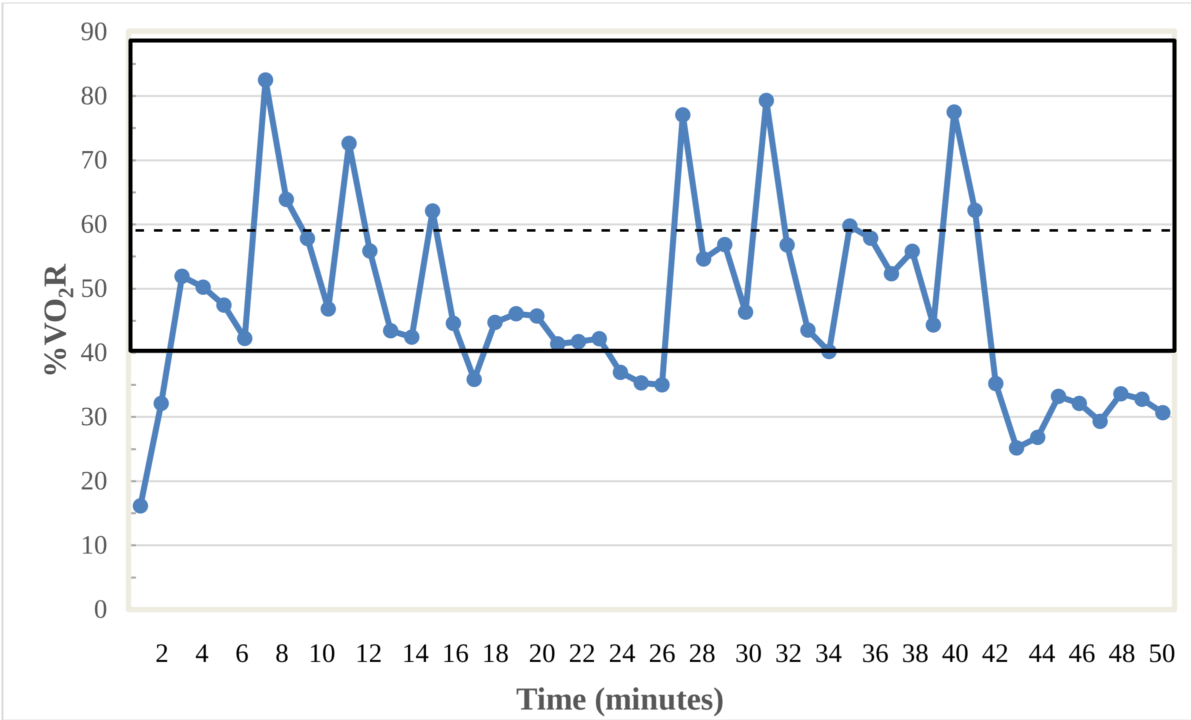


Figure 4. Average %VO_2R during the aqua cycling class. ACSM guidelines recommend exercising between 40-89% of VO_2R, which is represented by the boxed area on the graph. The separation between moderate and vigorous intensity ranges within the guidelines is represented by the dotted line.

Energy expenditure (kcal/min) during the aqua cycling class is presented in Figure 5. The average energy expenditure was 7.3 $\pm$ 1.31 kcal/min. The number of calories expended during the entire workout averaged 363 $\pm$ 65.5 kcals.

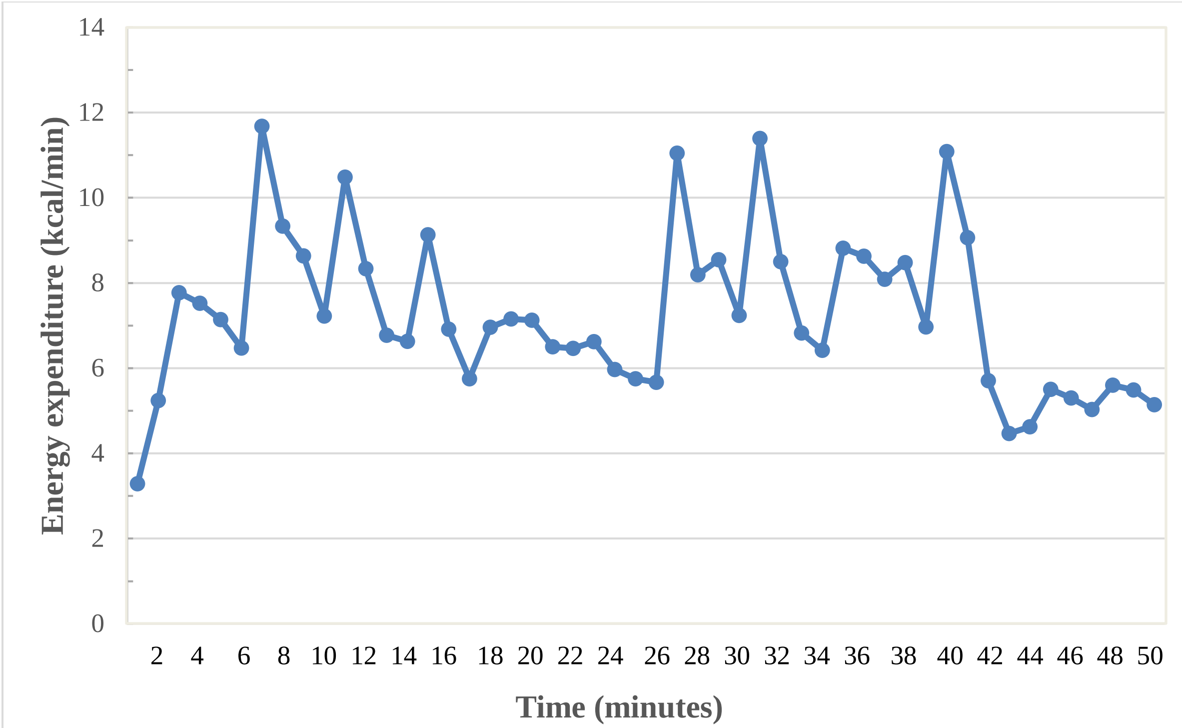


Figure 5. Average by-minute energy expenditure (kcal/min) during the aqua cycling class.

Average RPE values (6-20 Borg Scale) at the end of each segment of the aqua cycling class are presented in Figure 6. The average RPE for the entire aqua cycling class was 11.0 $\pm$ .79. Excluding the warm-up and cool-down, the average RPE for just the 40-minute workout portion of the class was 12.2 $\pm$ .95.

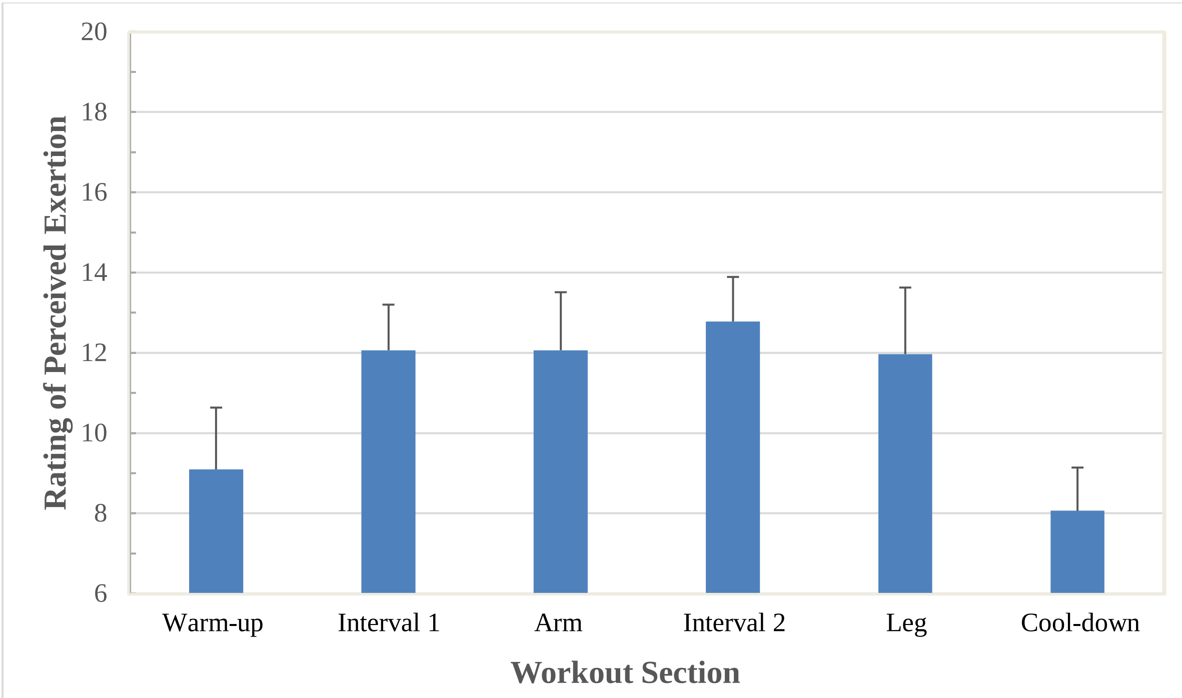


Figure 6. Average RPE at end of each segment of the aqua cycling class.

DISCUSSION

The purpose of this study was to determine the relative exercise intensity and energy expenditure during an aqua cycling class and determine if aqua cycling meets ACSM guidelines for exercise prescription. To our knowledge, there is no data evaluating the physiological responses to an aqua cycling class in any population.

ACSM guidelines recommend that an individual should exercise between 40-89% HRR and VO_2R in order to achieve cardiorespiratory benefit (ACSM, 2017). The current study found that subjects were exercising at an average of 49% of HRR and 47% of VO_2R during the aqua cycling class, which is within ACSM guidelines for improving cardiorespiratory endurance. These averages would be considered in the moderate intensity range (40-59% of HRR or VO_2R). But as can be seen in Figures 2 and 4, some portions of the workout were in the vigorous intensity range (60-89% HRR or VO_2R). This variation in exercise intensity is typical of the general choreographic plan common in cycling classes (Battista et al., 2008).

A key point is whether or not the percentage of HRR and VO_2R when exercising in the water provide a similar intensity as during land-based exercise. Garzon, Gayda, Nigam, Comtois and Juneau (2017) compared two maximal incremental exercise tests, one performed on the Hydrorider aquabike immersed in water up to the xiphoid process and one on a dryland ergocycle. Both exercise tests were performed at similar external power outputs. There was no significant difference between the average values of %HRR and %VO_2R for the same external power output during exercise on the immersible ergocycle and the dryland ergocycle. In other words, the relative intensity of aqua cycling and dryland cycling elicited similar %HRR and %VO_2R responses at similar external power outputs. Therefore, the ACSM guidelines for exercise prescription are accurate for exercise modalities in the water.

Rating of perceived exertion is another method used to determine relative exercise intensity. ACSM (2017) recommends exercising between 12-17 on the Borg RPE scale in order to reap cardiorespiratory benefits. During the 50-minute class, which included the warm-up and cool-down, the overall intensity was rated as 11.0, which would be classified as "fairly light" exercise, according to the verbal anchors on the Borg scale. However, when looking just at the 40-minute workout portion of the aqua cycling class, the average RPE was 12.2, which would be considered "light-moderate" exercise and falls within ACSM guidelines.

Donnelly et al. (2009) recommends expending 1200-2000 kcal per week (240-400 kcal/workout) in order to lose or manage body weight. Subjects in the current study burned an average of 363 kcals during the 50-minute class. This indicates that aqua cycling could be used as an effective workout for weight loss or management. This is especially important for the elderly or overweight individuals, or those who have musculoskeletal or orthopedic conditions where they cannot tolerate land-based exercise long enough or cannot exercise at a high enough intensity to burn a sufficient amount of calories to induce a weight loss or help maintain their weight. Our findings are consistent with those of Rebold et al. (2013) who noted that cycling underwater provides a low impact environment and the resistance provided by the water allows for high levels of energy expenditure with little musculoskeletal strain on the body.

An obvious question is how does an aqua cycling class compare to a land-based cycling class. Battista et al. (2008) found the average intensity of a 45-minute conventional indoor cycling class and a 35-minute indoor cycling class with 4 variations in choreography to be 74% and 66% of VO_2max, respectively. While there was significant variation in momentary exercise intensity due to the typical nature of an indoor cycling class, the intensity during the majority of both classes was within 75% to 80% of VO_2max, which is within the high-intensity range based on ACSM guidelines for improving cardiorespiratory endurance. Piacentini, Gianfelici, Faina, Figura, and Capranica (2009) evaluated an indoor cycling class that was specifically designed to improve cycling performance and promote weight loss. They found that subjects exercised at an average of 79% of VO_2max and 86% of HRmax, which also falls into the high-intensity range based on ACSM guidelines. Therefore, the researchers suggested that indoor cycling should be an activity for healthy, active individuals, and should be avoided by sedentary and older populations or those with health problems. In the current study, subjects were exercising at 49% HRR and 47% VO_2R, which corresponded to 69% of HRmax and 51% of VO_2max. Thus, the overall intensity was in the moderate range, which would be ideal for an older or more sedentary population.

Comparisons between different workouts can be made using metabolic equivalents (METs). Intensity is often classified based on METs because individuals have different VO_2max values, which would affect the calculated relative exercise intensity. Light-intensity physical activity is defined as 2.0-2.9 METs, moderate-intensity ranges from 3.0-5.9 METs, and activities $\geq$ 6.0 METs are considered vigorous physical activity (ACSM, 2017). In the current study, the average MET requirement was 5.8 $\pm$ .90 METs, which falls within the moderate-intensity category. Other activities that are of similar intensity include walking at 4.0 mph on level ground (5.0 METs) (Ainsworth et al., 2011), hula-hooping (5.9 METs) (Holthusen, Porcari, Foster, Doberstein, 2010), TRX Suspension Training (5.8 METs) (Smith, Snow, Fargo, Buchanan, Dalleck, 2016), stand-up paddle boarding at an easy pace (6.3 METs) (Andres, Porcari, Cress, Camic, Radtke, Foster, 2017), and Pound® (5.1 METs) (Ryskey et al., 2017).

Possible limitations of the current study include the fact that subjects performed this workout without other class members present and without a live instructor. Therefore the observed responses could possibly represent a conservative estimate of the exercise intensity of a typical aqua cycling class. Another limitation was that the subjects in this study were healthy, young adults. Responses in an older or more sedentary population could be somewhat different. Further research could be done to evaluate the cardiorespiratory response and relative exercise intensity of an aqua cycling class in other populations.

In summary, aqua cycling meets ACSM intensity guidelines for improving cardiovascular endurance and energy expenditure guidelines for maintaining and improving body composition for weight loss. It is an enjoyable low impact alternative for those with orthopedic issues that make weight bearing exercise problematic.

REFERENCES

Ainsworth, B.E., Haskell, W.L., Herrmann, S.D., Meckes, N., Bassett, J.R., Tudor-Locke, C., Greer, J.L., Venzina, J., Whitt-Glover, M.C., Leon, A.S. (2011). 2011 Compendium of physical activities: A second update of codes and MET values. *Medicine and Science in Sports and Exercise, 42*(8), 1575-1581. doi: 10.1249/MSS.0b013e31821ece12

Alberton, C.L., Pinto, S.S., Gorski, T., Antunes, A.H., Finatto, P., Cadore, E.L., Bergamin M., & Kruel, L.F.M. (2016). Rating of perceived exertion in maximal incremental tests during head-out water-based aerobic exercises. *Journal of Sports Sciences, 34*(18), 1691-1698. http://dx.doi.org/10.1080/02640414.2015.1134804

American College of Sports Medicine. (2017). *ACSM's guidelines for exercise testing and prescription* (10th ed.). Philadelphia, PA: Wolters Kluwer Health

Andres, J., Porcari, J.P., Cress, M.L., Camic, C., Radtke, K., Foster, C. (2017). Physiologic responses to standup paddleboarding. *GMJ, 10*(1), 26-28.

Barbosa, T.M., Marinho, D.A., Reis, V.M., Silva, A.J., & Bragada, J.A. (2009). Physiological assessment of head-out aquatic exercises in healthy subjects: A qualitative review. *Journal of Sports Science and Medicine, 8,* 179-189.

Battista, R.A., Foster, C., Andrew, J., Wright, G., Lucia, A., Porcari, J.P. (2008). Physiologic responses during indoor cycling. *The Journal of Strength and Conditioning Research, 22*(4), 1236-1241.

Borg, G. (1982). Psychophysical bases of perceived exertion. *Medicine and Science in Sports and Exercise, 14*(5), 377-381.

Brubaker, P., Ozemek, C., Gonzalez, A., Wiley, S., & Collins, G. (2011). Cardiorespiratory responses during underwater and land treadmill exercise in college athletes. *Journal of Sport Rehabilitation, 20,* 345-354.

Donnelly, J.E., Blair, S.N., Jakicic, J.M., Manore, M.M., Rankin, J.W., & Smith, B.K. (2009). American college of sports medicine position stand. Appropriate physical activity intervention strategies for weight loss and prevention of weight regain for adults. *Medicine and Science in Sports and Exercise, 41*(7), 1532.

Frangolias, D.D. & Rhodes, E.C. (1996). Metabolic responses and mechanisms during water immersion running and exercise. *Sports Med*, *22*(1), 38-53.

Garzon, M., Gayda, M., Nigam, A., Comtois, A., Juneau, M. (2017). Immersible ergocycle prescription as a function of relative exercise intensity. *Journal of Sport and Health Science, 6,* 219-224. http://dx.doi.org/10.1016/j.jshs.2015.12.004

Garzon, M., Juneau, M., Dupuy, O., Nigam, A., Bosquet, L., Comtois, A., & Gayda, M. (2015b). Cardiovascular and hemodynamic responses on dryland vs. immersed cycling. *Journal of Science and Medicine in Sport, 18*, 619-623. http://dx.doi.org/10.1016/j.jsams.2014.08.005

Giacomini, F., Ditroilo, M., Lucertini, F., DeVito, G., Gatta, G., Benelli, P. (2009). The cardiovascular response to underwater pedaling at different intensities: a comparison of 4 different water stationary bikes. *Journal of Sports Medicine and Physical Fitness, 49*(4), 432-439.

Greene, N.P., Greene, E.S., Carbuhn, A.F., Green, J.S., & Crouse, S.F. (2011). VO_2 prediction and cardiorespiratory responses during underwater treadmill exercise. *Research Quarterly for Exercise and Sport, 82*(2), 264-273. doi: 10.1080/02701367.2011.10599754

Handa, S., Masuki, S., Ohshio, T., Kamijo, Y., Takamata, A., Nose, H. (2016). Target intensity and interval walking training in water to enhance physical fitness in middle-aged and older women: a randomized controlled study. *European Journal of Applied Physiology, 116,* 203-215. doi: 10.1007/s00421-015-3267-9

Holthusen, J., Porcari, J., Foster, C., Doberstein, S. (2010). Hooping: Effective workout or child's play? *ACE Certified News,* 1-3.

Kanitz, A.C., Reichert, T., Liedtke, G.V., Pinto, S.S., Alberton, C.L., Antunes, A.H., Cadore, E.L., & Kruel, L.F.M. (2015). Maximal and anaerobic threshold cardiorespiratory responses during deep-water running. *Revista Brasileira de*

Cineantropometria e Desempenho Humano, 17(1), 41-50. http://dx.doi.org/10.5007/1980-0037.2015v17n1p41

Parfitt, R., Hensman, M.Y., & Lucas, S.J.E. (2017). Cerebral blood flow responses to aquatic treadmill exercise. *Medicine & Science in Sports & Exercise,* 1305-1312. doi: 10.1249/MSS.0000000000001230

Piacentini, M.F., Gianfelici, A., Faina, M., Figura, F., & Capranica, L. (2009). Evaluation of intensity during an interval Spinning® session: A field study. *Sport Sci Health, 5*, 29-36. doi: 10.1007/s11332-009-0073-y

Rebold, M.J., Kobak, M.S., & Otterstetter, R. (2013). The influence of a Tabata interval training program using an aquatic underwater treadmill on various performance variables. *The Journal of Strength and Conditioning Research, 27*(12), 3419-3425.

Rewald, S., Mesters, I., Lenssen, A.F., Bansi, J., Lambeck, J., de Bie, R.A., & Waller, B. (2017). Aquatic cycling – What do we know? A scoping review on head-out aquatic cycling. *PLoS ONE, 12*(5). https://doi.org/10.1371/journal.pone.0177704

Ryskey, A., Porcari, J.P., Radtke, K., Bramwell, S., Lee, T.E., & Foster, C. (2017). The energy expenditure and relative exercise intensity of Pound®.

Smith, L.E., Snow, J., Fargo, J., Buchanan, C.A., & Dalleck, L.C. (2016). The acute and chronic health benefits of TRX suspension training® in healthy adults. *Int J Res Ex Phys, 11*(2), 1-15.

Yazigi, F., Pinto, S., Colado, J., Escalante, Y., Armada-Da-Silva, P.A.S., Brasil, R., & Alves, F. (2013). The cadence and water temperature effect on physiological responses during water cycling. *European Journal of Sport Science, 13*(6), 659-665. http:dx.doi.org/10.1080/17461391.2013.770924

APPENDIX A
INFORMED CONSENT FORM

INFORMED CONSENT

Cardiorespiratory Responses in Aqua Cycling

I, ________________________, volunteer to participate in a research study being conducted at the University of Wisconsin-La Crosse.

Purpose and Procedures

- The purposes of this study are to 1) evaluate VO_2 max, heart rate, and rating of perceived exertion (RPE) during two maximal exercise tests 2) to measure heart rate, VO_2, and RPE responses during a 50-minute aqua cycling class and determine if aqua cycling meets ACSM guidelines for exercise prescription.
- Graduate students in the Clinical Exercise Physiology program will be conducting the research under the direction of Dr. John Porcari (ESS).
- My participation in this study will involve three separate sessions, each lasting approximately 1 hour.
- During one session I will perform a maximal test on an electrically braked bike at increased workloads every minute. I will be wearing a heart rate monitor and my oxygen consumption will be measured by having me breathe through a scuba-type mouthpiece.
- During the second session, I will complete a maximal test in the water on an aqua bike while increasing my speed every minute. During this test I will be wearing a heart rate monitor and my oxygen consumption will be measured by having me breathe through a scuba-type mouthpiece.
- During the last session, I will engage in a 50-minute aqua cycle spinning class, immersed in the pool up to my chest while wearing a scuba type mouthpiece and a heart rate monitor.

Potential Risks

- Fatigue, leg tiredness, and shortness of breath, similar to participating in any sort of maximal exercise are possible as a result of this study.
- I understand there may be some discomfort wearing a breathing mask.
- The risk of serious or life-threatening complications is very low (<1/10,000 tests) in apparently healthy, regularly exercising adults.
- The test will be stopped immediately upon any complications.
- There will be persons trained in CPR and Advanced Cardiac Life Support available for every test.

Benefits

- There are no primary benefits to myself other than knowledge about my personal fitness.
- Based on the results of the study, exercise professionals may be able to better guide the training of exercisers during aqua cycling.

Rights and Confidentiality

- My participation is voluntary.
- I may choose to discontinue my involvement in the study at any time without penalty.
- The results of this study have the potential of being published or presented at scientific meetings but my personal information will be kept confidential.

I have read the information provided on this consent form. I have been informed of the purposes of this test, the procedures, and expectations of myself as well as the testers, and have also been informed of the potential risks and benefits that may be associated with volunteering in this study. I have asked any and all questions that concerned me and received clear answers so as to fully understand all aspects of this study.

If I have any other questions that arise I may feel free to contact John Porcari, the principal investigator, at (608) 785-8684. Questions in regards to the protection of human subjects may be addressed to the University of Wisconsin-La Crosse Institutional Review Board for the Protection of Human Subjects at (608)785-8124.

Subject________________________________ Date__________________

Investigator____________________________ Date__________________

APPENDIX B
AQUA CYCLING CLASS

AQUA CYCLING CLASS

5 Minute Warm-Up

0-1: slow pedal ~ 50 RPMs
1-2: Increase RPMs + alternate arm swing
2-3: Increase RPMs + hill climb
3-4: Increase RPMs + alternate arm swing
4-4:30: Increase RPMs
4:30-5: Original slow pace

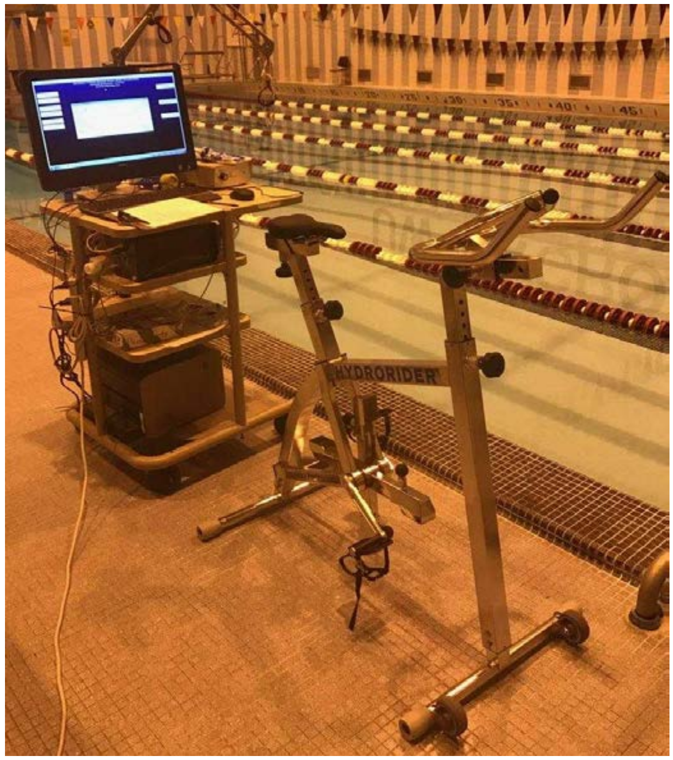
5 Minute Cool-Down

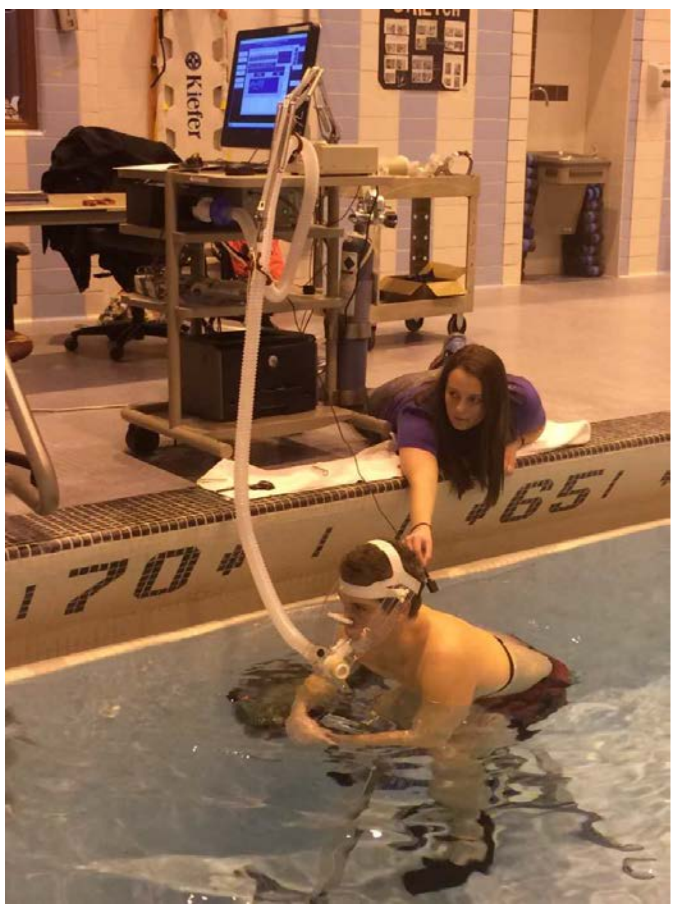
-own slow/easy pedal
-may utilize arms or no arms

40 Minute Workout

0-1: normal pedal (~70 RPMs)
1-2: all-out sitting pedal
2-3: normal pedal
3-4: moderate standing pedal
4-5: normal pedal
5-6: all-out standing pedal
6-7: normal pedal
7-8: backward moderate pedal
8-9: normal forward pedal
9-10: all-out backward pedal
10-12: RECOVERY – easy pedal
12-13: normal pedal + alternate arm swing
13-14: R front crawl scoop
14-15: L front crawl scoop
15-16: R+L forward 90º circle fists
16-17: R+L backward 90º circle fists
17-18: front arm cross
18-20: RECOVERY – moderate pedal
20-30: REPEAT INTERVAL
30-32: seat hold pedal
32-33: moderate standing pedal
33-34: normal pedal
34-35: all-out standing pedal
35-36: moderate crouch pedal
36-37: double high knees
37-38: R single leg swing
38-39: L single leg swing
39-40: easy pedal + push-ups

APPENDIX C
PICTURES OF AQUA CYCLING


HYDRORIDER


Kiefer

APPENDIX D
REVIEW OF THE LITERATURE

REVIEW OF THE LITERATURE

Purpose

The purpose of this literature review is to explain the benefits of water immersion, compare the physiological responses of land-based and water-based cycling, and investigate the unique equipment needed for this relatively new mode of physical activity.

Introduction

It is well known that exercise is important for overall health and disease prevention (Giacomini et al., 2009; ACSM, 2017). According to the current American College of Sport's Medicine (ACSM) Guidelines, it is recommended that individuals exercise 30-60 minutes a day, 3-5 days per week or at least 150 minutes per week (ACSM, 2017). However, many people do not meet these recommendations due to sedentary lifestyles or an inability to consistently adhere to an exercise program. Currently, about 31.1% of adults, globally, are physically inactive, and in the United States only 20.6% of adults meet both the aerobic and muscle strengthening recommendations (ACSM, 2017). In response to this lack of commitment to exercise, group exercise classes have emerged, providing a fun, encouraging, and social environment for people to work out in, making it easier to stick with a workout plan. One group fitness class that has recently emerged is aqua cycling. Aqua cycling is a cycling class combined with the therapeutic effects of water immersion. It was originally created by an Italian physical therapist that started the fitness trend in Europe in the early 2000's. While the modification of standard cycle ergometers for underwater use has been around since the 1960's for things such as physical therapy, rehabilitation (Frangolias & Rhodes, 1996), and simulating prolonged weightlessness, not until recently has aqua cycling caught on as another modality for maintaining and improving cardiorespiratory fitness (Rewald et al., 2017).

One of the first aqua cycling studios in the United States was opened in 2013 in New York, which sparked the spread of this fitness trend. Aqua exercise continues to increase in popularity as an alternative form of exercise to enhance physical fitness (Costa, Martins, de Lucas, & de Lima, 2017) as it is widely suitable for numerous populations (Garzon et al., 2015a), including individuals with musculoskeletal injuries or disabilities, neurological disabilities, the elderly or recovering athletes (Costa et al., 2017). Aqua cycling has also been shown to engage a large range of motion of the lower limbs, improve muscle strength and cardiovascular fitness, and no studies have reported adverse events related to aqua cycling (Rewald et al., 2017).

Physiological Effects of Water Immersion

Water immersion alone has many positive physiological and psychological effects on the body. For example, individuals have reported lower anxiety states (Barabosa, Marinho, Reis, Silva, & Bragada, 2009) and a sense of wellness (Kruel, Posser, Alberton, Pinto, & da Silva Oliveira, 2009) while being immersed in water. In addition, being immersed in water is less thermally stressful (Rebold, Kobak, & Otterstetter, 2013). This is due to the fact that the rate of heat loss in water is four times faster than in air for the same temperature due to water's greater thermal conductivity (Rebold et al., 2013; Barbosa et al., 2009). Therefore, the heart does not have to work as hard to maintain cardiac performance, since the heat disperses more easily (Rebold et al., 2013).

Hydrostatic pressure also has an effect on the body while immersed in water. The hydrostatic pressure causes vasoconstriction in the periphery, resulting in a blood shift to the chest cavity (Barbosa et al., 2009; Garzon et al., 2015b; Kanitz et al., 2015; Kruel et al., 2009; Meyer & Leblanc, 2008; Parfitt, Hensman, & Lucas, 2017; Reilly, Dowzer, & Cable, 2003). This increases venous return, which results in an increase in stroke volume via an enhanced Frank Starling mechanism (Barbosa et al., 2009). There is an increase in cardiac output with a slightly reduced heart rate (HR) (Arborelius, Balldin, Lilja, & Lundgren, 1972; Garzon et al., 2015b; Kanitz et al., 2015; Parfitt et al., 2017; Reilly et al., 2003; Smith et al., 1998). However, a negative effect of water immersion is a reduction in lung function (Smith et al., 1998; Ayme, Rossi, Gavarry, Chaumet, & Boussuges, 2015) due to the hydrostatic pressure compressing the abdomen, raising the diaphragm, and restricting the inspiratory muscles (Reilly et al., 2003). On the contrary, Brubaker et al (2011) reported that their results were not affected by the compressive forces of water, since the tidal volumes of the subjects were unaffected in their study comparing the cardiorespiratory responses during underwater and land treadmill exercise in college athletes.

Due to the buoyancy force, there is a reduction in musculoskeletal loading when immersed in water (Alkurdi, Paul, Sadowski, & Dolny, 2010; Brubaker, Ozemek, Gonzalez, Wiley, & Collins, 2011; Parfitt et al., 2017), providing a low impact environment for joints (Costa et al., 2017; Rebold et al., 2013). This reduced musculoskeletal loading environment is especially important for athletes who want to avoid overtraining or injury, but still maintain the principle of specificity throughout their season (Rebold et al., 2013). For example, runners or cyclists are able to still run or bike, but in a low impact environment which prevents overtraining and simultaneously maintains or even improves their training status. The buoyancy effect is also beneficial for the older adult population or individuals with musculoskeletal injuries (Costa et al., 2017) since there is less stress on their joints while in the water, allowing them to continue getting the benefits of cardiovascular exercise without putting too much stress on the rest of their body. Furthermore, due to this reduced hydrostatic weight, the body requires less muscle recruitment to maintain posture or execute exercises while in the water (Kanitz et al., 2015).

Physiological Effects of Aquatic Exercise Compared to Land-Based Exercise

While just being immersed in water causes physiological changes, cardiorespiratory variables also differ during exercise in water compared to on land. First, the overall training effect has been shown to be greater in water than on land (Handa et al., 2016). In a study conducted by Handa et al (2016), middle-aged women were divided into two groups, a land-based walking group or a water-based walking group. They performed an eight week walking exercise program consisting of sets of fast and slow walking, staying within a rating of 16-18 on the 6-20 Borg scale while fast walking (Handa et al., 2016). The study found that the women were able to exercise at a higher exercise intensity in the water than on land due to improved subjective feelings, which resulted in greater gains in physical fitness (Handa et al., 2016).

When examining each cardiorespiratory variable separately however, there are many inconsistencies. There is a tendency of research to show that HR is lower in water-based exercise compared to land-based (Parfitt et al., 2017; Benelli, Ditroilo, & De Vito, 2004) including a lower maximal heart rate (HRmax) (Costa et al., 2017; Frangolias &

Rhodes, 1996; Kanitz et al., 2015; Rebold et al., 2013; Rewald et al., 2017). More specifically, Rebold et al. (2013) and Parfitt et al. (2017) found that the HRmax during aquatic exercise was approximately 10 beats per minute lower than during land exercise.

Sheldahl et al. (1987) performed a study with middle-aged, healthy men who underwent a graded submaximal exercise test on a cycle ergometer on land and in water and reported no difference in mean HRs in water and on land at rest, and at 40%, and 60% of VO_2max, only finding significantly lower mean HR in water at 80% of VO_2max. Similarly, Brubaker et al. (2011) reported no significant differences between HR at matched stages of submaximal land and aquatic treadmill exercise in college athletes. Yazigi et al. (2013) found similar HRmax values for land and underwater cycling as well.

Heart rate is affected by the temperature of the water in which the subject is immersed and the level of immersion (Frangolias & Rhodes, 1996), which could account for some of the inconsistences in HR data since not all of the experiments were conducted under the same conditions. Most studies, however, had a water temperature between 27-30 degrees Celsius and a water immersion level up to the subject’s xiphoid process.

Stroke volume and cardiac output are consistently shown to be elevated in water-based exercise compared to land-based exercise in healthy populations (Frangolias & Rhodes, 1996; Parfitt et al., 2017; Garzon et al., 2015b), with cardiac output to be .7 liters per min higher in water compared with on land (Sheldahl et al., 1987). The increased cardiac output seems to be the result of the increased stroke volume since most data show a reduction in HR during water immersion and aquatic exercise (Parfitt et al., 2017).

The majority of studies show similar VO_2 and VO_2max values for aquatic-based and land-based running (Brubaker et al., 2011; Greene, N.P., Greene, E.S., Carbuhn, Green, & Crouse, 2011), cycling (Frangolias & Rhodes, 1996; Yazigi et al., 2013; Rewald et al., 2017), and stepping (Pugh, Sprung, Ono, Spence, Thijssen, Carter, & Green, 2015). For example, Yazigi et al. (2013) compared the maximal physiological responses for young males during a maximal land cycling test and two maximal water cycling tests which were performed in different water temperatures. After a familiarization session, participants performed each maximal test in a random order with a 48-hour interval between each. They found that land and aquatic cycling elicit similar VO_2max values, concluding that both exercises, land-based and water-based cycling, induce similar cardiorespiratory and VO_2 responses. Furthermore, an important finding of this study was that water cycling is strenuous enough to the point of eliciting maximum HR and VO_2, therefore, aqua cycling can provide enough training stimulus to improve cardiorespiratory fitness (Yazigi et al., 2013).

There is a lack of research that investigates energy expenditure in underwater exercise. However, the few studies that did assess energy expenditure vary in their conclusions. Ayme et al. (2015) found no significant difference between energy expenditure on land versus in water in their study, which involved healthy subjects ergo-cycling for 1 hour at 35%-40% VO_2peak. However, Alkurdi et al. (2010) studied the effect of water depth on energy expenditure and perception of effort in female subjects while walking. They reported that energy expenditure, along with HR and RPE, increased significantly as water depth was lowered from above, at, and to below the xiphoid process level (Alkurdi et al., 2010). This could be due to the different factors determining energy expenditure in water than those for on land. For instance, the buoyancy force in water reduces hydrostatic weight which reduces the energy needed to vertically move the body (Kruel et al., 2009). Yet, the drag forces in the aquatic environment due to the increased viscosity and density of water compared to air increases the energy expenditure needed to perform horizontal displacements. So depending on the body position and velocity at which the body is moving in the water, the energy expenditure in water may be lower, similar, or higher compared to on land (Kruel et al., 2009).

Water resistance and drag forces are two other factors that play a role in the physiological effects of underwater exercise. As a result of the increase viscosity and density, water provides resistance to movement (Rebold et al., 2013). During exercise on an immersed ergo-cycle, Garzon et al. (2015a) reported that the external forces are mainly caused by the pedaling system itself and by leg movement drag which is dependent on the size of the legs and the rate at which the subject is pedaling. According to Costa et al. (2017), higher pedal cadences require more energy to overcome the drag forces. With this known and due to the buoyancy force, being immersed in water allows individuals to expend high levels of energy with relatively little strain on the body (Rebold et al., 2013).

Perceived Exertion with Aquatic Exercise Compared to Land-Based Exercise

Rating of perceived exertion is a subjective indicator of the degree of physical strain (Borg, 1982). It is a way to quantify subjective symptoms by integrating information including signals from peripheral working muscles, and cardiovascular, central nervous system, and respiratory function. Borg created a RPE scale which increases linearly with the exercise intensity (Borg, 1982). Rating of perceived exertion is simple, virtually no cost, and an effective method to monitor intensity in individuals on medications interfering with the HR response (Pinto et al., 2015). Pinto et al. (2015) conducted a study where subjects performed aquatic stationary running with flotation equipment and found that there was a significant and positive relationship between overall RPE and all cardiorespiratory variables, including VO_2 and HR. They concluded that ventilation and percentage of maximal muscle activation of the biceps brachii best explained the overall RPE (Pinto et al., 2015). Similarly, Alberton et al. (2016) studied RPE in maximal incremental tests in aquatic aerobic exercise and also found a significant relationship between RPE and percent of peak oxygen consumption (%VO_2peak), confirming that RPE may be effectively used for aquatic exercise intensity prescription. This is further confirmed with research by Brubaker et al. (2011) who demonstrated no significant differences in RPE at matched stages of submaximal exercise between underwater and land treadmill running in college athletes. On the other hand, Barbosa et al. (2009) concluded that RPE is higher during aquatic exercises than on land after conducting a review of literature on healthy subjects performing head-out aquatic exercises.

Contrary to these findings, Olkoski et al. (2014) conducted a study investigating the correlation between RPE and physiological variables during aquatic exercise and used a pyramid method of increasing and decreasing intensity through six stages. They found that RPE was positively and significantly correlated with VO_2, but only at stages 3 and 4, which were higher intensity exercise stages, before decreasing intensity in stages 5 and 6 (Olkoski et al., 2014). This might be explained by some characteristics of the aquatic environment, for as exercising in water can give a sense of well-being (Olkoski et al., 2014). In addition, no significant correlation was found between HR and RPE (Olkoski et al., 2014).

One investigation looking at different methods for monitoring intensity during water-based aerobic exercise in female college students reported that RPE scores did not accurately classify the level of intensity of exercise, since all exercises performed were classified as "moderate" on the RPE scale, despite increasing and decreasing intensity of exercise (Raffaelli, Galvani, Lanza, & Zamparo, 2012). They suggest using HR to more accurately classify intensity of water exercises (Raffaelli et al., 2012), even though the use of RPE to accurately monitor intensity of exercise has been well documented (Alberton et al., 2016).

Aquatic Cycling Ergometers

One possible reason for inconsistencies in the literature for aquatic aerobic exercise, and more specifically for aquatic cycling, may be due to the variations in equipment used. Initial studies conducted on underwater cycling placed a stationary bike in a swimming pool which was connected by a chain to a standard dry land cycle ergometer (Costa et al., 2017). With this setup, subjects could not change resistance themselves and it required extensive modifications to the land-based bike. Now, in order to change resistance during underwater cycling one must either alter their pedal cadence or attach varying sized blades, which increases the frontal surface area and as a result increases the resistance one must pedal against. This adjustable frontal surface area underwater bike design (Hidrocycle®, Brazil) was demonstrated to work in eliciting a strong linear relationship between %VO_2peak versus %HRpeak (Costa et al., 2017).

Giacomini et al. (2009) compared the cardiovascular responses to pedaling at different intensities on four different water stationary bikes and demonstrated that different models of water stationary bikes can elicit very different cardiovascular responses. This indicates that the type of equipment used plays a major role in the results of each study and can help explain perhaps some of the inconsistencies in the data concerning cardiorespiratory responses in aquatic exercise.

Summary

While it originally was used for the purpose of rehabilitation, aquatic cycling has transformed into a unique fitness trend, now emerging in fitness studios all over Europe and the United States. Exercising underwater allows for high levels of energy expenditure with little strain on the body (Rebold et al., 2013). Compared to land-based cycling, aquatic cycling may provide a greater overall training benefit, due to the increased drag of the water on the lower extremities (Handa et al., 2016). However, when looking at individual cardiorespiratory variables, there are many inconsistencies regarding HR, VO_2, and RPE between water-based and land-based cycling.

REFERENCES

Alberton, C.L., Pinto, S.S., Gorski, T., Antunes, A.H., Finatto, P., Cadore, E.L., Bergamin M., & Kruel, L.F.M. (2016). Rating of perceived exertion in maximal incremental tests during head-out water-based aerobic exercises. *Journal of Sports Sciences, 34*(18), 1691-1698. http://dx.doi.org/10.1080/02640414.2015.1134804

Alkurdi, W., Paul, D.R., Sadowski, K., & Dolny, D.G. (2010). The effect of water depth on energy expenditure and perception of effort in female subjects while walking. *International Journal of Aquatic Research and Education, 4,* 49-60.

American College of Sports Medicine. (2017). *ACSM's guidelines for exercise testing and prescription* (10th ed.). Philadelphia, PA: Wolters Kluwer Health

Arborelius, M. Jr., Balldin, U. I., Lilja, B., & Lundgren C. E. G. (1972). Hemodynamic changes in man during immersion with the head above water. *Aerospace Medicine, 43*(6), 592- 598.

Ayme, K., Rossi, P., Gavarry, O., Chaumet, G., & Boussuges, A. (2015). Cardiorespiratory alterations induced by low-intensity exercise performed in water or on land. *Applied Physiology Nutrition and Metabolism, 40*(4), 309-315. doi: 10.1139/apnm-2014-0264

Barbosa, T.M., Marinho, D.A., Reis, V.M., Silva, A.J., & Bragada, J.A. (2009). Physiological assessment of head-out aquatic exercises in healthy subjects: A qualitative review. *Journal of Sports Science and Medicine, 8,* 179-189.

Benelli, P., Ditroilo, M., & De Vito, G. (2004). Physiological responses to fitness activities: A comparison between land-based and water aerobics exercise. *Journal of Strength and Conditioning Research, 18*(4), 719-722.

Brubaker, P., Ozemek, C., Gonzalez, A., Wiley, S., & Collins, G. (2011). Cardiorespiratory responses during underwater and land treadmill exercise in college athletes. *Journal of Sport Rehabilitation, 20,* 345-354.

Borg, G. (1982). Psychophysical bases of perceived exertion. *Medicine and Science in Sports and Exercise, 14*(5), 377-381.

Costa, V.P., Martins, J.A.N., de Lucas, R.D., & de Lima, J.R.P. (2017). Physiological responses during an incremental exercise test performed on underwater stationary bike. *Sport Science Health, 13,* 87-92. doi: 10.1007/s11332-016-0329-2

Frangolias, D.D. & Rhodes, E.C. (1996). Metabolic responses and mechanisms during water immersion running and exercise. *Sports Med, 22*(1), 38-53.

Garzon, M., Gayda, M., Garzon, L., Juneau, M., Nigam, A., Leone, M., & Comtois, A.S. (2015). Biomechanical analysis to determine the external power output on an immersible ergocycle. *European Journal of Sport Science*, *15*(4), 271-278. http://dx.doi.org/10.1080/17461391.2014.932015

Garzon, M., Juneau, M., Dupuy, O., Nigam, A., Bosquet, L., Comtois, A., & Gayda, M. (2015). Cardiovascular and hemodynamic responses on dryland vs. immersed cycling. *Journal of Science and Medicine in Sport, 18,* 619-623. http://dx.doi.org/10.1016/j.jsams.2014.08.005

Giacomini, F., Ditroilo, M., Lucertini, F., DeVito, G., Gatta, G., Benelli, P. (2009). The cardiovascular response to underwater pedaling at different intensities: a comparison of 4 different water stationary bikes. *Journal of Sports Medicine and Physical Fitness*, *49*(4), 432-439.

Greene, N.P., Greene, E.S., Carbuhn, A.F., Green, J.S., & Crouse, S.F. (2011). VO_2 prediction and cardiorespiratory responses during underwater treadmill exercise. *Research Quarterly for Exercise and Sport*, *82*(2), 264-273. doi: 10.1080/02701367.2011.10599754

Handa, S., Masuki, S., Ohshio, T., Kamijo, Y., Takamata, A., Nose, H. (2016). Target intensity and interval walking training in water to enhance physical fitness in middle-aged and older women: a randomized controlled study. *European Journal of Applied Physiology*, *116*, 203-215. doi: 10.1007/s00421-015-3267-9

Kanitz, A.C., Reichert, T., Liedtke, G.V., Pinto, S.S., Alberton, C.L., Antunes, A.H., Cadore, E.L., & Kruel, L.F.M. (2015). Maximal and anaerobic threshold cardiorespiratory responses during deep-water running. *Revista Brasileira de Cineantropometria e Desempenho Humano, 17*(1), 41-50. http://dx.doi.org/10.5007/1980-0037.2015v17n1p41

Kruel, L.F.M., Posser, M.S., Alberton, C.L., Pinto, S.S., & da Silva Oliveira, A. (2009). Comparison of energy expenditure between continuous and interval water aerobic routines. *International Journal of Aquatic Research and Education, 3,* 186-196.

Meyer, K. & Leblanc, M.C. (2008). Aquatic therapies in patients with compromised left ventricular function and heart failure. *Clinical and Investigative Medicine, 31*(2), 90-97.

Olkoski, M., Matheus, S., de Moraes, E., Tusset, D., dos Santos, L., & Nogueira, J. (2014). Correlation between physiological variables and rate of perceived exertion during a water exercises classes. *Revista Andaluza de Medicina del Deporte, 7*(3), 111-114.

Parfitt, R., Hensman, M.Y., & Lucas, S.J.E. (2017). Cerebral blood flow responses to aquatic treadmill exercise. *Medicine & Science in Sports & Exercise,* 1305-1312. doi: 10.1249/MSS.0000000000001230

Pinto, S.S., Alberton, C.L., Zaffari, P., Cadore, E.L., Kanitz, A.C., Liedtke, G.V., Tartaruga, M.P., & Kruel, L.F.M. (2015). Rating of perceived exertion and physiological responses in water-based exercise. *Journal of Human Kinetics, 49,* 99-108. doi: 10.1515/hukin-2015-0112

Pugh, C. J. A., Sprung, V. S., Ono, K., Spence, A. L., Thijssen, D. H. J., Carter, H. H., & Green, D. J. (2015). The effect of water immersion during exercise on cerebral blood flow. *Medicine & Science in Sports & Exercise*, *47*(2), 299-306.

Raffaelli, C., Galvani, C., Lanza, M., Zamparo, P. (2012). Different methods for monitoring intensity during water-based aerobic exercises. *European Journal of Applied Physiology*, *112,* 125-134. doi: 10.1007/s00421-011-1963-7

Rebold, M.J., Kobak, M.S., & Otterstetter, R. (2013). The influence of a Tabata interval training program using an aquatic underwater treadmill on various performance variables. *The Journal of Strength and Conditioning Research, 27*(12), 3419-3425.

Reilly, T., Dowzer, C.N., & Cable, N.T. (2003). The physiology of deep-water running. *Journal of Sports Sciences, 21*, 959-972. doi: 10.1080/02640410310001641368

Rewald, S., Mesters, I., Lenssen, A.F., Bansi, J., Lambeck, J., de Bie, R.A., & Waller, B. (2017). Aquatic cycling – What do we know? A scoping review on head-out aquatic cycling. *PLoS ONE, 12*(5). https://doi.org/10.1371/journal.pone.0177704

Sheldahl, L.M., Tristani, F.E., Clifford, P.S., Hughes, C.V., Sobocinski, K.A., & Morris, R.D. (1987). Effect of head-out water immersion on cardiorespiratory response to dynamic exercise. *Journal of the American College of Cardiology, 10*, 1254-1258.

Smith, D.E., Kaye, A.D., Mubarek, S.K., Kusnick, B.A., Anwar, M., Friedman, I.M., & Nossaman, B.D. (1998). Cardiac effects of water immersion in healthy volunteers. *Echocardiography: A Journal of CV Ultrasound and Allied Tech*, *15*(1), 35-42.

Yazigi, F., Pinto, S., Colado, J., Escalante, Y., Armada-Da-Silva, P.A.S., Brasil, R., & Alves, F. (2013). The cadence and water temperature effect on physiological responses during water cycling. *European Journal of Sport Science, 13*(6), 659-665. http:dx.doi.org/10.1080/17461391.2013.770924