The Effects of a Brief Meditative Breathing Session on Recovery from Moderate Aerobic Exercise

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Abstract

Meditative practices have been shown to have many beneficial effects such as performance boosts, relaxation, and reductions in anxiety. Studies among athletes have shown a correlation between enhanced physical ability and meditative practice. While previous studies have examined effects of long-term meditative improvements, we examined how a single meditative breathing session affected recovery rates. Our study investigated if a positive correlation exists between acute meditative breathing prior to exercise and recovery time. Our study examined three physiological variables: heart rate, respiratory rate, and grip strength. Heart rate and respiratory rate recovery were measured over time, while grip strength was compared to original baselines for a percent change for control and experimental groups. The effects of meditation on recovery time were not statistically significant and therefore did not support our hypothesis. A single acute meditative breathing session prior to exercise did not have any effect on recovery rate after exercise. Different modifications in future studies may show a significant difference between these variables and more fully explain the effects of mediation on aerobic recovery time.

Introduction

A recent trend has emerged among professional athletes of focusing and calming one’s mind through meditation in order to boost performance (Neporent, 2016). Meditation is not only an enterprise for the mind, often benefitting those who participate through reductions in anxiety, but one for the body, as well (Kabat-Zinn *et al.*, 1992). Research in progressive muscle relaxation as a form of meditation demonstrates that participants who completed relaxation training and a total of 30 minutes of progressive muscle relaxation recovered more quickly from sympathetic arousal as measured by somatic anxiety after visual stressors compared to those who did not receive the treatment (Rausch *et al.*, 2006). Meditative practice also improved cardiovascular health, as evidenced by significant decreases in heart rate, skin conductance, and respiratory rate of participants who completed five days of mindfulness-based meditation training compared to their non-meditating counterparts (Tang *et al.*, 2009).

Focused breathing is a consistent part of many forms of meditation. Diaphragmatic breathing, for example, is a form of controlled and attentive breathing in which the individual inhales by contraction of their diaphragm alone, excluding the intercostal muscles. This type of breathing causes an expansion of the abdomen, as opposed to the expansion of the chest cavity, as the lungs fill. Research has revealed the physiological benefits of diaphragmatic breathing. In a study exploring the relationship between diaphragmatic breathing and oxidative stress levels, athletes were asked to complete either one hour of focused diaphragmatic breathing or one hour of simple relaxation following exhaustive exercise. Those who practiced diaphragmatic breathing showed significantly greater reductions in oxidative stress compared to control participants both a few hours after exercise and 24 hours post-exercise (Martarelli *et al*., 2011). Additionally, in a study of collegiate athletes, researchers found practicing diaphragmatic breathing for seven 35-40 minute sessions over a period of three weeks significantly decreased absences due to injury and illness and resulted in fewer clinical visits compared to those who did not receive this intervention (Perna *et al.*, 2003).

While the beneficial effects of meditation and diaphragmatic breathing seem compelling, there is little research assessing the effects of brief, acute breathing regimens on the body. Additionally, it is not known whether following this regimen prior to moderate aerobic exercise, a known cardiovascular and respiratory stressor, will affect recovery rates and maximum power output. With the increasing demands of exercise comes an increased need for oxygen delivery to muscle tissues. In turn, heart rate and respiratory rate increase in order to meet the increasing needs of the body. Both heart rate and respiratory rate fluctuate in order to maintain homeostasis during exercise and recovery from exercise. Previous studies have demonstrated exponential decay of heart rate during recovery and a positive correlation between heart rate recovery after exercise and mortality, suggesting that recovery of heart rate following exercise is an indicator of overall cardiovascular health (Cole *et al.*, 1999). Cardiovascular health is closely tied to respiratory function, and respiratory rate has also been demonstrated to decrease exponentially post-exercise (Davies *et al.*, 1972). As research has shown beneficial effects of meditative practices, such as diaphragmatic breathing, on cardiovascular function and respiratory rate, the current study used recovery of heart rate and respiratory rate as indicators of the effects of diaphragmatic breathing post-exercise (Tang *et al.*, 2009). Additionally, previous research has shown that maximum grip strength is highly correlated with overall muscle strength (Wind *et al.*, 2009). The effects of diaphragmatic breathing on grip strength have not been previously explored.

This study asks whether having participants meditate through diaphragmatic breathing for a brief single session prior to acute aerobic exercise on a stationary bike will affect post workout recovery rates. The physiological indices used to test participant recovery include heart rate and respiratory rate. Maximum grip strength was also measured before and after exercise to determine the effects of meditation on muscular power output. A control group of individuals completed the same acute workout regimen without prior meditative breathing before the same physiological variables were measured. Based on previous studies showing the ability of longer-term meditative breathing to lower both heart rate and respiration rate, in addition to decreasing overall sympathetic drive, we hypothesized that acute diaphragmatic breathing prior to exercise would result in a more rapid return towards baseline physiological levels of both heart rate and respiration and reduce the loss of muscular power output as measured by maximum grip strength post exercise when compared to non-meditating controls (Jevning *et al.*, 1992).

Methods and Materials

Participants for this study were volunteers from the Physiology 435 section during the Spring 2016 term at the University of Wisconsin-Madison. Each student was given a consent form to read and sign before beginning the experiment. Volunteers were surveyed to determine general characteristics of age, height, and weight, as well as their general level of physical activity. In addition, we asked that they report any long-term meditation practices that may confound our results. An outline of the protocol for this experiment can be found below in Figure 1.

Participants (n=26) were randomly assigned to either the experimental or control group on the day each participant completed the experiment. The control group did not participate in any meditative breathing prior to the exercise regime whereas the experimental group did. Volunteers who participated in meditative breathing were directed to the mediation room directly after signing a consent form. The participants were guided by the experimenter to practice focused and relaxed meditative breathing for five minutes with the lights off and door closed. The volunteers were asked to lie on their backs in a relaxed position with one hand over the heart and one hand on the abdomen just below the rib cage. Participants were then asked to inhale through the nose for three seconds and exhale through the mouth for five seconds. This breathing occurred by using the diaphragm only and not the intercostals, so that the abdomen rose and the chest did not. The experimenter stayed in the room for the full five minutes and opened the door at the end of this period to signal an end to the meditation. After the treatment, the subject was directed to begin the exercise protocol. Control group participants were directed straight to the exercise regime of the experiment without any prior wait time.

Experimental subjects were asked to sit on a Cycle Trainer 390 R Exercise Bike (Gold's Gym®. Irving, TX. Model# GGEX61712). Participants' baseline heart rate was measured using a digital pulse oximeter (Nonin Medical Inc. Plymouth, MN. Model#9843) and baseline respiratory rate through the use of a BSL Respiratory Effort Xdcr (BioPac Systems, Inc. Goleta, CA. Model#SS5LB). The pulse oximeter was placed on the non-dominant hand's index finger and the respiratory belt was placed around the upper chest above the nipples. The respiratory belt was then calibrated. After the participant rested for 30 seconds, a baseline reading was recorded and the participants were asked to squeeze the hand dynamometer (BioPac Systems, Inc. Goleta, CA. Model#SS25LA) for 5 seconds as hard as they could with their dominant hand to measure maximum grip strength.

Participants were then asked to ride the stationary bike until they reached a heart rate of 130-140 beats per minute or approximately 60-70% of their maximum heart rate as determined by age. Each subject was able to see the pulse oximeter during this time so they were aware when they reached the appropriate heart rate range. After reaching 130-140 beats per minute, the participant was asked to maintain a heart rate in this range for two minutes. During the exercise regime, the heart rate of the participant was recorded every 30 seconds and respiration rate was measured continuously.

After two minutes of exercise with a heart rate of 130-140 beats per minute, the participant ceased exercising, the participant was asked to perform another grip strength measurement with the hand dynamometer for five seconds. The participant rested while sitting on the bike for five minutes. The pulse oximeter was removed from the view of the participant and continued to measure respiration rate and heart rate as indicated above. After five minutes of rest, the subject was asked to squeeze the hand dynamometer a final time for a maximum grip strength reading. The control group participants followed the same protocol as the experimental group, but did not complete the meditative breathing activity prior to exercise.

Analysis

All data was analyzed using Microsoft Excel. T-tests were used to compare the physiological measurements of recovery between the experimental and control groups in order to determine if the treatment of an acute, brief meditative breathing exercise resulted in a significant difference between heart rate, respiration rate, and maximum grip strength following physical exertion. A curve of best fit was calculated graphically for the heart rate and respiration rate data of each participant. The decay time constant was then calculated using these curves of best fit. From here, the means of the decay time constants could be calculated and analyzed statistically using a t-test. The grip strength values taken from each participant, both immediately and after a five-minute recovery session, were assed by calculating the percent deviations from their baseline value taken immediately before exercise. These means of the individual deviations were then calculated and analyzed statistically using a t-test.

Results

Subject Characteristics

Analysis of gender, BMI, previous meditation experience, average hours of exercise per week, and average intensity of weekly exercise (collected via survey) across the meditative breathing (N=13) and control (N=13) groups did not suggest the presence of confounding variables that could have obscured a significant difference of recovery after exercise due to meditative breathing.

Recovery of Heart Rate

For heart rate recovery, experimental participants who meditated prior to exercise on a stationary bike had a mean decay time constant of 40.23 +/- 4.11 seconds. Control participants who did not meditate prior to exercise on a stationary bike had a mean decay time constant of 37.33 +/- 5.48 seconds. After statistical analysis, no significant difference in heart rate recovery toward baseline was observed between meditation and control groups (p=0.1283) (Figure 2).

Recovery of Respiration Rate

Both experimental and control participant groups had a mean decay time constant of 28.00 seconds for respiration rate, with standard deviations of 8.92 seconds and 7.00 seconds respectively. There was no statistical difference in respiration rate recovery toward baseline observed between meditation and control groups (p=1.00) (Figure 3).

Deviation of Muscular Power Output from Baseline

Participant muscular power output, as measured by the percent deviation of maximum grip strength from baseline measurements was calculated both immediately and five minutes after exercise had ceased. Immediately post-exercise, experimental group participants had a mean grip strength deviation of 5.25 +/- 14.15 % from baseline. At this time point, the control group participants had a mean grip strength deviation of 10.55 +/- 31.10 % from baseline. Five minutes post exercise, experimental group participants had a mean grip strength deviation of 1.07 +/- 15.65 % from baseline. For the control group participants five minutes post-exercise, there was a mean deviation of -4.02 +/- 18.21 % from baseline. No significant difference was observed between meditation and control groups in percent deviation of maximum grip strength from baseline either immediately (p=0.5833) or five minutes after exercise had ceased (p=0.5428) (Figure 4).

Discussion

In this experiment, we examined the effects of an acute session of meditation using diaphragmatic breathing on the physiological variables of heart rate and respiration rate, along with power output as measured by maximum grip strength during recovery following a brief period of moderate aerobic exercise. We hypothesized that participants who meditated would recover more quickly post-exercise, with both heart and respiration rates decreasing faster than those of corresponding participants in the control group. We also hypothesized that the reduction in maximum grip strength following physical activity would be less in the experimental (meditative breathing) group, compared to control participants. Our hypothesis was not supported, as none of our results showed any significant difference in the variables measured between experimental and control groups.

Much of our hypothesized results were based on the assumption that a short session of meditative diaphragmatic breathing immediately prior to exercise would be sufficient for an observable effect on exercise recovery. Interestingly, our study showed no effect from the experimental conditions on exercise recovery whatsoever. Indeed, many previous studies involving meditation have focused on longer-term practices, with regular sessions of meditation coupled to physiological changes. One study had participants complete a rigorous training regimen in a meditative technique, and then practice said technique twice daily for a period of three months before collecting physiological data (Nidich *et al.*, 2009). Our experiment, however, only evaluated the effects of a single acute session of meditative breathing. It is possible that meditation has no effect on recovery rates whatsoever, and any effects seen psychologically may not have physiological counterparts. However, it is more likely that meditation has a cumulative effect, and some time is needed for measurable physiological changes to become apparent. A previous study has shown a correlation between meditation experience and thickness in certain areas of the cerebral cortex, suggesting that physiological changes brought about by meditation may compound over time (Lazar *et al.*, 2005).

Other factors could have influenced the results of this study as well. For one, each individual was asked to exercise until heart rate reached a goal of 130-140 beats per minute. This was used to approximate maximum exertion, as we did not have the resources to establish a more accurate maximum for each individual’s health profile. Thus, data could have been affected by each participant’s own fitness level. However, after analyzing data taken on participant health characteristics, no significant correlation was observed between any of the measured variables when comparing the experimental and control groups.

Given the large amounts of variation in grip strength measurements both within and between participants, we are skeptical about the conclusions we can draw from this data. Even though we are not confident in this data, it did not change our overall belief in the implications of this study. Some of the variation noted could possibly be attributed to participant compliance in using their maximum grip strength when tested.

In addition, it was difficult to assess compliance with meditative breathing procedures. Participants were given detailed instructions for the diaphragmatic breathing session, but it was not possible to determine how focused they were on the meditation, and some may well have conducted the exercise differently than others or been distracted by personal matters. Finally, our sample size was relatively small, with only 13 participants each in the control and experimental conditions. While the data was insignificant for these 26 individuals, it is difficult to generalize the results of diaphragmatic breathing on exercise recovery to the population as a whole. All of our participants were college-age students at the University of Wisconsin, and results may have been different given a more representative and larger study group.

Although this experiment showed no significant effect of short term meditation on exercise recovery, there is much room for future study in this area. Meditation for longer periods of time and on a regular basis could be evaluated for its effects on recovery from exercise. In addition, techniques other than diaphragmatic breathing, perhaps Transcendental or Insight Meditation, could be compared for their effectiveness. This data would be useful for athletics programs in creating an optimized meditation plan that would most benefit performance and physiological recovery, as well as for individuals seeking to improve personal exercise regimens.

Future studies could also examine broader effects of short term meditative breathing on different aspects of physical health and wellbeing. Especially if physiological changes are occurring in the brain, tests of cognitive function with and without meditative breathing could inform and enhance study practices in academic settings. Even if recovery from exercise is not affected, it is certainly possible that other relevant physiological changes are occurring that could influence performance in other areas.

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Figures and Legends

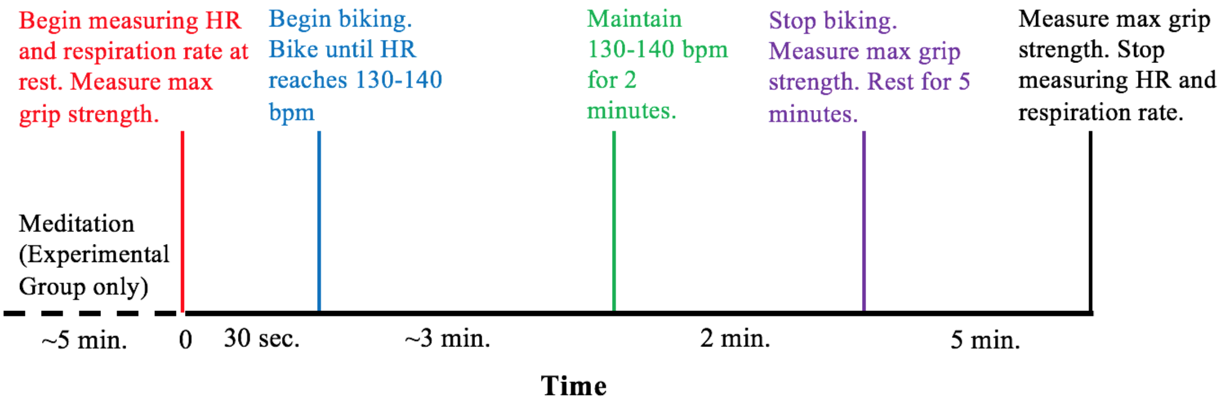

Figure 1: Experimental timeline for each participant.

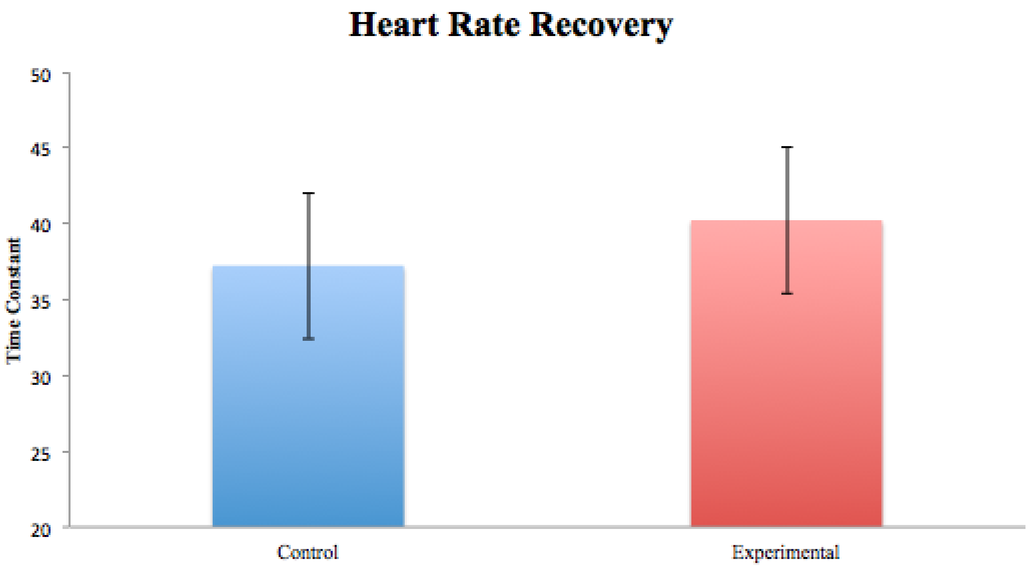

Figure 2: The mean recovery of participant heart rate toward baseline for both meditation (N=13) and control groups (N=13), as measured by time constant of exponential decay. Mean recovery for the meditation participants (M = 40.23 seconds, SD = 4.11 seconds) did not significantly differ from that of control participants (M = 37.33 seconds, SD = 5.48 seconds) (p=0.1283). Error bars represent +/- 1 SD.

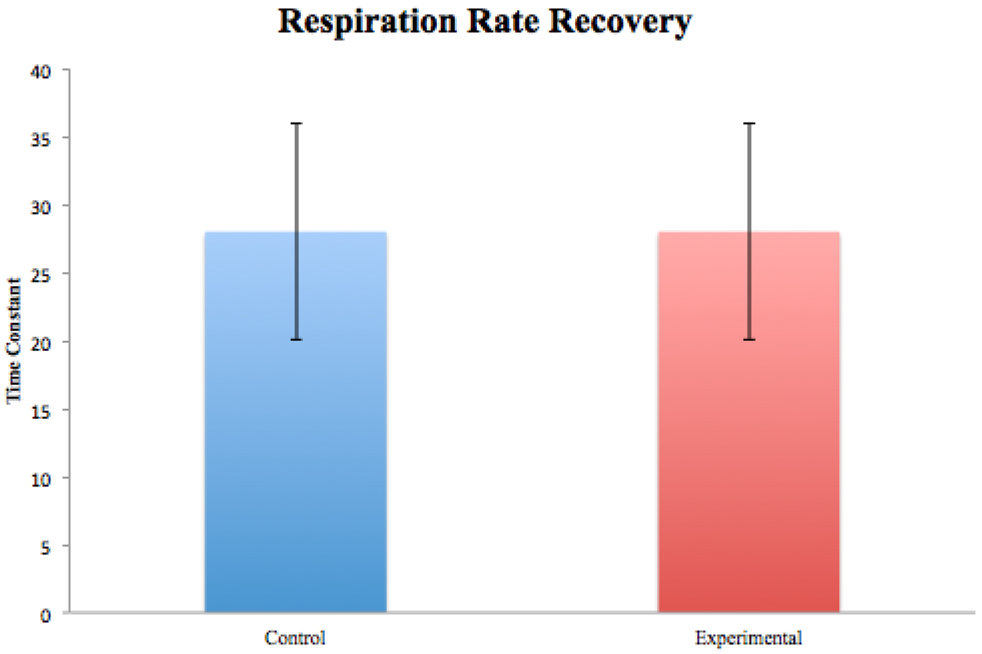

Figure 3: The mean recovery of participant respiration rate toward baseline for both meditation (N=13) and control groups (N=13), as measured by time constant of exponential decay. No significant difference was found between the mean recovery of respiration rate after exercise of the experimental group (M = 28.00 seconds, SD = 8.92 seconds) and control group (M = 28.00 seconds, SD = 7.00 seconds) (p=1.0). Error bars represent +/- 1 SD.

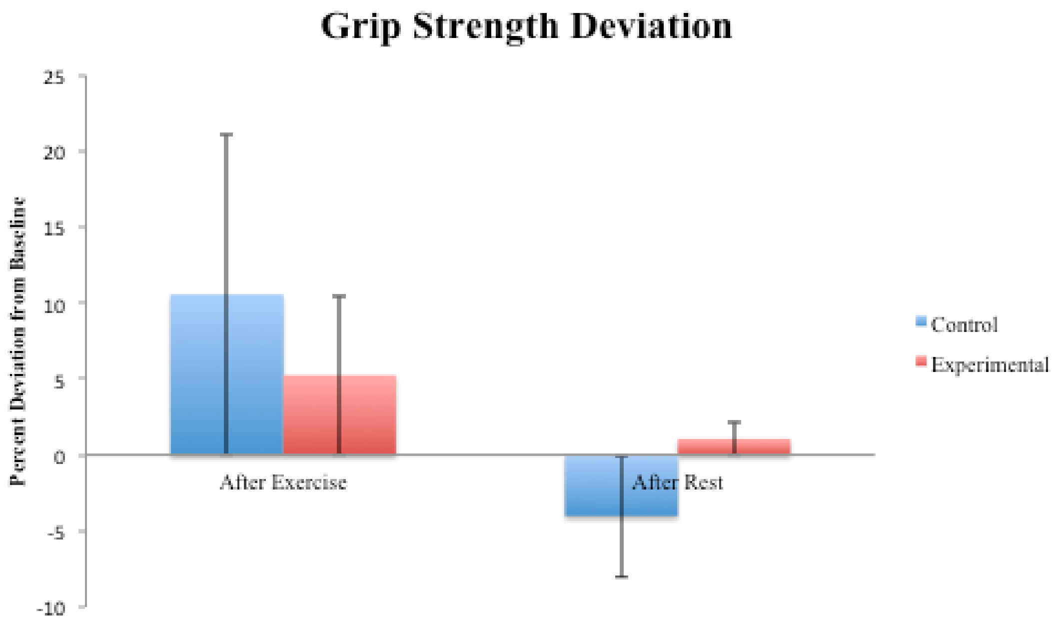

Figure 4: The muscular power output post-exercise as measured by the percent deviation of maximum grip strength from baseline measurements both immediately and five minutes after exercise had ceased for both the meditation (N=13) and control groups (N=13). The mean deviation from baseline did not significantly differ between participants in the meditation group (M = 5.25 %, SD = 14.15 %) and control group (M = 10.55 %, SD = 31.30 %) immediately following exercise (p=0.5833). Similarly, no significant differences in mean deviation from baseline were found between meditation participants (M = 1.07 %, SD = 15.65 %) and control participants (M = -4.02 %, SD = 18.21 %) after five minutes of recovery from exercise. Error bars represent +/- 1 SD.

Survey Variable	Results (Average)	Range
Age	21 years	19 – 23 years
Height	1.77 meters	1.60 – 1.93 meters
Weight	161.50 lbs	100 – 270 lbs
BMI	23.26	18.08 – 34.33
Hours of exercise per week	4.86 hours	0 – 12
Intensity level of exercise (1-10)	6	0 – 9
Prior meditation experience	7 participants	N/A

Participants	Total
Overall	26
Female	10
Male	16

Table 1: Survey data taken from each participant including total count and gender, as well as means and ranges for age, height, weight, BMI, hours of exercise per week, intensity level of exercise (1-10) and prior meditation experience. All survey data was self-reported by the participants.