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Original Research Article

Correlation between Heart Rate, Estimated Heart Rate, and Rating of Perceived Exertion during Aerobic Exercise

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Abstract

Introduction: Over the years heart rate (HR) has been used to determine intensity or how hard somebody is working out. However, it was our perception that most individuals do not know how to use HR in their fitness programs. Our goal was to find whether or not students were aware of their exercising HR and, if not, analyze the discrepancy that existed between the actual HR and estimated HR. **Methods:** Participating in either sport activity classes or running, subjects first started with a demographic questionnaire to determine basic information. Next, each subject was educated on the Borg Rating of Perceived Exertion (RPE) Scale, the method by which they reported their RPE. Heart rate monitors were then placed on individuals so that during exercise their heart rate could accurately and easily be determined. For 20 minutes, as participants exercised, they were asked to estimate their HR and RPE every five minutes. Their estimated RPE was recorded and their estimated HR was compared to their actual HR. **Results:** The running participants' estimated HRs vs. actual HRs included; at 5 minutes (111.2, 140.9, $p < .001$), at 10 minutes (124.0, 153.7, $p < .001$), at 15 minutes (129.5, 149.6, $p < .001$), and at 20 minutes (126.8, 147.3, $p < .001$). The sport activity participants' values included; at 5 minutes (101.3, 135.5, $p < .001$), at 10 minutes (115.4, 144.5, $p < .001$), at 15 minutes (116.7, 141.1, $p < .003$), and at 20 minutes (119.2, 141.2, $p < .004$). **Conclusion:** This was an indication that during moderate to vigorous exercise, students did not have an understanding of what their current HR was, and that an optimal HR was not maintained during exercise. Due to these findings, we concluded that it would be beneficial for students to be better educated on target heart rate values and for teachers to be more aware of the intensity levels during their classes.

Key Words: Intensity, Running, Sport Activity

Introduction

The heart is a fascinating hollow muscle that pumps blood throughout the blood vessels by continuous rhythmic contraction. The blood it pumps, takes oxygen and nutrients to the cells and the rest of the body. HR is measured in beats per minute and, according to the Mayo Clinic, is considered normal at rest if it falls anywhere between 60–100 beats per minute¹. Heart rate is used in the medical field, competitive training and is a common way of analyzing intensity level during routine exercise. Our research will focus specifically on analyzing intensity levels during exercise.

During exercise it is important to do so at the proper intensity. If one exercises at a level that is too intense, they are unable to sustain the exercise for a sufficient amount of time and for that reason, it is likely that their goals may not be reached as quickly and the benefits will not be as drastic as they possibly could be. On the other hand, if the exercise is not intense enough, the exercise must be sustained for a long duration of time in order to produce results. Because time is so precious in our society, many people do not have sufficient time to exercise at such a low intensity. It is for these reasons that exercising at a proper intensity for the desired amount of time is so important.

As was mentioned previously, our research involved the use of HR as a way to monitor intensity levels during exercise. The most effective exercise takes place within an

ideal heart rate zone called the Target Heart Rate (THR); this zone varies based on an individual's age, fitness level and desired results. As explained by Karvonen and Vuorimaa², there are several methods to determine target heart rate and with each method comes argument as to why it is best. In addition, based on an individual's goals, the THR for that person will be altered and shifted in order to meet their needs. For example, if an individual's goal is to burn fat and lose weight, he/she will exercise at a lower intensity than if a person's goal was to improve their cardiovascular endurance. However for the purpose of simplicity, the method we used to find THR for moderate to intense activity is subtract your age from 220 and find 50% to 70% of that number. This is the range where within the THR lies. According to the Centers for Disease and Control and Prevention³, 50% to 70% of maximum HR is a common range for the average, recreational runner/athlete. For that reason, we will base our discussion in large part, around this range.

There are many benefits of exercising at or within a THR zone, in fact, the development and maintenance of cardiorespiratory fitness and proper body composition in healthy adults, depends heavily on the intensity of the exercise in which they participate. During activity, HR needs to be kept within a range of percentages of maximum HR⁴. As you can see, being conscious and aware of your HR during training can help you exercise effectively

and efficiently. Each phase and type of training have certain intensities, at which, results are best achieved. Whether it is warming up, weight loss, aerobic training or endurance training, each happen within different percentages of maximum heart rate. Generally, however, for weight loss the THR zone decreases and the amount of time necessary increases, and on the other hand, for cardiovascular training, the THR increases and the amount of time necessary decreases. If you are not aiming to get your heart rate into your individual target heart rate zone, you are not making your exercise effective. It was our belief that the majority of individuals do not know how to use HR in their fitness programs.

Little scientific research has been done on the correlation between actual heart rates and estimated heart rates of individuals. However, much research has been done on the relationship between Borg's Rating of Perceived Exertion (RPE) scale, which ranges from 6-20, and heart rate. Babcock, Paterson, and Cunningham⁵ found that the RPE scale is useful because the participant learns to associate the THR range with a certain whole-body perception of effort, decreasing the need for frequent pulse rate measurements. In fact the motive for the advent of Borg's scale was to help the average person easily and accurately quantify their level of exertion. The correlation exists between the number on the scale and heart rate by a factor of 10^6 . For example, 14 on Borg's scale corresponds to 140 bpm. In order to

become accustomed to the Borg scale, the participant must exercise at a given intensity and while exercising at that intensity, they are told to note how they feel and to associate that feeling with a number. As the intensity and feelings of fatigue increase, so does the RPE number. As useful a tool as the RPE scale is, it is also important to acknowledge the fact that the majority of people are not aware of this correlation much less that this tool even exists. Therefore, HR training may be the answer to personally measuring the level of intensity of exercise.

Utah Valley University (UVU), and many other universities across the nation, offers fitness and sport classes to give students the opportunity to stay active, improve their skills and maintain or improve their fitness levels. In the general population of these classes, it seems that very few participants, if any, are focused on their training HR zone. Rather, they are focused on winning, improving skills, losing weight, getting skinnier, etc. For these reasons, we hypothesized that students are unaware of their HR and whether or not it falls within their desired THR zone.

Methods

Participants

The participants for this study were students enrolled in general fitness and other sport activity classes at UVU. A total of forty-seven subjects volunteered to participate in the study; N=23 from fitness classes and N=24 from sport activity classes.

The twenty-three students from the fitness classes participated in the research by running on a treadmill and the twenty-four students from the sport activity classes participated in either basketball (N=12) or volleyball (N=12). Of all the sport classes offered at UVU, the most common are volleyball and basketball with classes being offered throughout the morning and into the early afternoon. For this reason, participants in these classes were chosen as subjects due to the convenience of time and location of classes. In addition, we felt that there would be a wide variety of people in these classes which meant differing body types, fitness levels, ages, etc. It was decided that the data for both male and female subjects would be grouped together because the gender of the participant, we felt, did not affect the results. All participants signed an Institutional Review Board approved informed-consent form before participation.

Experimental Design

After completing a demographic questionnaire, each participant was given an Omron HR100C heart rate chest strap to monitor HR; however, participants were not given a watch that could sync with the strap. To ensure each strap worked properly, each strap was fitted and correctly placed on the participant's chest with the assistance of the researcher. For those participants whose HR was tested while running, the treadmill HR monitor displays

were covered so that participants could not see their actual HR values. Participants were instructed to run at a self-selected pace for 20 minutes. At 5 minutes of running, researchers asked the twenty three running participants for their estimated HR, in beats per minute (bpm), and Rating of Perceived Exertion (RPE) using the Borg scale while the runners continued at a constant pace. The same procedure was used after 10 minutes, 15 minutes and 20 minutes of running.

Basketball and Volleyball players participating in the study followed the same procedures as the running participants and were asked to participate in their respective sports at their normal level of intensity. They were then interrupted for just a short time while playing to report their HR and RPE at 5, 10, 15 and 20 minutes so that their exercising HR was disturbed minimally. The researchers wore the watches that synced with the HR straps. While participants reported estimated HR and RPE to the researchers, researchers were able to find the actual HR of each participant with the watches being worn because of being within proximity of the chest strap being worn by the participant. The watches were capable of picking up several HRs, so participants were isolated from one another during data collection intervals to prevent any misreading. Participants' estimated HR, RPE, and actual HR were recorded with their other demographic information. Four sets of data were gathered for each

participant, one set pertaining to each interval when the data was recorded (5, 10, 15 and 20 minutes).

Statistical analyses

Estimated and actual HRs were compared and correlations were made by using a two-tailed T-test with the alpha level set at 0.05.

The program used to analyze the data was the Statistical Package for Social Sciences version 19 (SPSS). The anthropometrics of the participants are as follows: mean height (69.3 ± 4.0 in.), mean weight (158 ± 26.6 lbs.), mean age (20.9 ± 2.5), mean BMI (23.0 ± 2.6). Demographics were separated by male and female, but it was decided that the statistics would be analyzed together. The reason for this decision was based on the fact that no significant variance was found between the estimated and actual HR of a male participant versus a female participant; these participants were used as their own control. Before conducting the tests, we were curious as to whether or not a correlation would exist between the different genders, however, no such correlation was found, and therefore, the data was combined. The difference between the sport activities (volleyball and basketball) was not considered and data from basketball participants and volleyball participants were combined. The reason for this is that, much like the gender consideration, after analyzing the data, no significant discrepancy was found between the two activities tested. Both volleyball and basketball are intense and active sports

that require similar movements. Because of this, we noted that the average of both the actual HR and estimated HR values were very similar. We felt that for this reason, on average, most volleyball and basketball participants exercise at similar intensities and therefore the statistics could be combined.

Results

The first set of data (Figure 1) pertains to the data collected from the results of the twenty-three participants from the fitness classes, and are as follows: at 5 minutes (111.2, 140.9, $p < .001$), at 10 minutes (124.0, 153.7, $p < .001$), at 15 minutes (129.5, 149.6, $p < .001$), and at 20 minutes (126.8, 147.3, $p < .001$). The second data set (Figure 2) pertains to the twenty-four subjects who participated from the sport activity classes and are as follows: at 5 minutes (101.3, 135.5, $p < .001$), at 10 minutes (115.4, 144.5, $p < .001$), at 15 minutes (116.7, 141.1, $p < .003$), and at 20 minutes (119.2, 141.2, $p < .004$).

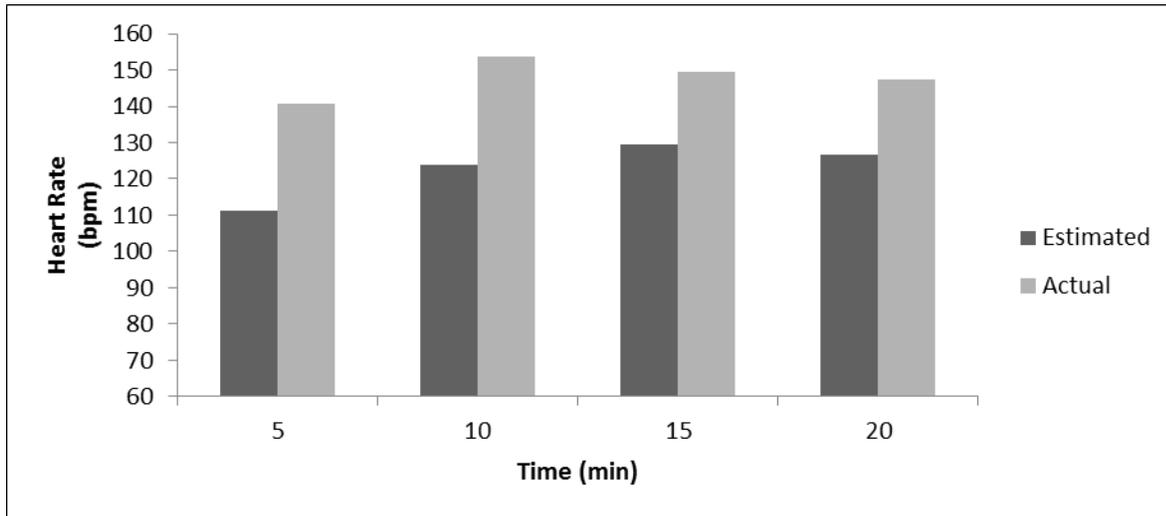


Figure 1. Estimated and actual HR of fitness class participants.

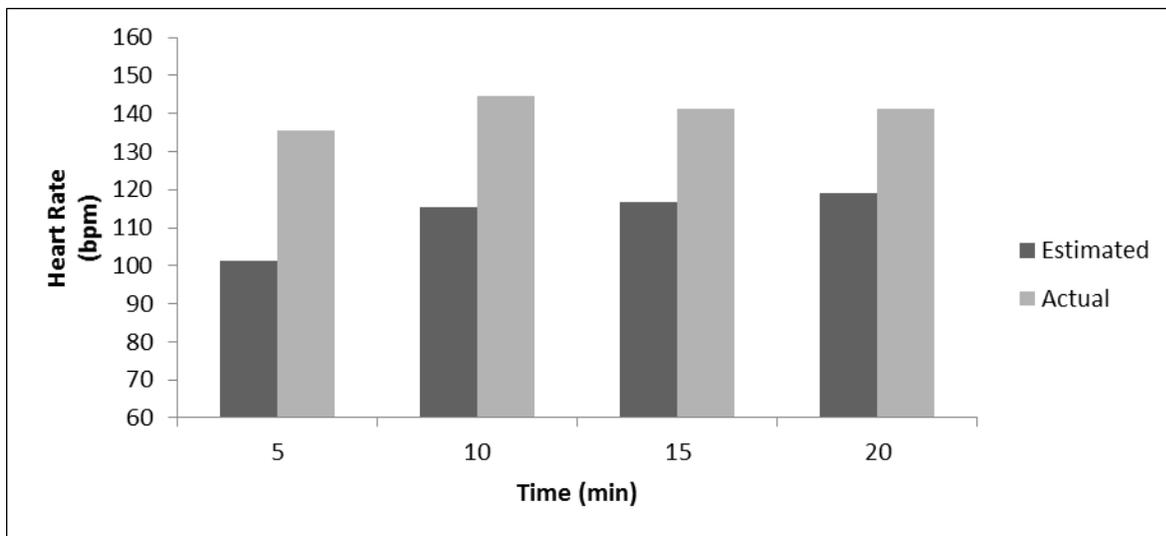


Figure 2. Estimated and actual HR of sport activity class participants.

Table 2. Estimated and actual heart rate values for Fitness Class and Sport Class participants.

Time	Fitness Class Participants			Sport Class Participants		
	Estimated HR	Actual HR	P-value	Estimated HR	Actual HR	P-value
5min	111	141	0.001	101	136	0.001
10min	124	154	0.001	115	145	0.001
15min	130	150	0.001	117	141	0.003
20min	127	147	0.001	119	141	0.004

Discussion

Upon receiving each student's estimated HR during exercise, researchers found that on average, students underestimated their actual HR value. Regardless of the activity in which they were participating, all subject estimated HRs were under the actual HRs by at least 20 bpm (Table 1). The participants in the classes did not have an accurate understanding of what their actual HR was during exercise and therefore, an optimal HR, for any goals they may have had, was not maintained during exercise. However, an interesting trend was identified. When comparing the running data set with that of the sport activity, the actual HRs of the running participants were higher than the actual HRs of the sport activity participants'. This is understandable for the fact that while playing basketball or volleyball there are short pauses throughout the game during which players can rest and allow their HR to decrease before continuing play.

In contrast, running at a constant pace is a bit more rigorous and therefore can lead to a higher HR. The interesting observance is that the estimated HRs follow a similar pattern. The estimated HRs of the running participants were higher than those of the sport activity participants. Based on this information, it seems that even though the students were not accurate in their estimations, the perception of intensity they felt was. Meaning, it would be expected that the subjects participating in

running would estimate their HR to be higher because of the amount of rigor they perceived while exercising. In contrast, the sport activity participants did not experience the same level of intensity while exercising and thus did not estimate their HR to be quite as high. This suggests, that students are aware of the differing levels of intensity but are not able to accurately associate an intensity level with a HR.

The average age of the individuals participating was 20.9 ± 2.5 (years). If we use the average age of the tested subjects to find an average THR for the group of participants we would calculate it as follows: $(220 - 21) \times 0.50 = 99.5$ bpm and $(220 - 21) \times 0.70 = 139.3$ bpm. These two values give the upper and lower boundaries of THR of 50% - 70% of a 21-year-old individual. With that range now in mind, we find that the only point during the exercise bouts of either group that fell within that range was the 5 minute mark of those participating in a sports activity with an average actual HR of 135.5 bpm (Table 1). At every other point during the procedure the subjects were exercising much too intensely, for this particular zone, and at one point (at 10 minutes during the running) the average HR was 7% above the upper boundary of the THR.

Even though this was the case, it does not necessarily mean their exercise was done in vain. As mentioned previously, as exercise goals vary so does the THR. Throughout the

discussion we have stated that as a general guideline 50% to 70% of heart rate max is the THR for the general population. However, depending on the direction of the training this may be altered. According to the American College of Sports Medicine⁷, the proper intensity for cardiorespiratory fitness ranges anywhere from 70% - 90% of the heart rate max, again depending on the fitness level of the individual. Based on these values the range for a THR would be 139.9 – 179.1 bpm. In our sample, at nearly every interval where data was gathered the students' HR fell within this range.

The differing ranges are significant and can lead one to wonder into which range these students fall. However, this question is one that will not be touched on in this discussion. The fact of the matter is that the students underestimated their exercising HR at each point during the study. As a result of these findings we can assume, no matter the motive of the students' exercise and no matter the THR they are aiming for, they are unable to accurately assess it. In addition, because the demographic of the tested population was so diverse we believe that the general population of students and likely entire population in general cannot accurately estimate their HR during exercise. We conclude that students are unable to predict and exercise at the recommended HR intensity and as a result, unable to maximize health related benefits associated with exercise.

Conclusions

The average college student cannot accurately estimate his/her HR during exercise. Regardless of the type or style of exercise, we believe that students will continue underestimating their HR because it is not something they are aware of or are concerned with during exercise. Because of this we believe that the efficacy of their exercise is not maximized and these students would benefit from education on HR values and their meaning. The reason for these conclusions deal with what has been discussed formerly; exercising at too high of an intensity causes one to fatigue more quickly and thus not receive the potential benefit from the exercise. In addition to this education, implementation of small, wearable HR monitors in exercise related classes could potentially increase students' awareness of their own HR and it's tendencies during exercise.

Furthermore, there are other applications that stem from these findings. One of which deals with practices held by competitive athletes and their coaching staffs. It seems that if the general population exercises at a level of intensity that is considerably too high, one could assume that the practices held by athletes, who are expected to compete at levels of intensity that are even higher and more rigorous, would also be too intense leading to increased HR responses. The consequences of this issue would be that the athletes fatigue too quickly causing their physical and mental

progress to be hindered as well as increase his/her chance of injury. Overtraining may be caused by too much high intensity training and/or too little regeneration (recovery) time often combined with other training and non-training stressors⁸. It seems that the best way to combat this issue would be to schedule practices in a way that would allow the athletes sufficient rest in between intense sessions.

However, regardless of the motive, all participants underestimated their HRs during exercise. Because of this finding, we can safely assume that the general population is also unable to accurately estimate their HR during exercise and therefore is not benefitting as much as they possibly could from their exercise. We conclude that athletes and students alike would greatly benefit from becoming educated on the topic of HR and the importance of THR during exercise. Whether it be competitive or recreational, being aware of your HR and its tendencies makes exercise much more effective.

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