Pain Levels and Rating of Perceived Exertion of People with Herniated Lumbar Disc While Walking in Two Environments

Brenda L. Cunningham-Boerger
Western Michigan University

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PAIN LEVELS AND RATINGS OF PERCEIVED EXERTION
OF PEOPLE WITH HERNIATED LUMBAR DISC WHILE
WALKING IN TWO ENVIRONMENTS

by
Brenda L. Cunningham-Boerger

A Thesis
Submitted to the
Faculty of The Graduate College
in partial fulfillment of the
requirements for the
Degree of Master of Arts
Department of Health, Physical Education
and Recreation

Western Michigan University
Kalamazoo, Michigan
December 1996
PAIN LEVELS AND RATINGS OF PERCEIVED EXERTION OF PEOPLE WITH HERNIATED LUMBAR DISC WHILE WALKING IN TWO ENVIRONMENTS

Brenda L. Cunningham-Boerger, M. A.
Western Michigan University, 1996

The purpose of the study was to investigate if walking in water is an effective substitute for walking on land as an aerobic exercise for people with herniated lumbar disc. The study involved the dependent variables of perceived pain levels (PPL) and ratings of perceived exertion (RPE). Independent variables were walking condition and work intensity. Land walking was performed on a treadmill; water walking was performed in an indoor pool 4.5 ft deep and 90°F. Work was set at four different intensities, based on the formula for predicting maximum heart rate (MHR), 220 minus age. The graded work intensities were calculated by multiplying MHR by four percentages: (1) 50%, (2) 60%, (3) 70%, and (4) 80%. Participants (N = 20) were 12 males and 8 females. The subjects walked on 2 separate days with 24 hr (1 day) to 480 hr (20 days) separating the walks. Each subject walked for 2 min at each intensity. RPE and PPL were recorded after each intensity. The Borg RPE scale that rates exertion from 6 to 20 was used. PPL was collected using the Borg PPL scale that rates pain from 0 to 10+. For each of the dependent variables, a randomized block factorial design was analyzed. Results of the study demonstrated that for similar work intensities: (a) RPE during walking was greater on land than in water, and (b) PPL during walking was greater in water than land.
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ACKNOWLEDGMENTS

As with most research, many individuals are involved in the process and product. This certainly was the case with my thesis. First and foremost, I want to wholeheartedly thank my graduate advisor, professor, and member of my thesis committee, Dr. Mary Dawson. Without her unending support and encouragement I would probably not be completing my thesis nor my degree. She accepted no excuses yet dried my tears. Thank you, Dr. Dawson. Dr. Pat Frye, a member of my thesis committee, helped me think through my design by asking hard but necessary questions. Dr. Roger Zabik, the third member of my thesis committee, for his physiological point of view. Kalamazoo Valley Orthopedics physicians and business manager, Don Luke, R.N., for use of their facility. A special thanks to their evening staff for their friendliness and helpfulness to me and my subjects. Thank you to Cyndi Kemple, O.T.R., for her help in recruiting subjects. And thank you very much to my subjects who, sight unseen in many cases, were willing to undergo testing despite their pain, discomfort, and inconvenience. Finally, I want to thank my two sons, Joshua and Jesse, for their understanding and patience while their mom was away from home attending classes, collecting data, reading books, or staring at the computer. Guys, this one's for you.

Brenda L. Cunningham-Boerger

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CHAPTER I

INTRODUCTION

Recent research has indicated that improvement in one’s level of general fitness may be obtained by moderate increases in his or her activity level. Cardiovascular training effects may be seen by: (a) engaging in aerobic activities that elevate the heart rate from 55% to 90% of the predicted maximum heart rate (intensity), (b) maintaining the elevated heart rate for 15 to 60 min (duration), and (c) repeating the activity three to five times per week (frequency; American College of Sports Medicine [ACSM], 1991). There are many aerobic activities from which to choose. This allows most people the opportunity to pick one they enjoy, which tends to increase their motivation level. However, certain populations have physical problems that may limit their choice of aerobic activities and limit the extent to which they may engage in an aerobic activity. The challenge is to design a program that meets the specific needs of the special population, but still maintains the standards of intensity, duration, and frequency required to improve one’s level of physical fitness.

Statement of the Problem

The problem of the study was to investigate whether walking in water is an effective substitute for walking on land as an aerobic exercise for people with herniated lumbar disc. Perceived pain levels (PPL) and ratings of perceived exertion (RPE) while walking on land and in water at four different work intensities were compared.
Purpose of the Study

People with hemiated lumbar disc usually experience low back pain as well as pain or numbness and tingling in one or both lower extremities. The pain levels are frequently high enough to interfere with the activities of daily living and preclude involvement in conventional land aerobic exercise due to the high impact forces they may experience. There is a need to develop alternate aerobic exercise choices for these people to allow them to engage in activity that will improve or maintain a healthy level of fitness without experiencing high impact forces.

Water is an excellent alternate aerobic exercise environment. Swimming is a water exercise, but is limited to those who have developed some degree of skill. However, there is little scientific evidence available to determine caloric expenditures for water exercises other than for swimming. In this study the effects of an activity most people are able to perform without special skill, walking, were assessed. Walking in water, due to the buoyancy effect, can unload the lumbar spine of up to 90% of the body’s weight (McNeal, 1988). Walking in 4.5 ft of water (chest deep) can unload the lumbar spine of up to 75% of the individual’s body weight.

Delimitations

The study was delimited to:

1. Twenty subjects, 8 females and 12 males, age 22 to 50 years, with various levels of cardiovascular fitness.

2. Subjects who were referred to the researcher by medical professionals within Kalamazoo County, Michigan.

3. Subjects who had previously been diagnosed by a computerized tomographic scan (CTS) or magnetic resonance image (MRI) as having a hemiated lumbar disc.
4. Subjects who had no previous surgical intervention for their herniated lumbar disc.

5. Subjects who were under the medical management of a physician at the time of the study.

6. Two experimental conditions: (1) walking in water and (2) walking on land.

7. A pool with a water temperature of 90°F and a depth of 4.5 ft.

8. Two dependent variables: (1) PPL and (2) RPE.

Limitations

The study was limited by: (a) the opportunistic nature of subject selection, and (b) the impact of current medical treatments or other exercise choices on a subject’s participation.

Hypotheses

The following hypotheses were formulated based on the design of the study, the literature review, and the investigator's experience:

1. At measured levels of work intensity, subjects will experience lower PPL while walking in water than while walking on land.

2. At measured levels of work intensity, subjects will experience similar RPE while walking in water and while walking on land.

3. Subjects will experience increased RPE as the work intensity increases.

4. Subjects will experience changes in PPL at different work intensities.

Definition of Terms

Certain terms needed defining to help clarify the research. Those terms were:
Lumbar: the part of the spinal column between the ribs and pelvis (Webster, 1986).

Disc: a layer of cartilage between the bony vertebrae; fibrous outer tissues enclosing a pulpy center (Webster, 1986).

Herniated Disc: a protrusion of the pulpy center through the outer fibrous tissues, possibly irritating or pinching nerves as they leave the spinal cord (Kessler & Hertling, 1983).

Computerized Tomographic Scan (CTS): a diagnostic tool that constructs computer images of x-rays to show a cross sectional view of muscle, soft tissue, and bone (Kalamazoo Neuro Imaging Center, Inc., 1994).

Magnetic Resonance Imaging (MRI): a diagnostic tool that uses strong magnetic field and radio waves to produce pictures that detect and define the differences between healthy and diseased tissue (Kalamazoo Neuro Imaging Center, Inc., 1994).
CHAPTER II

LITERATURE REVIEW

People with low back pain find that many of their routine daily activities produce pain. People with low back pain or numbness and tingling radiating into one or both of the lower extremities appear to have a difficult time tolerating activity. As a result, strength and endurance decline, affecting general levels of health and fitness. Recent rehabilitation trends have turned toward utilizing water as a medium in which to assist people in increasing activity levels to the point of improving cardiovascular fitness.

Water exercise and rehabilitation are nothing new. Water exercise facilitates movement, conditioning, and strength training in a low-impact environment. Since the early 1900s physical therapists have used warm water in whirlpools and contrast baths to treat range of motion, pain, and edema. The difference between water exercise and water therapy is that water therapy is a medically supervised treatment that uses warm water and gentle motions to aid recovery from an injury or to correct a particular problem (Grimes & Krasevec, 1983). Water exercise, on the other hand, uses the water’s resistance to achieve or maintain fitness.

Water Exercise

The literature indicated that the minimum intensity required for development of physical work capacity in unconditioned adults is approximately 70% of maximum heart rate or 50% to 60% of maximum oxygen uptake (VO2 max; McArdle & Katch,
VO2 max is the maximal rate at which oxygen can be taken up, distributed, and used by the body during physical activity ("V" is the volume of oxygen used per minute, "O2" is oxygen, and "max" represents maximal exercise conditions; Nieman, 1990). Martin et al. (1987) studied cardiovascular adaptations to swim training in sedentary but healthy men and women. The subjects performed a graded lap swim training program for a 12-week period of time, achieving 50% to 80% of their predetermined maximum heart rate. The researchers concluded that in middle-aged humans, adaptations achieved included a greater capacity for vasodilation in skeletal muscle and an enhanced cardiac pump capacity.

Vickery, Cureton, and Langstaff (1983) found similar results in their study of heart rate and energy expenditure during a program of aqua dynamics. They measured heart rate, oxygen uptake, and energy expenditure of three young women during aqua dynamic workouts at three work intensities: (1) 20 min, low intensity; (2) 30 min, middle intensity; and (3) 60 min, high intensity (President’s Council on Physical Fitness and Sports, 1981). Each workout consisted of a series of water exercises performed consecutively without stopping, followed by lap swimming. The oxygen uptake and heart rate responses in this study were just above the minimum values, which suggested that aqua dynamics has sufficient intensity to improve the physical work capacity of people who were poorly conditioned or had low levels of physical work capacity.

Evans, Cureton, and Purvis (1978) studied the metabolic and circulatory responses to walking and jogging in water. They concluded that when subjects walked and jogged in water, water resistance and buoyancy caused high levels of energy expenditure with relatively little movement and strain on lower extremity joints. Thus jogging in water would be a valuable mode of conditioning for developing and maintaining work capacity and cardiovascular fitness.
Water Versus Land Exercise

Johnson, Stromme, Adamczyk, and Tennoe (1977) compared the oxygen consumption and heart rate response during identical calisthenic type exercises performed on land and in water. Two exercises, one with the arms moving and one with the legs moving, were performed in a standing position. The arm exercise was performed at 0° to 90° of shoulder flexion-extension and abduction-adduction with the elbows extended and the palms facing the direction of movement. The leg exercise was hip flexion and extension with the knees extended. Both heart rate and oxygen consumption were greater during exercise in water. Viscosity, friction, and turbulence are the dominant resistive forces in water, and they provide a greater load during exercise than the primary resistive force of gravity on land exercise. The researchers also found that although arm exercises performed in the water required less energy than leg exercises in the water, arm exercises performed in water required significantly greater oxygen than the same exercises performed on land.

Bishop, Frazier, Smith, and Jacobs (1989) compared the physiological responses to running on a treadmill to running in water while wearing a buoyant vest. They found ventilation, oxygen uptake, and respiratory quotient significantly higher during treadmill running. Water running elicited a 36% lower metabolic cost than treadmill running despite the subject’s efforts to maintain a similar level of exertion. The authors suggested that water running may help to lessen the rate of deconditioning of injured athletes, however, the metabolic cost of water running is significantly greater than that of treadmill running.

Perceived Exertion

The use of perceived exertion has been proposed as a complement to heart rate
be carried out at an intensity between 12 to 14 on the RPE scale. Borg (1982) found that the mean heart rate was equivalent to RPE multiplied by 10 for most work intensities. Burke and Keenan (1984) studied energy cost, heart rate, and perceived exertion during a specific swim activity, the elementary backstroke. The purposes of the study were to determine the energy cost of the elementary backstroke and to see if heart rate and perceived exertion were useful for monitoring exercise intensity. The healthy subjects swam the elementary backstroke at four different intensities. Velocity, V02, heart rate, and RPE were measured. Burke and Keenan found that the subjects were able to exercise at intensities recommended by the ACSM for healthy adults, 55% to 90% of maximum heart rate reserve. In addition, subjects’ RPE were within the intensity level of 12 to 14 described by Burke and Borg. Burke and Keenan concluded that exercise levels in a training program can be easily individualized by monitoring heart rate and RPE.

In a study by Bishop et al. (1989), perceived exertion ratings were measured at the same time as the metabolic measurements. Although the findings did not substantiate higher metabolic costs for water running than for land running, the subjects reported higher RPE during the water exercise. Confidence and familiarity in subjects’ abilities to perform on land as opposed to performing in water was suggested as a reason why the subjects worked with a lower perception of exertion on the treadmill.

Pain

Pain is a sensation of discomfort, hurt, stress or agony resulting from the stimulation of specific nerve endings. It may indicate an immediate injury or be a response to actual tissue damage. Pain may also exist independent of any physiological base. Many variables indicate a person’s threshold for pain. Research has shown that
the threshold for recognizing pain is approximately equal from one person to another; the degree to which each one reacts to pain varies tremendously (Fobes, 1985).

Pain is a subjective symptom relating to objective findings. Therefore, to measure pain, a method is needed to quantify these subjective symptoms. Borg (1982) developed a rating scale constructed as a category scale with ratio properties. Category expressions like "weak", "somewhat strong", and "strong" provide an individual meaning of each value and allow for a verbal expression that is simple and understandable by most people. The ratio properties, i.e., an absolute 0 and the same distance between all consecutive scale values, allows for direct measurements and mathematical calculations.

Summary

The literature provided evidence that supports the use of water as an environment for aerobic exercise with appropriate intensity and duration to increase or maintain a healthy level of cardiovascular fitness. The literature also provided methods similar to those used in land exercise settings to assure that the work being done was sufficient to maintain or increase cardiovascular fitness levels. Previous research has focused on healthy subjects with high levels of cardiovascular and motor fitness.
CHAPTER III

METHODS AND PROCEDURES

The purpose of the study was to compare PPL and RPE of people with herniated lumbar disc while they walked in two different environments: (1) water and (2) land. The subjects walked for approximately 10 min at four different work intensities. This chapter is organized into the following sections: (a) subjects, (b) instrumentation, (c) testing procedures, and (d) design and analysis.

Subjects

The 20 subjects, 8 females and 12 males, were between 22 and 50 years of age. All had been positively diagnosed as having herniated lumbar disc by CTS or MRI. Applicants had been referred to the study by local medical professionals suggesting participation via a letter (Appendix A), or volunteering in response to a flyer (Appendix B) displayed in a variety of medical settings. The applicants were asked to complete a medical health history questionnaire (Appendix C). Applicants checking any of the listed conditions were eliminated. Applicants were asked to sign an informed consent for exercise testing (Appendix D). The first 20 qualified applicants who were willing to participate were chosen. The study was approved by the Human Subjects Institutional Review Board, Western Michigan University (Appendix E).

Instrumentation

The subjects were tested in two environments, an indoor pool and on a
treadmill. Heart rates were monitored while walking to establish work intensity. RPE and PPL were recorded after each intensity.

Pool

The indoor pool utilized in this study was 30 ft wide by 60 ft long and 4.5 ft deep. The water was 90°F. The pool was located at Southwestern Michigan Sports Medicine Clinic, Kalamazoo, Michigan.

Treadmill

A Quinton Instruments treadmill, model 643 (Seattle, WA), was utilized. The treadmill was located at the exercise physiology laboratory at Western Michigan University, Kalamazoo, Michigan.

Heart Rate

Heart rates were collected with a Polar Waterproof Vantage XL Mobile Heart Rate Monitor (Polar USA, Stamford, CT). Maximal heart rates (MHR) were predicted using the formula 220 - age in years (Nieman, 1990). This is the highest estimated heart rate that can be measured when one is brought to total exhaustion during a graded exercise test (Lamb, 1989). Four work intensities were calculated: (1) 50%, (2) 60%, (3) 70%, and (4) 80%, by multiplying the percentage x MHR. These values are within the minimum and maximum percentages suggested by ACSM (1991). Appendix F displays a table of these work intensities.

RPE

The Borg RPE scale, which rates exertion from 6 to 20 (Appendix G), was chosen. This scale has been proposed to be used in most cases because it gives values
that grow linearly with work load and heart rate, and because no other scale seems to correlate better with heart rate (Borg, 1973).

**PPL**

The Borg PPL scale, which rates pain from 0 to 10+ (Appendix H), was chosen. This scale combines category expressions for the number values and ratio properties, allowing for direct measurements and mathematical calculations (Borg, 1982).

**Testing Procedures**

As applicants were accepted into the study they were assigned to a testing date and environment dependent upon their availability and the availability of each testing facility. Subjects were tested for land and water walking on 2 different days. At each visit MHR, was determined and work intensity values were calculated.

**Land Walking**

On the day of testing land walking, the protocol and sequence of the test were explained in detail, including a demonstration of walking on the treadmill as well as getting on and off. Subjects were instructed to maintain a steady pace and a forward-facing posture and to use the support rails only for balance. The grade of the treadmill was maintained at 0% for the duration of the test.

Subjects warmed up by walking around the room for 5 min at a self-chosen pace below 50% of MHR. After 5 min, heart rate, RPE, and PPL were recorded. The speed of the treadmill was initially set at 1.5 mph and slowly increased as needed until the subject's heart rate reached the first work intensity. This intensity was maintained for 2 min to achieve a steady state. Steady state was achieved when heart rate stayed
within 5 beats per minute of the target heart rate for 2 to 4 min (Nieman, 1990). Testing continued by increasing the speed until the remaining three intensities were reached: (1) 60% of MHR, (2) 70% of MHR, and (3) 80% of MHR. Data were collected during the last 15 s of each intensity. Recovery included a 4-min period of walking around the room at a self-chosen pace.

**Water Walking**

On the day of testing water walking, the protocol and sequence of the test were explained in detail, including a demonstration of water walking. Subjects were instructed to maintain as normal a gait pattern as they could and an upright posture. Arms could be held in or out of the water, whichever was most comfortable.

Subjects warmed up for 5 min at a self-chosen pace below 50% of MHR. After 5 min, heart rate, RPE, and PPL were recorded. Subjects then increased their speed until the first work intensity was reached. This pace was maintained for 2 min to achieve a steady state. Testing continued by slowly increasing speed then maintaining that pace for the remaining three intensities: (1) 60% of MHR, (2) 70% of MHR, and (3) 80% of MHR. Data were collected during the last 15 s of each intensity. Recovery included a 4-min period of walking in the pool at a self-chosen pace.

**Data Collection**

A placard displaying the RPE scale was placed to the side of each subject during testing. The investigator read the following script to all subjects:

Your goal is to rate your feelings that are caused by the work and not the work itself. These feelings should be general, that is about the body as a whole. We will not ask you to specify the feeling but to select a number that most accurately corresponds to your perception of your total body feeling. Keep in mind there are no right or wrong numbers. Use any number you think is appropriate (Noble, Metz, & Randolph, 1973, p. 105).
During the last 15 s of each work intensity, the subject was asked to give an oral numerical response to his or her exertion.

A placard displaying the PPL scale was also placed to the side of the subject during testing. The investigator read the following script to all subjects:

We want you to pay attention to any increase in your level of pain. This feeling should be about a general increase in your pain level, not any one symptom such as leg or lower back pain. There are no right or wrong numbers. Use any number you think is appropriate (Blankenship, 1989, p. 613).

After giving an RPE value, each subject was asked to give an oral numerical response to his or her level of pain.

Design and Analysis

Subjects were assigned to begin their testing on land or in water dependent upon their availability and the availability of each facility. The exercise sessions were scheduled so that 24 hours (1 day) to 480 hours (20 days) separated the two sessions. Four work intensities were chosen: (1) 50% of MHR, (2) 60% of MHR, (3) 70% of MHR, and (4) 80% of MHR. The work intensities were based on the subject’s MHR determined by the formula, 220 - age in years.

Dependent variables in this study were RPE and PPL. The data were computed by a randomized block factorial ANOVA design with two factors, walking and work intensity. The computer program utilized was BMDP2V (Dixon, Brown, Engelman, & Jennrich, 1990).
CHAPTER IV

RESULTS AND DISCUSSION

The problem of the study was to investigate whether walking in water is an effective substitute for walking on land as an aerobic exercise for people with herniated lumbar disc. PPL and RPE while subjects walked in water and on land were compared at four different work intensities.

Results

The 20 subjects, 12 males and 8 females, participated in the study. Their ages ranged from 22 to 50 years of age; the mean age was 41.1 years. The subjects were referred to the study by medical professionals within Kalamazoo County, Michigan. Each subject provided documentation of his or her diagnosis of herniated lumbar disc. Testing was done according to the availability of the subject and each facility. There were 15 subjects tested in the pool first; 5 subjects were tested on land first. There were 5 patients tested in both environments within 24 hours (1 day), 5 subjects within 48 hours (2 days), 7 subjects within 72 hours (3 days), 1 subject within 84 hours (6 days), 1 subject within 360 hours (15 days), and 1 subject within 480 hours (20 days). There were 2 subjects unable to complete the fourth work intensity (80% of MHR) in both environments due to increased PPL.

For both land and water environments, the following dependent variables were measured:

1. RPE was measured at four work intensities: (1) 50% of MHR, (2) 60% of MHR, (3) 70% of MHR and (4) 80% of MHR.
2. PPL was measured at four work intensities: (1) 50% of MHR, (2) 60% of MHR, (3) 70% of MHR and (4) 80% of MHR.

For each of the dependent variables a randomized block factorial ANOVA design was calculated (Kirk, 1968).

RPE

The ANOVA results for RPE are presented in Table 1. Pertinent RPE results were as follows:

1. A significant difference was found between the conditions, $M = 10.63$ and $M = 11.32$ for water and land, respectively, $F(1, 119) = 6.09, p < .05$.

2. A significant difference was found among the work intensities, $M = 7.53, M = 9.97, M = 12.33$, and $M = 14.01$ for 50%, 60%, 70%, and 80% of MHR, respectively, $F(3, 119) = 101.99, p < .05$.

3. The interaction effect between conditions and work intensities was not significant, $F(3, 119) = 1.28, p > .05$.

PPL

The ANOVA results for PPL are presented in Table 2. Pertinent PPL results were as follows:

1. A significant difference was found between the conditions, $M = 1.71$ and $M = 1.21$ for water and land, respectively, $F(1, 119) = 5.20, p < .05$.

2. A significant difference was found among the work intensities, $M = 0.69, M = 2.00, M = 1.81$, and $M = 2.28$ for 50%, 60%, 70%, and 80% of MHR, respectively, $F(3, 119) = 10.67, p < .05$.

3. The interaction effect between conditions and work intensities was not significant, $F(3, 119) = 0.29, p > .05$. 

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Table 1
ANOVA Summary Table for Ratings of Perceived Exertion (RPE)

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* p < .05.

Table 2
ANOVA Summary Table for Perceived Pain Levels (PPL)

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<td>Condition (C)</td>
<td>9.0</td>
<td>1</td>
<td>9.0</td>
<td>5.20*</td>
</tr>
<tr>
<td>Work (W)</td>
<td>55.36</td>
<td>3</td>
<td>18.45</td>
<td>10.67*</td>
</tr>
<tr>
<td>C x W</td>
<td>1.50</td>
<td>3</td>
<td>0.50</td>
<td>0.29</td>
</tr>
<tr>
<td>Residual</td>
<td>205.83</td>
<td>119</td>
<td>1.73</td>
<td></td>
</tr>
</tbody>
</table>

* p < .05.
Discussion

The results are compared to the proposed hypothesis that RPE would be higher on land than in water and PPL would be lower in water than on land. The results are organized into RPE and PPL.

RPE

One hypothesis of the study stated that the subjects will experience similar RPE while walking in water and while walking on land. However, the significant difference in means between the two conditions indicated that the subjects in this study experienced higher RPE on land than in water. A variety of reasons may explain this unexpected result. Because these subjects all had a diagnosis that presumes pain during land-based activities, they may have felt discomfort while exercising on the land and associated these feelings with increased feelings of exertion. Previous painful experiences during land walking may have led the subjects to expect and, therefore, experience higher levels of exertion. Higher RPE in this study is in contrast to a study by Bishop et al. (1989), in which subjects reported higher RPE during water exercise. The Bishop et al. study suggested confidence and familiarity as a reason why the subjects worked with a lower RPE on land. Buoyancy may have been responsible for the lower RPE in water than on land. Napoletan and Hicks (1995) stated the prolonged flight phase characteristic of gait in water affords the subject an opportunity to float momentarily while taking the next step, thereby decreasing the exertion. Additionally, the subjects had to match the speed of the treadmill during land walking, whereas in water, speed changes could occur as needed as long as heart rate was maintained to within 5 beats per minute of their work intensity. Burke and Keenan (1984) concluded
that exercise levels in a training program can be easily individualized by monitoring heart rate and RPE, but this might not be the case with diagnostic populations.

A second hypothesis stated that subjects would experience increased RPE as the work intensity increased. This was shown by the significant differences in the means among the four different work intensities. At each successive intensity, the RPE increased. Borg (1973) has shown that there is a linear relationship between RPE and exercising heart rate, and this study’s findings concurred.

PPL

A third hypothesis stated that the subjects would experience lower PPL while walking in water than while walking on land. Significant difference in means between the two conditions indicated that subjects felt greater PPL in water than on land. Johnson et al. (1977) stated viscosity, friction, and turbulence are the dominant resistive forces in water providing a greater load during water exercise than the primary resistive force of gravity on land exercise. Although the effects of gravity are reduced in water, these additional forces provide a greater cardiovascular and metabolic load during exercise in water. Additionally, the frontal or horizontal resistance of water to a body in motion makes it difficult to reproduce normal ambulatory posture, leading to increased biomechanical stresses to the lumbar area (Napolean & Hicks, 1995). These subjects have herniated lumbar disc, and changes in posture would affect the lumbar area, possibly contributing to increased pain during water walking. Archimede’s principle states that a body floating or submerged in liquid is buoyed up by a force equal to the weight of the liquid displaced (White, 1956). The same medium that buoy up a body gives resistance to movement through it. Lowman and Roen (1952) stated that, in water, there seems to be greater relative activity of the muscles of joint stabilization than on land. The buoyancy of the water may have prevented the subject’s
body from stabilizing itself to a fixed surface leading to increased muscle work and subsequently increased pain. Given the higher RPE on land, the subjects may have been focusing on their exertion instead of their pain. Attention given to exertion may have distracted attention given to pain, leading to a lower PPL. Although higher pain levels were found in the water walking sessions, it should be noted that the reported pain levels for both the land and water exercise were at the low end of the PPL scale, indicating "very weak" to "weak" pain levels.

The fourth hypothesis stated that subjects would experience changes in PPL at different work intensities. The significant differences among the work intensities indicated that this was the case. However, subjects indicated less pain during the third work intensity, 70% MHR, than in the second work intensity, 60% MHR. The mean score increased again during the fourth work intensity. This pattern may have been caused by the 2 subjects who were not able to complete all 4 levels of work intensities due to pain.
CHAPTER V

SUMMARY, FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The problem of this study was to investigate whether walking in water is an effective substitute for walking on land as an aerobic exercise for people with herniated lumbar disc. Twenty subjects, 8 females and 12 males, walked in two environments: (1) a 4.5 ft deep pool of 90°F water, and (2) a treadmill on land, at four different work intensities: (1) 50%, (2) 60%, (3) 70%, and (4) 80% of MHR. PPL and RPE were measured and compared. One hypothesis stated that subjects will experience lower PPL while walking in water than while walking on land. A second hypothesis stated that subjects will experience similar RPE while walking in water than while walking on land.

Findings

Significant differences in RPE were found between the two conditions, $F(1, 119) = 6.09, p < .05$, with subjects reporting higher RPE on land than in water. This was the opposite of what was expected, and the opposite of results from previous studies. However, RPE did increase as the intensity of the work increased, $F(3, 119) = 101.99, p < .05$.

Significant differences in PPL were found between the two conditions, $F(1, 119) = 5.20, p < .05$ with subjects reporting higher PPL in water than on land. This again was the opposite of what was expected. PPL increased as work intensity
increased except at the 70% MHR work intensity level, where there was a decrease in the mean scores of 0.19, F(3, 119) = 10.67, p < .05. The mean did return to a higher value for the 80% MHR work intensity.

Conclusion

This study demonstrated that walking in water, while producing slightly different effects on both RPE and PPL, is an effective substitute for walking on land as an aerobic exercise for people with herniated lumbar disc because the subjects were able to achieve and maintain aerobic intensities sufficient to positively affect their cardiovascular fitness. RPE during walking was greater on land than in water for similar work intensities. PPL during walking was greater in water than on land for similar work intensities.

Recommendations

After completing this study, several recommendations can be made for future research:

1. Determine the extent of cardiovascular responses to exercise in a water environment for diagnostic populations.

2. Investigate the use of RPE as a measurement of work intensity for diagnostic populations.

3. Investigate the use of PPL as a measurement of work intensity for diagnostic populations.

4. Study diagnostic populations performing in both land and water environments at aerobic intensities for aerobic durations (15 to 60 min).

5. Retest subjects after a period of time and compare results of the two time periods.
6. Design a study for diagnostic populations to repeat the activity two to three times per week for 3 to 4 weeks.
Appendix A
Medical Professional Letter
Dear ________________,

I am Brenda L. Cunningham-Boerger, P.T., owner of Boerger & Assoc., physical therapy services and consultation. I am presently working toward my Master of Arts in Exercise Science degree at Western Michigan University, Kalamazoo, MI. For my thesis I'm preparing a study titled "Pain Levels and Ratings of Perceived Exertion of People with Herniated Lumbar Disc While Walking in Two Environments". The purpose of the study is to investigate whether walking in water is an effective substitute for walking on land as an aerobic exercise for people with herniated lumbar disc. Subjects will work at four intensity levels: (1) 50%, (2) 60%, (3) 70%, & (4) 80% of their predicted maximum heart rate as determined by the formula 220 minus age. The subjects will work at each of these intensities for 2 to 4 min for a maximum of 10 min.

The study is delimited by:

1. Fifteen females and 15 males, 20 to 60 years of age, with various levels of cardiovascular fitness.

2. Subjects who have been positively diagnosed by a computerized tomographic scan (CTS) or magnetic resonance image (MRI) as having a herniated lumbar disc.

3. Subjects who have had no previous surgical intervention for their herniated lumbar disc.

4. Two experimental conditions: (1) walking in water and (2) walking on land.

5. A pool with a water temperature of 90° F and depth of 4.5 ft.
6. Two dependent variables: (1) perceived pain level and (2) rating of perceived exertion.

The study will be limited by:

1. The opportunistic nature of subject selection.
2. The impact of current medical treatments or other exercise choices on subject participation.

Any patients in your practice with a diagnosis of herniated lumbar disc would qualify for application to the study. If you know of no other medical conditions which would preclude their participation, I would appreciate your sharing the attached informational flyer and my business card. This will permit your patient to contact me if they are interested. If not, their identity has remained confidential. If you have any questions regarding this study, please contact either me at 616-327-6088, or Dr. Mary Dawson, principal investigator, at 616-387-2711. A copy of the study results will be available to you upon request. Thank you for your time and consideration.

Sincerely,

Brenda L. Cunningham-Boerger, P.T.
Appendix B

Volunteer Flyer
Hello. I am Brenda L. Cunningham-Boerger, P.T., owner of Boerger & Assoc., physical therapy services and consultation. I am presently working toward my Master of Arts in Exercise Science degree at Western Michigan University, Kalamazoo, MI. For my thesis I'm preparing a study titled "Pain Levels and Ratings of Perceived Exertion of People with Herniated Lumbar Disc While Walking in Two Environments". My project will have people with positive diagnosis of herniated lumbar disc walk once on a treadmill and once in water. Subjects will walk at four different speeds based on their age, determined by the formula 220 minus age. They will be asked to give a number response to pain levels and to a feeling described as perceived exertion.

To be eligible for this study applicants must have a positive diagnosis of herniated lumbar disc as indicated by a CTS or MRI, and have not had any previous surgery for this diagnosis. Applicants will need to fill out a health questionnaire to determine if there are any additional health concerns which would eliminate them from the study. The treadmill walk will be at the University Recreation Center, Western Michigan University, Kalamazoo, MI. The water walk will be at the indoor pool at Southwestern Michigan Sports Medicine Clinic, 315 Turwill Lane, Kalamazoo, MI. Each session will be approximately 30 min to 45 min. There will be opportunity to test the equipment and become familiar to the activity before testing. Any questions will be answered as thoroughly as possible to help increase comfort and confidence during participation. Subjects may refuse to participate or quit at any time during the study without prejudice or penalty.

If you are interested in applying for this study or simply want more information, please contact me at the address below for an informational packet. Thank you for your time and consideration.
Appendix C
Medical Health History Questionnaire
Medical Health History Questionnaire

Subject Code #_________________________ Date________________________

Age________________________ Sex________________________

Check any conditions which apply to your medical health:

_____ hypertension
_____ diabetes
_____ heart problems, chest pain, abnormal EKG
_____ chronic illness (tuberculosis, multiple sclerosis, cancer, etc.)
_____ lung problems, asthma, emphysema
_____ muscle or joint problems sufficient to interfere with routine activities
_____ currently pregnant

Do you have any fears of being in a pool?____________

Have you ever been on a treadmill?____________
Appendix D

Informed Consent for Exercise Testing
Western Michigan University
Department of Health, Physical Education and Recreation.

Principal Investigator: Dr. Mary Dawson
Research Associate: Brenda L. Cunningham-Boerger

I have been invited to participate in a research project titled "Pain Levels and Ratings of Perceived Exertion of People with Herniated Lumbar Disc While Walking in Two Environments". I understand that this research is intended to compare ratings of perceived exertion and perceived pain levels while walking on land and in water at four different heart rate intensities. I further understand that this project is for Brenda L. Cunningham-Boerger's master thesis.

My consent to participate in this project indicates that I will be asked to attend two, approximately 45 min sessions with Ms. Cunningham-Boerger. I will be asked to meet for one water session at Southwestern Michigan Sports Medicine Clinic, 315 Turwill Lane, Kalamazoo, MI, and for one land session at the exercise physiology lab, University Recreation Center, Western Michigan University, Kalamazoo, MI. One session will involve walking on a treadmill and one session in 4.5 ft of 90° F water. My heart rate will be monitored, and the exercise intensity will be determined by a formula using my age (220 - age). Intensity will not exceed 80% of my maximum heart rate.

As in all research, there may be unforeseen risks to me, the participant. I agree to abstain from alcohol consumption for at least 24 hours before each testing session. I understand that my exercise will be stopped if during this test I exhibit any of the following signs of distress: (1) I am exhausted and I wish to stop, (2) the monitoring system fails, (3) I have chest pain or abnormal heart beats, (4) my heart rate is above 80% of my age predicted maximum heart rate, (5) I am short of breath, (6) I am lightheaded, (7) I am confused, (8) I am nauseated and/or (9) I have musculoskeletal pain. If I incur an accidental injury, appropriate emergency measures will be taken; however, no additional compensation or treatment will be made available to me except as otherwise stated in this consent form. I understand that at both locations for testing, emergency procedures/protocol will be displayed and will be adhered to by the research
staff. I understand that one potential risk of my participation in this project is that I may experience increased levels of pain. If this situation should arise, I accept responsibility for contacting my physician. One way in which I may benefit from this activity is having the opportunity to learn to monitor my exercising heart rate, perceived pain levels and perceived exertion levels at four different heart rate intensities while walking on land and in water.

I understand that all the information collected from me is confidential. That means that my name will not appear on any papers on which this information is recorded. The forms will all be coded, and Ms. Cunningham-Boerger will keep a separate master list with the names of participants and the corresponding code numbers. Once the data are collected and analyzed, the master list will be destroyed. All other forms will be retained for 3 years in a locked file in the principal investigator's laboratory.

I understand that I may refuse to participate or quit at any time during the study without prejudice or penalty; this decision will not affect any physiological or medical treatment, rehabilitation or prescription that I am or will be receiving. If I have any questions or concerns about this study, I may contact either Dr. Mary Dawson, at 616-387-2711 or Brenda L. Cunningham-Boerger at 616-327-6088. I may also contact the Chair of Human Subjects Institutional Review Board at 616-387-8293 or the Vice President for Research at 616-387-8298 with any concerns that I have. My signature below indicates that I understand the purpose and requirements of the study and that I agree to participate.

__________________________________________  __________________________
Signature                                              Date
Appendix E

Approval from Human Subjects Institutional Review Board
Date: September 26, 1995
To: Brenda Boerger
From: Richard Wright, Chair
Re: HSIRB Project Number 95-06-09

This letter will serve as confirmation that your research project entitled "Comparing land and water walking at four different heart rate intensities on perceived pain levels and ratings of perceived exertion of people with herniated lumbar disc" has been approved as revised under the full category of review by the Human Subjects Institutional Review Board. The conditions and duration of this approval are specified in the Policies of Western Michigan University. You may now begin to implement the research as described in the application.

Please note that you must seek specific approval for any changes in this design. You must also seek reapproval if the project extends beyond the termination date. In addition if there are any unanticipated adverse reactions or unanticipated events associated with the conduct of this research, you should immediately suspend the project and contact the Chair of the HSIRB for consultation.

The Board wishes you success in the pursuit of your research goals.

Approval Termination: September 26, 1996

xc: Mary Dawson, HPER
Appendix F

Calculated Intensities for Exercising Heart Rates
### Calculated Intensities for Exercising Heart Rates

<table>
<thead>
<tr>
<th>Age</th>
<th>Maximal Heart Rate</th>
<th>Target Training Zones</th>
</tr>
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<tbody>
<tr>
<td></td>
<td></td>
<td>50%</td>
</tr>
<tr>
<td>20</td>
<td>200</td>
<td>100</td>
</tr>
<tr>
<td>25</td>
<td>195</td>
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<td>60</td>
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Appendix G

Borg Rating of Perceived Exertion Scale (RPE)
Borg Rating of Perceived Exertion Scale (RPE)

<table>
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<th>corresponds to</th>
<th>&amp; Target Heart Rate value</th>
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<tbody>
<tr>
<td>6</td>
<td>Nothing at all</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Very, very light</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Very light</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Very light</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Fairly light</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Somewhat hard</td>
<td>60%</td>
</tr>
<tr>
<td>13</td>
<td>Hard</td>
<td>70%</td>
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<td>14</td>
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<td>80%</td>
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</tr>
<tr>
<td>18</td>
<td></td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>Very, very hard</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Appendix H

Borg Perceived Pain Level Scale (PPL)
Borg Perceived Pain Level Scale (PPL)

This pain value corresponds to

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<th>Pain Value</th>
<th>Description</th>
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<tbody>
<tr>
<td>0</td>
<td>Normal, no pain</td>
</tr>
<tr>
<td>0.5</td>
<td>Very, very weak</td>
</tr>
<tr>
<td>1</td>
<td>Very weak</td>
</tr>
<tr>
<td>2</td>
<td>Weak</td>
</tr>
<tr>
<td>3</td>
<td>Moderate</td>
</tr>
<tr>
<td>4</td>
<td>Somewhat strong</td>
</tr>
<tr>
<td>5</td>
<td>Strong</td>
</tr>
<tr>
<td>6</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Very strong</td>
</tr>
<tr>
<td>8</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Very, very strong</td>
</tr>
<tr>
<td>10+</td>
<td>Emergency</td>
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</table>

BIBLIOGRAPHY

About CT. (n.d.). Kalamazoo, MI: Kalamazoo Neuro Imaging Center.

About MRI. (n.d.). Kalamazoo, MI: Kalamazoo Neuro Imaging Center.


