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Heart Rate Response and Rate of Perceived Exertion Comparison on the Treadmill versus Elliptical

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HEART RATE RESPONSE AND RATE OF PERCIEVED EXERTION COMPARISON ON THE TREADMILL VERSUS THE ELLIPTICAL

by

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CHAPTER 1

INTRODUCTION

Physical activity and exercise are important components to add into everyday life. The American College of Sports Medicine (ACSM) recommends that adults over the age of 18 participate in at least 150 minutes of moderate intensity endurance training a week and resistance train all major muscle groups at least 2 times a week (ACSM, 2017). Resistance training is important for various reasons including muscle strength, bone strength, and preventing injuries. Endurance training is important for cardiovascular function. Both endurance training and resistance training are important factors in preventing noncommunicable diseases such as heart disease or diabetes (Archer & Blair, 2012).

Treadmills and ellipticals are two popular pieces of equipment for endurance training. Generally, the elliptical is deemed as an easier form of exercise compared to treadmill running. This is due to the guided direction of the elliptical and the type of impact each piece of equipment has on the body. Impact can be in relation to the gait cycle the body undergoes, which is different when comparing treadmill running and elliptical training. One full gait cycle consists of one foot leaving the ground and that same foot coming back in contact with the ground (Nicola & Jewison, 2012). When it comes to gait, running consists of two main phases, the stance phase and the swing phase, both of which have different components. The stance phase consists of foot strike, mid strike, and take off. Then, the swing phase consists of lower extremity swings throughout the air from the moment of take-off to foot strike (Nicola & Jewison, 2012). When using an elliptical machine, the participant's foot stays planted on the machine. So, the only similarity in gait between elliptical training and treadmill running would be the movement of the hips and the knees. Overall, treadmill running could be harder on the human body due to

the planting impact of the feet and the user not holding on to the machine.

Treadmill running and elliptical running are different movements for the body. When an individual is running on the treadmill, he or she is typically in the upright position, on a flat surface, with the treadmill belt guiding the pace of the movement. On the elliptical, the individual's body is going with the oscillations of the machine at a slight incline. With the two being different movements for the body, different muscles are recruited when using the machines. When investigating the muscles used during treadmill running and elliptical training, researchers discovered that the elliptical trainer uses more upper body muscles when compared to treadmill running (Sozen, 2010). These muscles include the biceps brachii, triceps brachii, pectoralis major, and trapezius. The researchers also found that the activation of the gastrocnemius and the gluteus maximus muscles in the lower extremity were much higher during treadmill exercises compared to elliptical training (Sozen, 2010). The rest of the lower extremity muscles did not show any significant differences between the two machines. With that being said, the results of this study demonstrate that treadmill running and elliptical training can both aerobically train the body, but work different muscles while doing so.

When exercising for general fitness, the type of exercise and intensity can become important. There are two main intensity levels that are important for exercise. This includes moderate intensity activity, which is 64%-76% of heart rate max, and vigorous intensity activity, which is 77%-93% of heart rate max (Centers for Disease Control and Prevention, 2022). In general, those who exercise at higher intensities on a more regular basis, tend to have a higher subjective well-being (Wicker & Frick, 2017). Meaning that those who participate in moderate to vigorous intensity exercise on a regular basis, tend to have a more positive attitude about life and the activities that are part of it. There are various ways to measure exercise intensity during

exercise. Heart rate, exertion charts, talk and singing tests are a few of those ways. But, heart rate and rate of perceived exertion (RPE) are two of the most common ways to measure exercise intensity. Heart rate can be measured by palpation or even a smart watch. It is measured in beats per minute (bpm), which is the number of times the heart beats per minute. RPE can be measured using a scale, specifically the Borg scale, which is a measurement of how hard a person feels their body is working. A person can rate RPE based on his or her personal experience during exercise including breathlessness, aches in the muscles, effort, or fatigue (Borg, 1998).

Sometimes runners need alternate forms of endurance training, whether this be cycling, swimming, walking, or elliptical training. The question arises, when looking at exercise intensity, could those alternate forms be sufficient enough to replace running? Physiological changes following different endurance training modalities over time have been studied. In relation to cardiovascular fitness, elliptical training and the stair stepper have both been found to develop significant cardiovascular improvements compared to treadmill running when the training volume, frequency, and intensity are similar (Egana, 2004). Previous research has also found that individuals exercising on a treadmill or elliptical at a self-selected pace, did not show huge differences in heart rate response (Egana, 2004). Others have questioned if results would be different if the intensity was chosen or determined for individuals (Green et al. 2004). Meaning, whether the treadmill or the elliptical would elicit a higher heart rate response to exercise.

Males and females also have a different response to exercise intensity. Males typically have a larger muscle mass and a larger heart, where females usually have a smaller lean body mass and different hormone levels (Carter, 2003). These differences cause the body's heart rate to react differently to exercise. The main similarity between the two genders is that heart rate

does increase in response to exercise, but the increase most likely is not the same due to males and females having a different range for resting heart rate, males generally having a lower heart rate (Ostchega, 2011).

The purpose of this study is to a.) determine if the elliptical trainer can elicit the same heart rate response as running on a treadmill b.) determine if there is a difference in RPE between the two machines at the same intensity and c.) compare and contrast the heart rate response between a male and a female. It is hypothesized that a.) treadmill running will produce a higher heart rate than elliptical running at the same intensity b.) the elliptical trainer will have a lower RPE rating and c.) the male will have a greater heart rate response compared to the female.

CHAPTER 2

METHODOLOGY

Participants of this study included 1 male and 1 female, both over the age of 18. This study was based on a volunteer basis and participants could withdraw any time if necessary. To be considered for the study, an individual had to be 18 years or older, familiar with endurance training, comfortable walking and running on a treadmill, and comfortable using an elliptical trainer. Each participant was informed of the purpose of the study as well as the risks of participating. Those included falling off the treadmill or elliptical or any exercise associated physiological response.

Testing was split into two days. Each participant was assigned a one-hour time slot each day to complete the treadmill protocol and the elliptical protocol. Day one consisted of reviewing the procedures, signing the consent form, and the treadmill protocol. The elliptical protocol was conducted on day two. A heart rate monitor was worn for each protocol and a BORG scale was placed in front of each participant to assess RPE.

The treadmill protocol consisted of a 15-minutes with 5 stages, each stage lasting 3 minutes. During each stage, heart rate was measured twice and RPE once. Stage one consisted of minutes 1-3, where heart rate was measured at minute 1, minute 3 and RPE was measured at minute 2. During this stage treadmill speed was set to 2.5 miles per hour (mph). For stage two, the speed was increased to 3.5 mph for minutes 3-6, heart rate was measured at minute 4, minute 6, and RPE was measured at minute 5. Stage three was conducted at 4.5 mph for minutes 6-9, heart rate was measured at minute 7, minute 9, and RPE was measured at minute 8. Treadmill speed was increased to 5.5 mph for stage four for minutes 9-12, heart rate was measured at minute 10, minute 12, and RPE was measured at minute 11. For stage five, treadmill speed was

increased to 6.0-6.5 mph for minutes 12-15. This speed was based on the performance of the participant or the participant's ability to run. Heart rate was measured at minute 13, minute 15 and RPE was recorded at minute 14. At the conclusion of stage five, a cool-down was conducted. Treadmill speed was decreased to 3.0 mph for minute 1, minute 2, then to 2.0 mph until the subject was ready to stop. A final heart rate reading was measured before exiting the treadmill.

Each participant arrived for the second day of testing. Each stage of the protocol was explained, the heart rate monitor was applied, and resting heart rate was collected. The elliptical protocol was similar to the treadmill protocol. It consisted of a 15-minute protocol with 5 stages, each stage lasting 3 minutes. Heart rate was measured twice, during the first and last minute of each stage. RPE was measured once during the second minute of each stage. Stage one, minute 1 through minute 3, was at the level 1 setting of the elliptical. Stage two, minute 3 through minute 6, was increased to level 2 of the elliptical. For stage three, minute 6 through 9, the elliptical was increased to level 4. Stage four, minute 9 through minute 12, the elliptical was set at level 5. For the final stage, minutes 12 through minute 15, the elliptical was increased to level 6. At the conclusion of 15 minutes, a 3-minute cool down was completed before the participant exited the treadmill. The elliptical was decreased back to level 2 for minute 1 and 2, then level 1 for the final minute of the cool down. Heart rate was collected one last time at the conclusion of the cool down.

CHAPTER 3

RESULTS

Each participant was able to complete both the treadmill and elliptical protocols without any issues. Table 1 demonstrates heart rate response for both the male and female participant on the treadmill. The male's average heart rate on the treadmill was 119.1 bpm and the female's average was 125.8 bpm. Table 2 represents the heart rate response for the elliptical. The average heart rate for the male on the elliptical was 105.8 bpm and the female's average was 118.1 bpm. Table 3 demonstrates the RPE readings for the treadmill and Table 4 presents the RPE readings for the elliptical. When comparing the two pieces of equipment, the RPE readings were not drastically different. Both the treadmill and elliptical produced approximately the same rate of perceived exertion.

Table 5 presents the male and female's resting heart rate and cool down heart rate. Both participants had a higher resting heart rate on Day 1 for the treadmill protocol. The male's resting heart rate was within the same range for both days, while the female's heart rate was much lower for Day 2. When comparing resting heart rate and the highest heart rate reached on the treadmill, the male's difference was 78 bpm and the female's difference was 85 bpm. The elliptical showed a smaller difference, the male's being 34 bpm and the female's being 56 bpm.

When looking at just the male, heart rate was greatest with the treadmill protocol. The treadmill protocol produced the greatest heart rate, 157 bpm, and the greatest RPE rating, 19. On the elliptical, the greatest heart rate reached was 111 bpm, 46 bpm lower than the treadmill. The average heart rate for the treadmill was drastically higher compared to the elliptical, representing that the body and heart are working harder on the treadmill. For both protocols, RPE rating increased during each stage. This represents as the speed or level increases, so does the

perceived exertion. On the treadmill, the male participant rated stage 5 as a 19 on the BORG scale, which is classified as “very, very hard,” while classifying stage 5 on the elliptical as a 15. This represents that running on a treadmill could be perceived as a more difficult task than using an elliptical machine.

For the female subject, heart rate was greatest on the treadmill, being 136 bpm, but the elliptical caused a great heart rate response as well, the highest being 131 bpm. As the intensity increased on both machines, heart rate also increased, showing that both machines produced a similar heart rate response. Stage 3 produced the greatest heart rate on the treadmill, which could be due to the change from walking to a slight jog. There was not a drastic difference between the average heart rate for the two machines, the difference being 7.7 bpm. When comparing RPE ratings, each stage had a similar perceived exertion. The highest RPE on the treadmill was a 16 and 14 on the elliptical; both being during stage 5. These readings are within the same range on the BORG scale.

Both the male and the female subject had an increase in heart rate and RPE on both pieces of equipment. The female participant reached a greater heart rate on both machines when compared to the male. On the treadmill, the female had a higher heart rate on stages 1-3, but lower heart rate than the male on stages 4 and 5. The female participant had a higher heart rate reading during each stage of the elliptical protocol when compared to the male. Overall, the female had a greater heart rate response on both protocols.

Table 1: Heart Rate (HR) Response to Treadmill Protocol

	Stage 1		Stage 2		Stage 3		Stage 4		Stage 5	
	HR 1	HR 2	HR 1	HR 2	HR 1	HR 2	HR 1	HR 2	HR 1	HR 2
Male	94	84	100	100	119	121	129	137	150	157
Female	97	103	119	122	120	167	129	125	140	136

Table 2: Heart Rate (HR) Response to Elliptical Protocol

	Stage 1		Stage 2		Stage 3		Stage 4		Stage 5	
	HR 1	HR 2	HR 1	HR 2	HR 1	HR 2	HR 1	HR 2	HR 1	HR 2
Male	105	110	101	102	106	107	106	104	106	111
Female	110	113	120	112	121	121	117	121	115	131

Table 3: Rate of Perceived Exertion (RPE) to Treadmill Protocol

	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5
Male	7	11	13	15	19
Female	7	11	12	13	16

Table 4: Rate of Perceived Exertion (RPE) to Elliptical Protocol

	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5
Male	7	9	13	15	15
Female	7	9	11	13	14

Table 5: Resting Heart Rate (HR) and Cool Down Heart Rate (HR)

	Treadmill Resting HR	HR After Treadmill Cool Down	Elliptical Resting HR	HR After Elliptical Cool Down
Male	79	100	77	97
Female	82	112	75	109

CHAPTER 4

DISCUSSION

Results demonstrate that running on a treadmill will produce a greater heart rate than higher levels on an elliptical. The lower levels of the elliptical produce a higher heart rate when compared to walking speeds on the treadmill. Information like this becomes important when exercise professionals begin prescribing exercise. ACSM's guidelines for exercise intensity is generally based on heart rate, so knowing heart rate response to a certain speed on specific pieces of equipment can become useful.

Also, the results of this study demonstrate that males and females have a different heart rate response to endurance training. Cardiovascular adaptations between the two genders have not been deeply investigated (Carter, 2003), but a deeper knowledge can aid in training the two genders recreationally and sport specific. Based on the results of this study, if a male was interested in a cardiovascular training at a higher intensity, running at 5.5 mph or greater on the treadmill would be beneficial. For females, based on the results, elliptical training and running on the treadmill could elicit similar cardiovascular improvements.

Both quantitative and qualitative measures were used to describe exercise intensity. Heart rate was the body's reaction to the speed or level of the machine and was given as a numerical response on the heart rate monitor. The Borg scale is the most common scale used for perceived exertion to describe exercise intensity (Borg, 1998). Using both quantitative and qualitative measures were important to understand the results. RPE expressed how hard the subject felt he or she was working, while heart rate response represented how hard the subject's body was working.

This study was based on individuals who are active and participate in endurance training

regularly. Sedentary individuals or individuals who participate in only resistance training would potentially have different results. Also, both individuals were young, which could sometimes have influences on resting heart rate and heart rate response to exercise. It was found that heart rate recovery after exercise can be slower in older individuals, but the researchers found that trained individuals had a better heart rate response when compared to untrained individuals (Darr, 1998). So, when it comes to prescribing exercise intensity on both the treadmill and the elliptical, physically active individuals would most likely be able to withstand higher intensities compared to untrained individuals.

In conclusion, it is important to understand an individuals goals and fitness levels before determining what time of endurance exercise is needed. This study demonstrates that higher level on the elliptical are not sufficient to replace running due to the body's heart rate response. Even though running should not be replaced, using the elliptical as a way to aerobically train could be encouraged.

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APPENDICES

APPENDIX A

Data Collection

Subject #

Treadmill Protocol

Resting Heart Rate _____

Stage	Time (min)	Speed	HR 1	RPE	HR 2
1	1-3	2.5			
2	3-6	3.5			
3	6-9	4.5			
4	9-12	5.5			
5	12-15	6-6.5			

Cool Down Heart Rate _____

Elliptical Protocol

Resting Heart Rate _____

Stage	Time (min)	Speed/Level	HR 1	RPE	HR 2
1	1-3	1			
2	3-6	2			
3	6-9	4			
4	9-12	5			
5	12-15	6			

Cool Down Heart Rate _____

APPENDIX B

Borg Scale

7	**Very, very light**
8	
9	**Very light**
10	
11	**Fairly light**
12	
13	**Somewhat hard**
14	
15	**Hard**
16	
17	**Very Hard**
18	
19	**Very, very hard**
20	

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