



Original Article

Comparison of the effects of external focus of attention with metaphor and internal focus of attention on temporal changes in seating pressure during sitting motion in community-dwelling elderly people

MASARU TAJIRI, RPT, MS¹⁾, HITOMI NISHIZAWA, RPT, PhD²⁾, TEIJI KIMURA, RPT, PhD^{2)*}

¹⁾ Hokushin General Hospital, Geriatric Health Services Facility Moegi, Japan

²⁾ School of Health Sciences, Faculty of Medicine, Shinshu University: 3-1-1 Asahi, Matsumoto City, Nagano 390-8621, Japan

Abstract. [Purpose] This study aimed to clarify the optimal method of attention focus in which temporal changes in the seating pressure can induce effective sitting motion in order to prevent osteoporotic vertebral fractures in the elderly. [Participants and Methods] This study included 101 community-dwelling elderly people. The participants were seated in a chair with a force plate under two conditions: external focus of attention with metaphor and internal focus of attention. We evaluated and analyzed the seating pressure by using the force plate and the sitting motion with a three-dimensional motion capture system. The unit time sitting pressure value and the trunk forward tilt angle were calculated and compared between the two conditions. [Results] The unit time sitting pressure value was significantly smaller in the external condition than the internal condition. The trunk forward tilt angle was significantly greater in the internal condition than the external condition. [Conclusion] This study demonstrated that external focus of attention with metaphor can induce a sitting motion with a slower temporal change in sitting pressure than the internal focus of attention. We concluded that external focus of attention with metaphor may be an effective instruction to prevent osteoporotic vertebral fractures in the elderly.

Key words: Metaphor, Focus of attention, Sitting motion

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INTRODUCTION

It is estimated that the population of people aged 65 years and above in Japan will peak at 39.35 million in 2042, and the projected aging rate is estimated to reach 35.3% in 2040, which will continue to rise thereafter¹⁾. With the aging population in Japan, the prevalence of osteoporotic vertebral fractures (OVF), a global public health problem, is also rising²⁾.

Briggs et al.³⁾ pointed out that the multifactorial etiology underlying OVF is due to the interaction of four factors: bone properties, macroscopic properties, global environment, and local environment. Under bone properties, when bone mineral density decreases to 0.3 g/cm², the factor of risk (Φ), which is the ratio of the load that the bone receives divided by the load that causes the bone to fracture, becomes $\Phi > 1$; daily activities is one such factor that puts a heavy load on the vertebral body⁴⁻⁶⁾. Under macroscopic properties, the relationship between vertebral body size and bone strength shows a positive correlation, so vertebral body size is a predictor of fracture risk³⁾. Under global environment, the movement of lifting things, the action of bending forward at the trunk, and the action of rising from a chair are considered to be involved in the genera-

*Corresponding author. Teiji Kimura (E-mail: tkimura@shinshu-u.ac.jp)

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tion of OVF³). Vedantam²) also stated that daily activities such as sitting from a standing position onto a low chair induce microtrauma, resulting in OVF. Under local environment, four factors such as neuromuscular control, muscle force, muscle strength, and intervertebral disk integrity have been pointed out³). Decreasing the strength of paraspinal muscles increases kyphosis, which results in increased vertebral compression load and decreased ability to withstand shearing forces³). Thus, the muscles involved in the stability of the posture and shape of the spine are controlled by the central nervous system, and the disruption of this stability may be a contributing factor in OVF³). In this study, we focused on neuromuscular control from the viewpoint of these four factors; if accurate and precise motor control can be achieved, the possibility of OVF will be reduced, no matter the etiology. Then, we considered the movement of the trunk in the sagittal plane during the sitting motion, which is one of the factors of the global environment, and the temporal change in the seating pressure derived from the force plate placed on the chair.

The sitting motion is a motion that depends on somatosensory information⁷), and it is focused on accurately lowering the body with finer postural control relative to the seated position^{7, 8}). In addition, when the sitting motion of the elderly is compared with that of the younger population, the trunk forward tilt angle in elderly is smaller than younger because the elderly need to maintain the balance during the sitting motion⁹). Furthermore, the sitting motion is risky for the elderly people⁹) whose lower limb muscle strength, postural stability, and balance are deteriorated by aging¹⁰). Therefore, when attention to the sitting motion is reduced, fine postural control and accuracy in the sitting motion are decreased, it becomes difficult to perform a sitting motion that gradually increases the seating pressure (smoothness of the seating pressure). As a result, a sudden landing on the buttocks occurs, which may be a cause of OVF.

It has been reported that the use of focus of attention (FOA) for motor control in the elderly causes differences in the acquisition and learning efficiency of movement¹¹). FOA is classified into two types: internal focus of attention (IFA), which directs one's attention to own movements, and external focus of attention (EFA), which focuses on the effects of one's movements on the environment or apparatus¹¹). It is said that EFA results in a more efficient performance by reducing the involvement of consciousness^{11, 12}), the reliance on working memory¹³) in the motor control process, and the impact on the affordance in relation to visual perception¹⁴). Much of the previous literature suggests that EFA is more effective because IFA is said to constrain the motor system, disrupt the automatic control processes of coordination movement, and result in poor performance (constrained action hypothesis)^{11, 12}), and it relies on working memory¹³) and emphasizes proprioceptive sensory feedback¹⁴).

From the previous literature, many of the exercise tasks in which EFA was more effective involved a target object such as a ball, a tool such as a bat to hit the target object, and a target such as a goal. In contrast, some previous studies have also reported that IFA may be more effective than EFA in non-tool-based¹⁵) and proprioceptive sense-focused motor tasks¹⁴). From these previous studies, it was thought that in terms of smoothness of seating pressure, the EFA condition is dominant based on the constrained action hypothesis from the perspective of the automatic control processes of coordination movement, but the IFA condition is also dominant in terms of tasks in which the proprioceptive sense is dominant. On the other hand, Wulf¹¹) suggested that for skills that do not have an obvious effects on the environment, the use of metaphors and similes tends to distract the performer's attention from one's movements and at the same time provide a mental image of the movement goal, which produces results similar to those of EFA instructions. With regard to metaphor, Thibodeau et al.¹⁶) have suggested that describing the topic of discussion in terms of semantically unrelated domains enhances brain activity, promotes reasoning, and influences the way of thinking and behavior. Therefore, instruction based on the EFA are considered to be more effective if coupled with metaphor because the content of the instruction can be imagined by inference and can be linked to the effects or results of the exercise, such as behavioral changes. Sawada et al.¹⁷) compared the motor learning of younger children and older children on dance skills using metaphorical verbal instructions, which used words that younger children know and can quickly recall, along with movement-relevant instructions. The results showed that the metaphorical verbal instructions were more effective than the movement-relevant instructions¹⁷). Based on these previous studies, it is considered that the EFA with metaphor (EFA-M) can induce better smoothness of seating pressure than IFA in sitting motion without a target object.

However, there are no studies comparing the differences of performance between the instruction based on the EFA-M condition and the instruction based on the IFA condition on how to perform sitting motion. In addition, there are also no studies using the temporal changes in seating pressure during sitting motion as an index that may be related to the development of OVF in community-dwelling elderly people. In the previous study by Wulf¹¹), the effects on performance and motor learning were examined for three conditions: the EFA condition, the IFA condition, and the control condition. So, since the control condition is not applied in the clinical setting of Physical Therapy, this study focused on the verification of differences between the EFA and IFA conditions.

This study aimed to clarify a more effective instruction method by using FOA in preventing OVF by quantitatively comparing and verifying the smoothness of the seating pressure using force plate and body alignment using a three-dimensional motion analysis system in the sitting motion using the EFA-M and IFA conditions in community-dwelling elderly people.

PARTICIPANTS AND METHODS

A total of 110 elderly people living in the vicinity of Nakano City, Nagano Prefecture, Japan, who agreed to cooperate as research participants in response to verbal and written explanations of this study, were included in this study. Of these,

101 community-dwelling participants (mean age: 73.1 ± 6.0 years, age range: 65–89 years, males: 47, females: 54) who did not apply for long-term care insurance, had no orthopedic or neurological diseases of the lower limbs or a history of such diseases, maintained cognitive function with a score of 24 or higher on the Mini-Mental State Examination (MMSE)¹⁸, and were independent in their ability to move unaided were finally included (Tables 1, 2).

All participants provided written consent prior to participating in this study, which was approved by the Shinshu University Institutional Review Board (Approval number: 4635) and conformed to the Declaration of Helsinki.

Participants were seated at 90° knee joint flexion on a force plate placed on the seat of a height-adjustable chair. At that time, the foot was set to a comfortable position. In order to calculate the joint angle, the reflective marker (10 mm in diameter) placed on the acromion, greater trochanter, lateral knee joint space, and lateral malleolus on the left side of each participant, as previously described by Dubost et al⁹). The participants were subsequently asked to stand with their arms folded across in front of their chest so that the marker at the greater trochanter was not hidden, and this position was set as the starting position.

The measurement procedure was as follows: First, measurements were performed by randomly assigning the participants to EFA condition or IFA condition using the permuted-block method, and then second measurements were performed under different conditions from the first time. The rest period between the first and second conditions was set to 5 min based on previous studies^{19, 20}). The measurements were repeated three times after three sessions of sitting practice under the two conditions. For the sitting practice, the task instructions were explained for each condition, and for each practice session, the movement was explained and questions from the participants were addressed. In addition, if the participants could not understand the content of the task after three practice sessions, the explanation and practice sessions were repeated until the participants understood the task. In such cases, the number of repetitions was recorded. However, none of the participants needed to practice more than the specified number of times before the measurements in each condition.

Thibodeau et al.¹⁶) reported that prior knowledge and attitude play an important role in being able to establish and make inferences from a metaphor. And they suggested that experience like motion evoke clearly delineated schematic knowledge¹⁶). Based on this suggestion, which states the importance of prior knowledge and experience like motion in utilizing the metaphor, EFA-M has set the instruction to “avoid waves on the bathtub surface when entering the bathtub”. Therefore, the content of metaphor in instruction for the EFA condition were as follows: “Please sit on the chair and avoid making waves as much as possible, imagining that you are sitting in the bathtub”. The corresponding instructions for the IFA condition were, “Please sit on the chair as slowly as possible with your body leaning forward”.

Regarding the comprehension of EFA instructions, Lotze et al.²¹) evaluated the degree of imagery using the visual analogue scale (VAS). Therefore, in this study, the degree of imagery in the instruction by the EFA-M was also assessed using the VAS after the EFA condition was implemented. To evaluate the VAS, participants were asked to write the degree of imagery they felt at the time on a 10-cm horizontal straight line, with the left end being “no imagery at all” and the right end being “very good imagery”. Then, the length from the left end of the line was used as the score (Table 1).

As for the measurement of sitting motion, the seating pressure was measured by amplifying the signal from a Force plate (sampling frequency 128 Hz: OR6-6-2 K-PT, AMTI Co., Ltd., Watertown, MA, USA), placed on the seat surface of the chair, using an amplifier (MINIAMP MSA-6, AMTI Co., Ltd.). The amplified signals were captured on a laptop computer using BIMUTAS II (Kissei Comtec Inc., Nagano, Japan). The alignment of the trunk and lower limbs during the sitting motion was measured and analyzed using the movement of the four reflective markers as indices, with the use of a three-dimensional motion capture system (3D camera; OptiTrack V120: Trio, NaturPoint Inc., Corvallis, OR, USA) set up in the sagittal plane at a distance of 2 m from each participant. The data of seating pressure and alignment were input into the KineAnalyzer (Kissei Comtec Inc., Nagano, Japan), and the seating pressure data were integrated after applying an 8-Hz low-pass filter.

The study by Dubost et al.⁹), which compared the angular displacement of the trunk in the sitting motion with aging, reported the maximal trunk forward tilt angle is at the time of seat-on. However, it was difficult to identify the seating pressure using the maximal trunk forward tilt angle as an index of seat-on because the maximal trunk forward tilt angle and the ground contact of the buttocks were not always the same timing in this study. On the other hand, Mourey et al.⁷) reported that the angular velocity of the trunk in the sitting motion of elderly people changed abruptly from negative to positive when seat-on. Therefore, the end point of landing on the seat surface was defined as the lowest point at which the angular velocity

Table 1. Characteristics of participants

Participants	101
Age (years)	73.1 ± 6.0 (65–89)
Gender (males/females)	(47/54)
MMSE (points)	28.5 ± 1.4 (25–30)
VAS (points)	79.5 ± 15.0 (33–100)

MMSE: Mini-Mental State Examination; VAS: Visual analogue scale.
Data are mean \pm SD.

Table 2. Excluded participants

Lower back pain	1
Painless bilateral knee arthropathy	1
Pain in both knee joints	1
Previous total knee arthroplasty	1
Premature ageing	1
Problems during measurement	4

of the trunk changes from negative to positive in this study. Hence, the seating pressure at the inflection point was used as an index of the seat-on in the present study (Fig. 1).

In the data analysis, the difference of seating pressure and the time between the start of the sitting position and the end of the sitting position was defined as the sitting pressure value (N) and the required time (sec), respectively. As the main outcome, the sitting pressure value per unit time (the unit time sitting pressure value: N/sec) was calculated. As a sub-outcome, the trunk forward tilt angle in the EFA-M condition and IFA condition were analyzed, and since the trunk forward tilt induces an increase in the compressive load on the vertebral bodies and a decrease in their ability to resist shearing forces³⁾, we calculated the trunk forward tilt angle (degrees) from the angle between the line connecting the acromion and greater trochanter markers and the vertical axis to measure the trunk angle in the sitting motion of the elderly people.

For statistical analyses, we first calculated the intraclass correlation coefficient (ICC (1.1)) for the three trials. This was owing to the fact that the sitting motion is usually an unconscious motion, but in this study, the attention using non-routine EFA or IFA was directed to the sitting motion. Therefore, the reproducibility of the sitting motion was examined by ICC (1.1). The normality of the obtained data was then checked using the Kolmogorov–Smirnov test. Since no normality was found for comparisons between conditions in terms of sitting pressure values, required time, unit time sitting pressure values, and trunk forward tilt angle, the Wilcoxon signed-rank test was conducted as a nonparametric test. All statistical processing was performed using IBM SPSS Statistics 27 (IBM Corporation, Armonk, NY, USA). The significance level was set at 5%. In addition, the effect size in the unit time sitting pressure value among two conditions was calculated using G*power 3.1.9.7 (Heinrich-Heine-Universität Düsseldorf, Germany).

RESULTS

The results of ICC (1, 1) are presented in the order of the EFA-M and IFA for each measurement item as follows: sitting pressure value, 0.65 and 0.65; required time, 0.66 and 0.73; unit time sitting pressure value, 0.85 and 0.68; trunk angle, 0.70 and 0.57.

The results of the mean and standard deviation of each measurement under each condition are shown in Table 3. Concerning the sitting pressure value, there was no significant difference between the EFA-M and IFA. The required time was significantly longer in the EFA-M condition than the IFA condition ($p=0.015$) (Table 3). The main outcome, the unit time sitting pressure value, was significantly smaller in the EFA-M condition than the IFA condition ($p=0.001$) (Table 3). The effect size in the unit time sitting pressure value was 0.35 between the EFA-M condition and IFA condition. For the sub-outcome, the trunk forward tilt angle in the IFA condition was significantly greater than the EFA-M condition ($p<0.001$) (Table 3).

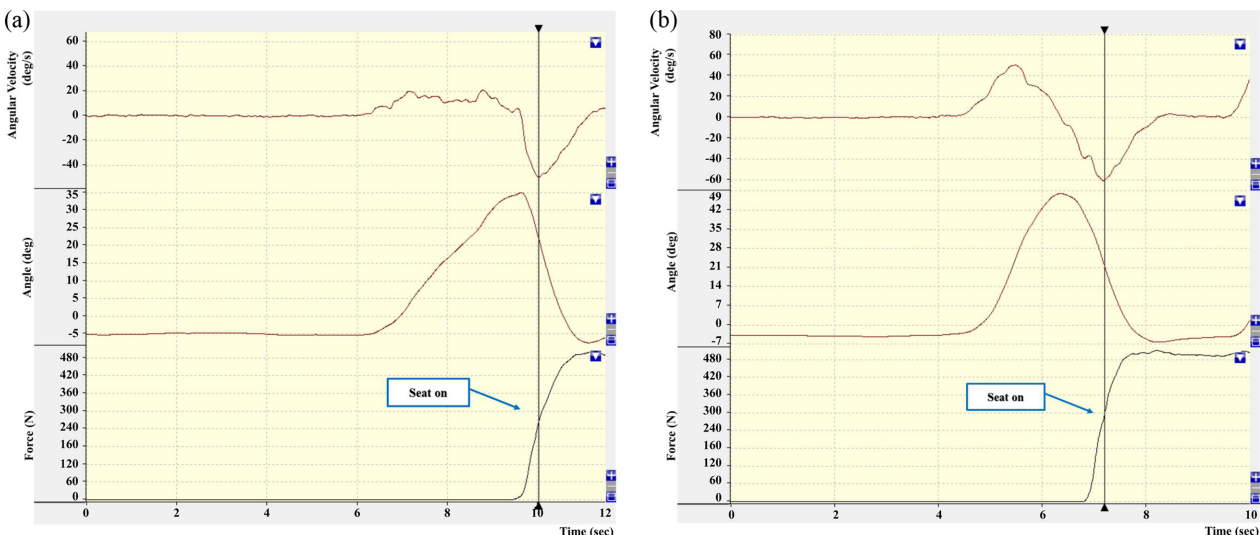


Fig. 1 a. An example of body alignment and sitting pressure values under the EFA-M conditions. b. An example of body alignment and sitting pressure values under the IFA conditions.

Seat-on point is the lowest point at which the angular velocity of the trunk changes from negative to positive, according to the previous study by Mourey et al.⁷⁾

Force: the seating pressure, Angle: the trunk forward tilt angle, Angular Velocity: the angular velocity of the trunk.

Table 3. EFA and IFA comparison for measurement items

	EFA	IFA
Sitting pressure value (N)	253.01 ± 75.44	255.32 ± 73.64
Required time (sec)	0.81 ± 0.39*	0.72 ± 0.38
Unit time sitting pressure value (N/sec)	381.4 ± 188.2**	447.0 ± 263.1
Trunk forward tilt angle (deg)	24.7 ± 7.6***	29.1 ± 7.4

EFA: external focus of attention; IFA: internal focus of attention.

Statistically significant, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Data are mean ± SD.

DISCUSSION

In this study, 101 community-dwelling elderly people who were able to walk unaided were recruited to a quantitative comparison and verification of different FOA methods.

As result, since results of ICC(1,1) in this study were moderate to almost substantial in Landis scale²²⁾, it was considered that reproducibility of individual data was tolerable. Therefore, we consider that the reproducibility of the sitting motion both of EFA-M condition and IFA condition in this study was almost good despite being an extraordinary consciousness because daily sitting movements do not require special consciousness for the community-dwelling elderly people.

As a main outcome, unit time sitting pressure values in the EFA-M condition were significantly smaller than the IFA conditions and the effect size was almost medium²³⁾ at 0.35. This result was considered to be due to the fact that required time in the EFA-M was significantly longer than that in IFA, although the sitting pressure value was not significantly different between the two conditions. From this result, it was considered that EFA-M can induce smoother sitting motion than IFA. It was thought that the reason why EFA-M was able to induce a smoother sitting motion than IFA as a result of this study was due to the effects of both the EFA and metaphor. At first, the effect of EFA is considered to emphasize automatically sitting motion based on the constrained action hypothesis. Wulf¹¹⁾ described the constrained action hypothesis as “Focusing on one’s movements constitutes a conscious intervention into control process that would ‘normally’ regulate movements effectively and efficiently. That is, trying to actively control those movements disrupts automatic control processes of coordination movement. As a result, performance is poor. Focusing on the movement effect promotes a more automatic type of control. It takes advantage of unconscious and reflexive processes and allows them to control our movement to a greater extent. As a result, performance and learning are enhanced”.

Next, the effect of metaphor is considered to emphasize the distraction the participant’s attention from their body movements and at the same time provide a mental image of the sitting motion. Because the average score of the VAS evaluation in the degree of the EFA-M imagery was almost good, it is considered that the instruction of EFA as a metaphor used this study may have become easier for participants to imagine. Thibodeau et al.¹⁶⁾ described the dominance of metaphor as the representation of the topic under discussion in terms of a semantically unrelated domain to increase brain activity, promote reasoning, and influence thinking and behavior. The instruction such as “Please sit on the chair and avoid making waves as much as possible, imagining that you are sitting in the bathtub” was used as the EFA-M in this study. Based on the comment by Thibodeau et al.¹⁶⁾, we thought that the metaphor such as “avoid making waves as much as possible, imagining that you are sitting in the bathtub” prompted the reasoning “sit down slowly” for smooth sitting motion.

From the above, it was suggested that the instruction based on the EFA-M proposed by Wulf¹¹⁾ can improve the motor performance such as sitting motion in which is controlled by proprioceptive sense without special object more than the IFA which commonly used in clinical settings of Physical Therapy.

As a sub-outcome, the trunk forward tilt angle in sitting motion in the IFA condition was significantly greater than the EFA-M condition, but the unit time pressure value in IFA condition was significantly larger than the EFA-M condition. From these results, it was considered that although the trunk forward tilt angle in the IFA condition was deeper than the EFA-M condition, it is possible that the automatism and smoothness of the sitting movement as a systemic movement in IFA were inferior to the EFA-M condition. This can be explained from the viewpoint of the constrained action hypothesis proposed by Wulf¹¹⁾. From the above, it was suggested that the effect of overload on the vertebral body was less in the EFA-M condition than the IFA condition, with regard to the report by Briggs et al.³⁾ that an increase in the trunk forward tilt angle induces an increase in the compressive load on the vertebral body and a decrease in the resistance to shearing forces.

The limitations of this study are as follows: First, the position of the feet and the position where the buttocks are placed on the surface were not specified because priority was given to the optimal sitting motion of the individual. In the same condition, the measurement environment did not change because the tasks were performed continuously, but between conditions and between individuals, the measurement environment may have differed, such as the distance between the two feet or the distance from the foot to the chair, because of breaks and practice. Second, we did not investigate whether the three practice sessions prior to measurement in this study were appropriate, although no participant required more than four practice sessions. Third, the load on the spine during the sitting motion was not measured.

As conclusion, it was suggested that instruction based on the EFA-M in sitting motion can be more effective instruction than instruction based on the IFA condition from the perspective of dominant of both EFA and metaphor in order to prevent OVF in community dwelling-elderly people. It was considered that the further study was needed to clarify the difference in automaticity in the whole-body kinetic chain of the sitting motion of the elderly depending on the differences in the FOA.

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Conflict of interest

There is no conflict of interest.

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