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# Recovery posture post HIIT exercise in the active population

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## Abstract

**Introduction**: By stimulating the sympathetic nervous system during a high intensity cycle HIIT workout, the effects of body posture on heart rate recovery can be recorded as the body is returning to a resting state. **Purpose**: The purpose of this study is to explore the physiology of recovery related to different body positions after high intensity exercise in order to account for the quickest recovery. **Design**: Original research. **Methods**: 18 healthy college aged individuals, 9 males, 8 females, mean age 21.7 ± 2.22, performed a submaximal HIIT workout on a cycle ergometer with a metabolic cart to record respiratory data. Each participant was randomly assigned a different rotation of recovery positions: hands on knees (HK), hands on head (HH), and seated with hands on hips (HI). The workout consisted of 8 bouts of 20 seconds on 10 seconds off cycling at 85 rpm. This was repeated 3 times assuming a different recovery posture after each round. **Results**: The $VCO_2$ ($p$ = .068) and $V_E$ ($p$ = .053) for HH vs. HK posture revealed trends towards significance. There was an effect of order (first versus third positions) for HRR ($p$ = .007). **Conclusions**: The hands on knees position shows trends towards greater ventilation volume and $VCO_2$ compared to hands on head or hands on hips. In order for athletes to eliminate more $CO_2$ after a HIIT workout a HK position should be assumed. **Key words**: HIIT, heart rate recovery, recovery posture, ventilation rate, spirometry

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The topic of recovery position in relation to how quickly heart rate decreases has not been widely covered in the literature. During exercise, the autonomic nervous system (ANS) shifts the body from a resting state to a stressed state. The ANS is broken down into the parasympathetic nervous system (PNS) and the sympathetic nervous system (SNS). The PNS activates the body to "rest and digest" or conserve energy. It slows the heart rate (HR), increases intestinal activity, and induces bronchoconstriction. The SNS activates the body to "fight or flight" or respond to stressful events. The body releases a boost of hormones signaling the body to increase HR and pump blood to muscles so they can function properly. In other words, as the heart rate starts to increase the parasympathetic nervous system withdraws and the sympathetic nervous system dominates and continues to work at greater intensities (Zygmunt & Stanczyk, 2010; Besnier et al., 2017). This change in physiologic behavior can be monitored by recording cardiorespiratory functions. (Barak et al., 2011; Barak et al., 2010; Buchheit et al., 2009; Javorka et al.). Multiple factors influence the ANS, some being emotional state, ingested food, or body position.

Body position has an effect on how quickly the heart can recover (Skaggs et al., 2016; Michaelson et al., 2017). In order to allow full expansion of the lungs, the diaphragm should be positioned in the zone of apposition (ZOA). This position allows the diaphragm to work most efficiently (Kocjan et al., 2017; Michaelson et al., 2017). The function of the diaphragm relies heavily on the anatomical alignment of the fibers length-tension relationship and posterolateral movement of the lower rib cage (Michaelson et al., 2017). During inhalation, the abdominal muscles eccentrically contract assisting the diaphragm in keeping its optimal length-tension relationship as well as the ribs internally rotating, creating space in the thoracic cavity. The actions are reversed in exhalation (Kocjan et al., 2017; Michaelson et al., 2017). Michaelson and colleagues (2017) and Skaggs and colleagues (2016) discovered by placing hands on one's head, the trunk is extended, and the rib cage is externally rotated thus not allowing the diaphragm function fully. Concluding that athletes should stand in a bent over position with their hands on their knees promoting trunk flexion and internal rotation of the rib cage increasing the ZOA.

By understanding the way the body works in recovery could potentially maximize the efficiency of athletes competing in high intensity training. However, studies to date have focused on upright weight-bearing activity such as running. The purpose of this project is to explore the physiology of recovery related to different body positions after an intense cycling exercise. By stimulating the sympathetic nervous system during a cycle high intensity interval training (HIIT) workout, the effects of body posture on recovery can be recorded as the body is returning to a resting state (Barak et al., 2011; Barak et al., 2010; Buchheit et al., 2009; Javorka et al.). The hypothesis is if the participants assume a hands on knees posture post high intensity cycling workout their rate of recovery will be shorter than hands on head.

## Methods

### *Participants*

The participants for this study were recruited by email from the Movement Science Department. The email included the recruitment flyer that was also placed around Grand Valley State campus. The participants were included based on the following criteria, 18-30 years of age and active according to World Health Organization standards (150 minutes a week of mild-moderate intensity exercise or 75 minutes of vigorous exercise). Exclusion criteria included, people who previously suffered from an injury to a muscle or bone in the last 6 months, have heart disease, are taking any medication that may impact blood pressure or function, have asthma or diabetes. Subject demographics are represented in Table 1.

| **Table 1.**<br>**Participant Demographics** | |
|---|---|
| Sex | 9 males; 8 females |
| Age (mean ± stnd dev) | 21.7 ± 2.22 |
| Weight (kg; mean ± stnd dev) | 147.9 ± 15.85 |
| Height (in; mean ± stnd dev) | 66.7 ± 2.80 |

*Procedures*

The following procedures were approved by the Grand Valley State University institute review board (IRB# 22-024-H). Each participant gave consent prior to beginning participation in this study and was free to withdraw at any point with no repercussions.

The ParvoMedics TrueOne 2400 metabolic system was used for the collection of breath-by-breath spirometry data. This system has previously been shown to have accurate and reliable measurements in comparison to a criterion standard (Douglas bag collection) at both rest and at any exercise intensities (Crouter et al., 2006). The measurements that were recorded in each round of exercise were heart rate immediately after exercise and at the end of the 1st minute of recovery, the recovery position assumed that round, tidal volume ($V_T$), minute ventilation ($V_E$), volume of carbon dioxide ($VCO_2$), respiration rate (RR), heart rate recovery (HRR), heart rate (HR), and rating of perceived exertion (RPE; Skaggs et al., 2016).

The participants were fitted with a spirometer mask, a chest band to record heart rate, and to the WattBike Pro ergometer. A 4 minute stationary period was done at the beginning of the session in order to orient the participant to the equipment. This consisted of the participant sitting on the bike with the chest band and face mask on recording resting data. The exercise was designed as high intensity interval training in order to place appropriate stress on the body to increase heart rate and breathing rate. The exercise protocol consisted of 8 intervals of 20 seconds of cycling at 85 revolutions per minute (rpm) and 10 seconds of rest. Each participant was randomly assigned a different rotation of recovery positions: hands on knees (HK), hands on head (HH), and seated with hands on hips (HI). This was repeated 3 times assuming a different recovery posture after each round. Recovery positions were randomized using the Excel randomization function. After each round of exercise 50% of HRR was calculated to ensure adequate recovery to start next round. This was done by taking the absolute drop of HR from peak to 50% recovery.

*Statistical analysis*

The number of participants was found using G.Power application power analyses. The significance level was at 0.05, power(1-ß error prob) of 0.80, number of measurements of 4, and an effect size of 0.25 was used to analyze all 3 levels of posture. The resulting participant number was 24. Descriptive statistics were determined for each variable. A repeated measures ANOVA, with the significance level at 0.05 was done for all 3 levels of position for each variable. A Tukey post hoc analysis was used to determine significance ($p = 0.05$) between positions on dependent variables. A secondary analysis for an order effect was examined for each dependent variable.

**Results**

Eighteen out of 20 participants' data was used for the analysis. Due to processor malfunction $VCO_2$ data for participant 9,14,15, and 19 had to be removed. Due to cart malfunctions participants 1 and 4 had to be removed. Due to malfunction of the heart rate monitor during data collection of participant 7, HR had to be removed. A repeated measures ANOVA analysis (3 levels of posture) gave the following measures. The $VCO_2$ ($F(1,42) = 2.666$, $p = 0.082$), $V_E$ ($F(1,54) = 2.905$, $p = 0.064$), $V_T$ ($F(1,54) = 1.255$, $p = 0.294$), RR ($F(1,54) = .232$, $p = 0.794$), and HRR ($F(1,51) = 0.257$, $p = 0.774$) did not show any significance in relation to posture (see Table 2). Tukey post hoc revealed trends towards significance for $VCO_2$ ($p = 0.068$) and $V_E$ ($p = 0.053$) for HH vs. HK. Cohen's d was also used to analyze effect size between $VCO_2$ (d= 0.799, r = .371) and $V_e$ (d = 0.735, r = 0.345) for HH vs. HK.

A secondary analysis for order (for all levels of posture and all dependent variables) gave the following results. The order of HRR ($F(1,39) = 5.322$, $p = 0.009$) showed significance. Tukey post hoc analysis showed significantly ($p = 0.007$) faster recovery time for the first position (34 ± 5 bpm) compared to the last (42 ± 8 bpm) position assumed during the HIIT workout. $VCO_2$ ($F(1,39) = 0.814$, $p = 0.451$), $V_E$ ($F(1,39) = 0.883$, $p = 0.422$), $V_T$ ($F(1,39) = 0.874$, $p = 0.426$), RR ($F(1,39) = 0.599$, $p = 0.555$) did not show any significant differences.

**Table 2.**
**Cardiorespiratory measures** (mean ± standard deviation)

| | HH | HK | HI |
|---|---|---|---|
| $VCO_2$ (L/min) | 0.69 ± .32 | 0.95 ± .33 | 0.85 ± .23 |
| $V_E$ (L/min) | 25.25 ± 9.47 | 31.66 ± 7.91 | 29.13 ± 6.44 |
| RR (bpm) | 21.51 ± 6.72 | 22.79 ± 4.67 | 22.17 ± 5.28 |
| $V_T$ (L) | 1.20 ± .54 | 1.42 ± .38 | 1.37 ± .38 |
| HRR (bpm) | 38 ± 10 | 39 ±7 | 37 ± 5 |

**Discussion**

This study investigated the different effects of body position in terms of recovery after a cycling HIIT workout. The results have revealed that posture had no significant effect on recovery of cardiorespiratory function. However, the data does show trends suggesting that hands on knees posture allows for more ventilation and CO2 to be exhaled during recovery compared to hands on head. The first and third positions in each randomized order showed significance in terms of HRR. This most likely represents the accumulating fatigue that is experienced with the increasing duration of the HIIT workout.

In order to get full function of the diaphragm, the zone of apposition needs to be met (Kocjan et al., 2017). It has been reported the hands on knees position increases trunk flexion and internal rotation of the rib cage allowing ZOA to be achieved. This most likely explains why there are trends for larger volumes of air being exchanged with HK than the HH or HI postures. Skaggs and colleagues (2016) were the first to challenge this topic. They investigated how arm and body position affects ventilation in high school athletes. The postures examined were hands behind the head, arms at the sides, and leaning forward with hands resting on the knees. They recorded maximum voluntary ventilation with a spirometer. Significant data was gathered supporting leaning forwards with hands on knees to be the most efficient in exhaling greater amounts of air than hands at their sides or on their head. In comparison to the findings of this study the volume of air expired is trending towards HK due to the effects body posture has on HRR.

The main argument for HH posture is by placing hands on one’s head the rib cage is passively opened relieving stress from the accessory breathing musculature to allow for full expansion of the lungs. In contrast, the hands on knees position allows the diagram to function in its most efficient position, and engages abdominal muscles to help force air out. By assuming a HH position the thoraco-lumbar region is extended therefore stretching the fibers of the diaphragm placing it in a suboptimal position. Michaelson and colleagues (2017) investigated these same positions and concluded similar results. They examined the effects of two different recovery postures (HH and HK) as a form of immediate recovery from HIIT. They found an improved heart rate recovery, greater $V_T$, and increased $VCO_2$ with HK compared with HH. Concluding again the hands on knees posture allows for a greater amount of $VCO_2$ elimination and heart rate recovery. A potential reason for Michaelson and colleagues (2017) finding significance in their data may be due to differences in exercise protocol. One round of exercise for one recovery position amounted to be 16 minutes of intense exercise compared to this studies protocol only amounting to 2 minutes and 40 seconds of intense exercise.

Body posture has an effect on how quickly someone can recover. Multiple studies have concluded hands on knees is by far the most beneficial especially when recovering from an intense work out (Michaelson et al., 2017; Skaggs et al., 2016). Other studies in the literature have investigated other postures such as seated active recovery, supine, supine with legs elevated and more (Barak et al., 2010; Barak et al., 2011; Besnier et al.,2017; Szczygiet et al., 2018; Boyle et al., 2010). These studies have found significant data suggesting laying supine post exercise is most beneficial to increasing heart rate recovery due to less gravitational force applied on the heart. However laying down is not practical for an athlete looking for a quick form of efficient recovery in between bouts of exercise.

**Conclusions and practical applications**

Athletes are constantly told to keep their hands on their head after athletic participation. On the basis of the specific findings in this study the hands on knees position shows trends towards greater ventilation volume and $VCO_2$ compared to hands on head. During a HIIT workout anaerobic systems are utilized. These systems create more $VCO_2$ therefore by assuming a hands on knees position athletes are able to eliminate more $VCO_2$ at a higher rate than a hands on head position. By optimizing how the body functions to recover is a crucial part to developing and implementing plans for recovery in all types of people who are physically active.

**Study limitations**

There were some limitations to this study. The total number of participants did not reach the power analysis determined number. In addition, recovery posture was not directly measured to ensure ZOA was reached. Michaelson and colleagues (2017) used inclinometers to ensure 10 degrees of flexion was assumed by each of their participants.

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