Cardiovascular Responses to Isometric Hand Grip vs. Relaxed Hand Grip in Sustained Cycling Efforts

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Abstract

Canivel, RG, Wyatt, FB, and Baker, JS. Cardiovascular responses to isometric hand grip vs. relaxed hand grip in sustained cycling efforts. *J Strength Cond Res* 26(11): 3101–3105, 2012—Peripheral isometric contractions may lead to enhanced performance. Previous research using hand grip protocols indicates increased stabilization and peak power outputs. Research is lacking with the grip vs. no-grip protocol during sustained efforts. The purpose of this study is to determine cardiovascular reactions (i.e., heart rate [HR], blood pressure [BP], and rate pressure product [RPP]) during sustained cycling via an isometric and relaxed hand grip. Nine ($n = 9$) recreational cyclists participated in this study. After signing a medical and physical readiness questionnaire, the subjects were randomly assigned to 1 of 2 different protocols. Preexercising values of the HR (beats per minute), BP (miilimeters of mercury), height (centimeters), weight (kilograms), and age (years) were assessed before testing. A Monark bicycle ergometer was used for testing. Grip was substantiated through the use of a hand grip dynamometer at 20 kg of tension. Protocol 1 used an isometric "Hand Grip" scenario at 150 W for 20 minutes. Protocol 2 used a "Relaxed Hand Grip" at the same power and time. During the 20-minute exercise test, HR (POLAR), BP (stethoscope and sphygmomanometer), and calculated RPP (HR × systolic BP [SPB]/100) were recorded every minute. Statistical measures included mean and *SD*s between protocols, and dependent samples *t*-tests were used to examine differences between grip and no-grip protocols. At an alpha of ≤0.05, SBP did show a significant increase when using no grip, 161.4 (5.1) mm Hg vs. grip, 154.1 (6.6) mm Hg. However, rate pressure product and heart rate showed no significant differences between protocols. Our data suggested that the use of an isometric hand grip is transient and diminishes over time.

Key Words rate pressure product, sustained power, blood pressure

Introduction

Cycling is a sport that has been regarded as a lower body dominant form of exercise that emphasizes the use of the quadriceps, hamstrings, gluteus, hip flexors, and to some degree the gastrocnemius. In recent years, there has been substantial research on the influence the upper body (i.e., Hand Grip) contributes during high-intensity cycling efforts lasting ≤30 seconds (1,2,5). There is speculation that peripheral isometric contractions may lead to enhanced power output during performance. Research has identified that the upper body via hand grip helps to stabilize the lower body during cycling efforts. This results in a better transfer of kinetic energy on the power stroke. Furthermore, increases in peak power output (PPO) and increased, posttest blood lactate concentrations were observed during grip protocols (1). Researchers also discovered that the "With Grip" protocols had a positive association between grip strength and PPO (e.g., the stronger the hand grip strength, the higher the PPO observed). In 2007, Dore et al. investigated the differences in upper body contribution during a cycle ergometry test; they used 5- and 20-second sprint intervals along differences in gender (i.e., men and women). Results showed that men showed higher power outputs because of higher grip strength as compared with women. It is important to note that in many of these experiments assessment by researchers discovered that "without grip" protocol proved to be less effective in generating PPO, but fatigue indices were lower than those who used the 'with grip" protocol (1). Current research has focused primarily on short-term power output (i.e., 10–30 seconds) during grip vs. no-grip protocols along with possible physiological stress markers.

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TABLE 1. Descriptive and mean (*SD*) values during the cycle ergometer testing.*

Age (y)	36 (13.6)
Height (cm)	157.8 (10)
Weight (kg)	80.9 (13.9)
Grip HR (b·min^{-1})	140.1 (5.9)
No-grip HR (b·min^{-1})	140.7 (4.9)
Grip WH	227.1 (17.8)
No-grip WH	225.1 (18.4)
Grip SBP (mm Hg)	154 (6.6)
No-grip SBP (mm Hg)	161.4 (5.1)

*HR = heart rate; SBP = systolic blood pressure; WH = work of the heart.

As a result, this study will examine grip vs. no-grip protocol and sustained (i.e., 20 minutes) power output. Physiological differences may exist during sustained power output between gripping vs. nongripping. Several questions may be identified in relation to the aforementioned scenario: Could there be performance increases while using an isometric grip for a sustained period of time? If there are any improvements, what are the physiological costs in relation to cardiovascular parameters (i.e., heart rate [HR], blood pressure [BP], and rate pressure product [RPP])? Therefore, the purpose of this study was to compare cardiovascular responses during sustained power output and upper body isometric hand grip vs. an upper body nonhandgrip protocol.

METHODS

Experimental Approach to the Problem

The study used a controlled-crossover design in which an isometric hand grip during a 20-minute cycle ergometer test was examined. The subjects were randomly assigned to a "Grip" day and "Relaxed Grip" day. Random selection procedures were used for test order (i.e., grip vs. no-grip). After random placement into the first test procedure, the subjects were tested a second time in the alternative procedure between 48 and 72 hours. To quantify and compare results between the 2 days, minute-by-minute cardiovascular measures were taken (e.g., HR, BP, and calculated RPP). These cardiovascular variables would indicate any elevations in the aforementioned variables, which could signify increased myocardial demand.

Subjects

A total of 9 subjects ($n = 9$) (i.e., 7 men and 2 women) volunteered to be participants in this study. All the subjects were experienced, recreational cyclists (e.g., U.S. Cycling Federation Category 3 or 4 cyclist and had been riding for 5 ± years) All were healthy and were within an age bracket of 21–55 years. All the cyclists in our study were tested during early summer in a cardiopulmonary laboratory, and all of our participants were in the midst of their cycling training. In addition, the participants were encouraged not to alter (i.e., reduce or add) to their current food or fluid intake and to abstain from training between tests. Two days before testing, each subject was required to visit the exercise laboratory. Upon arrival at the exercise laboratory, all the participants were required to sign an informed consent document approved by the Midwestern State University Human Subjects in Research Committee; a physical readiness questionnaire, and a medical questionnaire that asked for the subjects' current age, height, weight, and current health status. A familiarization process was conducted with all the subjects before testing.

Procedures

Each subject was scheduled a 2-day time frame for testing during the same week. For example, subject A was to report to the laboratory Monday was *randomly assigned* to either a grip or relaxed-grip test and then returned 2 days later for the second required test. To reduce the possibility of any circadian and diurnal effects, all the subjects reported for their testing on both days at 9 AM with the exercise protocol beginning no later than 9:20 AM. The subjects were asked to sit quietly for 5 minutes and then preexercise values were assessed. These included the following: resting HR (beats per minute), resting BP thru auscultation (millimeters of mercury) (sphygmomanometer), body fat analysis via skinfold calipers (%), height (centimeters) and weight (kilograms).

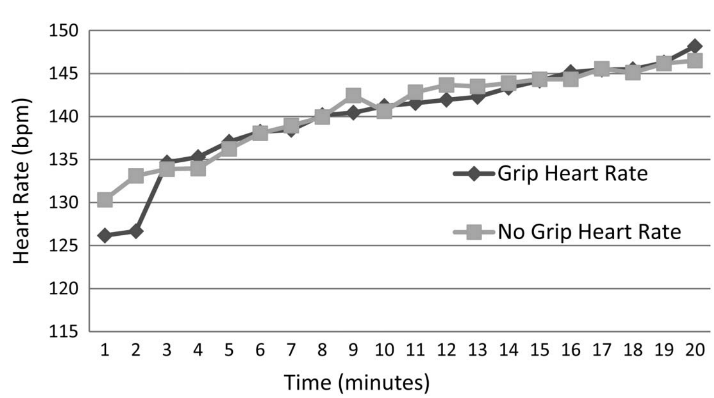

Figure 1. Comparison of heart rate responses.

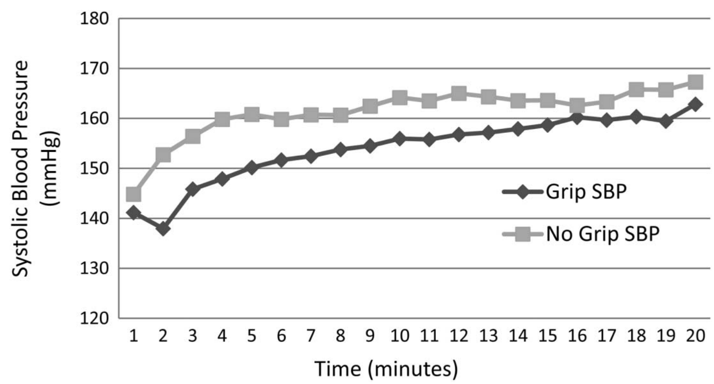

Figure 2. Comparison of systolic blood pressure responses.

Protocols

After resting measures and bike adjustments were done, the subjects were allowed 5 minutes of warm-up. A set power output of 150 W for 20 minutes was estimated to be sustainable for all the subjects to get accurate physiological readings. Exercise measures included the following: HR (beats per minute), BP (millimeters per mercury), RPP (= SBP × HR/100) and ratings of perceived exertion (RPE 6–20). The aforementioned measures were taken minute by minute. For reliability, all preexercise and exercise measures for (i.e., anthropometric and cardiovascular) were taken at the same anatomical site and the same technician was used for the duration of this study.

A Monark 850 cycle ergometer was used and calibrated for each subject. For each subject, appropriate knee flexion for power stroke was measured at 10° with the use of a goniometer. Handlebar adjustments and other bike adjustments were marked and recorded. To ensure accurate isometric-relaxed gripping, a hand grip dynamometer and modeling clay were used. Tension grip was established at 20 kg. Modeling clay was put on both right and left handlebars, and the subjects were instructed to grip firmly to make noticeable impressions (grip) and fresh clay was used on the "relaxed grip" day with subjects instructed not to make an impression during the ride. Furthermore, during the exercise protocol (grip-day), visual monitoring of the participants' forearms and hands were conducted to help ensure that the participants were not relaxing their hands. Nothing for arousal was allowed (e.g., music or verbal) to control for any type of physiological excitation.

Statistical Analyses

Descriptive statistics (mean + *SD*) were used to establish group age (years), resting HR (beats per minute), resting BP (millimeters of mercury), body fat (percent), and height (centimeters). Each subject was randomly assigned to 1 of 2 treatments for the first test. The second test day was the remaining treatment and done after a 48- to 72-hour rest period. A *t*-test for dependent samples was used to compare exercising values between treatment test protocols. In addition, a Pearson Product *r* correlation coefficient was calculated to see if the following were statistically associated: RPE, exercising BP, HR, and RPP. Statistical significance was set a priori at $p < 0.05$.

Results

Descriptive statistics including mean (*SD*) values for all 9 subjects and their ergometer results can be seen in Table 1.

Based on the statistical analysis, the only cardiovascular measure showing significance (alpha of $p \leq 0.05$) was systolic blood pressure (SBP). Interestingly, the no-grip protocol elicited a greater systolic BP than did the grip protocol. However, HR response and work of the heart (WH) were not statistically different between protocols. Cardiovascular responses to the 2 protocols can be seen in Figures 1.

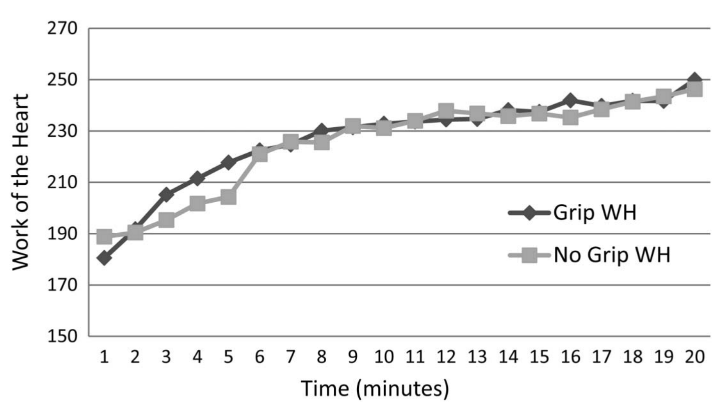

Figure 3. Comparison of work of the heart.

Discussion

Analysis of the protocols yielded interesting results and findings. On examining Figure 1 (HR), one can draw the conclusion that there were no statistical differences between grip protocols and no-grip protocols. The gradual increase in the HR over time is consistent with the findings of past work investigating cardiac drift. The WH or RPP should demonstrate if the experimental protocols elicited extra myocardial and metabolic cost to the human body. Based on Figure 3, there was no statistically significant difference in WH between protocols. The one notable difference between protocols in cardiovascular measures within this study was found with systolic BP (SBP; alpha of $p \leq 0.05$).

Figure 2 indicates that SBP was altered between protocols. Yet, it was during the no-grip protocol that SBP increased significantly more than the grip protocol (alpha $p \leq 0.05$). Reduced BP in this study differs from the findings of Lydakis et al (8). They found an increase in cardiovascular parameters (i.e., SBP) as a result of gripping. Their conclusions were neurologically based involving sympathetic activation as a result of gripping resulting in an increase in vasoconstriction, peripheral resistance and thus increased SBP. Stewart et al. (10), Costa and Biaggioni (3), and Davies and Starkie (4) all found similar results to those of Lydakis et al., in that isometric gripping increased BP. These authors note a pressor reflex associated with receptor activation (i.e., mechano- and metabo-) during gripping. Of these studies, the longest held isometric grip was 2 minutes in length, and all were done with subjects in a nonexercising state. In this study, it was hypothesized that the grip protocol might impede blood flow to the periphery, activate the aforementioned pressor reflex, and thus raise SBP more than the no-grip protocol. However, this was not the case. Yet these findings are consistent with those of McGowan et al. (9) investigating isometric hand grip in hypertensives. They found endothelial-dependent vasodilation in peripheral limbs after isometric handgripping. Speculation was that following constriction of vascular beds with the isometric grip, flow-mediated release of nitric oxide (NO) allowed for enhanced dilation, blood flow, and reduced BP. Another possibility for the reduced BP in the grip protocol stems from metabolite accumulation in the periphery leading to reactive vasodilation and thus reduced peripheral resistance (1). In a related study, Ichinose et al. (6) noted that peripheral hypotension may follow initial baroreflex-induced vasoconstriction leading to reduced flow and thus activating the muscle metaboreflex from the aforementioned metabolite accumulation. One possible reason for the discrepancy in the 2 interpretations may be that in this study, the time of the sustained grip (20 minutes) allowed for a transitory effect of gripping. Thus, it is likely that initiation of the grip elicits sympathetic vasoconstriction to the periphery. Upon closer examination of Figure 2, it is noted that within the first 3 minutes of the test the grip protocol seems to elicit a greater fluctuation in SBP. A post hoc analysis of change (D) in response between protocols did not yield statistical significance even though visual inspection indicates greater variance within the grip protocol SBP response. This study elucidates that sympathetic activation and vasoconstrictor tone may have subsided, over time, with the use of a sustained grip. Jianhua et al. (7) investigated three time variations in isometric contractions and SBP response. From their findings, Jianhua et al. concluded that within a time span of 5-, 10-, and 15-second isometric contraction, the SBP was not different. However, they did note that fluctuations were greater in the 15-second group compared with those of the 5- and 10-second contraction group. Their conclusions point to a subsiding of the cushion reflex, which plays a role in short-term BP regulation, over time. In the parameters of this study, it is believed that after initial neural activation of vasoconstriction, a reactive vasodilatation brought on by the aforementioned metabolite accumulation, afferent signaling and subsequent flow-mediated NO release would result in vasodilatation and reduced SBP in the grip protocol group.

In conclusion, this study determined that peripheral isometric contractions during sustained cycling efforts of equal power output affect some but not all cardiovascular parameters. Primarily, SBP significantly decreased with grip, whereas the HR and WH were not different. This study and its implications related to performance in sustained cycling efforts appear to be minimal. Many of the physiological findings observed were similar to the findings of Jianhua et al. (7) and McGowan et al. (9). This study, along with related research on isometric hand grip (1,2), illustrates differences in how lower body work maybe influenced by the upper body to isometric contractions based on power output and time. Future research might examine cardiovascular parameters and how intermittent gripping with equal power and time might affect physiology during road cycling.

Practical Applications

For the competitive cyclist, this study could prove to be important when riding in sprint cycling, time trials, or endurance cycling events. Cycling coaches must realize that despite much of the work being performed by the legs, the upper body plays an important role and could be considered a synergist while on the bike. Proper hand grip provides stabilization of the lower body and results in better torque on the pedal stroke. As a result, initial power is augmented in short, high-intensity bouts but becomes transient and almost diminishes during sustained efforts. After reading this study in its entirety, the cycling coach or athlete should be advised that tight handgripping during the entire course of an event would not be advantageous. However, when faced with a hard climb or sprint, handgripping has revealed to be beneficial in increasing power output.

Although this study emphasizes its finding to the road cycling population, the findings of this study could also be transposed to other athletic populations. Individuals who participate in weight or resistance training use a grip; therefore, this study could certainly have an impact on their training. The similarities between gripping a barbell and that of road bike handles are analogous. Lastly, daily activities such as carrying groceries, gardening, or shoveling all incorporate a grip and thus may benefit from the findings of this study. Performing these activities for extended periods of time all have physiological-metabolic consequence because of the use of handgripping.

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