

Association Between Heart Rate Variability and Perceived Physical Exertion

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Abstract: Heart rate variability (HRV) is the fluctuation that exists in time intervals between contiguous heart beats. Fluctuations in heart rate can reflect nonlinear, complex interactions between different physiological systems including the brain and heart. HRV serves as a functional indicator of autonomic nervous system regulation, however, associations between HRV and the degree of psychologically perceived exertion remain unexplored. This project seeks to develop and validate a quantitative tool to assess whether a relationship exists between HRV and perceived exertion. To evaluate this question, 10 healthy college students over the age of 18 with no previous exposure to forceful and/or repetitive manual tasks within 8 weeks of beginning the study will be asked complete 1800 cycles of a simple manual task 25 minutes per day for five consecutive days. The task will be divided into two eight minutes intervals and one nine-minute interval, separated by a 10-minute rest period between intervals. HRV will be recorded using a heart rate monitor and analyzed using HRV analysis software. Perceived exertion will be assessed in the participant every 2 minutes. Electromyography data from the subject's dominant shoulder and extensor carpi radialis brevis will be collected to ensure that muscular activity remains below 15% of the maximal voluntary contraction (MVC). We predict that a positive correlation will exist between HRV, perceived exertion and electromyography data and evaluate whether there is an association between HRV and perceived exertion. Furthermore, it will provide the basis for the development of a method for the quantitative measurement of physical exertion.

Keywords: Heart Rate Variability, Rating of Perceived Exertion, Electromyography

1. Introduction and background.

Nowadays, there are different methods used to assess a person's psychological perception of exertion while performing different physical activities. Borg's Rating of Perceived Exertion (RPE) has been used to assess physical effort during exercise and with workers performing manual lifting tasks (Borg, 1982; Jakobsen, Sundstrup, Persson, Andersen, & Andersen, 2014). Furthermore, there are different methods to assess physical and psychological stress using heart rate variability (HRV). However, a relationship HRV and perceived exertion has not been explored. Therefore, the main goal of this study is to explore a possible relationship between HRV and psychological perceived exertion.

1.1 Borg Rating of Perceived Exertion

Borg's Rating of Perceived Exertion (RPE) is a tool used to assess the level of intensity in physical activities. Perceived exertion as defined by Borg (1982), is an indicator of how much effort is being used to complete a physical activity. It is founded on a person's physical sensations while performing physical activity, including increases in heart rate, respiration or breathing rate, muscular fatigue and sweating. Even though the RPE is a subjective measure, it may suggest a good estimation of the current heart rate while performing physical activity (Borg, 1998).

The RPE scale has been used as a tool to measure changes in psychologically perceived and physiologically measured exertion in different physical activities. Lagally, McCaw, Young, Medema, and Thomas (2004) used the RPE scale to assess the changes in perceived exertion while performing bench press exercises in trained and untrained individuals, the results of the study suggested an increase in RPE ratings when the intensity of the exercise, measured using electromyography (EMG), increased.

1.2 Heart Rate Variability

Heart rate variability is defined as the Chronological difference between successive heartbeats measured in milliseconds, representing the vagal nerve pulse activity on the sinoatrial node. Research on HRV focuses mainly on behavioral and mood states, regulation of emotions, cognitive function, brain plasticity, and biological functions including inflammation processes and metabolic homeostasis. Changes in HRV may indicate the development of conditions and diseases including cardiovascular disease and psychiatric illnesses.

The relationship between HRV and workload has been studied and it is used by elite and recreational athletes to suggest training loads. Sartor, Valiati, Valsecchi, Vailati, and La Torre (2013), used a sample of 10 elite gymnast to evaluate HRV as a tool to prescribe training loads, the results of the study suggested that HRV can be used to monitor psychophysiological status and training loads in elite gymnasts. Similarly, Saboul, Balducci, Millet, Pialoux, and Hautier (2016) studied the possibility to use HRV for the assessment of training load and proper rest intervals, the results of the study suggested that changes in HRV during exercise and recovery are affected by the psychological impact and intensity of the exercise being performed.

2. Proposed Research and Concluding Remarks

Currently, there is not a clear association between HRV and psychological perceived exertion. This ongoing research seeks to explore the development and validation of a quantitative tool for the assessment of a possible relationship between HRV and perceived exertion, as an alternative to the Borgs RPE scale.

In order to evaluate the development of a quantitative tool for the measurement of psychologically perceived exertion, a small sample of 10 healthy college students will be used. The participants included in the study will be between 18 and 25 years old, with no previous exposure to repetitive and/or forceful manual task for at least 8 weeks before the start of the study. The participants will be asked to complete 1800 cycles of a simple manual task for five consecutive days, using only their dominant arm. The manual task will consist of lifting and lowering a 0.5 lb. ball at three different levels. The 1800 cycles will be performed at a rate of 72 beats per minute for 25 minutes. The 25 minutes of the manual task will be divided into two 8-minute stages and one 9-minute stage with two 10-minute breaks in between.

HRV will be obtained by continuously recording the participants heart rate using a Polar H10 heart rate sensor connected to the HRV logger recording software. Participants will be asked to wear the heart rate monitor in their chest while performing the manual task and during breaks. Changes in frequency and time domains will be assessed using Kubios Premium Heart Rate Variability Analysis Software.

The perceived exertion will be assessed every two minutes while the participants are performing the manual task and halfway into their breaks. Subjects will be verbally asked where they rank on the RPE scale and the corresponding numerical value will be recorded.

To ensure that participants are exerting a relatively equal physical effort, electromyography (EMG) data will be recorded during the physical activity and rest periods. The Noraxon mini DTS system will be used to monitor all EMG data of the subject's dominant arm. An evaluation of the maximal voluntary contraction (MVC) of the anterior deltoid and extensor carpi radialis brevis muscles will be performed before the start of the test. The participants' muscular contractions will remain at a threshold below the 15% of their MVC.

The correlation between HRV and RPE values for all five days will be assessed using SPSS statistical analysis software.

The protocol has been submitted for Institutional Review Board (IRB) approval before the start of the study. We predict a positive correlation between HRV and RPE values while participants are performing the manual task and during breaks. Assuming a positive correlation between HRV and RPE, the development of a quantitative tool for the measurement of psychologically perceived exertion based on HRV will be developed and validated.

3. References

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