Effects of posture regulation on mood states, heart rate, and test performance in children

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Abstract

This experiment aimed to investigate the effects of seated posture regulation on children's psychological and physiological state and test performance. Thirty-eight boys (mean age: 12.3 ± 0.53 years) participated in both upright and normal posture conditions in a within-participants design. Participants completed a two-dimensional mood scale to measure psychological mood states and performed three tests (calculation, listening comprehension, and word memory). Heart rate, as an index of physiological arousal state, was measured. Upright posture resulted in greater vitality and pleasure, as well as increased heart rate, compared to normal posture. Upright posture also led to significantly higher scores for calculation and listening comprehension tests. Moreover, the increases in vitality level positively influenced increases in calculation and listening comprehension test scores. This study suggests that adopting an upright posture results in maintaining a positive psychological state and improving test performance of children.

Keywords: posture; mood; test performance; self-regulation; body-mind connection

Most children wish to achieve high scores on tests while attending school. To accomplish this, children need to concentrate on their classes and daily studies. This in turn requires optimal regulation of their psychological and physiological states in order to achieve their best performance on tasks. In this study, we focused on the effects of seated posture as a regulation method of psychological and physiological states, and investigated whether posture regulation (i.e., adopting an upright posture) affects test performance in children.

Effects of Psychological Mood States on Task Performance

Several studies have found that psychological mood states can influence test performance amongst children (Hallam, Price, & Katsarou, 2002; Owens, Stevenson, Hadwin, & Norgate, 2012; Ramirez & Beilock, 2011). Accordingly, it can be expected that regulating children's psychological state can lead to higher test performance. Getting high scores and grades could give children the possibility of obtaining better evaluations from their teachers, better grades, getting scholarships, and entering good universities. Therefore, what is the best mood state for task performance?

Positive affect improves task performance (Baron, 1990; Baron & Thomley, 1994; Erez & Isen, 2002), problem solving on tasks (Isen, Daubman, & Nowicki, 1987; Subramaniam, Kounios, Parrish, & Jung-Beeman, 2009), and cognitive function (Fredrickson, 2001). Other studies have suggested that positive affect enhances creativity and facilitates problem-solving amongst children (Greene & Noice, 1988). The arousal level also appears to affect one's ability to perform a task (e.g., Ito et al., 2011; O'Connell et al., 2008). The decline in arousal causes inhibition of attention and cognitive function, resulting in a decrease in performance during tasks conducted in a sitting position (Caldwell, Prazinko, & Caldwell, 2003). Therefore, maintaining a high level of arousal could improve task performances (Khan, Brinkman, & Hierons, 2011). For example, Khan et al. (2011) reported that a relatively high level of arousal was best for tasks performed in a sitting position. Increased arousal has been associated with improved performance on calculation tasks (Ito et al., 2011; Omori, Sawairi, Kubota, & Murakami, 2007), sustained attention tasks (O'Connell et al., 2008). Byun et al. (2014) indicated that the psychological arousal level is positively correlated with cognitive task performance. To our knowledge, only a few studies have investigated whether maintaining a relatively high arousal state heightens children's task performance. However, a reduced level of arousal might become a problem when doing routine tasks such as homework and classroom activities (Gumora & Arsenio, 2002). Therefore, it could be expected that maintaining a high level of arousal leads to high task performance in children. From these studies, it can be predicted that positive and high arousal states are key elements in improving task performance even amongst children while they are in a seated position.

Several researchers consider one's current mood states to be comprised of two dimensions: (1) pleasure (i.e., positive and negative mood), and (2) activation (i.e., high arousal and low arousal) (e.g., Feldman, Barrett & Russell, 1998; Laresn & Diener, 1992; Sakairi, Nakatsuka, & Shimizu, 2013). Sakairi et al. (2013) developed the Two-Dimensional Mood Scale which adopts this two-dimensional model. This scale measures levels of vitality (i.e., high arousal positive state) and stability (i.e., low arousal positive state). Based on these scores, pleasure level and arousal level are calculated. It has been shown that an increase in vitality level is positively correlated with improved task performance (Inagaki, Amemiya, Matsuura, Kim, & Sakairi, 2015). Furthermore, vitality level has been positively correlated with psychological ‘flow’, which is a state of deep absorption in an activity that is intrinsically enjoyable (Csikszentmihalyi, 1990), and is indicative of one's level of concentration on tasks (Yagi & Sakairi, 2009). These findings suggest that up-regulating the vitality level to a high state could improve task performance.

Effects of Posture Regulation on Psychological Mood and Physiological State

Turning now to psychological mood states regulation in real school situations, from an educational perspective, it is better for students to make such adjustments to suit their own needs. Posture regulation is one such method. Previous studies have shown a relationship between posture and the psychological state (e.g., Dael, Mortillaro, & Scherer, 2012; Darwin, 1872,1965). For example, Prior research suggests that changing one's posture can have the effect of changing one's emotional state (e.g., Nair, Sagar, Sollers, Consedine, & Broadbent, 2015; Rossberg-Gempton & Poole, 1993). In Eastern cultures, the practice of Zen and meditation emphasizes the importance of posture as a method of regulating the psychological state (Sakairi, Sugamura, & Suzuki, 2011). Moreover, the effects of the regulating posture have been scientifically demonstrated as well. Good sitting posture has been associated with increased confidence in thought and self-evaluation (Briñol, Petty, & Wagner, 2009), whereas a closed posture has been associated with unpleasant emotion when compared to an open posture (Rossberg-Gempton & Poole, 1993). Wilson and Peper (2004) found that positive thoughts were easier to recall when in an upright posture than when in a slumped posture. In addition to affecting psychological state, posture regulation has been shown to influence physiological factors as well. For example, a standing posture was found to increase EEG arousal relative to a sitting posture, which led to better performance on a psychomotor vigilance task (Caldwell et al., 2003). Adopting an upright seated posture increased heart rate (Sugamura & Shibahara, 2002). Compared to contractive postures, expansive, open postures have been reported to enhance feelings of power, increase testosterone, decrease cortisol, increase risk tolerance (Carney, Cuddy, & Yap, 2010), and improve job interview performance (Cuddy, Wilmuth, Yap, & Carney, 2015). However, it has been pointed out that this research has not been replicated (Ranehill et al., 2015; Ronay, Tybur, Huijstee, & Morssinkhof, 2017). Moreover, the effects of power-poses on confidence and the endocrine system are still controversial. However, after taking other studies into consideration, we assumed it is plausible that posture regulation would have an effect on the physiological state (Nair et al., 2015; Rossberg-Gempton & Poole, 1993).

Based on the current literature, adopting an upright seated posture would be expected to improve levels of psychological vitality and test performance and could easily be implemented in the classroom. Schulman and Shontz (1971) examined the effects of standing, sitting erect, sitting bent, or a supine posture on task performance. Participants attained the highest accuracy rate on the problem solving task while sitting erect. Similarly, Riskind and Gotay (1982) found that sitting erect produced a longer tolerance for unsolvable tasks than sitting slumped, however the authors found no difference in self-reported mood. This absence of posture effects on psychological states may be attributable to the method conducted in the study as well as the unstructured model with which emotions are often assessed (Nair et al., 2015). As a follow-up to this study, Nair et al. (2015) used a measure based on the two-dimensional model described above, and demonstrated that adopting an upright posture helped participants maintain a ‘high arousal positive state’, as well as a ‘positive state’, compared to a slumped posture. In the present study, this high arousal positive state is referred to as *vitality* and the positive state as *pleasure*. Therefore, people who adopt an upright posture would be expected to maintain high levels of vitality and pleasure as components of the same psychological factor. Since upright posture has been shown to increase heart rate (Sugamura & Shibahara, 2002), it may cause physiological activation as well.

However, previous studies have been conducted on adults, and research targeting children are limited. Noda and Tanaka-Matsumi (2008) demonstrated that a classroom-based behavioral intervention package aimed at improving children’s sitting posture enhanced their academic writing productivity, as well as the sitting posture. This suggests the possibility that regulating posture improves task performance even in children. However, the effects of posture regulation on psychological and physiological states have not been investigated to date. Nevertheless, mind-body techniques similar to posture regulation, such as progressive muscle relaxation (Lohaus & Klein-Hessling, 2003) and yoga (Hagen, & Nayar, 2014) have already proven to be effective even for children. Therefore, this study was designed to investigate the applicability of hypotheses of previous studies with adults to children.

For these reasons, an upright posture may be able to achieve the psychological and physiological states that are suitable for improving performance on learning tests. Furthermore, most previous studies have only examined the effects of upright posture by comparing it to slumped posture, which is expected to cause more negative mood states and thereby decrease test performance. Research comparing upright posture to normal posture has been limited. To demonstrate the effectiveness of upright posture in daily situations, it is necessary to compare upright posture and normal posture because it will allow us to see whether upright posture provides any added benefit to normal posture.

Present Study

The purpose of this study was to examine the effects of regulating posture on children's psychological and physiological states as well as their test performance. In this study, we have used posture regulation as a method of adjusting the psychological mood state and physiological states. Calculation, listening comprehension, and word memory tests were used to evaluate the ability required to perform well in a school setting. We hypothesized that adopting an upright seated posture, compared to a normal posture, would enable children to maintain high levels of psychological vitality and pleasure and would lead to an increase in heart rate as an index of physiological arousal. We also predicted that the results of the learning performance tests would improve with upright posture compared to normal posture, and that this improvement would be related to psychological vitality levels.

Method

Participants

Thirty-eight boys (mean age 12.3 ± 0.53 years) with normal hearing and reading ability in Japanese were recruited from Tuskuba City in Ibaraki, Japan. Written informed consent was obtained from all participants and their parents. Previous research that compared upright and slumped posture found a large effect size for upright posture on psychological state and task persistence (Nair et al., 2015). Nair et al. (2015) suggested the possibility that comparing upright and normal postures could result in smaller effect size than comparing upright and slumped posture. Thus, based on a moderate effect size, d = .50, a power analysis was conducted using G*power 3.1, with alpha of .05, and a power of .80, which indicated that 34 participants would be required for a matched pairs test.

Posture Intervention

Since this study targeted children of the developmental stages whose physique, muscle strength, and usual posture are greatly different, forcing them to adopt a particular posture can be stressful for some. Hence, in this study, we adopted a method that participants adopt instructed posture to the extent that they do not feel stress. Then, the validity of the intervention was confirmed by checking to what extent the posture was actually regulated during the experiment. Below are the instruction and definition for posture condition.

Normal posture: participant's usual posture without any instruction.

Instruction: 'sit in the same posture that you always have'

Upright posture: Upright posture: straighten their back. Body angle at 90 degrees (Haruki, 2011).

Instruction: 'straighten your back, and loosen your shoulder muscles'

Usual desks and chairs that are available in Japanese schools (KOKUYO; Osaka, Japan) were used in this study. Each desk and chair size were chosen for each child according to Japanese industrial standards.

＜' INSERT FIGURE 1 ABOUT HERE '＞

Measures

Posture analysis. The posture of each participant was recorded by a video camera from a directly horizontal angle. The videos were cut every 30 seconds, and postures were measured and later analysed at two time periods: before the intervention (baseline) and during the performance tests. A digitizing system (DKH; Tokyo, Japan) was used to digitize manually the locations of three body points: the acromion, vertex of curve of the back, and greater trochanter. The posture analysis method is shown in Figure 2. A straight vertical line (line B) was drawn from the vertex of the curve of the back perpendicular to the straight line that connected the acromion and greater trochanter (line A). The ratio of the lines was then multiplied by 100 (B/A × 100) and used as an index of the curve of the back (Milne & Lauder, 1974). The angle (A') between line A and the horizontal was used to assess the angle of the body.

＜' INSERT FIGURE 2 ABOUT HERE '＞

Psychological mood states. Psychological mood states were assessed with the Two-Dimensional Mood Scale (TDMS; Sakairi et al., 2013). The TDMS was developed as a psychometric scale with eight items measured using mood-expressing words. Each word combined both pleasure and arousal states in the following categories: (a) high arousal-pleasure (energetic, lively); (b) low arousal-displeasure (lethargic, listless); (c) low arousal-pleasure (relaxed, calm); (d) high arousal-displeasure (irritated, nervous). The participants were asked to respond with their present psychological state before the posture intervention (baseline), after the posture intervention, and after the performance tests, using a six-point Likert scale, from 0 = 'not at all' to 5 = 'extremely'. Vitality level, which represents low arousal-displeasure to high arousal-pleasure (−10 to +10 points), and stability level, which represents high arousal-displeasure to low arousal-pleasure (−10 to +10 points), were measured. Based on these scores, pleasure level (vitality + stability: −20 to +20 points) and arousal level (vitality − stability: −20 to +20 points) were calculated. Cronbach's α in this study indicated that the reliabilities of each scale for vitality, stability, pleasure, and arousal were .60, .72, .60, .52, respectively. The alphas in this study had a relatively low value compared to a previous study (Sakairi et al., 2013). However, Oshio (2011) pointed out that alpha does not have a clear criterion but should be reviewed if it was less than .50. Therefore, there was no problem with the alphas in this study. 'Arousal' had a low value of α = .58, also in Sakairi et al. (2013). Sakairi et al. (2013) indicated the reason for this was that 'arousal' is calculated by the difference between 'vitality' and 'stability' (vitality - stability). Feldt and Brennan (1989) pointed out that the reliability of the difference score with a positive correlation inevitably resulted in low values. Moreover, Sperman-Brown's coefficient showed that the reliabilities of each scale for vitality, stability, pleasure, and arousal were .84, .74, .81, .77, respectively. All scales reached a satisfactory level of reliability. It has been demonstrated that the TDMS can be used with children over 12 years of age (IMF; Tokyo, Japan).

Performance tests. Three types of tests were created to assess abilities used in actual school settings. The first was a calculation test to assess the speed of calculation processing. The second was a listening comprehension test to assess whether participants could carefully listen to their teacher. The third was a word memory test to assess the number of words in a text participants could remember. Several versions of each performance tests were created and counterbalanced to alleviate difficulty effects. All three tests were created with the assistance of three teachers currently employed in public elementary and middle schools to ensure content validity.

The calculation tests comprised 66 questions, which included repetitions of the following types of problems: single-digit additions with single-digit solutions (e.g., 3 + 4 =?); single-digit additions with multiple-digit solutions (e.g., 8 + 5 =?); single-digit subtractions with single-digit solutions (e.g., 6 − 2 =?); subtractions which required borrowing (e.g., 16 − 9 =?); single-digit multiplications (e.g., 4 × 9 =?); and divisions with single-digit solutions (e.g., 45 ÷ 5 =?). The participants were given one minute to write down as many responses as they could.

The listening comprehension tests were created with reference to the sixth section of the Kyoto University NX intelligence test (Saccess Bell, Hiroshima, Japan), which has been standardized in Japan (Osaka & Umemoto, 1973). The content of these tests were stories that were spoken in actual classrooms. Voice recordings of currently employed teachers were used. The listening time was approximately 1 minute and 30 seconds, and the comprehension test had 10 questions with a total of 17 possible points.

The word memory tests evaluated memory for commonly used nouns (e.g., book, moon, milk, cat, school). These tests were based on the Japanese language version of a reading span test (Osaka & Osaka, 1994), which consists of a list of sentences. Participants were asked to memorize the nouns in each sentence. To prevent the participants from answering based purely on short-term memory, they were asked to respond to the TDMS after they had read the text. After giving responses on the mood scale, the participants were asked to write as many words as they could recall. The test consisted of 15 questions and the response period was 1 minute. The performance tests are available from the corresponding author.

Physiological measures. Heart rate was continuously measured by the Equivital EQ02

LifeMonitor (Hidalgo; Cambridge, United Kingdom). The validity and reliability of this device as a physiological measurement has been confirmed (Liu, Zhu, Wang, Ye, & Li, 2013). Heart rate was measured for two minutes before the start of the experiment as a baseline and during the performance tests.

Procedure

Before participating in the experiment, the participants were given one day to practice the TDMS and sample performance tests. The experimental sessions were conducted in a laboratory with groups of 3 or 4 students. First, the participants were fitted with life monitors (EQ02) to measure their heart rate. After it was confirmed that heart rate was being measured, participants were given two minutes of rest. Second, the participants were asked to respond to the TDMS to measure their psychological mood states. Third, instructions were given about posture. For the upright posture conditions, the participants were told to 'straighten your back, and loosen your shoulder muscles.' For the normal posture condition, they were told to 'sit in the same posture that you always have.' The participants were also told to maintain the instructed posture throughout the experiment. After it was confirmed by the experimenter that the participants had adopted the designated posture, they were asked to maintain the posture for two minutes, and then to response once again to TDMS. Finally, the performance tests were conducted, in the following order: calculation, listening comprehension, and word memory. To prevent the participants from answering based purely on short-term memory for the word memory tests, the participants were asked to respond first to the TDMS and then to recall as many words as they could remember.

These procedures were conducted in both postures for each participant on different days (i.e., in a within-participants design). The order of the posture condition was counterbalanced to alleviate any ordering effects. The reason for adopting a within-participant design in this study, unlike in previous research (e.g., Nair et al., 2015), was the difficulty in securing the homogeneity of the group which is a prerequisite for between-participants design. This study targeted children in a developmental stage in which individual differences in intelligence, physique, and muscle strength are large. Therefore, the advantage of the design used in this study was that it isolated independent variable responsible for experimental effects, and heightening confidence in the conclusion that posture differences were responsible for observed changes in mood states, heart rate, and tests performance.

Statistical Analysis

Posture (index of the curve of the back and angle of the body) and heart rate were analysed using 2 × 2 ANOVAs for repeated measurements, with the within-participants factors instructed posture condition (normal and upright) and time (baseline and during the performance test). Psychological mood states were analysed using 2 × 3 ANOVAs for repeated measurements, with the within-participants factors instructed posture condition (normal and upright) and time (baseline, after the posture intervention, and after the performance test). Bonferroni corrections were applied to significant F values. To control for Type I error, a MANOVA was used to investigate differences in the numbers of correct answers in the calculation, listening comprehension, and word memory tests between the two posture conditions that had a within-participant design. Differences in scores between posture conditions were calculated separately for each task. A MANOVA with Identity Matrix using these difference scores (3 levels) as dependent variables indicated that all these scores were zero. Statistical analyses above were conducted using SPSS Statistics 22. We conducted the method outlined in Montoya and Hayes (2017), as well as Judd, Kenny, and McClelland (2001) to examine whether psychological mood states mediated changes in test performance by testing the mediation using a two-condition within-participants design. These analyses were conducted using Mplus 7.4. The statistical significance level was set at $p < .05$.

Results

Of the 38 participants, three were not able to participate in both conditions and one did not provide complete data for psychological state; they were excluded from the analyses.

Postural Manipulation

The difference in the curve of the back and the angle of the body at baseline and during the performance tests were compared between instructed posture conditions. There were significant Condition (normal versus upright) × Time (baseline versus during test performance) interaction effects for both the curve of the back and the angle of the body (see Table 1). There were no significant differences in posture between conditions at baseline, but significant differences were found for both the curve of the back and the angle of the body during the performance tests ($p < .001$). There was a larger curve in the back and the body leaned farther forwards in the normal condition than in the upright condition during the performance tests. These results are consistent with the definition of a good posture, which is ‘their back is straightened, and the body angle is close to 90 degrees’ (Haruki, 2011). Therefore, the effectiveness of the posture manipulation was confirmed.

＜’ INSERT TABLE 1 ABOUT HERE ’＞

Psychological Mood States

In order to examine the influence of posture on mood states, 2 (Condition: normal and upright) × 3 (Time: baseline, after posture intervention, and after performance tests) ANOVAs were conducted for vitality, stability, pleasure, and arousal levels from the TDMS (see Table 2, Figure 3). There were significant main effects of condition for vitality and pleasure, and significant main effects of time for stability and a marginally significant effect of time for pleasure and arousal. There were a significant Condition × Time interactions for vitality and arousal and a marginally significant interaction for pleasure. All psychological mood states did not differ between the upright condition and the normal condition at baseline. After the postural intervention, vitality was significantly higher in the upright condition than in the normal condition, $F(1, 33) = 12.19.$, $p = .001$, $\eta_p^2 = .27$. Vitality was also significantly higher in the upright condition after the performance test, $F(1, 33) = 8.56$, $p = .006$, $\eta_p^2 = .21$. Stability decreased only in the normal condition from after the postural intervention to after the performance test (*ps* = .006). Pleasure was marginally significantly higher in the upright condition compared to the normal condition after the postural intervention, $F(1, 33) = 3.52$, $p = .070$, $\eta_p^2 = .10$, and it was significantly higher after the performance test, $F(1, 33) = 8.54$, $p = .006$, $\eta_p^2 = .21$. Arousal was significantly higher in the upright condition than in the normal condition after the postural intervention, $F(1, 33) = 5.26$, $p = .028$, $\eta_p^2 = .14$.

＜’ INSERT TABLE 2 and FIGURE 3 ABOUT HERE ’＞

Test Performance

To examine the influence of posture on test scores, An MANOVA tested for differences in scores between the posture conditions for the calculation, listening comprehension, word memory tests, and order of posture (normal first vs. upright first). Since the MANOVA showed no effects of posture order, $F(3, 30) = .80$, $p = .50$, Pillai's trace = .074, the order factor was removed from the model. The results showed significant effects of posture conditions on test performance, $F(3, 31) = 3.60$, $p = .024$, Pillai's trace = .26. As posthoc tests, an ANOVA was conducted for each variable, checking for differences in test scores between posture conditions of each test score. Results indicated significantly higher scores in the upright posture condition compared to the normal posture condition in calculation tests, $F(1, 33) = 6.91$, $p = .013$. Moreover, the upright posture showed significantly higher scores than the normal posture in listening comprehension tests, $F(1, 33) = 5.32$, $p = .028$. However, there was no significant difference between upright and normal posture conditions in word memory test scores, $F(1, 33) = 2.05$, $p = .16$. These results indicate that adopting an upright posture improved children’s calculation and listening comprehension performance, relative to a normal posture. Figure 4 displays all test scores respectively.

＜’ INSERT FIGURE 4 ABOUT HERE ’＞

Are Psychological Mood States Responsible for Improved Test Performance?

To answer this question, mediation analyses were conducted for within-subject designs by considering the posture conditions as an independent variable (X), the psychological mood states after the posture intervention (before the performance test) as a mediator (M), and test performance as the dependent variable (Y). Judd et al. (2001) first require confirming if there is a significant difference in M between the two conditions. Second, it is necessary to examine whether there is a significant difference in Y between the two conditions. In this study, only vitality levels satisfy the first criterion of M, and calculation tests and listening comprehension tests meet the second criterion of Y. Therefore, we examined whether the vitality level mediated calculation and listening comprehension test performance. Judd et al. (2001) also indicated that full mediation could be established by a significant coefficient for the mediator following a non-significant coefficient for the intercept term, which indicates that differences in psychological mood states would predict all the difference in tests performance. The results of this study showed that the difference in vitality levels significantly predicted calculation ($z = 2.91$, $p = .004$) and listening comprehension tests performance ($z = 2.19$, $p = .028$), whereas the intercept coefficient was not different from zero ($z = 1.05$, $p = .30$ and $z = 1.01$, $p = .31$). These results suggest that difference in vitality levels fully mediated the effect of posture changes on calculation and listening comprehension test performance. In other words, this study supports the notion that an upright posture positively influences vitality levels and thus improves test performance.

Heart Rate Response

Due to limitations in the number of the heart rate monitoring equipment, we were unable to obtain data from all participants. Therefore 22 participants were randomly chosen, and their heart rate data were evaluated. There was a significant Condition × Time interaction for heart rate, $F(1, 21) = 5.77$, $p = .026$, $\eta_p^2 = .22$. There was no significant difference between the two baseline conditions (normal posture baseline: $M = 82.92$, $SE = 2.36$; upright posture baseline $M = 82.92$, $SE = 1.98$). Thus, the significant interaction seems to have resulted from increased heart rate with the upright posture from baseline to the performance tests, ($M = 85.29$, $SE = 2.08$), $F(1, 21) = 13.31$, $p = .002$, $\eta_p^2 = .39$, but with no corresponding change in normal posture ($M = 83.32$, $SE = 2.21$), $F(1, 21) = .25$, $p = .62$. The results indicated that adopting an upright posture increased heart rate.

Discussion

The objective of this study was to examine the influence of posture regulation on children's psychological and physiological states as well as their scores on learning performance tests. To our knowledge, this study presents the first experimental evidence for positive effects of upright seated posture on mood states, physiological arousal and test performance compared to normal seated posture in children. Adopting an upright posture enabled participants to maintain vitality and pleasure, as well as physiological arousal at high levels. The upright posture also improved calculation and listening test performance. Moreover, this improvement in test performance was fully mediated by the increase in vitality levels.

Explanation of Findings

Only a few previous studies have examined the effects of seated upright posture on psychological mood states. Nair et al. (2015) showed that upright participants reported more positive and higher arousal states relative to those with a slumped posture. The present study extended Nair et al.'s results by demonstrating that upright posture has a greater positive impact on vitality and pleasure level than normal posture as well. Furthermore, this is one of the first studies to show that holding an upright posture can have positive effects on the mood states in children. Taken together, the current data support the notion that upright posture is an effective method of regulating one's psychological state in daily life, including school settings.

The mechanisms of the effects of changing postures on psychological mood states remain unclear, but possible candidates are the effects of physiological change. In this study, adopting an upright posture increased heart rate which is a result that is consistent with previous findings (Sugamura & Shibahara, 2002). Increase in the heart rate was assumed to be caused by an increase in muscle activity in the trunk that affected autonomic nervous activity and neuroendocrine levels (Caldwell et al., 2003; Nair et al., 2015). Prior research suggests that physiological and psychological states are closely related (Kreibig, 2010), and therefore, it is possible to postulate that changes in physiological states due to posture regulation would affect a person's psychological state. The increase in heart rate could have been due to an increase in fatigue, however in this study, upright posture was assumed not to cause a state of fatigue because the average heart rate in the upright posture condition was 85.3 ± 2.1 (bpm), which is within the range of very light state (Borg, 1982). Furthermore, taking into account the results showing that psychological vitality and pleasure levels of the participants were higher in the upright posture compared to the normal posture, the increased heart rate in the upright posture was expected to improve the low arousal and have a positive influence on the psychological state. However, one's psychological state can be influenced not only by one's physiological state but also by cognitive factors, such as proprioceptive stimulation from postures which can, in turn, affect emotion through a process of self-perception (Riskind & Gotay, 1982). Additional research is required to clarify the specific mechanisms involved.

Calculation, listening comprehension, and vocabulary memory tests were used to examine the effects of regulating posture on learning performance in a school setting. The current study showed that taking an upright posture produced better scores for calculation and listening comprehension tests than sitting in a normal posture. Although some previous studies have shown that an upright posture improves performance in problem solving (Schulman & Shontz, 1971), and motivational tasks (Riskind & Gotay, 1982) amongst adult subjects, this study presents evidence that an upright posture amongst children improves the performance of tasks required in a school setting as well. Furthermore, posture-related differences in vitality levels measured by the TDMS before the performance test fully mediated the effects of upright posture on both calculation and listening comprehension performance. Therefore, it is postulated that posture-related psychological mood change may enhance test performance. This contention is supported by findings suggesting that regulating psychological mood states influence task performance (e.g., Byun et al., 2014; Khan et al., 2011) and an increase in vitality levels is positively correlated with an increase in task performance (Inagaki et al., 2015). In this study, a normal posture had a low vitality level. On the other hand, holding an upright posture resulted in maintaining high vitality level. The effect of the upright posture observed in this study is consistent with the results of Nair et al. (2015). In brief, continuously holding a normal seated posture during task performance could lead to a decrease in arousal and a positive psychological state, which usually results in a decrease in performance (Khan et al., 2011). However, adopting an upright posture maintains vitality at a relatively high level, suggesting that an upright posture produces positive conditions for performance tasks. Consequently, although there was no significant difference in scores on the word memory test between posture conditions, the present results nevertheless support the notion that an upright seated posture maintains children's psychological mood states in a suitable condition for task performance, resulting in improved performance in tests.

On the other side, there are researches who maintain that posture manipulation does not affect either the psychological or the physiological state. Therefore a consensus remains to be reached. For example, Carney et al. (2010) demonstrated that high-power postures could cause improvements in testosterone, feelings of power, increased risk-taking and decreased cortisol. However, other studies have indicated this result could not be reproduced (Ranehill et al., 2015; Ronay, Tybur, Huijstee, & Morssinkhof, 2017). However, in this study, unlike in the studies on power poses, the time holding the upright posture was relatively long (approximately 15 minutes) compared to previous studies (2 - 6 minutes). Moreover, the posture was maintained even during task performance. Therefore, it is considered that the effect of posture regulation on mood states, physiological states, and test performance was demonstrated by this study.

Limitations and Suggestions for Future Research

Several limitations of the present study require consideration. First, only male participants aged 12 – 13 were included in this study. Although it is assumed that similar results would be obtained for female participants given the lack of sex differences found in the effects of posture regulation on task performance in a previous study (Schulman & Shontz, 1971), future investigations should investigate whether posture regulation has a positive effect on the psychological and physiological states and test performance of girls. Furthermore, it would also be worthwhile to examine whether posture regulation is effective for children in a variety of ages and developmental stages.

Second, simple verbal instructions were used as a posture manipulation to examine the effect of posture regulation by the intervention method that can be easily applied in schools, Therefore, it might be difficult to eliminate the demand effect, which is that participants simply tried harder when they were told to adopt an upright posture. However, Rossberg-Gempton and Poole (1993) have investigated the degree of expectation when instructed to hold a posture (e.g., ‘Would you please hold this position for ‘x’ seconds?’ or ‘When most people adopt this posture, they feel this positively’) could affect subjects’ emotional experiences. They reported that expectancy variables did not affect the psychological state, suggesting that the experimenter’s expectancy or demand characteristics could not affect posture induced mood changes. Therefore, it is expected that the influence of demand effect in this study was relatively small. Nevertheless, further research adopting procedures for minimizing demand effects, such as using a cover story or posture regulation by adjusting the desk or chair would have to be conducted to investigate the effect of pure posture regulation on task performance.

Third, This study was designed for application in actual school settings. Nevertheless, many factors need to be considered before applying experimental findings from the laboratory to classrooms. For example, in a real class, teachers have to deal with larger numbers of students. Therefore, more careful confirmation regarding whether students' postures are improved, or if students feel comfortable are necessary. Also, we only focused on the effects of adjusting posture on mood states and test performance over a relatively short time period. Since actual school classes and homework often extend over a longer period of time, it would be necessary to investigate the long-term duration of the posture regulation effects. A previous study found that a six-week intervention to improve children's sitting posture enhanced their academic writing productivity (Noda & Tanaka-Matsumi, 2009), therefore it would be worthwhile to examine whether a long-term intervention of posture regulation would enhance children's motivation for study, their exam results, or their school record.

Conclusion

In conclusion, the results suggest that adjusting children's posture may lead to better psychological and physiological states which, in turn, may enable them to perform better on tasks in a school setting. These findings are valuable given that the adjustment of sitting posture does not require space, time, or other restrictions, and it can, therefore, easily be applied in a real-world school setting.

Baron, R. A. (1990). Environmentally Induced Positive Affect: Its Impact on Self-Efficacy, Task Performance, Negotiation, and Conflict. *Journal of Applied Social Psychology*, *20*(5), 368-384. doi:10.1111/j.1559-1816.1990.tb00417.x

Baron, R. A., & Thomley, J. (1994). A Whiff of Reality Positive Affect as a Potential Mediator of the Effects of Pleasant Fragrances on Task Performance and Helping. *Environment and Behavior*, *26*(6), 766-784. doi:10.1177/0013916594266003

Borg, G. A. (1982). Psychophysical bases of perceived exertion. *Medicine and science in sports and exercise*, *14*(5), 377-381. doi:10.1249/00005768-198205000-00012

Briñol, P., Petty, R. E., & Wagner, B. (2009). Body posture effects on self-evaluation: A self-validation approach. *European Journal of Social Psychology*, *39*(6), 1053-1064. doi:10.1002/ejsp.607

Byun, K., Hyodo, K., Suwabe, K., Ochi, G., Sakairi, Y., Kato, M., Dan, I., & Soya, H. (2014). Positive effect of acute mild exercise on executive function via arousal-related prefrontal activations: an fNIRS study. *Neuroimage*, *98*, 336-345. doi:10.1016/j.neuroimage.2014.04.067

Caldwell, J. A., Prazinko, B., & Caldwell, J. L. (2003). Body posture affects electroencephalographic activity and psychomotor vigilance task performance in sleep-deprived subjects. *Clinical Neurophysiology*, *114*(1), 23-31. doi:10.1016/S1388-2457(02)00283-3

Carney, D. R., Cuddy, A. J., & Yap, A. J. (2010). Power posing brief nonverbal displays affect neuroendocrine levels and risk tolerance. *Psychological Science*, *21*(10), 1363-1368. doi:10.1177/0956797610383437

Csikszentmihalyi, M. (1990). *Flow: The psychology of optimal performance*. New York: Cambridge University Press.

Cuddy, A. J., Wilmuth, C. A., Yap, A. J., & Carney, D. R. (2015). Preparatory Power Posing Affects Nonverbal Presence and Job Interview Performance. *Journal of Applied Psychology*, *100*(4), 1286-1295. doi:10.1037/a0038543

Dael, N., Mortillaro, M., & Scherer, K. R. (2012). Emotion expression in body action and posture. *Emotion*, *12*(5), 1085. doi:10.1037/a0025737

Darwin, C. (1965). *The expression of the emotions in man and animals*. Chicago & London: University of Chicago press. (Original work published 1872)

Erez, A., & Isen, A. M. (2002). The influence of positive affect on the components of expectancy motivation. *Journal of Applied Psychology*, *87*(6), 1055-1067. doi:10.1037/0021-9010.87.6.1055

Feldman Barrett, L., & Russell, J. A. (1998). Independence and bipolarity in the structure of current affect. *Journal of personality and social psychology*, *74*(4), 967. doi:10.1037/0022-3514.74.4.967

Feldt, N. S., & Brennan, R. L. (1989). Reliability. In R. L. Lin (Ed.), Educational measurement (3rd ed.). New York: Macmillan, pp. 105-146.

Fredrickson, B. L. (2001). The role of positive emotions in positive psychology: The broaden-and-build theory of positive emotions. *American psychologist*, *56*(3), 218-226. doi:10.1037/0003-066X.56.3.218

Gumora, G., & Arsenio, W. F. (2002). Emotionality, emotion regulation, and school performance in middle school children. *Journal of school psychology*, *40*(5), 395-413. doi:org/10.1016/S0022-4405(02)00108-5

Greene, T. R., & Noice, H. (1988). Influence of positive affect upon creative thinking and problem solving in children. *Psychological reports*, *63*(3), 895-898. doi:10.2466/pr0.1988.63.3.895

Hagen, I., & Nayar, U. S. (2014). Yoga for children and young people's mental health and well-being: research review and reflections on the mental health potentials of yoga. *Frontiers in psychiatry*, *5*, 1-6. doi:10.3389/fpsyt.2014.00035

Hallam, S., Price, J., & Katsarou, G. (2002). The effects of background music on primary school pupils' task performance. *Educational studies*, *28*(2), 111-122. doi:10.1080/03055690220124551

Haruki, Y. (2011). Ugokigakokorowotsukuru [Motion makes mind]. Tokyo: Kodansha.

Inagaki, K., Amemiya, R., Mtsuura, Y., Kim, E., & Sakairi, Y. (2015, September). *Psychological "vitality level" measured by Two-Dimensional Mood Scale predicts task performance*. Poster session presented at the meeting of the Japanese Association of Health Psychology, Tokyo, Japan.

Isen, A. M., Daubman, K. A., & Nowicki, G. P. (1987). Positive affect facilitates creative problem solving. *Journal of personality and social psychology*, *52*(6), 1122-1131. doi:10.1037/0022-3514.52.6.1122

Ito, M., Nakazawa, T., Asahina, S., Ochiao, H., Suzuki, Y., & Ymamoto, T. (2011). The effect of stretching on performance of calculation task and scale of mood states. *Bulletin of Sports and Physical Education Research Center Hosei University, 29*, 19-28. Retrieved from http://hdl.handle.net/10114/6316

Judd, C. M., Kenny, D. A., & McClelland, G. H. (2001). Estimating and testing mediation and moderation in within-subject designs. *Psychological methods*, *6*(2), 115-134. doi:10.1037/1082-989X.6.2.115

Khan, I. A., Brinkman, W. P., & Hierons, R. M. (2011). Do moods affect programmers' debug performance?. *Cognition, Technology & Work*, *13*(4), 245-258. doi:10.1007/s10111-010-0164-1

Kreibig, S. D. (2010). Autonomic nervous system activity in emotion: A review. *Biological psychology*, *84*(3), 394-421. doi:10.1016/j.biopsycho.2010.03.010

Larsen, R. J., & Diener, E. (1992). Promises and problems with the circumplex model of emotion. In M. S. Clark (Ed.), *Review of personality and social psychology: Emotion*. Vol. 13 (pp. 25-59). Thousand Oaks: Sage.

Liu, Y., Zhu, S. H., Wang, G. H., Ye, F., & Li, P. Z. (2013). Validity and reliability of multiparameter physiological measurements recorded by the Equivital LifeMonitor during activities of various intensities. *Journal of occupational and environmental hygiene*, *10*(2), 78-85. doi:10.1080/15459624.2012.747404

Lohaus, A., & Klein-Hessling, J. (2003). Relaxation in children: Effects of extended and intensified training. *Psychology and Health*, *18*(2), 237-249. doi:10.1080/0887044021000057257

Nair, S., Sagar, M., Sollers, J. 3rd., Consedine, N., & Broadbent, E. (2015). Do slumped and upright postures affect stress responses? A randomized trial. *Health Psychology, 34*(6), 632-641. doi:10.1037/hea0000146

Noda, W., & Tanaka-Matsumi, J. (2009). Effect of a classroom-based behavioral intervention package on the improvement of children's sitting posture in Japan. *Behavior modification*, *33*(2), 263-273. doi:10.1177/0145445508321324

Milne, J. S., & Lauder, I. J. (1974). Age effects in kyphosis and lordosis in adults. *Annals of human biology*, *1*(3), 327-337. doi:10.1080/03014467400000351

Montoya, A. K., & Hayes, A. F. (2017). Two-condition within-participant statistical mediation analysis: A path-analytic framework. *Psychological Methods*, *22*(1), 6-27. doi:10.1037/met0000086

O'Connell, R. G., Bellgrove, M. A., Dockree, P. M., Lau, A., Fitzgerald, M., & Robertson, I. H. (2008). Self-alert training: Volitional modulation of autonomic arousal improves sustained attention. *Neuropsychologia*, *46*(5), 1379-1390. doi:10.1016/j.neuropsychologia.2007.12.018

Omori, H., Sawairi, M., Kubota, T., & Murakami, S. (2007). Influence of exercise on Performance of calculation task and study of mechanism by brain function measurement. *Journal of the school of Marine Science and Technology, Tokai University, 5*(5), 47-54. Retrieved from http://www2.scc.u-tokai.ac.jp/www3/kiyou/pdf/2007vol5_2/oomori.pdf

Osaka, M., & Osaka, N. (1994). Working memory capacity related to reading: measurement with the Japanese version of reading span test. *The Japanese journal of psychology*, *65*(5), 339-345. doi:10.4992/jjpsy.65.339

Osaka, A., & Umemoto, A. (1973). *Shintei Kyodai NX 15 dai nihan [Kyoto University new NX 15 intelligence test]*. Tokyo: Taisei Shuppan.

Oshio, A. (2011). SPSS to Amos niyoru shinri/chosa datakaiseki dainihan — inshibunseki/kyoubunsankouzoubunseki made [Psychological and survey data were analyzed by SPSS and Amos (2nd) — up to factor analysis and covariance structure analysis]. Tokyo: Tokyo Tosho.

Owens, M., Stevenson, J., Hadwin, J. A., & Norgate, R. (2012). Anxiety and depression in academic performance: An exploration of the mediating factors of worry and working memory. *School Psychology International*, *33*(4), 433-449. doi:10.1177/0143034311427433

Ranehill, E., Dreber, A., Johannesson, M., Leiberg, S., Sul, S., & Weber, R. A. (2015). Assessing the robustness of power posing: No effect on hormones and risk tolerance in a large sample of men and women. *Psychological Science*, *26*(5), 653-656. doi:10.1177/0956797614553946

Ramirez, G., & Beilock, S. L. (2011). Writing about testing worries boosts exam performance in the classroom. *science*, *331*(6014), 211-213. doi:10.1126/science.1199427

Riskind, J. H., & Gotay, C. C. (1982). Physical posture: Could it have regulatory or feedback effects on motivation and emotion?. *Motivation and Emotion*, *6*(3), 273-298. doi:10.1007/BF00992249

Ronay, R., Tybur, J. M., van Huijstee, D., & Morssinkhof, M. (2017). Embodied power, testosterone, and overconfidence as a causal pathway to risk-taking. *Comprehensive Results in Social Psychology*, *2*(1), 28-43. doi:10.1080/23743603.2016.1248081

Rossberg-Gempton, I., & Poole, G. D. (1993). The effect of open and closed postures on pleasant and unpleasant emotions. *The Arts in psychotherapy*, *20*(1), 75-82. doi:10.1016/0197-4556(93)90034-Y

Sakairi, Y., Sugamura, G., & Suzuki, M. (2011). Asian Meditation and Health. In Friedman, H. S. (Ed.). *The Oxford handbook of health psychology* (pp. 848-859). Oxford and New York: Oxford University Press.

Sakairi, Y., Nakatsuka, K., & Shimizu, T. (2013). Development of the Two-Dimensional Mood Scale for self-monitoring and self-regulation of momentary mood states. *Japanese Psychological Research*, *55*(4), 338-349. doi:10.1111/jpr.12021

Schulman, D., & Shontz, F. C. (1971). Body posture and thinking. *Perceptual and motor skills*, *32*(1), 27-33. doi:10.2466/pms.1971.32.1.27

Subramaniam, K., Kounios, J., Parrish, T. B., & Jung-Beeman, M. (2009). A brain mechanism for facilitation of insight by positive affect. *Journal of Cognitive Neuroscience*, *21*(3), 415-432. doi:10.1162/jocn.2009.21057

Sugamura, G., & Shibahara, S. (2002). Shisei [Posture]. In Haruki Y. (Ed.), *Embodied psychology* (pp. 91-134). Tokyo: Kawashima Shoten.

Wilson, V. E., & Peper, E. (2004). The effects of upright and slumped postures on the recall of positive and negative thoughts. *Applied psychophysiology and biofeedback*, *29*(3), 189-195. doi:10.1023/B:APBI.0000039057.32963.34

Yagi, T., & Sakairi, Y. (2009). Subjective Arousal and Experience of Flow during Positive Sports Events. *The Japanese Journal of Health Psychology*, *22*(1), 24-32. doi:10.11560/jahp.22.1_24

Table 1. Changes of Body Posture by Postural Intervention.

Posture	Condition	Time point	*M*	[95% CI]	*df*	*F*	*p*	η_p^2
Curve of the back	Normal	Baseline	33.54	[31.84, 35.24]	1.00	114.48	< .001	.78
		Performance test	34.31	[32.77, 35.85]				
	Upright	Baseline	34.55	[32.86, 36.23]				
		Performance test	25.84	[24.24, 27.43]				
Angle of the body	Normal	Baseline	85.11	[82.67, 87.55]	1.00	28.85	< .001	.47
		Performance test	82.18	[79.64, 84.73]				
	Upright	Baseline	82.56	[79.37, 85.75]				
		Performance test	88.46	[85.80, 91.11]				

Notes: CI = confidence interval. Changes of body posture (curve of the back and angle of the body) in both Normal and Upright condition before the postural intervention (baseline) and after the intervention (during the performance tests) are shown. Results of Condition × Time interaction tests are shown.

Table 2. Effects of Postural Intervention, Time, and Posture × Time Interactions on Psychological Mood States.

	df	*F*	*p*	η_p^2
Vitality				
Posture	1.00	7.84	.008	.19
Time	1.56	0.44	.60	.01
Posture × Time	1.55	5.60	.010	.15
Stability				
Posture	1.00	1.00	.33	.03
Time	2.00	6.04	.004	.16
Posture × Time	2.00	1.52	.23	.04
Pleasure				
Posture	1.00	5.62	.024	.15
Time	2.00	2.87	.064	.08
Posture × Time	2.00	2.79	.069	.08
Arousal				
Posture	1.00	0.90	.35	.03
Time	1.52	3.25	.060	.09
Posture × Time	2.00	4.06	.022	.11

Notes: Posture is normal and upright. Time is from baseline to after the postural intervention, to after the performance tests.

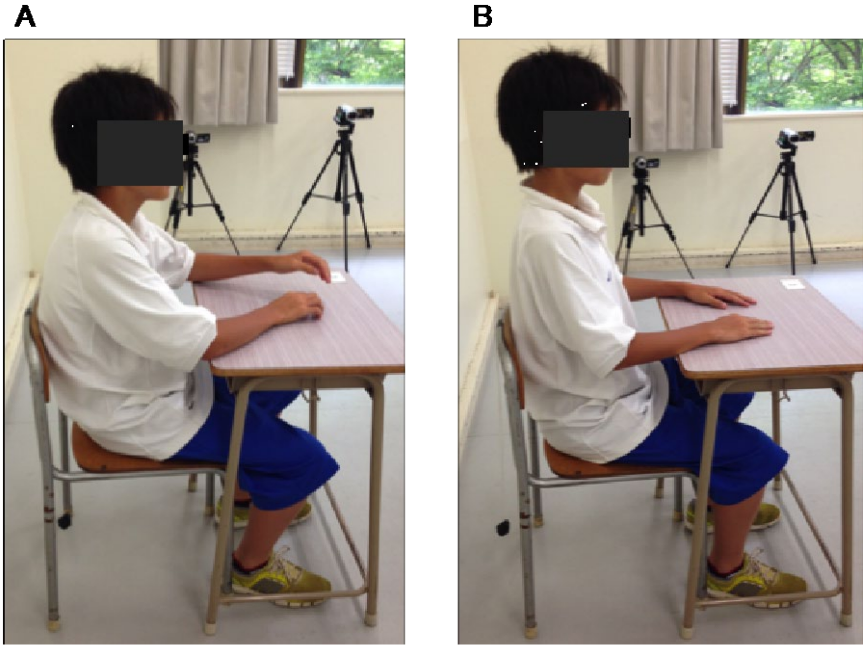

Figure 1. Postural condition. (A) Images of Normal posture. (B) Images of Upright posture.

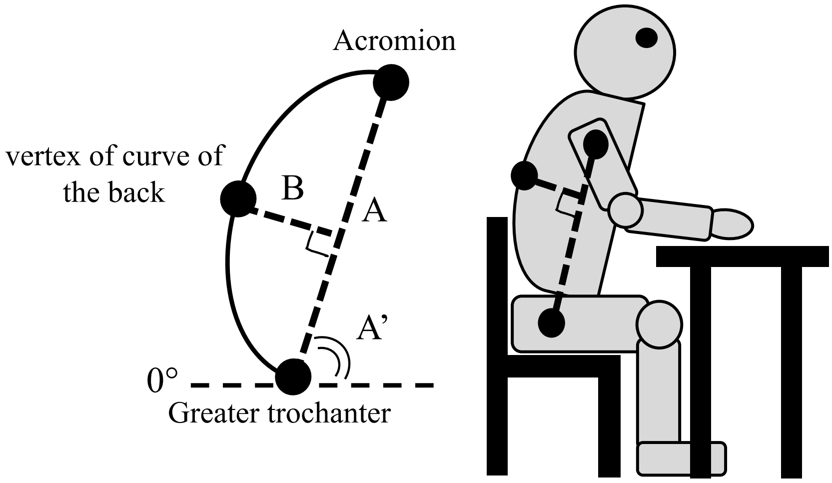

Figure 2. Method of posture analysis. The curve of the back was calculated as B/A×100. The angle of the body was evaluated by angle A'.

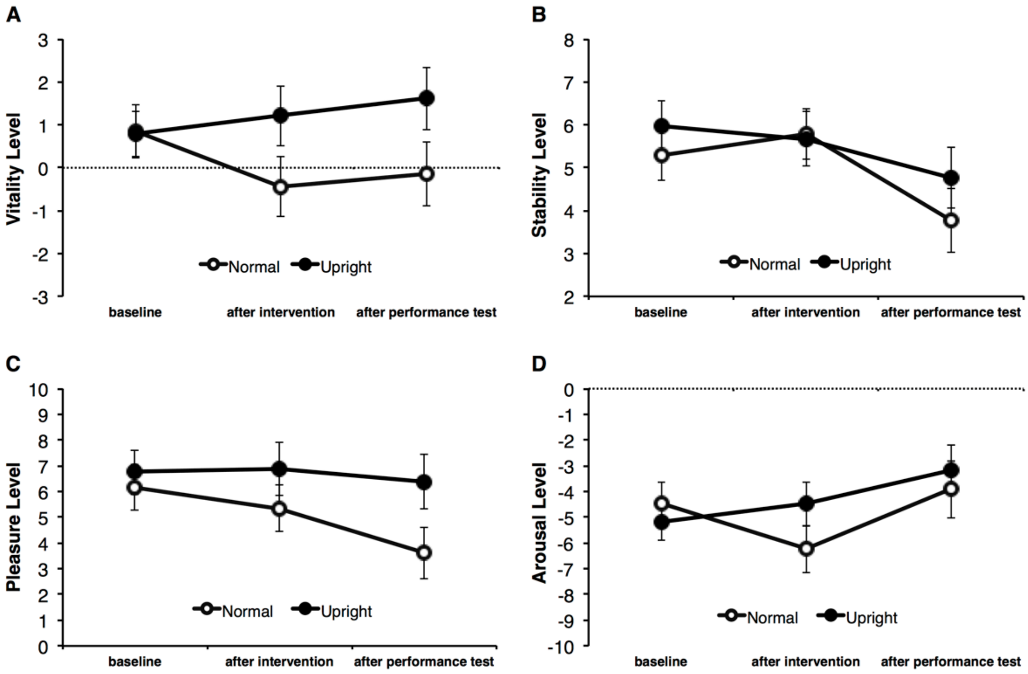

Figure 3. Mean scores for four psychological mood states in Normal and Upright posture conditions before the posture intervention (baseline), after posture intervention (after intervention), and after the performance test: (A) vitality level, (B) stability level, (C) pleasure level, and (D) arousal level. Error bars represent standard errors.

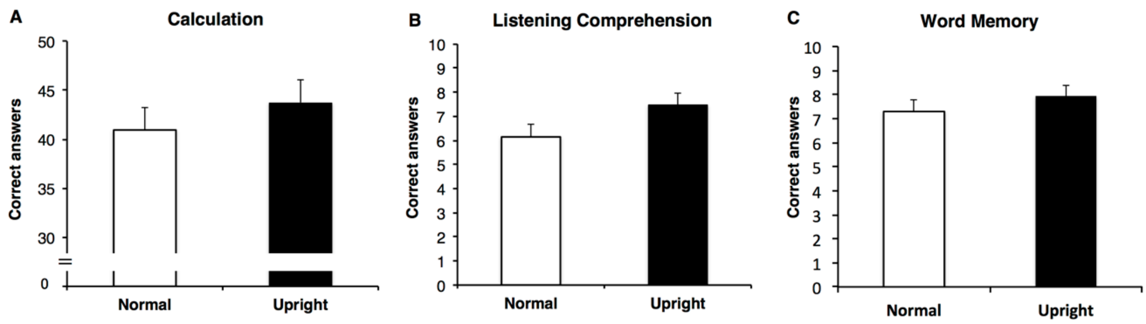

Figure 4. Mean number of the correct answers on three learning performance tests in Normal and Upright posture conditions: (A) calculation test, (B) listening comprehension test, (C) word memory test. Error bars represent standard errors.