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HEART RATE RESPONSES AND PERCEIVED EXERTION FOR BEGINNER AND RECREATIONAL SPORT CLIMBERS DURING INDOOR CLIMBING

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ABSTRACT

JEFFREY M. JANOT, JEFF P. STEFFEN, JOHN P. PORCARI, AND MARGARET A. MAHER. Heart rate responses and perceived exertion for beginner and recreational sport climbers during indoor climbing. JEPONLINE 3(1):1-7, 2000. The purpose of this investigation was to compare heart rate (HR) and ratings of perceived exertion (RPE) of beginner and recreational sport climbers during indoor climbing. Seventeen beginner (10 M and 7 F) and 17 recreational (10 M and 7 F) sport climbers climbed two routes that varied in difficulty (route 1 = 5.6, route 2 = 5.8 on the Yosemite Decimal Scale). HR responses were recorded at pre-climb, during climbing, and during recovery using a Polar XL HR monitor. RPE values were recorded after each climb using the Borg 15-point RPE scale. Significant differences ($p < .05$) in pre-climb HR, climbing HR, and RPE were found between beginner and recreational climbers, but not for recovery HR ($p > .05$). In addition, pre-climb HR responses were significantly higher ($p < .05$) than recovery HR in beginner climbers only. As expected, HR responses during climbing were significantly greater ($p < .05$) for route 2 compared to route 1 due to the increased difficulty of route 2. These results indicate that HR and RPE responses differ between beginner and recreational climbers during most conditions. The differences between the beginner and recreational climbers could be attributed to route familiarity, varied efficiency in climbing technique, a pressor response, or anxiety. These data show how climbers with varied skill levels respond during climbing and provide climbing instructors with information that may assist in designing climbing programs based on the individual skill of the climber.

Key Words: sport climbing, anxiety, psychological stress, climbing technique

INTRODUCTION

The popularity of indoor sport climbing as a recreational activity or competitive event has increased in recent years.[1-3] Maitland[4] attributed this gain in popularity to advancements in equipment safety and to the advent of indoor climbing facilities.[2-5] These facilities include treadwalls, laddermills, and artificial climbing walls. During the last decade, indoor climbing walls, in particular, have greatly increased in popularity.

Another factor that has contributed to the growth of sport climbing is its use as a form of exercise training.[4-7] Climbing has been described as a vigorous activity that demands muscular power and strength, flexibility, and aerobic endurance.[2] Mermier *et al*[8] reported that indoor sport climbing is adequate for increasing cardiorespiratory fitness and muscular endurance. In addition, sport climbing also compares favorably with other activities such as walking, cycling, playing tennis, and swimming in terms of similar rates of energy expenditure.[9] However, Williams *et al*[10] concluded that climbing produces a specialized type of fitness that enables improvement in climbing performance, but not necessarily overall fitness. Other researchers have theorized that climbing ability is dependent upon

experience and technique, which de-emphasizes the need for other physiological abilities.[11]
The amount of scientific research that addresses the physiological demands of sport climbing is relatively small.[8 12] To date, only a few studies have compared the physiological characteristics of climbers with differing climbing ability.[12] Thus, it is evident that more research is needed to further clarify the physiological demands of sport climbing. Therefore, the purpose of this study was to compare the heart rate (HR) responses and ratings of perceived exertion (RPE) of beginner and recreational sport climbers who climbed two selected routes on an artificial climbing wall.

METHODS

Subjects

Twenty male (M) and 14 female (F) volunteers were recruited from both an indoor sport climbing class and the general student body at the university. This study was approved by the University's Human Subjects Review Board. Prior to participating in the study, all subjects provided written informed consent. Given that previous research has revealed no significant differences between the physiological responses of male and female climbers, subjects were grouped by overall climbing experience only.[8] The recreational climbers (10 M and 7 F) were enrolled in a climbing class 7 wk prior to testing. These climbers also had previous climbing experience outside of class and were already familiar with the climbing routes used in this study. The beginner climbers (10 M and 7 F) had no prior climbing experience.

Pre-Climb Instructions

Prior to arriving for the climbing trials, the subjects were instructed not to eat, drink (except water), or smoke for at least 3 hr before the testing session. The subjects were also asked to refrain from physical activity 12 hr prior to climbing.

On the day of the testing session, each subject's height, body mass, age, and self-reported amount of weekly recreational activity (moderate- to high-intensity) were assessed. Shortly thereafter, subjects were given instruction on climbing safety precautions and the use of the Borg 15-point RPE scale.[13] Any questions that the subjects had were answered at that time. The subjects were also instructed not to remain stationary for more than 5 sec during each climb in order to make the climb as uniform as possible. The researchers closely monitored this during each climb. Other than the stationary time restriction, each subject was allowed to climb at a self-selected pace.

Prior to each climbing trial, the subjects were instructed to tie the designated climbing rope to their safety harness. After this was completed, each subject was allowed to rest and study the climbing route for 1 min. This time was designated as the pre-climb period.

Climbing Routes

An indoor climbing wall was used for the climbing trials. The climbing wall contained routes set upon portions of the wall that were strictly vertical or contained an overhang obstacle. The routes also contained various types and sizes of hand and footholds that added to the overall difficulty of the routes. The height of the wall was measured at 10.2 m (33.5 ft). Each subject climbed the routes in the same order with route 1 being the first route climbed. A 20-min rest period separated the two climbing trials. In accordance with the Yosemite Decimal System (YDS)[14] of rating, each route on the climbing wall was rated by grade of difficulty. Route 1 was given a difficulty rating of 5.6, and route 2 was given a difficulty rating of 5.9. These routes were considered as being achievable by beginner climbers.

Physiological Measures

HR was measured during three conditions: immediately prior to each climb (pre-climb), at the moment each climb was completed or at the moment of failure (climbing), and following a 10-min rest period after the climb (recovery). A Polar Advantage XL HR monitor (Polar Electro Inc., Finland) was used to assess HR. The monitor, consisting of a belt with electrodes, was placed on the subject's chest. This belt transmitted the HR to a watch placed on the subject's wrist. The HR was read from the watch and recorded. RPE was assessed using the Borg 15-point RPE scale[13] immediately after the subject completed each climb.

Statistical Analysis

Standard descriptive statistics were used to evaluate the characteristics of the two climbing groups. The independent variables in this study were group (beginner vs. recreational), route (route 1 vs. route 2), and condition (pre-climb, climbing, and

recovery). The HR responses recorded during the three conditions for both routes and groups were analyzed using a three-way mixed ANOVA. RPE values during climbing for both routes and groups were analyzed using a two-way mixed ANOVA. Tukey's HSD post hoc tests were used to determine differences among conditions, routes, and groups for HR, and routes and groups for RPE values. Alpha level was set at .05 to test statistical significance.

RESULTS

Table 1 presents the physical characteristics of the subjects. The mean HR and RPE responses for the beginner and recreational climbers are presented in Figures 1-3. There was no significant interaction of route x condition x group ($F(2,64) = .17$, $p > .05$) for HR. However, there was a significant interaction of group x condition ($F(1,32) = 7.71$, $p < .05$) for HR. Tukey's HSD comparisons indicated that HR values observed during pre-climb and climbing were significantly greater in the beginner climbers. On average, pre-climb and climbing HR were, respectively, 15.5% and 12.4% higher in beginner climbers compared to recreational climbers. Tukey's HSD comparisons also indicated that HR values were significantly greater during the pre-climb period compared to recovery in beginner climbers. In contrast, no significant differences in HR were observed between these conditions in recreational climbers. In addition, no significant differences were found in HR during recovery between climbing groups.

A significant interaction of route x condition ($F(2,64) = 21.99$, $p < .05$) for HR was also observed. Climbing HR responses were significantly higher during route 2, as was expected due to the increased difficulty of the route. There was no significant interaction of route x group ($F(1,16) = 1.06$, $p > .05$) for RPE. However, the main effects for route ($F(1,16) = 270.34$, $p < .05$) and group ($F(1,16) = 18.96$, $p < .05$) were significant. Overall, RPE values were significantly greater for route 2 compared to route 1, which was also expected. In addition, RPE values were significantly lower in the recreational climbers compared to beginner climbers for both routes.

Table 1. Physical characteristics of beginner (n = 17) and recreational (n = 17) climbers.

	Age (yr)	*Height (cm)*	*Body Mass (kg)*	*Rec activity (hr/wk)*
Beginner	21.2 (0.9)	176.0 (12.0)	76.0 (9.8)	3.1 (0.8)
Recreational	21.5 (1.2)	172.4 (10.3)	74.0 (7.2)	3.7 (0.6)

Data are Mean±SD

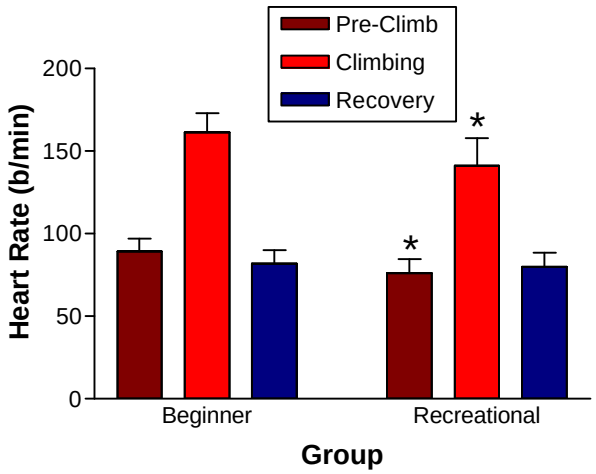


Figure 1. Mean±SD data for heart rate responses during route 1. * indicates statistical significance ($p<0.05$) from the same condition for the beginner group.

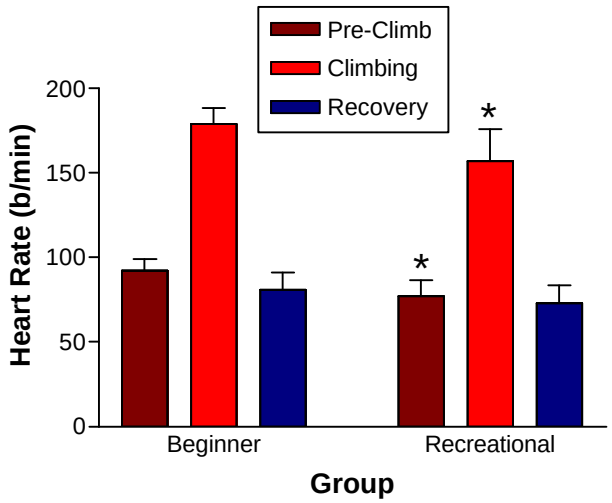
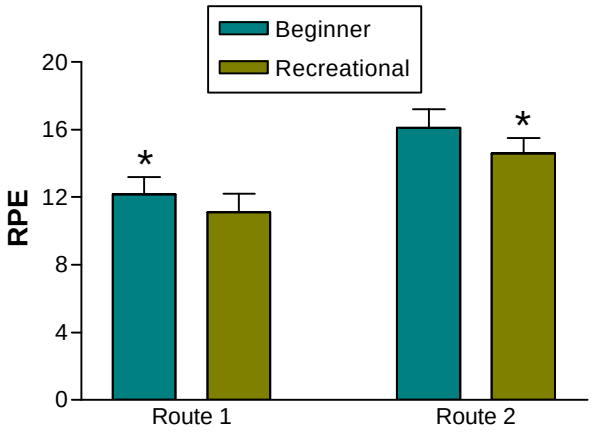


Figure 2. Mean±SD data for heart rate responses during route 2. * indicates statistical significance ($p<0.05$) from the same condition for the beginner group.

DISCUSSION

This study compared the HR responses and RPE of beginner and recreational climbers. HR and RPE were found to be significantly different between

Figure 3. Mean±SD data for RPE during both climbing trials (routes). * indicates statistical significance ($p<0.05$) between



groups beginner and recreational climbers in most conditions.

Pre-climb and Recovery HR

In the present study, pre-climb HR values were significantly lower in recreational climbers compared to beginner climbers. In contrast, other researchers have reported higher pre-climb HR values in expert climbers compared to the beginners.[9] Hardy and Martindale[9] attributed the elevated pre-climb HR to increased psychological arousal that expert climbers experience to prepare themselves for the climbing task. The beginner climbers in our study expressed some anxiety when questioned prior to beginning the climbing trials; whereas, the recreational climbers did not. This may have influenced pre-climb HR enough to produce greater HR responses in beginners compared to recreational climbers.

There were no previous studies comparing pre-climb and recovery HR values of different climbing groups. In the present study, a comparison was made between pre-climb and recovery HR within climbing groups to explore the possible influence of anxiety on HR. Significant differences were found between pre-climb and recovery HR in the beginner climbers for both routes. However, HR during recovery was not significantly different between beginner and recreational climbers. In general, recovery HR more accurately reflected the true "resting" HR value because it was measured after a 10-min rest period. Also, the climbers were not expected to climb immediately after the recovery HR was taken; whereas, the pre-climb HR was measured 1 min before the climbers began the climbing trials. These findings suggest that the HRs of beginner and recreational climbers are similar during recovery, but differed when they are faced with the task of climbing.

Climbing HR

Climbing imposes a physiological stress on the climber. In the present study, climbing HR values for both routes were higher in the beginner climbers. The climbing HR values of the beginner and recreational group ranged from 76-90% and 71-79% of the subjects' age-predicted maximum HR, respectively. These values are in close agreement with values (74-85% max HR) reported by Mermier *et al*[8] for experienced climbers. However, the subjects in the Mermier *et al*[8] study climbed two routes that were more difficult (5.9 and 5.11+ YDS) than the routes in the present study. Factors that may may explain, in part, why climbing HRs of the beginners were significantly higher than those of the more experienced, recreational climbers between the climbing groups are route familiarity, overall climbing technique, a pressor response, and psychological stress.

Hardy and Martindale[9] found that experienced climbers have a lower energy expenditure and climb much farther on a more difficult route than do beginner climbers. These findings suggested that skill and technique play an important role in determining the energy cost of climbing, which in turn could influence the heart rate response. Good climbing technique requires the use of the legs as the main means of progress when climbing.[11] In the present study, we observed that the beginner climbers tended to rely on their arms for movement, as opposed to their legs. Greater use of the arms compared to the legs is less efficient because the smaller muscles in the arms fatigue much faster than the larger muscles of the legs, resulting in decreased climbing performance and increased physiological stress.

In a study by Westcott,[15] a group of beginning climbers demonstrated greater climbing efficiency during a climbing test at the end of a 7-wk climbing program than they had 4 wk prior. Westcott[15] showed that good climbing technique and route familiarity can also affect HR responses (lower for a given difficulty) during climbing. The recreational

climbers in the present study climbed in a class 7 wk prior to the study and had previous experience climbing; whereas, the beginners did not. The experience of the recreational climbers may have aided them in choosing the best way to complete each route.

The observed differences in climbing HR between groups, as well as routes, could also be attributed to the occurrence of a pressor response. Mermier *et al*[8] found that HR, lactate, and oxygen consumption (VO_2) significantly increased in experienced climbers who climbed three, progressively difficult routes in succession. The increases in HR and lactate were attributed to the occurrence of increased isometric muscular contractions in the upper limbs. Interestingly, these researchers noted a disproportionate increase in HR relative to VO_2. This non-linear relationship was considered to be a strong indicator of isometric work during climbing.

Increasing route difficulty places a greater reliance on the arms to overcome obstacles. All subjects completed route 1 in its entirety, whereas all but two subjects from the recreational group completed route 2. However, all subjects reached the required mid-point of route 2. This observation clearly shows the difficulty that the beginner climbers had with route 2. An increase in HR is needed to facilitate greater perfusion through the arms as they are held in an overhead position.[8 16] However, simulated climbing has been shown to produce physiological responses (increased VO_2 and HR) similar to treadmill running and cycling,[17] which are activities that do not produce a pressor response.

In the present study, the subjects were instructed not to stop for more than 5 sec in order to produce a continuous, uniform movement throughout the climb. This was also done to minimize the duration of isometric muscular contractions in the climbers. This climbing protocol may have been effective in limiting the influence of a pressor response on HR during climbing. Periods of isometric muscular contractions can amount to be one-third of the total climbing time if not controlled by researchers.[18]

Williams *et al*[10] hypothesized that increased HR during climbing may be due more to anxiety-type psychological influences than physical exertion. The climbers in their study were required to climb a route after taking a beta-blocker (oxprenolol), and then again after taking a placebo tablet. As expected, the average climbing HR was significantly higher during the placebo trial than during the oxprenolol trial. An analysis of plasma catecholamine concentrations revealed no significant increases in norepinephrine levels during either trial. Williams *et al*[10] also stated that the climbers in their study expressed considerable anxiety during the climb while experiencing low physical exertion. Since norepinephrine levels are positively associated with increases in exercise intensity, it was suggested that the increased HR values are likely due to an anxiety-mediated withdrawal of vagal tone.

Also, Billat *et al*[18] addressed the possible influence of anxiety on HR responses to climbing. The objective was to minimize the influence of anxiety by familiarizing the subjects with the routes and also with the task of climbing itself by having climbers train for 5 hr on both routes, 1 wk before the climbing trials. The HR responses in this study were attributed to the physical aspects of climbing and not anxiety. Thus, techniques or tasks become less difficult and more familiar with learning. This allows the climber to concentrate more on the activity to be done and less on outside stimuli such as fear or anxiety.

RPE Responses to Climbing

In the present study, RPE values were significantly lower in recreational climbers compared to beginner climbers. The mean RPE values varied from 11.5 to 12.4 for route 1 and 14.4 to 15.1 for route 2 in the recreational and beginner climbing groups, respectively. RPE values also significantly increased during route 2 for both groups, substantiating the increased difficulty of route 2.

When RPE values were obtained in the current study, the beginner climbers reported increasing discomfort in the fingers and forearms which made climbing more difficult. Likewise, Pandolf *et al*[19] suggested that sensations of muscular discomfort and awkwardness may have caused elevated RPE values in subjects who used different laddermill climbing techniques. Therefore, it is likely that finger and forearm discomfort contributed to the

differences observed in RPE values between the climbing groups.

CONCLUSIONS

In conclusion, it was determined that pre-climb HR, climbing HR, and RPE differed between beginner and recreational climbers. These differences between climbing groups could be due to varied efficiency in climbing technique, a pressor response, anxiety, or route familiarity. These factors need to be explored in greater depth to determine their relative influence on HR and RPE during climbing by including measurements of VO_2 and administering anxiety scales.

The findings of this study may be beneficial to rock climbing instructors. It provides instructors with insights and information about how climbers with varied skill levels respond during climbing. This information can aid in designing a climbing program to fit the individual needs of climbers based on their overall skill and fitness level.

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