Body Position and its Effect on Heart Rate, Blood Pressure, and Respiration Rate After Induced Acute Mental Stress

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Key terms: acute mental stress, Wonderlic IQ test, body position, yoga

Word Count: 3,386

Abstract

A dominating presence in modern life is stress, manifesting from physical, mental, or emotional triggers. Stress induced hormonal variations can lead to physiological change such as increased heart rate, increased rate of respiration, and vasoconstriction. While everyone experiences stress to some degree, chronic stress may lead to compromised health. One strategy that has been shown to effectively combat elevated stress levels is yoga. The purpose of this study is to analyze how physiological symptoms resulting from acute mental stress are affected by body positions, specifically yoga positions. The 28 participants (14 male; 14 female) were randomly assigned to perform one of four body positions: standing up, laying down, sitting cross-legged, and Child's pose. To induce acute mental stress, participants were instructed to take a Wonderlic IQ test and informed that their performances would be compared to their peers. Following the stressor, participants assumed the assigned body position. It was hypothesized that the participants' physiological indicators of stress would measure closer to resting state by performing Child's pose as compared to sitting cross-legged. Body position was found to significantly affect heart rate and blood pressure. However, results did not support significant changes in respiration rate. Child's pose failed to reduce heart rate and on average increased heart rate by 6.1 bpm. Child's pose increased systolic and diastolic blood pressure by 20 mmHg and 14 mmHg, respectively. Sitting cross-legged decreased heart rate by 8.7 bpm, and increased the systolic and diastolic blood pressures by 1 mmHg and 3 mmHg, respectively. Respiration rate was unaffected. We found no other studies that investigated how body position may influence physiological stress symptoms after acute mental stress. Chronic stress is known to manifest adverse health effects. This study provides physiological insight to how stress may be efficiently managed in short time periods while exploring this relatively untouched corner of stress physiology research.

Introduction

Stress is a part of everyday life and can be caused by physical, mental, or emotional factors. Stressors can be external, such as environmental or social situations, or it can be internal, in the case of illness and invasive medical procedures. Stress initiates the "fight or flight" response, which is a complex reaction of both the sympathetic nervous system and the adrenocortical system. These two systems facilitate the release of the hormones cortisol, epinephrine and norepinephrine in response to stress and generate both immediate and long lasting physiological reactions. Cortisol is released in response to acute psychological stressors, especially if the acute stressor is out of the subject's control or is a social-evaluative threat (Dickerson et. al. 2004). The main effects of cortisol release include: the elevation of blood glucose levels, inhibition of parts of the immune system, and reduction of inflammation. Cortisol is also necessary for the sympathetic nervous system products, epinephrine and norepinephrine, to induce cardiovascular system changes including increased heart rate, increased rate of respiration, and vasoconstriction (Marieb, 2013). For short periods of time, the physiological "fight or flight" response is beneficial and can improve overall physical and mental function. However, when stress persists for long periods of time it can interfere with mental and physical well-being.

Developing and honing coping practices is a strategy used by many individuals to alleviate the detrimental symptoms of stress. One common practice used to relax, exercise the body, meditate and manage life's stressors is yoga. Yoga, particularly the pose when one lays down on his or her back, called Shavasana, has been shown to significantly improve recovery time from acute stress induced by physical exercise (Bera et al., 1998). Another type of yoga pose is Balasana, commonly known as "Child's pose". In Child's pose, the person is kneeling with the upper body bent forward with arms outstretched (Oxford Dictionary, 2015). It is utilized in yoga practice as a way to stretch and alleviate tension between more strenuous poses. During other forms of exercise, sitting cross-legged is used for the similar purpose of recuperation during arduous tasks. Sitting cross-legged confers a lower heart rate due to the lessened hydrostatic pressure required when the thigh is in a horizontal orientation as compared to standing when the thigh is vertical (Macwilliam, 1933). Despite the prevalence of Child's pose in contemporary practice, there is little research regarding its ability to reduce symptoms of acute mental stress. Is Child's pose more effective than sitting cross-legged at decreasing the physiological indicators of stress following an acute mental stressor?

It has been shown that heart rate and blood pressure are higher in standing and sitting positions due to gravity (Bera et al., 1998). Additionally, under the condition of rest, tilting from erect to supine induced a decrease of heart rate (85.1 to 65.7 bpm), an increase of stroke volume (84.4 to 111.4 ml), and a prolongation of left ventricular ejection time (LVET) (255.8 to 330.3 ms). In our preliminary study, we found that respiration rate increased after an acute mental stressor and then decreased after a period of lying down. Therefore, the negative control body position for this experiment is standing upright without movement and the positive control is laying down. The experimental groups are the participants assuming the Child's pose and those sitting on the floor cross-legged.

It is hypothesized that the participant's physiological indicators of stress will be closer to resting state in Child's pose than sitting cross-legged. Child's pose is expected to result in a lower heart rate because it requires less cardiovascular resistance to gravitational force than sitting up (Bera et al, 1998). Additionally, Child's pose is a relatively more horizontal pose than sitting cross-legged and may lead to a lower heart rate, increase in stroke volume and a prolongation of LVET similar to the effects of the supine position. Respiration rate is expected to decrease as heart rate decreases.

Methods

We tested a total of 28 (14 male; 14 female) people. To obtain measurements from participants, we used *BIOPAC* software *(*MP36, # MP36E1204002783, BIOPAC Systems, Inc., Goleta, CA, USA*)*. For our purposes, we used *BIOPAC* to measure respiratory cycles and further analyze beats per minute (bpm), also called respiratory cycles per minute.

Before participants were tested, the BSL Respiratory Effort Xdcr. (SS5LB, #13116897, BIOPAC Systems, Inc., Goleta, CA, USA), or respiratory belt, was calibrated on a specific researcher for consistency. The respiratory belt was attached externally to the researcher around the chest region just above the nipples. The researcher ensured that the belt was tight enough for proper measurements, but did not affect normal breathing. It is important to note that in any instance in which the respiration belt was used, the researcher or subject being measured had to be instructed to breathe only through his or her nose, as opposed to through his or her mouth for an accurate measurement.

To obtain baseline measurements, participants were fitted with the respiration belt following the same procedure as was used in the calibration process above. The respiration cycle measurements were taken for a 20-second interval. Participants were simultaneously fitted with a 10 Series Upper Arm Blood Pressure Monitor (BP791IT, #2014004275LG, Omron Healthcare Co., Ltd., Lake Forest, IL, USA) on the left arm to obtain blood pressure and heart rate measurements.

Immediately following the measurements, participants were directed to answer 15 questions sampled from the 50 question Wonderlic IQ test. A strict time limit of 3 minutes and 36 seconds was set. This time limit was scaled down from the original 12 minute Wonderlic IQ test. Participants were told that their results would be compared and ranked with the results of their peers. In this experiment, the test was used to trigger an acute stress response (Hollandsworth et al, 1979).

When the test time terminated, participants were told to remain sitting in the chair. Once again, blood pressure and heart rate measurements were taken and respiration cycle measurements were recorded for another 20-second interval. The blood pressure cuff was then removed and a researcher presented an image of one of four body positions for participants to perform. Body positions were equally assigned at random before the start of the experiment. The four body positions tested were standing up (negative control), laying down (positive control), sitting cross-legged, and Child's pose. Participants were instructed to remain in the designated position for exactly 3 minutes and 36 seconds, consistent with the duration of the Wonderlic IQ test. At the end of the specified time, a researcher then returned to the room and specifically instructed participants to remain in the position assigned. The final measurements for blood pressure and heart rate were retrieved and respiration measurements were recorded for a final 20-second interval. These final measurements are termed the "after-pose" measurements, even though the participant is still technically in the specified position while the measurements are being taken. It was recommended that participants remain in the position during the "after-pose" segment, in order to keep the physiological measurements from being changed by movement.

To analyze the data within the software, the researcher highlighted sections of the respiratory cycle graph that represented one cycle of respiration; this was considered "trough-to-trough" on the graph. Data measurements including peak-to-peak difference, bpm, and mean voltage change were obtained. The mean bpm was calculated for each 20-second interval. This analysis was carried out for each subject. The data was used to compare the effects each of the four body positions had on the subject's physiological measurements.

Results

Our initial hypothesis stated that Child's pose, a posture commonly used during yoga practice, would return participants' physiological measurements, including heart rate, systolic and diastolic blood pressure, and respiration rate, more efficiently towards resting state than the cross-legged body position. The results do not support our hypothesis. Figures 1-4 show the mean physiological measurements for heart rate, systolic and diastolic blood pressure, and respiration at baseline, after-stressor, and after-pose. Figure 5 illustrates the differences between the physiological measurements taken after the pose and after the acute mental stressor. Figure 6 shows the differences between measurements taken after the pose and at baseline.

Heart Rate Measurements

A significant difference was found to suggest there is a difference in heart rate as a result of the different poses ($p<0.05$). When comparing after-pose to after-stressor, standing increased heart rate by 12.0 bpm and Child's pose by 6.2 bpm. Conversely, sitting cross-legged decreased heart rate by 8.7 bpm and laying down reduced heart rate by 8.7 bpm (see Figure 5).

Child's pose is not the most effective of the tested poses at returning heart rate to baseline. In comparing baseline heart rate to after-pose heart rate, Child's pose and standing increased heart rate by 9.5 bpm and 10 bpm, respectively. Sitting and laying down decreased heart rate by 1.5 bpm and 9.5 bpm, respectively. Statistical evidence supports that the heart rate after-pose was significantly higher than baseline in Child's pose and standing position, ($p<0.05$). Heart rate after-pose was significantly lower than baseline for laying down, indicating that laying down decreased heart rate below their baseline ($p<0.05$). Sitting cross-legged, there was no significant difference between after-pose and baseline heart rates, indicating that participants who sat cross-legged, on average, returned very close to baseline following the pose ($p>0.05$) (see Figure 1 and Figure 6).

Blood Pressure Measurements

Significant differences were found in the systolic and diastolic blood pressures indicating that the differences seen between the poses were not due to random chance ($p<0.05$). The blood pressure results showed that Child's pose did not reduce blood pressure more than sitting cross-legged. Child's pose increased systolic and diastolic blood pressure by 19 mmHg and 14 mmHg, respectively. However, sitting cross-legged increased the systolic and diastolic blood pressures by just 1 mmHg and 3 mmHg, respectively. Also contrary to our hypothesis, laying down caused a 2 mmHg increase in systolic blood pressure and failed to change diastolic blood pressure. Standing decreased systolic blood pressure by 3 mmHg and increased diastolic blood pressure by 8 mmHg (see Figure 5).

In comparing baseline to after-pose systolic and diastolic blood pressure, Child's pose was least effective at returning blood pressure to baseline measurements. Child's pose resulted in an increased systolic and diastolic blood pressure by 15 mmHg and 11 mmHg, respectively, while sitting cross-legged decreased systolic by 3 mmHg and increased diastolic by 3 mmHg. Laying down increased systolic by 1 mmHg and decreased diastolic by 1 mmHg. Standing decreased systolic by 4 mmHg and increased diastolic by 4 mmHg. Systolic and diastolic blood pressures are significantly higher after-pose compared to baseline for Child's pose ($p<0.05$). For the other three poses, there was no significant difference between after-pose and baseline blood pressure measurements ($p>0.05$) (see Figure 2, Figure 3, and Figure 6).

Respiration Measurements

Minimal significant evidence to suggest the differences in respiration rates are not due to random chance ($p>0.05$). Although there was no significant difference, it was noted that sitting cross-legged decreased respiration rate by 3.65 cycles per minute, whilst Child's pose only decreased respiration rate by 0.11 cycles per minute. There was a mean increase of 3.24 cycles per minute for the participants laying down and a mean decrease of 2.21 cycles per minute for participants standing (see Figure 5).

There is minimal statistical evidence that the differences in respiration from baseline to after-pose are not due to random change in any of the poses ($p>0.05$). However, when comparing after-pose to baseline, Child's pose appeared to be the most effective at decreasing the respiration rate. This decrease was by 1.27 cycles per minute. Standing also decreased the respiration rate, but by only 0.57 cycles per minute. Sitting cross-legged and laying down increased respiration rate by 0.03 and 3.01 cycles per minute, respectively (see Figure 4 and Figure 6).

Discussion

Stress increases heart rate, systolic and diastolic blood pressure and respiration rate, via the induction of the autonomic nervous system. Practicing yoga is one way people attempt to alleviate stress. Particular poses, such as Shavasana pose, which is commonly known as laying down, are more effective at lowering these measurements due to a decrease in hydrostatic pressure of the thigh and decreased cardiovascular resistance against gravity (Bera et al., 1998). We hypothesized that Child's pose would also be able to lower heart rate, blood pressure, and respiration rate due to the recumbent upper half of the body, thus decreasing cardiovascular gravitational resistance.

In our study, there were a considerable amount of assumptions that were made, some more significant than others. The assumption of consistent participant history prior to the study was arguably the most substantial. We assumed participant history, both short and long-term, was consistent across all individuals. Transportation prior to the experiment (e.g. walking, biking, busing, or driving), may have drastically altered the physiological factors measured to be higher or lower than normal. Dietary habits, such as drinking coffee in the morning, may have artificially elevated the participants' measurement values. It was also assumed that time of day was irrelevant to measurements. However, the possibility of stressors throughout an individual's day could influence final measurements. Long-term history such as life-long diet habits, activity patterns, drug use, genetics, and acquired illness or disease may also increase the stochasticity of the measurements. The tension applied to the respiratory belt was assumed to be consistent among all of the participants. The elastic band's tension may have been inconsistent because participants were instructed to put the respiratory belt on themselves, which may have given rise to inconsistent respiratory rate values. We also assumed the acute mental stressor, the Wonderlic IQ test, was a sufficient stressor to illicit significant change in the measured physiological factors.

With considerable assumptions made, we also faced limitations that may have contributed to deviations in our measurements. For some participants, Child's pose was not relaxing possibly because of its restrictive nature on the body, either due to the participant's clothing, or the position itself. Finding a way for the participants to be more comfortable when performing the given position could help avoid undue stress. Concern was also raised as to whether the chosen IQ test was the most effective way to induce acute mental stress. Further analysis showed that there was no statistically significant evidence that the Wonderlic Test correlated to an increase in the physiological stress responses measured including heart rate, blood pressure, and respiration rate ($p>0.05$). A method that induces a stronger and more reliable stress response could provide more indicative results for how body position can relieve that stress. To induce a stronger stress response, a completely different method could be used, or the same test could be used but made more stressful by telling the participants that there will be either reward or penalization based on given answers. Another recommendation for future studies includes taking a fourth measurement after the participant has been out of the assigned resting position for 3 minutes and 36 seconds. This would investigate if certain poses are correlated to bringing physiological measurements closer to baseline once the participant is no longer in the position, indicating that a position has more of a long-term stress-relieving impact. One final consideration to make for future study would be the method for respiration measurement. Instead of being due to random chance, it was concluded that changes in respiration rate are more likely attributed to high variances in respiration measurements between participants. This may be avoided by a more accurate way to adjust the respiration belt or maintain its position and tension on the participant. Future studies conducted in this manner should take these limitations and assumptions into consideration in order to obtain more accurate measurements.

Despite the limitations, we can conclude from our study that body position can have a significant effect on heart rate and blood pressure after the onset of acute mental stress. Participants that performed the laying down position showed the most significant decreases in heart rate. Child's pose increased systolic and diastolic blood pressure more than the other poses, indicating that this position may not be a suitable form of stress relief in terms of physiological indicators. Respiration rates were not significantly affected by any of the positions. Although, the results contradicted our expectations on the effectiveness of Child's pose, we were able to support previous findings that laying down, or Shavasana, is an effective method of reducing the immediate physiological indicators of stress (Bera et al., 1998). Further study is necessary to assess how different body positions can reduce stress. With more investigations, which particular positions are most effective for acute mental stress relief may be determined and implemented for relaxation purposes to improve health and overall human well-being.

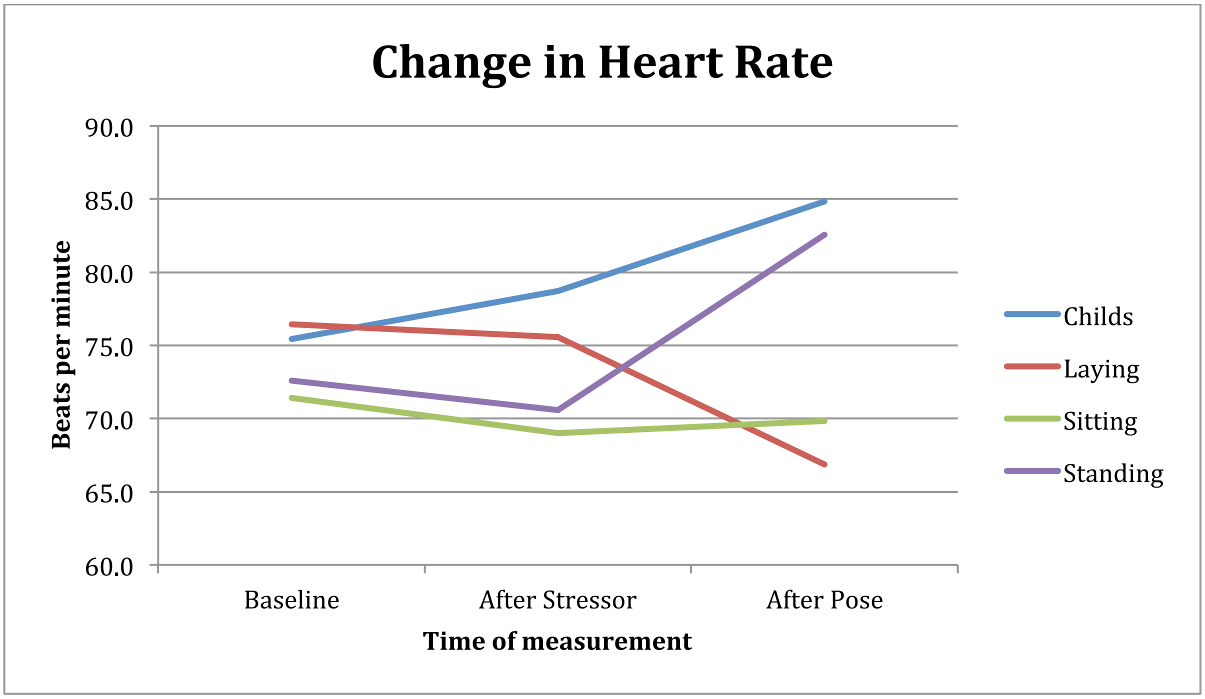

Figure 1. This graph represents the mean heart rates for each pose at baseline, after-stressor, and after-pose in beats per minute.

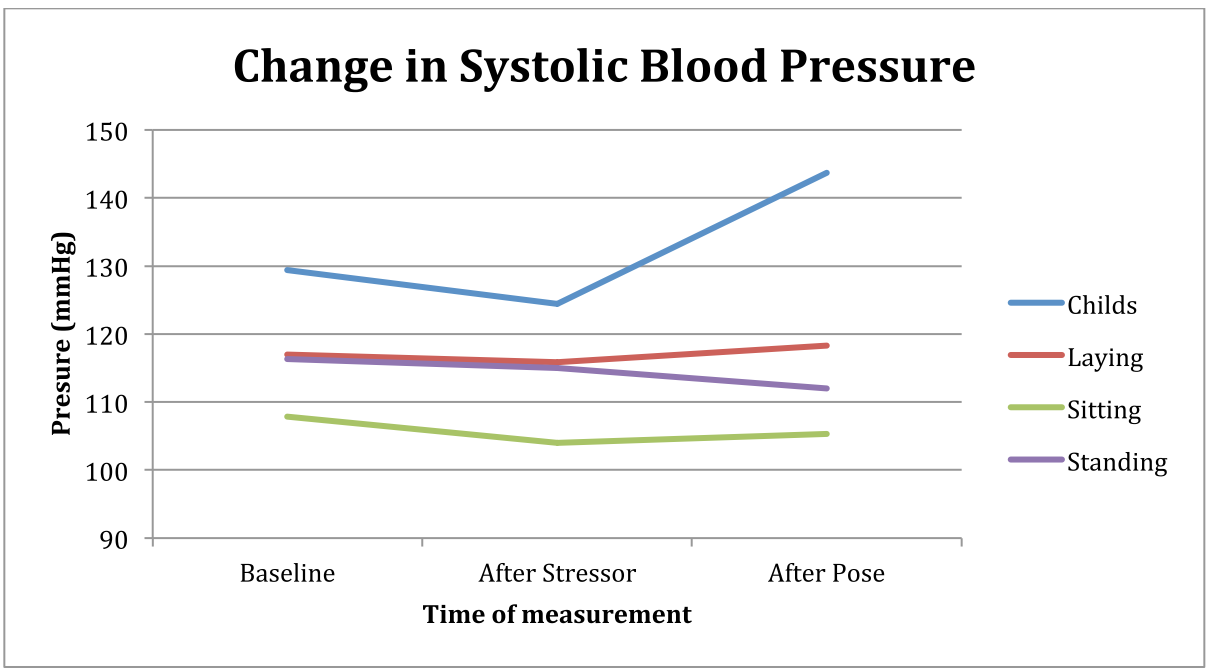

Figure 2. This graph represents the mean systolic blood pressure measurements for each pose at baseline, after-stressor, and after-pose in mmHg.

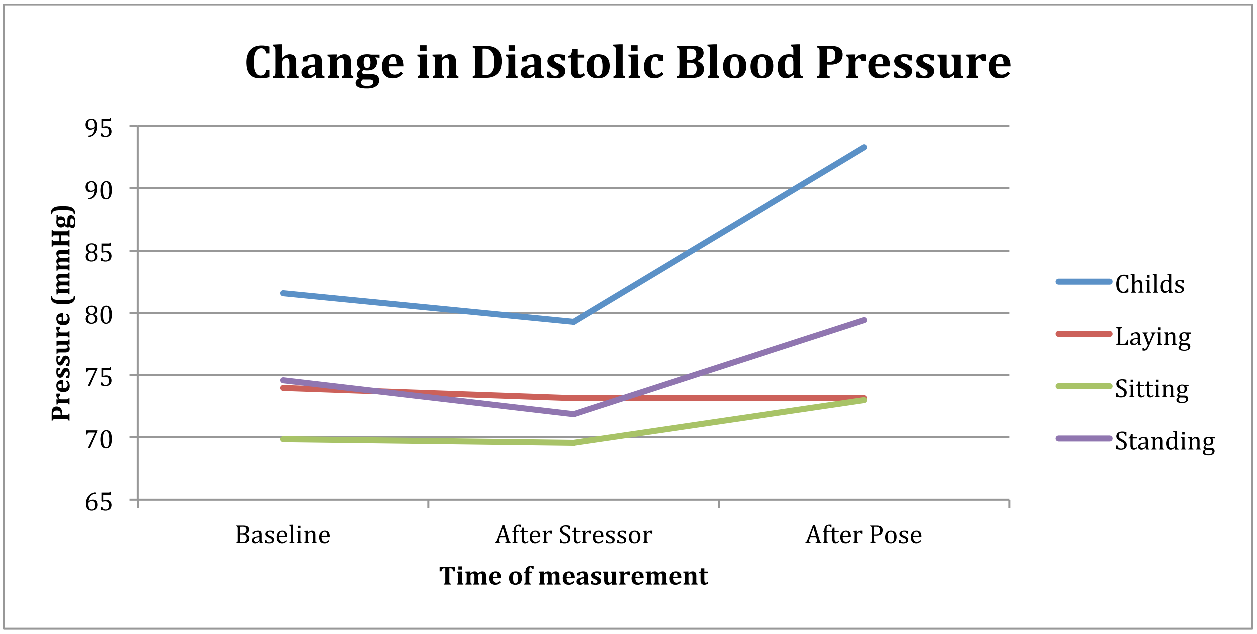

Figure 3. This graph represents the mean diastolic blood pressure measurements for each pose at baseline, after-stressor, and after-pose in mmHg.

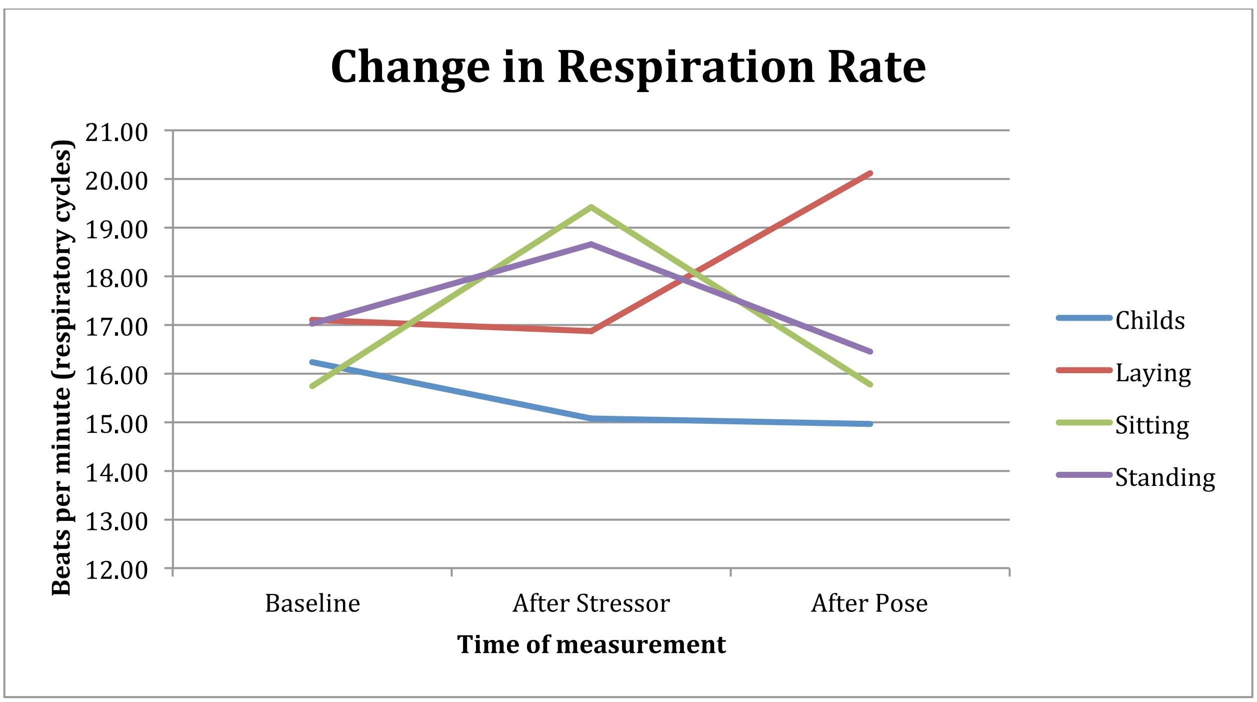

Figure 4. This graph represents the mean respiration measurements for each pose at baseline, after-stressor, and after-pose in beats per minute or respiratory cycles per minute.

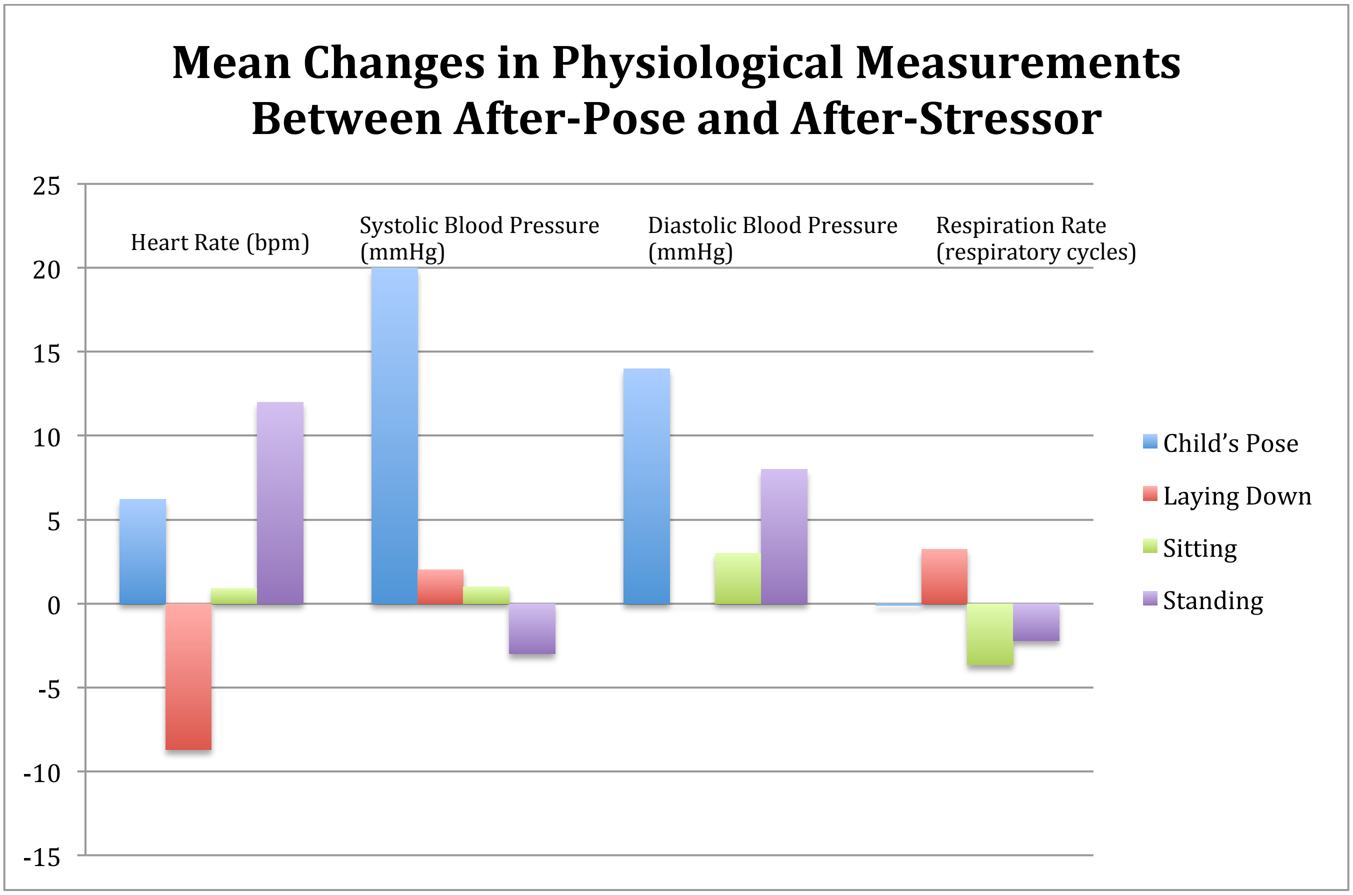

Figure 5. The graph above shows changes in measurement values between after-stressor and after-pose for heart rate, systolic and diastolic blood pressure, and respiration rate. Negatives (-) and positives (+) refer to decreases and increases in the gradient between after-stressor and after-pose measurements, respectively.

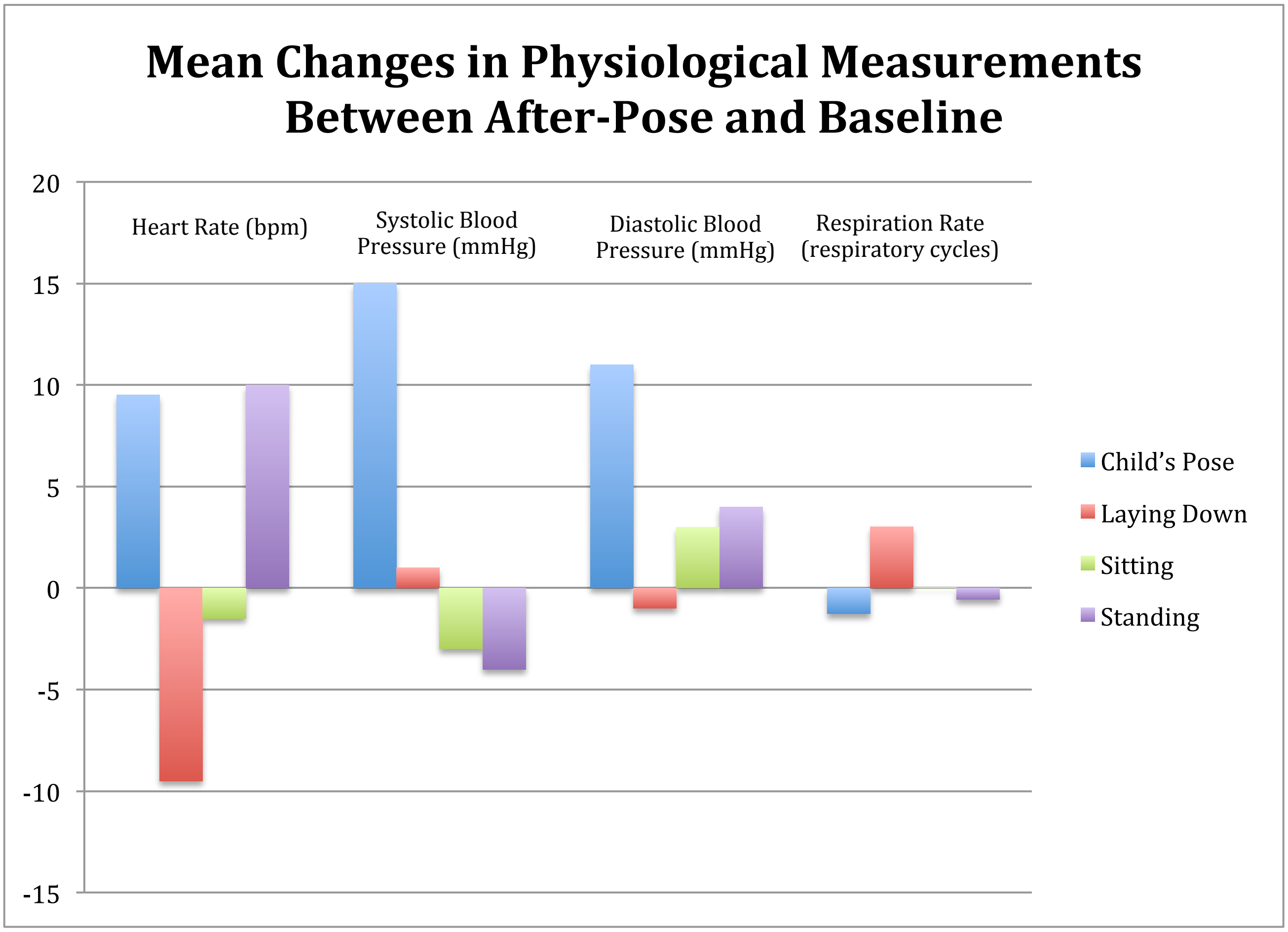

Figure 6. The graph above shows changes in measurement values between baseline and after-pose for heart rate, systolic and diastolic blood pressure, and respiration rate. Negatives (-) and positives (+) refer to decreases and increases in the gradient between baseline and after-pose measurements, respectively.

Acknowledgements
We thank Dr. Andrew Lokuta, Sonalee Barthakur, David Belair, Kristin Byrne for supporting our work.

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