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Original Article

A force plate analysis of sitting postures on a *Risshin* chair (Zazen-like, upright-support seating furniture) during lectures: An exploratory and preliminary study

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Abstract:
Background. "Posture" refers to both physical stance and mental attitude in both the East and West. Psychological research has demonstrated that posture reflects and alters emotions. In Japan, a tradition of regulating the body and mind by aligning posture exists, as exemplified by Zen meditation, and an upright sitting posture has been emphasized in school and home education. We developed the *risshin* chair, a modified version of the traditional school chair that helps students maintain an upright posture, and examined its educational effectiveness. *Purpose*. However, postural assessment in posture education involves various body parts, and holistic validation has been challenging. We propose the use of a force plate as a more quantitative and comprehensive method for measuring learners' macro-and microscopic body movements. This study aimed to obtain basic data on how the center of pressure (COP) changes between a *risshin* chair and a regular school chair in a quasi-educational setting in a laboratory and to preliminarily verify the effectiveness of force plate in postural education research. *Method*. Eleven students participated in the experiment, of whom 10 were included in the analysis. Each participant sat in a *risshin* chair or regular school chair and watched the lecture video in a counterbalanced order. Their COP changes were recorded during these trials, and they answered six questions on their reactions to the lecture. *Results.* Although we found no significant differences between chair conditions in subjective reports and in total COP length and others, the mean COP path length (p = .033, d = 0.80) and mean COP area length (p = .021, d = 0.88) were shorter, and the COP displacement (in the anterior-posterior direction) was also smaller (p = .006, d = 1.14) in the *risshin* chair than in the regular school chair. *Conclusions.* The results suggested that the *risshin* chair suppresses minute, rapid swaying and results in more leisurely body movements. This study provides initial insight into the effectiveness of force plates in quantifying sitting postures with little visible movement.
Keywords: back posture education, sitting postures, school chairs, center of pressure, Zen meditation, embodied cognition

Introduction

In both the West and East, the term "posture" refers to physical and mental attitudes. For instance, the German word *Körperhaltung*, which corresponds to the English word "posture," is a compound word of *Körper* (body) and *Haltung* (attitude). The Japanese word *kamae*, equivalent of the English word "stance," indicates both physical and mental readiness.

The fact that the words "posture" and "stance" describe both physical and mental aspects suggests more than mere idiomatic expressions. Lakoff and Johnson (1980), who developed the field of cognitive semantics, consider metaphors to be a matter not of language but of concepts, from which metaphors are formed. For example, emotions (e.g., falling into depression, feeling good), values (e.g., high/low quality), and positions (e.g., ascending the ladder of success, subordinate) are expressed by metaphors in the "up" and "down" directions. The meaning of abstract words is based on concrete, bodily experiences, and the "ups and downs" of emotional states come from physical positions due to power relations, as seen in animal behavior (Lakoff & Johnson, 1999; Johnson, 2007). In resonance with this, posture, along with facial expression, has been considered one of the most important channels of nonverbal behavior for communicating emotions to other (e.g., Argyle, 1988; Bull, 1987; Ekman & Friesen, 1967). Interestingly, many psychological studies have found that when one is in a certain mood, one is in the corresponding posture and vice versa.

The possibility that certain postures can produce specific emotions has been investigated, particularly in the context of the peripheral feedback model originally advanced by James (1884). Duclos et al. (1989) show that participants induced to adopt fearful (upper body twisted to the right, leaning back slightly), angry (fists clenched tightly, slightly leaning forward), and sad (no tension, head down, forward bending) postures

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experience specific emotions. A slumped posture tends to cause more depressive reactions in the learned helplessness task than an upright posture (Riskind & Gotay, 1982). Haruki and Suzuki (1994) systematically manipulated the angle of the trunk (2: upright, slumped) and the tilt of the head (3: face up, front, down) to reveal that the slumped and face-down postures produce the most depressive, weak, and unhealthy mood, whereas an upright and face-front or face-up posture produce the most confident, energetic, and healthy mood. In addition, they show that mood feels more vivid, strong, and realistic in the actual posture than in the imagined posture. One important finding shared by most postural studies is that a slumped posture is associated with negative affective valence and lower motivation, whereas an upright posture is associated with positive affect and relatively high motivation (for reviews, see Laird, 2007 and Sugamura, 2016).

Consistent with these scientific findings, East Asian contemplative traditions have historically emphasized the importance of an upright posture in the regulation of the body and mind. A good example is Zen Buddhism, which places considerable value on postural alignment prior to controlling breathing and keeping the mind calm. Yoga and Tai-Chi also have a tradition of emphasizing embodiment, which is referred to as *bodyfulness* (Caldwell, 2018; Sugamura & Warren, 2016; Sugamura et al., 2006; Sugamura, Takase, Haruki, & Koshikawa, 2007), and a straight back posture has been considered to serve a functional role as the "home position" of body posture.

With this *bodyful* tradition, the significance of "correcting one's posture" has been emphasized in the Japanese educational scene. For example, Nobuzo Mori (1896–1992), an educational philosopher of the Kyoto School, advocated "*ritsuyo*" (straightening one's lower back) education—a Zen-modeled pedagogical method of cultivating self-establishment—and worked to disseminate it in the school setting (Mori, 1983). In fact, a person with a straight back posture, whether in a sitting position, is more likely to be viewed as moral (Fukuichi & Sugamura, 2022). Thus, in Japan, it is important for students to correct their posture; if they lean a little too forward or backward, the teacher encourages them to straighten their back by placing a hand on the waist. Today, however, sexual harassment prevention has become a priority in schools, and teachers are not allowed to touch the students' bodies to adjust their posture.

Yutaka Haruki (1933–2019), the founder of "*shintai shinrigaku*" (embodied psychology; Haruki, 2002, 2011), who organically combined Jamesian theories of emotion and Buddhist philosophy (Sugamura, Haruki, & Koshikawa, 2007), conceived the idea of reviving postural education in the modern age by improving the student's study chair (Haruki, 2006). He and his colleagues introduced the *risshin* chair, which supports the Zazen-like natural sitting posture even for long periods of time, in elementary and junior high schools and have tested its effectiveness since 2005. For example, in a study conducted over a 6-month period with fifth-grade elementary school students (Haruki et al., 2006), chairs reduced irritability and increased calmness compared with conventional school chairs. Improvements in student motivation, concentration, and persistence were also confirmed through teacher evaluations.

In another experiment conducted in the same elementary school, students in all grades were asked to take classes in a regular school chair and in a *risshin* chair, in a counterbalanced order, and to rate the chairs and respond to their mood after class. The results showed that students in all grades significantly liked and wanted to resort to *risshin* chairs and that they felt more relaxed and calm as well as livelier and more energetic compared to when they used regular chairs (Sugamura et al., 2016). Murakami et al. (2022) found that in high school classes, the use of a *risshin* chair for a week affected mental health and daily meaning in life through a higher level of postural improvement and faster changes in classroom time perception.

One of the most challenging problems in the study of postural education is the quantitative definition and measurement of desired posture. With the advent of real-time joint-estimation programs such as OpenPose (Center for Technology Transfer and Enterprise Creation, Carnegie Mellon University; Cao et al., 2021), the quantification of physical posture—especially of the trunk—has become easier to introduce in real-life situations than in the past. However, they are not suitable for measuring the slight postural instability observed in the classroom. In a case study of middle school students with hyperactive tendencies (Sugamura et al., 2018), actual classroom scenes were filmed from the back of the classroom and compared the *risshin* chair and regular chair conditions in a within-participant design.

As similar learning situations were limited, two minutes of the writing scene at the beginning of the class were extracted for analysis. Body movements unrelated to the lesson were observed, including trunk tilting, rotation, backward leaning, leg bending, and leg crossing. The percentage of time spent in body movements was 88% in the normal condition and 48% in the *risshin* condition, suggesting that the chairs designed to support an upright posture may help relieve physical overactivity in students with hyperactive tendencies.

Force plates have been used extensively to study the standing position as a method of quantifying dynamic posture, especially in persons with equilibrium dysfunction (Chen et al., 2021; Quijoux et al., 2021), but are rarely used for the sitting posture. Based on these findings, we propose the use of a force plate as a more quantitative and comprehensive method of measuring learners' macro-and microscopic body movements. This study aimed to obtain basic data on how the center of pressure (COP) changes between a *risshin* chair and a regular school chair in a quasi-educational setting in a laboratory and to preliminarily verify the effectiveness of force plates in postural education research.

Material & methods

Participants

Japanese high school, undergraduate, and graduate students (five men and six women) from the Kansai area with no physical balance problems participated in this experiment.

Instruments

Regular school chairs (Kokuyo Corporation, SCH-NFU6GN, Student Chair) and *risshin* chairs (Okamasa Chair Manufacturing Company, Risshin Shusse Chair. Not-for-sale Prototype. The size and material details could not be provided due to possible patent applications.) were adopted. A dynamic balance evaluation system (Sports Sensing Corporation, SS-FP40AO-SY) was used as a force plate and connected to a 15-inch PC (DELL New Vostro 15 5000, Windows 10 Pro 64-bit, Intel core^{TM} i5-7200U) using a USB 2.0 cable. The measurement PC was placed at the rear of the laboratory, out of the participants' sight, and the experimenter gave instructions to the participants. The force plate was W400 mm x D400 mm x H100 mm in size and surrounded by a wooden step stool 100 mm high, with the chair placed on the force plate and the participant's feet on the step stool. An office desk and a 43-inch Ultra-High-Definition LCD monitor were set up in front of the participants, as shown in Fig.1.

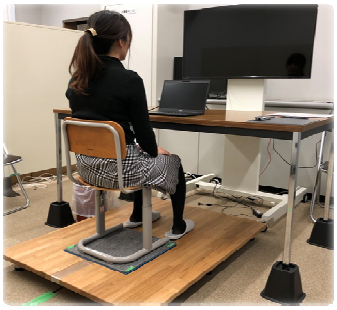

Fig. 1 An example of experimental setting in the control condition.

Stimulus

Two 9-minute portions taken from publicly available videos of university lectures in developmental psychology were used.

Procedure

The experimenter did not explain the characteristics of the chairs and the use of a force plate to the participants in advance but verbally explained that they would watch the lecture videos and answer simple questions in the laboratory and then obtained written consent to participate according to the Declaration of Helsinki and the Belmont Report. Each participant sat in a regular school chair or *risshin* chair and watched the lecture video in a counterbalanced order. They then answered six questions regarding their reactions to the lecture, such as interest and fatigue using a 5-point Likert scale (1 = *not at all applicable* to 5 = *very applicable*). Before each participant sat, the force plate was calibrated with the chair in place. The instructions for posture were as follows: "During the experiment, do not move your chair, do not place your feet on the instrument, and do not bend your knees to place them under the chair. Large movements, including leg and arm crossings, large hand and leg movements, upper-body swaying, and stretching should be avoided." None of the participants realized that they were sitting on the force plate. Finally, the experimenter explained the detailed purpose of the experiment and its background and paid a book token worth 3,000 yen as a reward. (It is to be mentioned that prior to this experiment, the same participants also practiced mindfulness for a short period of time in a separate experiment, which included compensation. This procedure and its results are not included in this report because it is unlikely to have a direct influence on the present results, and its purpose and scope are quite different from those of this study.)

Data collection and analysis / Statistical analysis

The COP data were collected and recorded at a sampling frequency of 1,000 Hz using dynamic balance evaluation software (Sports Sensing Corporation, SSbetaapp FP jushin doyo keisan) processed on the MATLAB platform (MathWorks Inc.). IBM SPSS Statistics was used for statistical analysis of the data.

Results

Ten participants were included in the analysis, after excluding one woman who fell asleep while watching the lecture. Within-participant *t*-tests (two-tailed) were conducted for two aspects of reactions to the lecture and representative indices of the COP in the two different chair conditions. Comparison of the mean ratings of the three lecture evaluation items *(I was interested in this talk; I would recommend this video to others; I would like to watch more.*) showed no significant differences, regardless of whether the participant viewed from the regular school chair or the *risshin* chair, t (10) = 0.48, p = .64, Cohen's d = 0.14. Similarly, a comparison of the rating means for the other three items (*I am tired; I thought of something unrelated. I became sleepy.*) between the regular and *risshin* chairs revealed no significant differences, t (10) = 1.52, p = .16, d = 0.46.

We found no significant differences between chair conditions in the total COP length, rectangular area, circumferential area, COP displacement (in the mediolateral direction), and root mean square (RMS). However, the mean COP path length was significantly shorter (t [9] = 2.52, p = .033, d = 0.80) in the *risshin* chair than in the regular chair, and the mean COP area length was also shorter (t [9] = 2.52, p = .033, d = 0.80) in the *regular* chair than in the *risshin* chair: t (9) = 2.78, p = .021, d = 0.88. The COP displacement (in the anterior-posterior direction) was also smaller (t [9] = 3.61, p = .006, d = 1.14) in the *risshin* chair than in the regular chair. Although the sample size of the present experiment was small within the framework of the null hypothesis significance test, the values of Cohen's D were sufficiently large to advance the discussion.

Discussion

We tested whether we could detect and assess quantitative differences in postural movements produced by regular school and *risshin* chairs. Preliminary analysis showed that perhaps due to the limited sample size in this experiment (N = 10), we could not detect significant differences between chair conditions in the questionnaire; however, we detected differences between conditions in some postural movements using the force plate. Specifically, although we found no differences in the total COP length between the conditions, the *risshin* chair had a shorter mean COP length and mean COP area length and a smaller COP displacement (anterior-posterior) than the normal chair. This means that the total amount of postural variability did not differ between the chair conditions, but the *risshin* chair might have suppressed the back-and-forth postural movement and fast swaying and slowed the motions overall. Because almost no COP studies have been conducted on sitting posture in a chair, the meaning of the parameters remains unknown. Therefore, it is difficult to interpret or infer the results of this study accurately. However, these results suggest the potential of force plates as a useful tool for the assessment of sitting postures on chairs.

In conventional posture education, most physical assessments have been based on first-person subjective reports (by the students themselves) and rarely on second-person subjective evaluations by others (by the teacher) or third-person behavioral observations (by the researcher). In this context, posture has been regarded as static, and the straightness of the trunk has mainly been evaluated. However, the force plate allows the moving posture to be quantified in a unified manner and reveals that the Zen-inspired chair suppresses minute, fast oscillations in posture, resulting in leisurely body movement. By nature, posture is a dynamic process, and a static posture is not the ideal state; rather, postural control is only possible with a certain degree of fluctuation. Future work will include an analysis of dynamic processes, such as spectral analysis, and their relationship with the participants' attentional control characteristics. It must be noted that this study is still exploratory and preliminary, and the measurement method has many unclear points, including instructions and calibration methods, parameter settings and analysis, and the appropriate interpretation of their meanings, which is definitely a topic that awaits further scrutiny.

Given that posture has both physical and psychological significance and that it could be covariant with emotion and cognition (e.g., Argyle, 1988; Crawford, 2014; Johnson, 2017), it is conceivable that the *risshin* chair would increase interest in the lecture; however, we found no significant differences between the chairs on those questions. One reason for this may be that, unlike previous research, the present study did not compare contrasting postures (e.g., slumped vs. upright) but only slightly changed the shape of the chairs, both of which were in the upright posture. Because interest in or attention to an object or event is specifically associated with a forward-leaning posture (Bull, 1987), it is possible that the upright support chair did not promote this type of emotion or cognition in a direct manner. Although this experiment was conducted in a very short lecture of less than 10 minutes, previous studies that investigated the effects of *risshin* chairs over a period of 1 week to 6 months in actual educational situations have confirmed the improvement of students' positive emotions and motivation (Haruki, 2006; Murakami et al., 2022). Therefore, even if no immediate effects are observed, medium- to long-term effects may still occur.

In general, the results did not contradict those of previous studies on the relationships between posture, emotion, and cognition. Instead, we were able to apply the findings of psychological posture research to the design of learning chairs and demonstrate the possibility of capturing dynamic changes using a force plate. Certainly, some class assignments require active body movements; thus, situations in which students need to sit quietly are still limited to listening to lectures or assignments in which they have to look at a computer screen. This methodology has only just begun in the context of school education, and more detailed studies will be required in the future, including clarification of the meaning of each parameter in the sitting posture, for the further development of posture education.

Conclusions

"Posture" refers to both physical stance and mental attitude in both the East and West. Psychological research has demonstrated that posture reflects and alters emotions. In Japan, there is a tradition of regulating the body and mind by aligning postures, as exemplified by Zen meditation. The significance of an upright sitting posture has been emphasized in school and home education. We developed the *risshin* chair, a modified version of the traditional school chair that helps students maintain an upright posture, and examined its educational effectiveness. Our previous studies have shown that the *risshin* chair makes students feel calm and inhibits body

movements unrelated to class. In this study, we attempted to holistically and chronologically assess the details of these postures using a force plate.

We compared the postures of students while watching a lecture using a *risshin* chair and an ordinary chair that is often used in schools. The results suggest that the *risshin* chair suppresses minute, rapid swaying and results in more leisurely body movements. This study provides initial insights into the effectiveness of force plates in quantifying seating postures with little visible movement in a more unified manner in a situation similar to an actual classroom setting. However, interest in lectures was not enhanced by the *risshin* chair. This may be partly due to the fact that it is a forward-leaning posture rather than an upright posture, which is most closely related to interest and attentiveness. However, as previous studies using *risshin* chairs have confirmed increased motivation compared to conventional school chairs, interest in lectures may also increase if the longer-term effects are investigated in actual educational settings.

The theoretical and practical implications of this study and related previous findings are that they have led to the development of a chair to improve the educational environment based on the Jamesian theory of the peripheral origin of emotion and recent findings on embodied cognition. Since posture conveys morality to others and regulates one's own emotions, psychological education through posture is expected to become an important theme for physical education in the future, transcending the boundaries of East and West.

Conflicts of interest: The authors declare that they receive no financial benefits from the sale of chairs (not commercially available) and have no competing interests.

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References

Argyle, M. (1988). *Bodily communication(2nd ed.).* Routledge.

Bull, P. E. (1987). *Posture and gesture*. Pergamon Press.

Caldwell, C. (2018). *Bodyfulness: Somatic practices for presence, empowerment, and waking up in this life.* Shambhala Publications.

Cao, Z., Hidalgo, G., Simon, T., Wei, S. E., & Sheikh, Y. (2021). Openpose: Realtime multi-person 2D pose estimation using part affinity fields. *IEEE Transactions on Pattern Analysis & Machine Intelligence, 43*(1), 172–186.

Chen, B., Liu, P., Xiao, F., Liu, Z., & Wang, Y. (2021). Review of the upright balance assessment based on the force plate. *International Journal of Environmental Research and Public Health, 18*(5), 2696. https://doi.org/10.3390/ijerph18052696

Crawford, L. E. (2014). The role of conceptual metaphor in memory. In M. Landau, M. D. Robinson, & B. P. Meier (Eds.), *The power of metaphor: Examining its influence on social life* (pp. 65–83). American Psychological Association.

Duclos, S. E., Laird, J. D., Schneider, E., Sexter, M., Stern, L., & Lighten, O. V. (1989). Emotion-specific effects of facial expressions and postures on emotional experience. *Journal of Personality and Social Psychology, 57,* 100–108.

Ekman, P., & Friesen, W. V. (1967). Head and body cues in the judgment of emotion: A reformulation. *Perceptual and Motor Skills, 24*, 711–724.

Fukuichi, A., & Sugamura, G. (2022). Sitting posture and moral impression formation: A focus on traditional Japanese sitting posture (*Seiza*). *Journal of Physical Education and Sport, 22*(2), 503–511.

Haruki, Y. (2002). *Embodied psychology* [in Japanese]. Kawashima Shoten.

Haruki, Y. (2006) Posture cultivation as education of the heart [in Japanese]. *Posture, 28,* 37–42.

Haruki, Y. (2011). *Body movement makes the mind: An invitation to embodied psychology* [in Japanese]. Kodansha.

Haruki, Y., Kitami, Y., Kubota, K., Mori, K., Ishikawa, R., & Suzuki, T. (2006). Posture cultivation as health education of mind-body unity [in Japanese]. *Proceedings of the 19th Annual Convention of the Japanese Association of Health Psychology.*

Haruki, Y., & Suzuki, M. (1994). Our posture dictates perception. In R. Lueder & K. Noro (Eds.), *Hard facts about soft machines: The ergonomics of seating* (pp. 133–143). Taylor & Francis.

James, W. T. (1884). The physical basis of emotion. *Psychological Review, 1*, 516–529.

Johnson, M. (2007). *The meaning of the body: Aesthetics of human understanding*. University of Chicago Press.

Johnson, M. (2017). *Embodied mind, meaning, and reason: How our bodies give rise to understanding*. University of Chicago Press.

Laird, J. D. (2007). *Feelings: The perception of self*. Oxford University Press.

Lakoff, G., & Johnson, M. (1980). *Metaphors we live by*. University of Chicago Press.

Lakoff, G., & Johnson, M. (1999). *Philosophy in the flesh: the embodied mind and its challenge to Western thought*. Basic Books.

Mori, N. (1983). *The complete works of Shinzo Mori (Continued ed., Vol. 5)* [in Japanese]. Mori Shinzo Zenshu Kankokai.

Murakami, Y., Hamada, T., & Sugamura, G. (2022). Effects of postural intervention using a "*risshin* chair" on classroom time perception, mental health, and life meaningfulness in high school students [in Japanese]. *Japan Journal of Physical Education, Health and Sport Sciences, 67*, 859–877.

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

Sugamura, G. (2016). Posture [in Japanese]. In Y. Haruki & H. Yamaguchi (Eds.), *Embodied psychology (2nd ed., 121–153)*. Kawashima Shoten.

Sugamura, G., Amemiya, R., Yamamoto, Y., Murakami, Y., Inagaki, K., Honmoto, S., Ueno, Y., Suzuki, T., & Haruki, Y. (2016, July). *The Zen-inspired back support chair makes elementary students feel more relaxed and lively: A postural feedback research in an educational setting.* Paper session presented at the 74th annual scientific conference of the International Council of Psychologists, Yokohama, Japan.

Sugamura, G., Haruki, Y., & Koshikawa, F. (2006, August). *Mindfulness and bodyfulness in the practices of meditation: A comparison of Western and Eastern theories of mind-body*. Poster session presented at the 1st Convention of Asian Psychological Association, Bali, Indonesia.

Sugamura, G., Haruki, Y., & Koshikawa, F. (2007). Building more solid bridges between Buddhism and Western psychology. *American Psychologist, 62*(9), 1080–1081.

Sugamura, G., Takase, H., Haruki, Y., & Koshikawa, F. (2007, August). *Bodyfulness and posture: Its concept and some empirical support.* Poster session presented at the 65th Convention of the International Council of Psychologists, San Diego, CA, USA.

Sugamura, G., & Warren, E. S. (2006). Conjoining paradigms: A dissolution-oriented approach to psychotherapy. In M. G. T. Kwee, K. J. Gergen, & F. Koshikawa (Eds.), *Horizons in Buddhist psychology: Practice, research & theory – Featuring a dialogue between the Dalai Lama and Aaron T. Beck* (pp. 379–397). Taos Institute.

Sugamura, G., Murakami, Y., Honmoto, S., Ueno, Y., Inagaki, K., Yamamoto, Y., Amamiya, R., Suzuki, T., & Haruki, Y. (2018, December). How does mindful "*ritsuyo*" education influence classroom behavior? Coding of elementary and junior high school students' postural changes during class and a preliminary analysis with junior high school students. *Proceedings of the 5th Annual Conference of the Japanese Association of Mindfulness,* 33.

Quijoux, F., Nicolaï, A., Chairi, I., Bargiotas, I., Ricard, D., Yelnik, A., Oudre, L., Bertin-Hugault, F., Vidal, P. P., Vayatis, N., Buffat, S., & Audiffren, J. (2021). A review of center of pressure (COP) variables to quantify standing balance in elderly people: Algorithms and open-access code. *Physiological Reports, 9*(22), e15067. https://doi.org/10.14814/phy2.15067