Effects of Applied Muscle Tension to Reduce Syncope and Vasovagal Symptoms

Research Thesis

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by

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Abstract

Applied muscle tension is recommended for reducing or preventing vasovagal symptoms. Recent literature has investigated the role of respiration in the reduction of syncope and vasovagal symptoms, but there is still a need to determine the specific muscle groups that achieve the greatest effect. Thus, the present pilot study sought to examine the role of respiration, specifically whether the use of core muscles during applied muscle tension influences respiration. Participants were 15 undergraduate students randomly assigned to one of three groups (applied muscle tension with core engagement, applied muscle tension without core engagement, or a distraction-control group) and were equipped with physiological monitoring equipment while undergoing a simulated blood draw. Results indicated that significant effects were present over time for end-tidal carbon dioxide, respiration rate, systolic and diastolic blood pressure. No group differences were present. Results also indicated that 80% of participants reported having at least some fear of having blood drawn, and a trend was present for fear predicting vasovagal symptoms.

Keywords: applied muscle tension; vasovagal symptoms; syncope; fear; respiration

Various medical procedures involve needles and are a vital part of individual and community health and safety, such as blood draw, injections, and vaccinations. These procedures are crucial to one's health and with the recent COVID-19 pandemic and other previous viruses, we can see the importance of these needle-related procedures, like vaccinations. However, needle-related fear of viewing blood can be a trigger of syncope or vasovagal symptoms (France et al., 2012). Blood injection injury phobia is a disorder in which a distinct feature is vasovagal symptoms (Ritz et al., 2010). Syncope accounts for 1% to 6% of all emergency department visits and has an estimated total hospitalization cost of $2.4 billion per year, with a mean cost of $5,400 per hospitalization (Sun et al., 2005). Interventions exist to reduce the frequency and severity of vasovagal symptoms, such as applied muscle tension. This study examined two forms of applied muscle tension and investigated how it may optimally produce an effect of reducing frequency and severity of vasovagal symptoms and risk of syncope.

What are Syncope and Vasovagal Symptoms?

Syncope is the transient loss of consciousness, while vasovagal symptoms include feeling faint, dizzy, or lightheaded (Matsushima et al., 2004). Types of syncope include reflex syncope, orthostatic hypotension, and cardiac syncope. Across all these categories, the brain does not receive enough oxygen, resulting in vasovagal symptoms or syncope (Miller & Kruse, 2005). When hypotension is occurring, blood flowing through the left and right ventricle receptors start to misconceive hypercontractile as overloading causing sympathetic stimulation (Miller & Kruse, 2005). These symptoms may last from a few seconds to a couple of minutes. For some people, this leads to a decrease in heart rate, and syncope (loss of consciousness) may occur. (Miller & Kruse 2005). It is important to note the close relation of the cardiovascular system in relation to the respiratory system when examining syncope and vasovagal symptoms. The lungs contain small air sacs known as alveoli which are wrapped by tiny blood vessels called capillaries that supply the body with the appropriate level of oxygen by diffusion of carbon dioxide and oxygen (West, 2014). The capillaries provide a sheet of blood in the alveolar wall allowing the alveoli to extract carbon dioxide and pump oxygen back into the blood stream. The blood rich in oxygen then flows through the left ventricle supplying the body's organs and cells with diffusion of oxygen (Klabunde, 2011). Hyperventilation is one respiratory factor that is associated with vasovagal symptoms or syncope. Hyperventilation occurs following breathing in deeply or at an increased rate of each breath (Ritz et al., 2010). Hyperventilating leads to hypocapnia, which is the decrease in levels of carbon dioxide in the blood stream and alveoli in the lungs. This is associated constriction of the cerebral blood vessels, leading to cerebral hypoperfusion due to, potentially contributing to vasovagal symptoms and syncope (Rawat et al., 2022; Immink et al., 2014; Fabregas & Fernández-Candil, 2016). While research regarding syncope is heavily focused on cardiological aspects related to blood pressure, it is also vital to recognize the respiratory system with syncope as well.

Psychological contributors to hyperventilation and cardiovascular dysregulation include increased anxiety in anticipation of, and fear during exposure to needles and/or blood. When a person is faced with exposure to the triggering stimulus (e.g., blood, needles, injections), it can result in hyperventilation. Thus, causing blood vessels to restrict, reducing cerebral blood flow. Subsequently, this leads to vasovagal symptoms (Ayala et al., 2010).

While syncope is medically benign, with loss of consciousness, people may experience a reduced quality of life and have an increased fall risk which can cause serious injury (Furtan et al, 2020; Ng et al., 2018). Traumatic head injuries happen with about 15-45% of patients experiencing syncope and of those injuries 0.6-4.8% are severe (Furtan et al. 2020). A study investigated the short- and long-term effects of syncopal patients presenting with head injuries. Results showed that syncope triggering a head injury did not increase short-term morality but did have an increased association with long-term morality (Furtan et al. 2020). A person who experiences reoccurring syncope can face the stress of day-to-day interference with their lifestyle, such as driving or interference with their job (Shaffer et al. 2001).

Further, vasovagal symptoms or syncope can be very distressing for the person experiencing it (Ng et al., 2018) and create anxiety that an episode could reoccur. A recent study has found that people experiencing vasovagal syncope reported higher levels of psychological complaints and are more likely to have a reoccurring episode as a result. In a study from Romme and colleagues (2011), participants who experience syncope with general psychological complaints were given non-pharmacological treatment to examine whether it influenced syncopal recurrence. Non-pharmacological treatment included high fluid and salt intake, leg-crossing, tensing of buttock and leg muscles, squatting, handgrip and arm tensing (Romme et al., 2011). Results concluded that participants with higher psychological complaints had increased risk of syncopal recurrence. Results also showed that non-pharmacological treatment was the biggest indicator of reoccurrence, with a reduction in syncope over time (Romme et al., 2011).

Blood Injection Injury Phobia and Fear

People with blood injection injury phobia, which affects ~4% of the population (Ritz et al., 2010), are at increased risk for vasovagal symptoms and syncope. This phobia is the intense fear or anxiety of injury, injections and/or needles, and blood. An estimated 75% of people with blood injection injury phobia have reported having vasovagal symptoms or full syncope when presented with injections, needles, or blood (Ayala et al., 2010). In a study by Gilchrist and colleagues (2015), vasovagal responses to blood-injection-injury phobia material were investigated where participants were presented with a graphic surgical education video. Participants were then assigned to a random group where they were permitted a viewing break whenever needed verses another group with an assigned viewing break. Results showed that 70% of people experienced some form of vasovagal symptoms and those who were assigned a break experienced higher levels of fear and heart rate variability (Gilchrist et al., 2015).

People who experience these types of fear and/or anxiety are likely to avoid medical procedures that include the use of needles or viewing blood that could result in major health consequences, such as vaccinations and blood draws, or may avoid medical settings altogether (Abado et al., 2021). A meta-analysis revealed that 27% of hospital employees, 18% of healthcare workers in long-term care facilities, and 8% of hospital workers exhibited influenza vaccine avoidance due to fear of needles or injections. Similarly, in a survey of 100 physicians, 71% reported needle fear was a contributor of avoiding the tetanus vaccine, and 71% and 69% for the influenza and pneumococcal vaccination (McLenon & Rogers 2018). These medical procedures are vital to maintaining the health and safety of oneself and others, thus calling for attention in interventions to decrease this anxiety and fear.

Even sub-clinical fear of having blood drawn and vaccine-relevant fears predict increased risk for vasovagal symptoms among blood donors and healthy adults obtaining the seasonal influenza vaccine, respectively (France et al., 2012; Kowalsky, 2023). As a result, further research on interventions to reduce the risk for vasovagal symptoms could benefit a large population of people experiencing anxiety or fear toward needles, blood, or injury.

Interventions for Vasovagal Symptoms

When experiencing syncope there are numerous recommendations for patients, including increasing sodium intake (Wang et al., 2021), increasing hydration, applied muscle tension, therapy, patient education, and pharmacological interventions (Guzman et al., 2013). While these may be helpful to some, there is limited research investigating specifics for the behavioral interventions (e.g., How much sodium is ideal? How much water to consume? Are other fluids more effective?). The present study focused on applied muscle tension to assess if core muscle engagement is influential.

Applied Muscle Tension

A behavioral intervention to help reduce vasovagal symptoms is applied muscle tension. Applied muscle tensing involves the tensing of the quadriceps, glutes, and core muscles, alternating between five seconds of tensing and five seconds of rest (Bodycoat et al., 2000). This repetition of muscle tension maintains the blood pressure by increasing the rate of return of blood to the heart (Krediet et al., 2005) and providing an increase in cerebral oxygenation (Kowalsky et al., 2011) to prevent or reduce vasovagal symptoms. Öst and colleagues (1989) were early developers of applied muscle tension for use with patients who experienced blood injection injury phobia. In their early studies, they examined various forms of applied tensing techniques, such as applied relaxation and applied tension, to yield the most effective outcome in treating blood injection injury phobia. Participants practiced the various techniques through a total of ten sessions exposed to different triggering stimuli, and results showed 90% of applied tension participants improved post-treatment (Öst et al., 1989). Applied muscle tension was later evaluated for use by blood donors to prevent vasovagal symptoms and syncope. Ditto and colleagues (2007) examined five different applied muscle tension groups (e.g., no-treatment control, full body applied tension, lower-body-tension group, upper-body-tension group, upper-body-tension with distraction group, and expectation-placebo group) and its impact on anxiety and vasovagal symptoms (the number of times donors needed to be reclined in the donation chair). Of the five different applied muscle tension techniques, it was found that the lower-body tension (donors using tension in their legs and abdomen) had significantly lower post-donation anxiety and were less likely to require chair reclining for symptom treatment (Ditto et al., 2007). While it was noted that leg and abdominal engagement were important aspects of applied muscle tension, physiological measures were not recorded and applied muscle tension without abdominal engagement was not evaluated. Applied muscle tension for use during intravenous catheter placement has also been evaluated.

A study was conducted examining the use of applied muscle tension by adolescents and young adult surgical patients who were at increased risk for vasovagal symptoms and syncope during insertion of a peripheral intravenous catheter (McIntyre-Patton et al., 2018). The study found significant results in reduction of vasovagal symptoms with the use of muscle tension with legs crossed versus the standard care control group. However, like the previous study, physiological and psychological measures were not recorded. Thus, further measures are needed to investigate the physiological effects of muscle tensing, such as respiratory rate, and blood pressure. Muscle tension is an extremely low-cost technique that can be learned very quickly and may reduce vasovagal symptoms during a procedure. This research could further benefit not just blood injection injury phobia but various medical settings with needle involvement such as routine blood draws, injections, or vaccinations.

The Present Study

Overall, we can see that syncope and vasovagal symptoms are relevant side effects when it comes to various medical procedures, especially for people who experience blood and needle-related fears. While oftentimes these effects are not seen as harmful, psychological distress and increased risk due to falling are concerns. We know from research that applied muscle tension has been a successful intervention in assisting the reduction of vasovagal symptoms; however, there are a few areas that warrant further examination.

Thus, the present pilot study seeks to evaluate the effect of two different versions of applied muscle tension (with and without core engagement) against a distraction control and assess if applied muscle tension with core engagement has a beneficial influence on respiration.

Specifically, we hypothesized that applied muscle tension with the use of core engagement will a significantly lower respiration rate, greater end-tidal carbon dioxide, and lower vasovagal symptoms compared to applied muscle tension without core engagement and the distraction-control group, during and following an arm illusion and simulated blood draw. A second aim of the study was to test if baseline fear of having blood drawn predicted vasovagal symptoms during or following the arm illusion and simulated blood draw.

Methods

Participants

Participants were recruited from The Ohio State Newark SONA Psychology Participation System. Exclusionary criteria included consuming caffeine, alcohol, or nicotine, or engaging in vigorous physical activity within the last six hours, pregnancy, use of medications that affect physical responses, or a medical condition that affects physical responses. The sample (n=15) was on average 18.4 years old (SD = .8, range 18-21), and self-reported gender as female (n=12, 80%) and male (n=3, 20%); race as Asian or Asian American (n=1, 6.7%), Black or African American (n=4, 26.7%), White (n=9, 60%), and more than one race (n=1, 6.7%); and ethnicity as Hispanic or Latinx (n=1, 6.7%) and not Hispanic or Latinx (n=14, 93.3%).

Self-report measures

Demographic characteristics. Participants filled out a physical copy questionnaire regarding their demographic characteristics and exclusionary criteria (e.g., race, gender, age, ethnicity; Appendix A).

Fear of having blood drawn. To screen for fear, participants answered a single item of: "How afraid are you of having blood drawn?" with a 5-point scale from 1 (*not at all*) to 5 (*extremely afraid*). Predictive validity of this single-item measure has been demonstrated within blood donation with greater pre-donation fear predicting increased vasovagal symptoms among blood donors (France et al., 2012; Appendix B).

Adapted Blood Donation Reactions Inventory-Short Form. An adapted version of the Blood Donation Reactions Inventory- short form was completed by each participant to measure the subjective physiological reactions of symptoms related to blood donation. Instructions were adapted to reflect the arm illusion and simulated blood draw instead of blood donation (Kowalsky et al., 2018). The 4-item short form was used to measure physiological reactions related to vasovagal syncope symptoms, including faintness, dizziness, lightheadedness, and weakness. A 6-point scale was used from 0 (*not at all*) to 5 (*to an extreme degree*; France et al., 2008; Labus et al., 2000; Appendix C).

Physiological measures

Respiration rate and end-tidal carbon dioxide. The Capnostream 35 (Medtronic) portable respiratory monitor was used to measure respiration rate. End-tidal carbon dioxide was also recorded which determines how much carbon dioxide is being exhaled after each breath. A nasal canula with oral sampling scoop was placed and connected to the portable device for measuring the output of carbon dioxide levels.

Blood pressure and pulse. The Omron 5 Series Wireless Upper Arm Blood Pressure Monitor was used to record systolic and diastolic blood pressure as well as pulse rate.

Procedure

After the informed consent procedure, participants filled out a series questionnaires measuring their demographics, exclusionary criteria (e.g., caffeine consumption), and fear of having blood drawn. Next, participants were directed to sit in a chair with their left arm on the testing chair. Their right arm was placed out of sight behind a computer monitor. Participants were then equipped with physiological monitoring equipment by the researcher. The nasal canula was placed in the participants nostrils and the blood pressure cuff was placed around their right arm. Participants were then asked to sit quietly to complete a five-minute baseline monitoring period. After this monitoring period was complete, an audio recording prompted participants to self-select one of four arms displayed on the monitor that looked most like their own to use for the video arm illusion and simulated blood draw. Next, participants were randomly assigned into one of three groups: a distraction-control group using gentle alternating toe points, an applied muscle tensing group including tension of quadriceps and glutes alone, or an applied muscle tensing group with the inclusion of quadriceps, glutes, and core muscles. Randomization was stratified based on presence or absence of fear of having blood drawn. Participants then heard the audio instructions for their assigned group and were given the opportunity to practice and ask questions.

To create the perception of ownership that the video arm belongs to the self, the video arm was displaying a brush going across the arm from elbow to palm in synchrony with the same sequence on the participant’s real arm performed by the researcher, to accomplish the illusion of ownership of the video arm. Then on the monitor, the video arm underwent a blood draw (Trost et al., 2017). This process was repeated on the participant's arm by rubbing the alcohol swab at the same location and gently placing the head of a small nail on the inner elbow in sync with the needle insertion.

After the arm illusion and simulated blood draw, the participant then entered a five-minute post-simulated blood draw period where participants continued their assigned exercise instructions (i.e., muscle tensing with core engagement, muscle tensing without core engagement, or no distraction-control), followed by a five-minute no exercise recovery period. Finally, at the end of the second recovery period the monitoring equipment was removed, and participants filled out a questionnaire including the adapted Blood Donation Reactions Inventory, and arm illusion ratings (Appendix D). Upon conclusion of the study, participants were debriefed.

Statistical analyses

Change scores from baseline were computed for physiological variables. One-way mixed ANOVAs and chi square tests of independence were used to evaluate baseline group differences in demographic characteristics, self-reported fear of having blood drawn, and physiological variables. Three group by 6 time point mixed ANOVAs tested for group differences in change in end-tidal carbon dioxide and respiration rate, and 3 group by 3 time point mixed ANOVAs tested systolic blood pressure, diastolic blood pressure, and pulse over time. Microsoft Excel was used for physiological data management and SPSS was used for all analyses.

Results

Tests for Differences at Baseline

As presented in Table 1, no significant differences were present between groups for age (F(2, 12) = .86, $p = .45$, $\eta^2 = .13$), baseline fear of having blood drawn (F(2, 12) = 1.29, $p = .31$,

$\eta^2 = .18$), end-tidal carbon dioxide (F(2,12) = 1.29, $p = .31$, $\eta^2 = .11$), respiratory rate (F(2,12) = .74, $p = .50$, $\eta^2 = .18$), and systolic blood pressure (F(2,12) = .30, $p = .75$, $\eta^2 = .05$), diastolic blood pressure (F(2,12) = 1.17, $p = .35$, $\eta^2 = .16$), and pulse (F(2,11) = 1.47, $p = .27$, $\eta^2 = .21$) at start of baseline. Similarly, no group differences were present at end of baseline for systolic blood pressure (F(2,12) = .27, $p = .77$, $\eta^2 = .04$), diastolic blood pressure (F(2,12) = 2.80, $p = .10$, $\eta^2 = .32$), and pulse (F(2,11) = .72, $p = .51$, $\eta^2 = .12$), although a stronger effect size was present for diastolic blood pressure.

Changes in End-tidal Carbon Dioxide

A mixed ANOVA tested group differences in change in end tidal carbon dioxide across time. A significant effect of time was present (Pillai's Trace = .92, F(5, 8) = 17.91, $p < .001$, partial $\eta^2 = .92$), with significant quadratic function present (F(1, 12) = 45.61, $p < .001$, partial $\eta^2 = .79$) reflecting a significant increase, followed by a decrease (see Figure 1). No significant effects were present by group (F(2, 12) = 2.18, $p = .16$, partial $\eta^2 = .27$) or group by time interaction (Pillai's Trace = .75, F(10, 18) = 1.07, $p = .43$, partial $\eta^2 = .37$).

Changes in Respiration Rate Over Time

Another mixed ANOVA tested group differences in change in respiration rate across time. A significant effect of time was present (Pillai's Trace = .74, F(5, 8) = 4.51, $p = .030$, partial $\eta^2 = .74$), with significant linear function present (F(1, 12) = 18.63, $p = .001$, partial $\eta^2 = .61$) reflecting a significant decrease (see Figure 2). No significant effects were present by group (F(2, 12) = .63, $p = .55$, partial $\eta^2 = .09$) or group by time interaction (Pillai's Trace = .85, F(10, 18) = 1.34, $p = .28$, partial $\eta^2 = .43$).

Changes in Blood Pressure and Pulse Rate

Next, mixed ANOVAs tested for group differences in blood pressure and pulse. For systolic blood pressure, a significant effect of time was present (Pillai's Trace = .65, F(2, 10) = 9.18, p=.005, partial $\eta^2 = .65$), with significant linear function (F(1, 11) = 14.94, p=.003, partial $\eta^2 = .58$) reflecting a significant decrease (see Figure 3). No significant effects were present by group (F(2, 11) = .42, $p = .67$, partial $\eta^2 = .07$) or group by time interaction (Pillai's Trace = .47, F(4, 22) = 1.71, $p = .18$, partial $\eta^2 = .24$). For diastolic blood pressure, a significant effect of time was present (Pillai's Trace = .49, F(2, 10) = 4.78, p=.035, partial $\eta^2 = .49$), with significant linear function (F(1, 11) = 9.91, p=.009, partial $\eta^2 = .47$) reflecting a significant decrease (see Figure 4). No significant effects were present by group (F(2, 11) = .74, $p = .50$, partial $\eta^2 = .12$) or group by time interaction (Pillai's Trace = .40, F(4, 22) = 1.37, $p = .28$, partial $\eta^2 = .20$). Finally, for pulse, no significant effects of time (Pillai's Trace = .21, F(2, 9) = 1.19, p=.35, partial $\eta^2 = .21$; see Figure 5), by group (F(2, 10) = 1.75, $p = .22$, partial $\eta^2 = .26$) or group by time interaction (Pillai's Trace = .35, F(4, 20) = 1.37, $p = .41$, partial $\eta^2 = .17$) were present.

Does fear predict vasovagal symptoms?

A linear regression analysis identified a trend for heightened fear of having blood drawn predicting greater self-reported vasovagal symptoms ($\beta = .46$, $p = .09$).

Discussion

This present study sought to examine the various effects of applied muscle tension techniques influence of respiration, specifically whether the use of core muscles influences respiration during muscle tension. In this present study, it was hypothesized that engagement of core muscles during applied muscle tension with quads and glutes would influence levels of respiration. Changes in end-tidal carbon dioxide were measured across the three groups and found a significant effect of time was present. We saw a steady increase from all three groups followed by a decrease in end-tidal carbon dioxide around time point four which was the start of the blood draw with needle insertion, followed by the two recovery periods. We can see the sharpest decline of all three groups from time point five, the recovery period with the assigned exercise, to the sixth time point, the recovery period without use of the assigned exercise. This shows that participants had a decrease over time in carbon dioxide levels at the end of the exhale in the recovery periods. These finding are consistent with previous research measuring end-tidal carbon dioxide levels and applied muscle tension (Kowalsky et al., 2018). Specifically, among a high fear adult sample, during the blood draw portion of the arm illusion and simulated blood draw and first minute of a recovery period, applied muscle tension with core engagement and a control condition experienced a decrease in end-tidal carbon dioxide.

Changes in respiration rate were also found to present a significant effect of time representing a significant decrease in respiration rate. From the first time point (the creation of the arm illusion) until the last time point (the recovery period without assigned exercise), there is a significant decrease in respiration rate over time for all three groups. Similar to end-tidal carbon dioxide, there were no significant effects between the three groups. Systolic and diastolic blood pressure decreased over time. When evaluating pulse rate, it was found that there were no significant effects of time, group, or group by time. Even though we do not see any group differences, the physiological findings are consistent with previous research when it comes to a decrease in end-tidal carbon dioxide, respiration rate, systolic, and diastolic blood pressure across time (Kowalsky et al., 2018; Mennitto et al., 2018). While previous research indicated that the effect of respiration decreases vasovagal symptoms, it has been reported that lower fear individuals tended to benefit more (Mennitto et al., 2018). There could be several reasons for this including participants who report higher fear may start with a higher respiration rate and have an increased challenge in controlling their respiration rate. With the present higher fear sample, this may have contributed to the absence of effects.

In this present study, we sought to also examine the effects of needle related fear. Within this sample of college students without recruitment targeting fearful individuals, 80% reported having some level of needle related fear with trend present for heightened fear, predicting greater self-reported vasovagal symptoms. This is consistent with current literature that younger ages seem to have heightened needle related fears (France et al., 2014). One sample of high school students had a doubled risk for an increased risk of vasovagal symptoms with the report of needle related fear (France et al., 2014). With this data we can examine that even amongst a small sample of college aged students, we still see a large proportion of participants endorsing fear of having blood drawn. Throughout the literature it has been shown that fear is a strong predictor of vasovagal reactions (Newman 2014; France et al., 2012). This poses an opportunity to investigate further into fear responses and vasovagal reactions especially in the younger populations. Needle related fear could cause an avoidance to necessary medical procedures that are crucial to one’s health such as vaccinations or blood draws.

One area worth noting is the instructions of the assigned exercise technique administered to the participants during the study. Participants had a difficult time adhering to instructions related to their assigned exercise during the arm illusion and simulated blood draw, with most reminded to engage in the appropriate exercise during the first recovery period. Participants listened to instructions of an audio recording for their assigned exercise and then had time after to practice with the researcher and ask questions. Participants consistently struggled to perform their exercise during the video arm illusion and following recovery period. This limitation has been found amongst previous research as well. A study by Ditto and colleagues (2003) was conducted during a blood donation to measure the reduction of vasovagal symptoms with applied muscle tension. The experimental group was asked to tense major muscle groups in five second intervals while steadily breathing during blood donation. The study reported mixed results, but 91% of the applied muscle tension group reported only tensing some of the time (Ditto et al, 2003). In future studies it could be advantageous to create and present a video of the assigned exercise to the participant for better understanding of instructions (e.g., Mennitto et al., 2018). In previous research, a period of biofeedback and a vibrating cue has also been used to remind the participant of the correct intervals of muscle constriction (Kowalsky et al., 2018; Kowalsky et al., 2013). These warrant consideration within future studies.

Conclusion

This present study had two main points of focus: evaluating two different forms of applied muscle tension and their impact on respiration compared to a distraction-control group, and if fear of having blood drawn predicted vasovagal symptoms. Significant effects of time were present for end-tidal carbon dioxide, respiration rate, systolic and diastolic blood pressure. No group differences were detected. Fear of having blood drawn was unexpectedly common. Even with some participants having difficulty adhering to their assigned exercise instructions, significant effects were still presented. With the effects shown, this pilot study is worth continuation to evaluate further effects of applied muscle tension and respiration.

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Table 1. Age, fear of having blood drawn, and physiological measures expressed as mean (SD) by group

Variables	Units	Group 1 (n=5)	Group 2 (n=5)	Group 3 (n=5)
Age	Years	18.2 (.4)	18.2 (.4)	18.8 (1.3)
Fear		3.4 (1.7)	2.2 (1.1)	2.4 (.9)
etCO	mmHg	37.7 (2.3)	35.8 (4.1)	38.3 (3.2)
RR	Breaths/min	16.5 (2.0)	18.6 (2.7)	15.7 (4.0)
Start of Baseline				
SBP	mmHg	108.7 (12.6)	112.4 (5.7)	108.8 (5.6)
DBP	mmHg	78.5 (8.7)	72.5 (6.3)	72.7 (5.8)
Pulse[1]	Beats/min	80.2 (15.1)	67.3 (13.1)	68.9 (9.2)
End of Baseline				
SBP	mmHg	106.6 (9.6)	106.2 (5.1)	103.6 (5.6)
DBP	mmHg	77.6 (9.3)	70.0 (6.1)	67.2 (5.6)
Pulse[1]	Beats/min	81.0 (13.3)	69.8 (15.3)	74.4 (14.2)

[1] n=1 missing for group 2. Group 1=applied muscle tension with core, Group 2=applied muscle tension without core, Group 3=distraction-control. etCO=end-tidal carbon dioxide, RR=respiratory rate, SBP=systolic blood pressure, DBP=diastolic blood pressure.

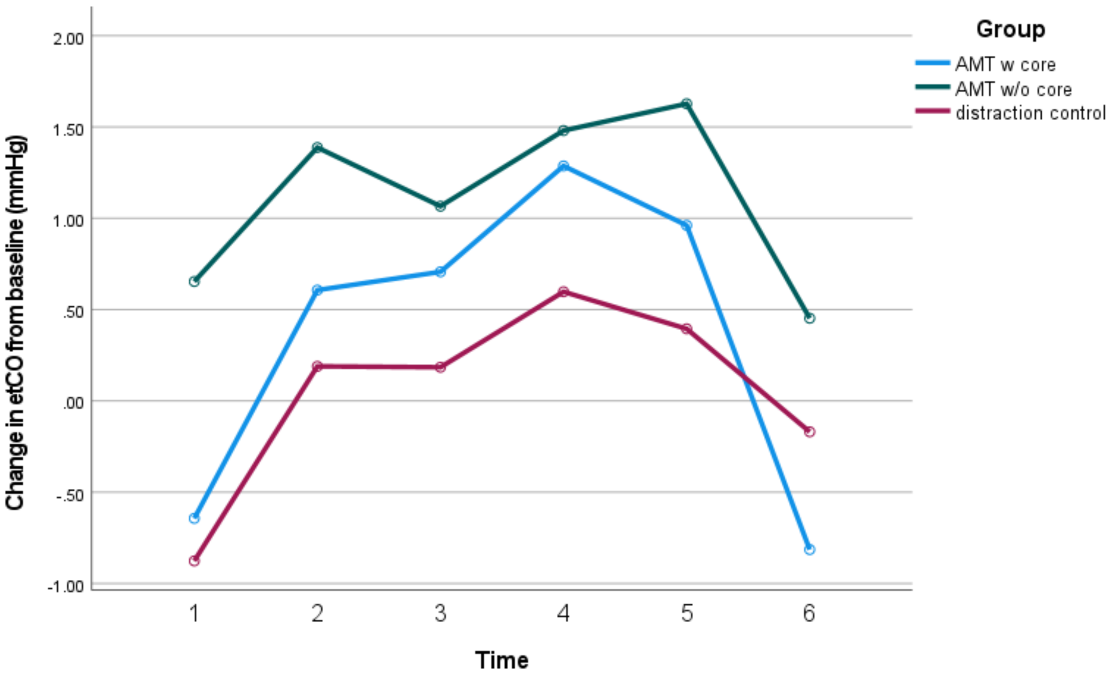

Figure 1. Mean change scores in end-tidal carbon dioxide across six time points from start of simulated blood draw to end of recovery period. Time points: 1=start of arm illusion video, 2= start of arm illusion creation, 3=preparation for blood draw, 4= insertion of needle and blood draw, 5= recovery period with assigned exercise, 6=recovery period without assigned exercise. AMT = applied muscle tension.

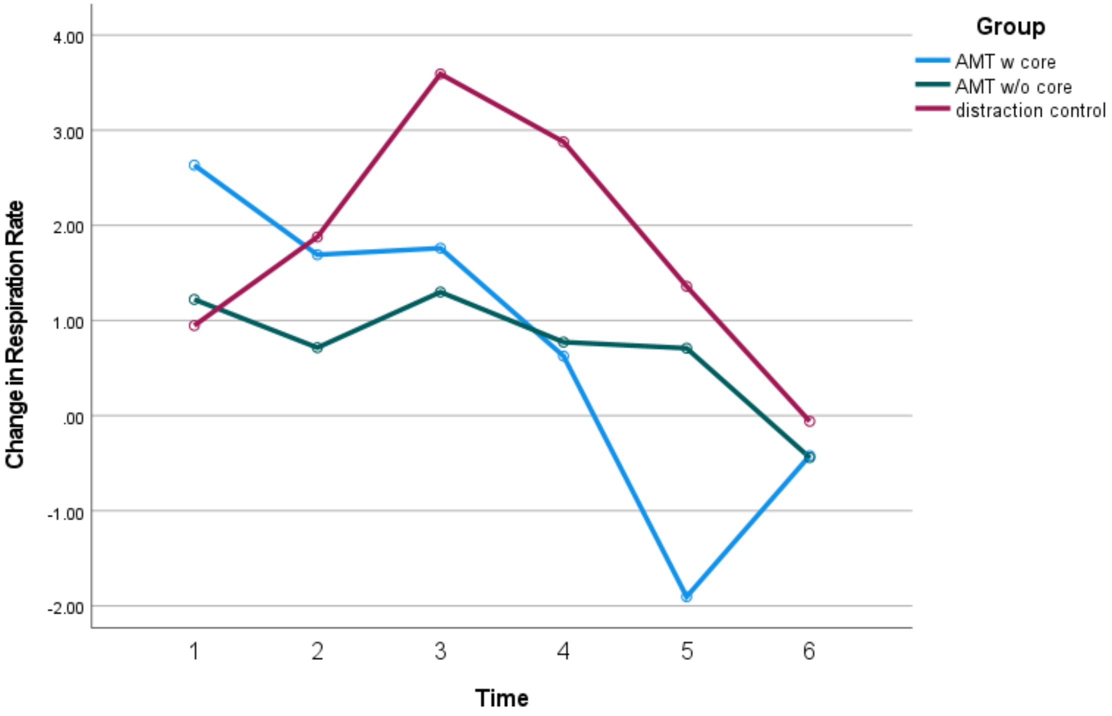

Figure 2. Mean change scores respiration rate across six time points from start of simulated blood draw to end of recovery period. Time points: 1=start of arm illusion video, 2= start of arm illusion creation, 3=preparation for blood draw, 4= insertion of needle and blood draw, 5= recovery period with assigned exercise, 6=recovery period without assigned exercise. AMT = applied muscle tension.

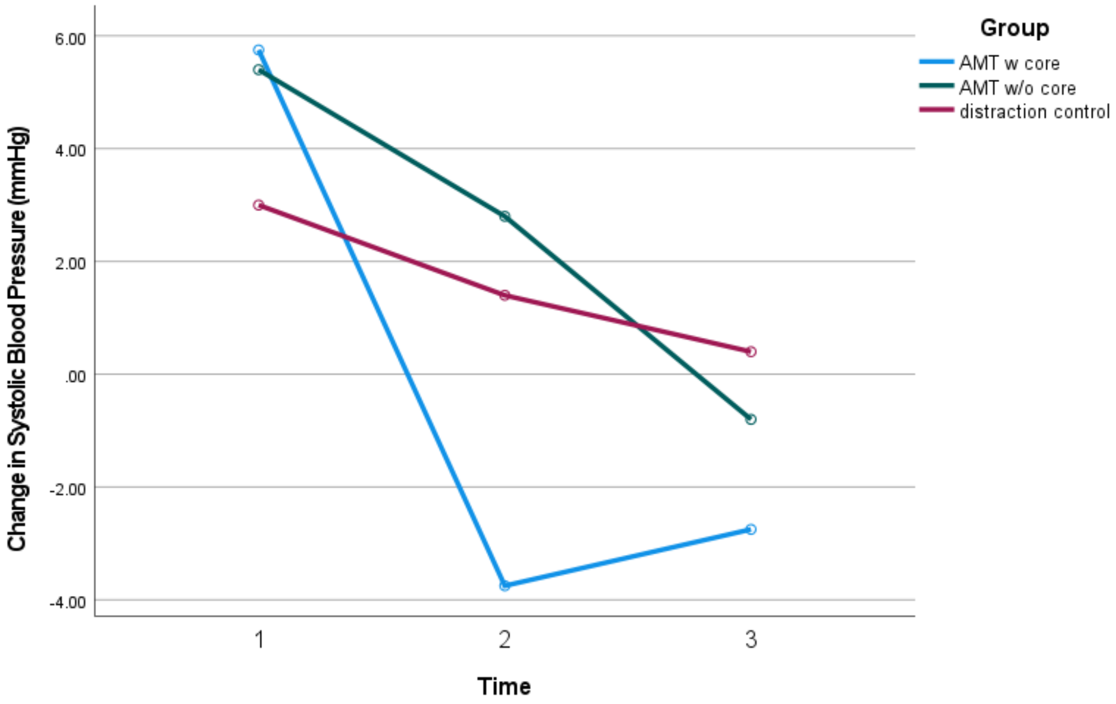

Figure 3. Mean changes in systolic blood pressure across three different time points. Time points: (1= start of first recovery with assigned exercise, 2= end of recovery one and start of recovery 2 without use of assigned exercise, 3= end of second recovery period). AMT = applied muscle tension.

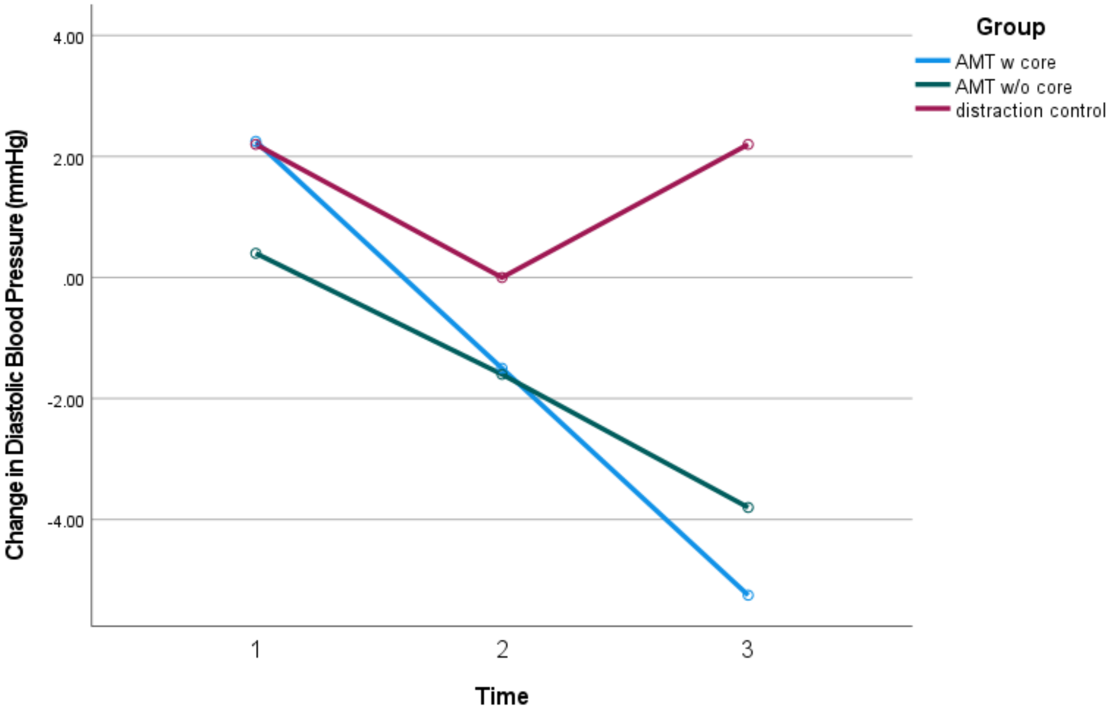

Figure 4. Mean changes in diastolic blood pressure across three different time points. Time points: (1= start of first recovery with assigned exercise, 2= end of recovery one and start of recovery 2 without use of assigned exercise, 3= end of second recovery period). AMT = applied muscle tension.

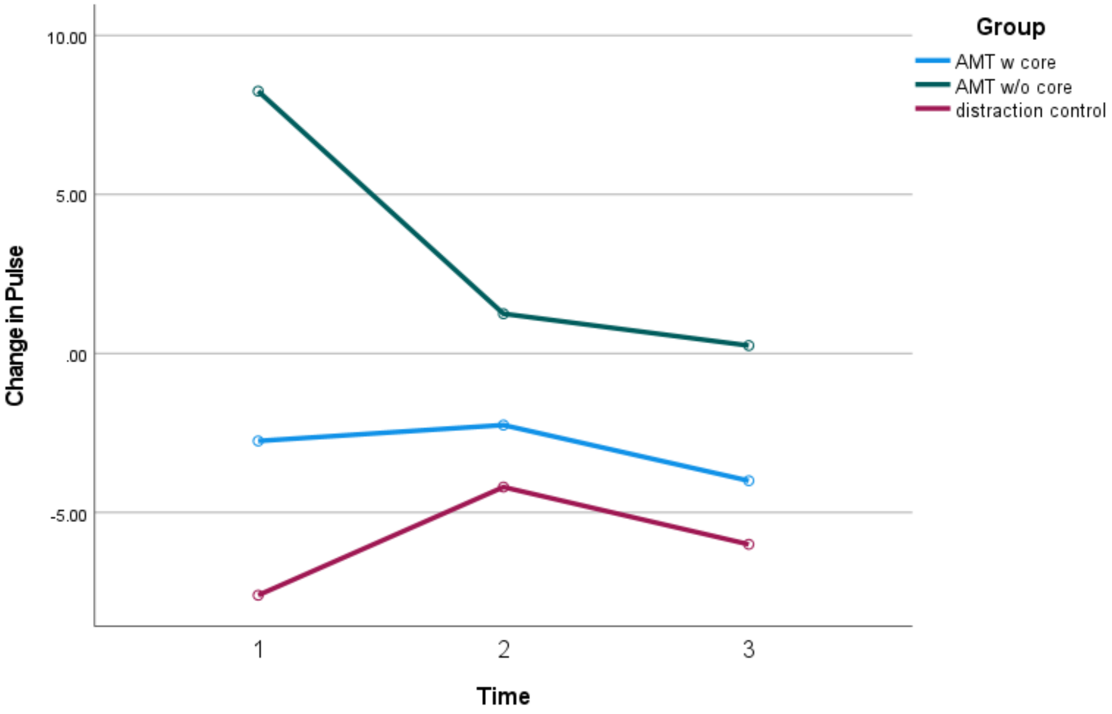

Figure 5. Mean changes in pulse rate across three different time points. Time points: (1= start of first recovery with assigned exercise, 2= end of recovery one and start of recovery 2 without use of assigned exercise, 3= end of second recovery period). AMT = applied muscle tension.

Appendix A

Demographic Information

How old are you? ______________

What race(s) do you identify with?

- American Indian / Alaska Native
- Asian
- Native Hawaiian or Other Pacific Islander
- Black or African American
- White
- More than One Race
- Other ________

What is your ethnicity?

- Hispanic or Latina/o
- Not Hispanic or Latina/o

Do you identify as:

- Female
- Male
- Other ______

Are you mainly:

- Left handed
- Right handed
- Ambidextrous

In the last six hours, have you:
Engaged in moderate or vigorous physical activity?

  - No
  - Yes
    - What and how much? _________________

In the last six hours, have you:
Consumed any caffeine?

  - No
  - Yes
    - What and how much? _________________

Consumed any alcohol?

  - No

- Yes
  - What and how much? _________________

Consumed any nicotine?

- No
- Yes
  - What and how much? _________________

Do you smoke?

- No
- Former smoker
- Yes
  - How many times do you smoke per day (e-cigarette or traditional)? ______
  - Pack or each cigarette?

Have you ever been diagnosed with a chronic medical or psychiatric disorder?

- No
- Yes
  - If yes, please describe _________________

Are you taking any medications for a chronic medical or psychiatric disorder?

- No
- Yes
  - If yes, please describe _________________

What is your height? ___________
What is your weight? ___________

Appendix B

Single Item Fear of Having Blood Drawn

How afraid are you of having blood drawn from your arm?

1=not at all afraid   2=somewhat afraid   3=moderately afraid   4=very afraid 5=extremely afraid

Appendix C

Adapted Blood Donation Reactions Inventory – Short Form

Directions: Please indicate the degree to which you experienced the following symptoms during or after the video by choosing a number between 0 and 5

0 = Not at all
1 = To a slight degree
2 = To a moderate degree
3 = To a strong degree
4 = To a very strong degree
5 = To an extreme degree

Faintness	0	1	2	3	4	5
Dizziness	0	1	2	3	4	5
Weakness	0	1	2	3	4	5
Lightheadedness	0	1	2	3	4	5

Appendix D

Arm Illusion Ratings

Please rate the extent to which you agree or disagree with the statements below by selecting the appropriate number.

I felt as if the video hand was my hand
0 1 2 3 4 5 6 7 8 9
I do not agree at all I agree completely

It seemed as if I were feeling the touch of the paintbrush in the location where I saw the rubber hand touched
0 1 2 3 4 5 6 7 8 9
I do not agree at all I agree completely

It seemed as though the touch I felt was caused by the paintbrush touching the video hand
0 1 2 3 4 5 6 7 8 9
I do not agree at all I agree completely