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# EFFECT OF TEMPERATURE ON THE FUNCTIONAL CHARACTERISTICS OF THE CARDIOVASCULAR SYSTEM IN ROWING ATHLETES

Khujabekov Mirzaakhmad Absamatovich

**Abstract:**
This article describes the opinions of foreign scientists about cardiovascular changes in rowing athletes. Temperature dependence of changes in the cardiovascular system of rowers was analyzed.

**Keywords**: Rowing, cardiovascular system, temperature changes.

## INTRODUCTION

"Rowing is a sport for dreamers. As long as you put in the work, you can own the dream. When the work stops, the dream disappears." –Jim Dietz, professional rowing coach.

In rowing there are many physiological strains imposed upon the body that are unlike those in any other sport. Rowing is a cyclical repetitive movement like running and cycling, but it involves the whole body. Instead of step-rates or cycling revolutions that alternate limbs and count upwards of 100 per minute, the process of rowing is an all-engaging power movement that contracts and expands the entire body at a controlled rate between 18 to 40 strokes per minute, depending on the distance of the race. The process of pulling an oar through the water consists of three overlapping motions of force: the leg drive, the layback, and the arm pull. Relative to exercises done in the gym, the leg drive is most related to the leg-press. The layback is consistent with the dead lift; the arm pull is similar to a seated row. The overlaying of these exercises could be compared to a power clean, in which a maximal amount of force is generated close to the floor through the legs to accelerate the weighted bar upwards; the back extends from a slightly bent forward angle to become perpendicular to the floor, while the arms are pulling and controlling the movement of the final part of the lift. Being such a physically demanding activity, a comparison study between elite highschool-aged male rowers and a control sample of the same age group revealed many differences in anthropomorphic measurements. According to Bourgois, et al. (2000), rowers were nearly 36 pounds heavier and nearly five inches taller than the control groups.

Compared to the control group, the bone widths (humerus and femur) and limb girths (biceps, thigh, and calf), were significantly greater. Being a physically demanding sport, successful rowers must be fit and reasonably within the standard BMI (body mass index) ranges and possess a greater degree of flexibility than the average person (Richter, Hamilton, & Roemer, 2011). In turn, completing a 2000m sprint race is approximately 70% aerobic, making it also physiologically demanding. Elite male rowers tend to have maximum VO2 measures greater than 6 L/min and incur oxygen deficits of up to 20 L (Yoshiga & Higuchi, 2003). During the standard racing distance, the energy expenditure has been estimated at 36 kcal/min or 2160 kcal/hr which makes it one of the most taxing sports recorded (Hagerman, 1984).

The place to start is the heart. As with all exercise, as the body starts moving, the heart has to work harder and faster to sustain blood flow to the rest of the body to provide nutrients and deliver oxygen while removing carbon dioxide and lactic acid as well as other cellular byproducts. Different sports present unique stresses on the heart. Continuous motion sports (e.g., long distance running) and isometric (e.g., power lifting) sports present much different challenges to the heart, while some others- swimming, cycling, rowing and cross-country skiing, are a combination of both, requiring the use of anaerobic and aerobic energy systems. While these sports training regiments may have some common elements, the ultimate goal requires sports specific achievement (Fagard, 1997).

As rowing is a combination of continuous motion and isometric exercise, the stress placed on the heart is unique. The beginning of the stroke, much like a powerlift, dramatically increases the blood pressure within the body, as well as the stroke volume of the heart. The resulting effect of this repeated movement is embodied in the structure of the left ventricle. This forced output increases the size, although not the shape of the heart, especially the left ventricle (Volianitis & Secher, 2009). ―During rowing blood flow is not allowed to increase at the expense of blood pressure, and muscle blood flow is reduced by 30% compared to that seen during exercise involving a small muscle mass‖.

Unlike most sports where the movement and body fatigue are products of the heart, in rowing, the heart is at the mercy of the stroke and the constraints that come with it. With the demands rowing places on the heart, and the mentioned constraints, the cardiac response may differ from other endurance sports. One response, measured in running and cycling occurring after the lapse of approximately 20 minutes, is that heart rate tends to gradually increase while blood outflow decreases. This phenomenon is known as cardiovascular (cardiac) drift. The purpose of this study is to observe if this phenomenon exists in rowing, the degree of heart rate change and at what point onset occurs.

There are several traits that set competitive rowers apart from other athletes. Many elements of rowers’ physiology have been recorded and are regularly used in the application of rower training regimens; however, some physiological elements that impact training remain untouched. One of these elements is how a prolonged session of rowing influences heart rate (HR) and output, and if those elements will drift as observed in other sports. As cardiac drift has not been studied in rowing, several factors may influence if and when it does, such as posture (i.e., the effects of a seated position as opposed to the more erect stances of cycling and running), heart size, and training regimens. Other elements that may play a factor is overall power output compared to other sports, as well as how training is monitored. The heart pumps blood throughout the body at about 60 beats per minute (bpm) at rest and at a normal blood pressure (BP) of 120 systolic and 80 diastolic. The amount of blood pumped out of the heart at each beat is referred to as stroke volume (SV). The cumulative amount of blood pumped out of the heart per minute is referred to as cardiac output (Q).

$$Q = HR \times SV$$

Cardiovascular drift is the phenomenon in which, during steady-state exercise at moderate intensity, a gradual increase of heart rate occurs despite no overall change in workload (Goodman, McLaughlin, & Liu, 2001). As the increase in heart rate occurs, a decline in stroke volume happens simultaneously, resulting in a constant overall cardiac output.

Evidence suggests many factors may affect cardiovascular function and heart rate variability. Research indicates that increases in heart rate in runners and cyclists follow a certain pattern during exercise: acclimation, stabilization, and cardiac drift. Dehydration and core temperature are consistent factors that affect the degree of cardiac drift, as shown in Figure 2 (Coyle & Gonzalez-Alonso, 2001).

According to a study that compared heart rates of treadmill running and rowing, heart rate (HR) is higher in running than in rowing, although the power output in rowing is higher (Buckley, Innreiten, Sim, & Estion, 2000). Lower heart rates may demonstrate that during rowing, more control is needed throughout the cardiopulmonary system. Maximal oxygen uptake was significantly higher during rowing which suggests that the body position, the extenuated number of muscles used during rowing, or a combination of both, require a lower heart rate for the same exercise intensity. Despite the higher demand for oxygen circulation during rowing due to the power strain on muscles, the seated position allows for the elevated flow of blood to and from the limbs to be directed through horizontal, not vertical, transport (Yushiga & Higuchi, 2002).

Studies have shown that rowing and cycling have nearly the same oxygen requirements in step transition to moderate and heavy workload—it would seem that similar interaction of heart rate would follow (Roberts, Wilderson, & Jones, 2005). However, the cycling cadence has been shown to cause large variations in the onset of cardiac drift between pedal revolution frequencies of 40 and 80 revolutions per minute (rpm), where the higher rpm created a significant difference in the culmination of cardiac drift (Kounalakis & Geladas, 2012).

The slower, more powerful stroke rate in rowing may produce a different pattern of cardiovascular drift. During regular breathing, the displacement of atmospheric air through the lungs occurs with approximately a 3mm Hg change in air pressure during inhalation and exhalation. However, the lungs and associated muscles allow for much more forceful activity, such as coughing and sneezing. Using these muscles by forcefully closing the glottis at full inhalation can increase the pressure of the lungs and abdominal cavity up to 150mm Hg or higher (McArdle, Katch, & Katch, 2010). At the beginning of each stroke while rowing, athletes perform this action, called the Valsalva maneuver. More specifically, holding of the breath increases pressure through the central body that allows for increased pressure and force through the trunk, but requires a large increase the blood pressure, which the seated position can accommodate (Volianitis & Secher, 2009). Overall, the uniqueness of the rowing position and technique allows for a higher VO2max and a maximized work load (Yoshiga & Higuchi, 2003).

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