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Effects of Dosed Physical Load on a Bicycle Ergometer on Electrocardiographic Parameters

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Abstract: ***Physical activity induces acute and chronic adaptations in cardiovascular function, which can be objectively evaluated using electrocardiography (ECG). The objective was to investigate changes in heart rate (HR) and R–R interval following primary and repeated bouts of dosed physical load using a bicycle ergometer. Four healthy male adults (22–27 years) underwent ECG recording at rest, immediately after a 10-minute cycling bout, after 5 minutes of recovery, and again following a second cycling bout after a 30-minute rest. Mean HR and R–R intervals were analysed using descriptive statistics and significance testing ($p < .05$). HR increased significantly after the first physical load and demonstrated a comparatively attenuated response during the second load, suggesting early cardiovascular adaptation. The R–R interval decreased with exercise and gradually returned toward baseline during recovery. Repeated aerobic physical load results in measurable autonomic and cardiac adaptations, reflected by moderated HR response and recovery of R–R intervals. These findings support the role of regular aerobic activity in promoting cardiovascular efficiency.***

Keywords: electrocardiography, heart rate, R–R interval, bicycle ergometer, physical activity

1. Introduction

Sedentary lifestyle patterns, unhealthy dietary habits, smoking, and alcohol consumption have contributed significantly to the rising global burden of cardiovascular diseases (Centres for Disease Control and Prevention [CDC], 1996; American Heart Association [AHA], 1994). Regular physical activity is recognised as a major protective factor that improves cardiovascular efficiency and reduces the risk of morbidity and mortality associated with cardiac disorders (Shephard, 2018; McArdle et al., 2015). Electrocardiography (ECG) is a non-invasive and reliable method used to record the electrical activity of the heart and to evaluate cardiac rhythm, rate, and conduction patterns under both resting and exercise conditions (Thygesen et al., 2016; StatPearls Publishing, 2023). ECG-derived parameters such as heart rate and R–R interval are commonly used to assess autonomic regulation of the heart during physical stress and recovery (Klabunde, 2012; Wasserman et al., 2012). Understanding the changes in ECG parameters following acute and repeated physical load provides valuable insight into cardiovascular adaptation to exercise and supports the promotion of physically active lifestyles (Saltin & Rowell, 1980; Rowell, 1986).

2. Literature Review

2.1 Cardiac Structure and Function

The heart is a muscular organ responsible for maintaining systemic and pulmonary circulation through rhythmic and coordinated contractions (Guyton & Hall, 2021). It consists of four chambers—two atria and two ventricles—separated by valves that ensure unidirectional blood flow and efficient pumping action (NCERT, 2023). The electrical activity of the heart originates from the sinoatrial node, which acts as the natural pacemaker, and is conducted through the atrioventricular node, bundle of His, and Purkinje fibres to coordinate atrial and ventricular contraction (Guyton & Hall, 2021; Robbins et al., 2021).

2.2 Cardiac Cycle and Electrical Activity

A complete cardiac cycle consists of systole and diastole and occurs approximately 70–75 times per minute in a healthy adult at rest (Guyton & Hall, 2021). During exercise, stroke volume and cardiac output increase due to enhanced venous return, myocardial contractility, and autonomic modulation (Rowell, 1986; Wasserman et al., 2012). The ECG waveform represents different phases of cardiac electrical activity, where the P wave corresponds to atrial depolarisation, the QRS complex represents ventricular depolarisation, and the T wave reflects ventricular repolarisation (Einthoven, 1924; Thygesen et al., 2016). These components provide important information regarding cardiac rhythm and conduction during physical activity (StatPearls Publishing, 2023).

2.3 Effect of Physical Activity on Heart Rate

Aerobic exercise produces an immediate increase in heart rate primarily due to withdrawal of parasympathetic tone followed by increased sympathetic stimulation (McArdle et al., 2015; Plowman & Smith, 2017). With regular training, resting heart rate decreases, and post-exercise recovery becomes faster, indicating improved cardiac efficiency and autonomic balance (Saltin & Rowell, 1980; Shephard, 2018). Repeated exposure to physical load results in cardiovascular adaptations that reduce the heart rate response during subsequent exercise bouts, thereby lowering physiological strain on the heart (Seiler & Tønnessen, 2009; Wasserman et al., 2012).

3. Experimental Study

3.1 Study Design and Participants

A laboratory-based experimental study was conducted on four healthy male volunteers aged 22–27 years. Participants were free from known cardiovascular or systemic disease and provided informed consent before participation.

3.2 Instrumentation

ECG recordings were obtained using the BIOPAC Student Lab system with standard disposable electrodes. A stationary bicycle ergometer (Domyos VM 230) was used to provide controlled aerobic physical load.

Experimental Protocol

ECG was recorded under the following conditions:

1) Resting supine position (control).
2) Immediately after 10 minutes of cycling (Load 1).
3) After 5 minutes of recovery.
4) Immediately after a second cycling bout following a 30-minute rest (Load 2).
5) After an additional 5 minutes of recovery.

Heart rate and R–R interval values were extracted and averaged across subjects.

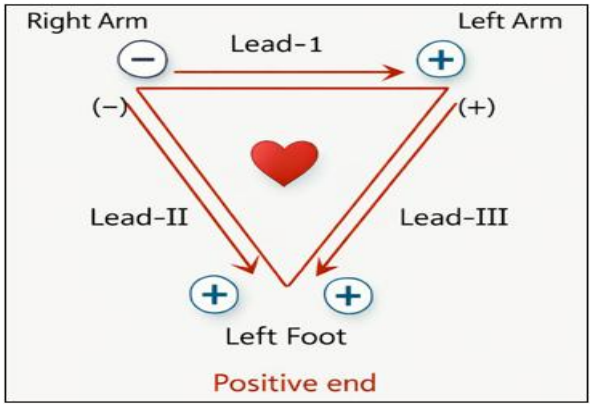

Figure 1: ECG Electrode setup used for study

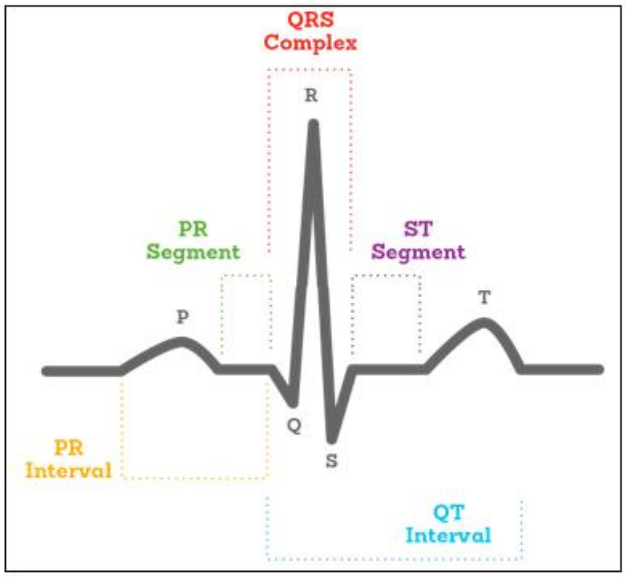

Figure 2: Changes in R–R interval (seconds) at rest, during physical load, and recovery phases.

4. Results

Heart rate increased significantly following the first bout of physical load compared to resting values, which is a normal physiological response to aerobic exercise (AHA, 1994; McArdle et al., 2015). During the second physical load, the heart rate response was comparatively attenuated, suggesting early cardiovascular adaptation to repeated exercise stimulus (Saltin & Rowell, 1980; Seiler & Tønnessen, 2009). The R–R interval showed a significant reduction during exercise and gradually increased during recovery phases, reflecting autonomic modulation of cardiac activity (StatPearls Publishing, 2023; Klabunde, 2012). Adequate rest resulted in a return of R–R interval values toward baseline levels, indicating effective cardiovascular recovery (Wasserman et al., 2012).

5. Discussion

Dosed aerobic exercise performed on a bicycle ergometer produces significant and measurable changes in ECG parameters, particularly heart rate and R–R interval (Thygesen et al., 2016). Repeated physical load results in a moderated heart rate response and improved recovery, reflecting early cardiovascular adaptation (Saltin & Rowell, 1980; Shephard, 2018). Regular aerobic exercise, therefore, plays a vital role in improving cardiac efficiency and overall cardiovascular health (CDC, 1996; AHA, 1994).

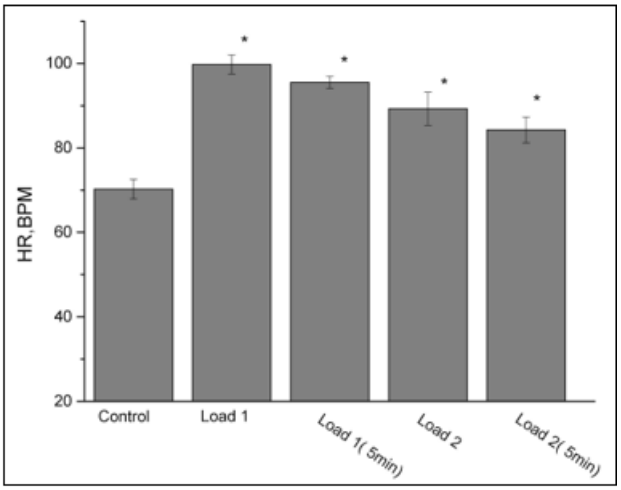

Figure 3: (bar graph illustrating HR (bpm) in rest and physical loads). The change of the heart rate after physical load, 5 min of resting, repeated physical load and the next 5 min of resting

6. Conclusion

Dosed aerobic exercise on a bicycle ergometer produces significant changes in ECG parameters. Repeated physical load results in a moderated heart rate response and improved recovery, reflecting early cardiovascular adaptation. Regular aerobic exercise may therefore contribute to improved cardiac efficiency and overall cardiovascular health.

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