The effects of a defecation posture, supported by the upper limbs, on respiratory function

Daisuke Tashiro, OTR1,2)*, Masami Nakahara, RPT3), Eiji Kitajima, OTR2), Kenzo Haraguchi, OTR2)

1) Department of Occupational Therapy, Faculty of Rehabilitation, Kobegakuin University: 518 Ikawadanichou Arise, Nishi-ku, Kobe City, Hyogo 651-2180, Japan
2) Graduate School of Health and Medical Science, International University of Health and Welfare Graduate School of Medical Welfare, Japan

Abstract. [Purpose] In this study, we aimed to determine which typical postures or an arm-supported posture were more comfortable and conducive to respiratory function, during seated defecation. [Participants and Methods] In 73 healthy adults, we measured and compared respiratory function and subjective contentment associated with 3 sitting defecation postures: upright, forward-leaning, and arm-supported forward-leaning. [Results] Vital capacity (VC), forced vital capacity (FVC), maximal expiratory pressure (MEP), and subjective comfort were significantly greater in the arm-supported forward-leaning position than in the other 2 positions. [Conclusion] The arm-supported forward-leaning position for defection increased the VC and was subjectively comfortable. Moreover, the high MEP in this position, compared with the other 2 positions, may have facilitated strain. A detailed examination of the cause for the observed increase in comfort was beyond the scope of this study; therefore, this effect requires further investigation.

Key words: Defecation, Posture, Respiratory function

INTRODUCTION

In elderly people, respiratory function often decreases with aging1). Horsley et al.2) reported that over 30% of elderly people experience dyspnea in their activities of daily living (ADL). Therefore, ADL from a respiratory standpoint needs to be improved in elderly people. Defecation is a frequent ADL, and elderly people are prone to constipation due to decreased physical activity and food intake associated with aging3). When constipated, the need to maintain a sitting position while excreting or straining strenuously places a significant physical burden in elderly people4). Levison et al.5) reported that “the oxygen consumption increased by several-fold in tense muscles than in relaxed muscles and that its amount in respiratory muscles increased to 30% of the oxygen uptake in all muscles at rest, indicating that maintaining a sitting position for a long duration during defecation increases fatigue. In addition, defecation likely leads to dyspnea due to the augmented abdominal pressure from straining. For these reasons, a comfortable defecation posture that involves minimal physical burden is desired.

Typically, humans use 2 types of sitting defecation postures, including the upright position, with the hands placed on the thighs, and the forward-leaning position, with both forearms and elbows placed on the thighs. The forward-leaning position had been known to decrease the anorectal angle and to increase the defecation volume6). Notably, the use of toilet seats results in a posterior pelvic tilt and can induce excessive kyphosis. Secker-Walker et al.7) reported that kyphosis increased the respiratory workload and raised concerns that maintaining a prolonged sitting position may induce dyspnea and fatigue. Moreover, the forward-leaning position typically entails anterior protrusion of the head, with the ribs pulled down and the rib...
cage sunken, and is not considered a good position8).

Currently, a wall-mounted front supporting handrail and a forward tilt posture-assisting handrail have become widely available to reduce the physical burden of defecation. The resulting arm-supported forward-leaning position was shown to have positive effects, such as improvement of respiratory function9, reduction of dyspnea10, and decreased work of breathing11. However, most previous studies utilized chairs and, thus far, few studies have validated the effects of the arm-supported forward-leaning position using a toilet seat.

The purpose of this study was to compare the respiratory function between the typical defecation postures and an arm-supported posture, in order to determine a comfortable defecation posture. The findings would provide evidence that may be used when adjusting the defecation environment, such as the use of a front supporting handrail or a forward tilt posture-assisting handrail, and to provide movement guidance. Consequently, we can anticipate a reduction in physical burden, leading to a comfortable ADL in elderly people.

PARTICIPANTS AND METHODS

This study included 73 healthy adults (27 males and 46 females; age, 21.2 ± 1.2 years; height, 162.6 ± 9.7 cm; weight, 56.9 ± 9.7 kg). Those with serious respiratory diseases or motor system disorders that can affect the defecation posture were excluded. This study was approved by the International University of Health and Welfare Ethics Review Board, and informed consent was obtained from all participants before the study (approval number: 18-Iph-025).

Measurements were compared and examined among 3 sitting defecation postures, including upright position, forward-leaning position, and arm-supported forward-leaning position. The upright position entailed placing the hands on the thighs; the forward-leaning position entailed a forward tilt, with both forearms and elbows resting on the thighs; and the arm-supported forward-leaning position entailed a 45-degree bending position12, with the elbows resting on top of the posture-assisting handrail (Rakusukesan SRC, idea life care, Nagano, Japan). In all postures, the legs were placed shoulder-width apart, with the soles of the feet flat on the floor. A portable toilet, with a 40-cm seat height (Zaraku, SEKISUI, Tokyo, Japan), was used in the study. Next, respiratory function and subjective comfort were determined.

Using a spirometer (Multi-functional Spirometer HI-801, Chest, Tokyo, Japan), respiratory function was measured in terms of vital capacity (VC), tidal volume (TV), inspiratory residual volume (IRV), expiratory residual volume (ERV), inspiratory capacity (IC), forced vital capacity (FVC), forced expiratory volume in one second (FEV1), and FEV1/FVC (FEV1%), peak expiratory flow (PEF), as indices of comfort in defecation posture, and the maximal inspiratory pressure (MIP) and maximal expiratory pressure (MEP), as indices of straining in defecation posture. A nose clip was used during the spirometry measurements. An adjustable, front–back, left–right, fixing device was used, so that the spirometry measurements could be performed without the participant holding the spirometer (Fig. 1). After sufficient practice, following the guidelines by the American Thoracic Society and European Respiratory Society13, 14, measurements were made 3 times in each posture, and the maximum value was used for the analyses. Before each measurement, the instrument was always calibrated, and its precision was verified. Consistent instruction timing and method were used during the measurements. The participants were asked to remove or loosen their belts and undergarments, which may have compressed the abdominal area prior to measurement. The order of posture was randomized. Participants were given at least 3 minutes of break before each measurement, in order to minimize the effects on the measurements in the latter half of the posturing. Subjective comfort was determined by ranking and a numerical rating scale (NRS), which quantified the level of breathing comfort on a scale of 11 stages (0–10), after measuring the VC.

SPSS Statistics version 24.0 (International Business Machines Corp., Armonk, NY, USA) was used for statistical analysis. For the comparison of respiratory function and NRS among the postures, one-way repeated measures analysis of variance, with gender, height, and body weight as covariates, was used. Multiple comparisons with the Bonferroni method was performed when there was a significant main effect. χ2 test was used to compare subjective comfort ranking among the postures. A p value of <0.05 was considered statistically significant.

![Fig. 1. Three defecation postures. A: upright position, B: forward-leaning position, C: arm-supported forward-leaning position.](image-url)
Table 1. Respiratory function in the 3 defecation postures

|                | Upright position | Forward-leaning position | Arm-supported forward-leaning position |
|----------------|------------------|--------------------------|----------------------------------------|
| VC (L)         | 3.70 ± 0.92      | 3.70 ± 0.95              | 3.79 ± 0.95**‡‡                     |
| TV (L)         | 0.79 ± 0.37      | 0.83 ± 0.41              | 0.83 ± 0.38                           |
| IRV (L)        | 1.61 ± 0.46      | 1.49 ± 0.44**            | 1.58 ± 0.43†                         |
| ERV (L)        | 1.65 ± 0.58      | 1.71 ± 0.65              | 1.74 ± 0.66**§                       |
| IC (L)         | 2.29 ± 0.56      | 2.22 ± 0.53              | 2.30 ± 0.53†                         |
| FVC (L)        | 3.79 ± 1.00      | 3.80 ± 0.97              | 3.86 ± 0.96**§§                      |
| FEV1 (L)       | 3.31 ± 1.03      | 3.34 ± 0.98              | 3.37 ± 0.99                           |
| FEV1% (%)      | 88.54 ± 9.24     | 88.98 ± 8.08             | 89.31 ± 7.75                         |
| PEF (L/sec)    | 6.39 ± 2.80      | 6.51 ± 2.93              | 6.71 ± 3.04*                         |
| MEP (cmH2O)    | 53.68 ± 25.60    | 53.79 ± 25.94            | 56.83 ± 25.07*§                      |
| MIP (cmH2O)    | 59.44 ± 26.63    | 58.16 ± 25.36            | 61.67 ± 25.27                        |

Values are mean ± SD.
Multiple comparisons (Bonferroni).
*p<0.05 vs. upright position, **p<0.01 vs. upright position, †p<0.05 vs. forward-leaning position, ‡‡p<0.01 vs. forward-leaning position.
Covariates: gender, height, body weight.

Table 2. Numerical rating scale (NRS) in the 3 excretion postures

|                | NRS†  |
|----------------|-------|
| Upright position| 5.82 ± 2.24** |
| Forward-leaning position| 6.11 ± 2.14** |
| Arm-supported forward-leaning position| 7.56 ± 1.53   |

Values are mean ± SD.
†11 stages (0–10) High score: A sense of comfort is high.
Multiple comparisons (Bonferroni).
**p<0.01 vs. arm-supported forward-leaning position.
Covariates: gender, height, body weight.

RESULTS

Table 1 shows the respiratory function in each posture. Compared with the upright and forward-leaning positions, the arm-supported forward-leaning position had significantly greater VC (p<0.01 vs. both) and FVC (p<0.05 vs. the upright position, p<0.01 vs. the forward-leaning position). IRV was significantly lower in the forward-leaning position than in the upright position (p<0.01) and arm-supported forward-leaning position (p<0.05). IC was significantly greater in the arm-supported forward-leaning position than in the forward-leaning position (p<0.05). Compared with the upright position, the arm-supported forward-leaning position had significantly greater ERV (p<0.01), PEF (p<0.05), and MEP (p<0.05). TV, FEV1, FEV1%, and MIP were not significantly different among the 3 postures.

Based on the subjective comfort ranking (Table 2), the arm-supported forward-leaning position was the most comfortable (n=41), followed by the forward-leaning position (n=18) and the upright position (n=14). Residual analysis showed significant differences in the number of responses, with the greatest in the arm-supported forward-leaning position, followed by the forward-leaning and upright positions (p<0.01). Moreover, the NRS score was significantly greater in the arm-supported forward-leaning position than in the upright and forward-leaning positions (p<0.01).

DISCUSSION

This study compared and examined 3 sitting postures to determine a comfortable posture during defecation. For respiratory function, IRV was the greatest in the upright position, probably because this position, compared with the forward-leaning and arm-supported forward-leaning positions, does not restrict breathing movements and allows free movement of the abdominal area (15). Prandi et al. (16) reported that the inspiratory muscle function decreased in the arm-supported posture, which involves a forward tilt of the body trunk. In the forward-leaning and arm-supported forward-leaning positions, which were similar to the arm-supported posture described previously, the shoulder girdle was fixed due to the arm support and had restricted range of motion; this likely lowered the IRV, compared with that in the upright position. In addition, IRV was greater in the arm-supported forward-leaning position than in the forward-leaning position, probably because the former position entailed
IC was greater in the arm-supported forward-leaning position than in the other 2 positions. This result may be attributed to the comparable TV between the arm-supported forward-leaning and the forward-leaning positions. Moreover, the IC results were considered to reflect the IRV.

ERV was greater in the arm-supported forward-leaning position than in the other 2 positions. This finding was consistent with those of previous studies. Because the exhalation volume is driven by abdominal muscle activity, the forward tilt of the body trunk in the arm-supported forward-leaning position likely increased the abdominal pressure and assisted in exhalation.

VC was significantly greater in the arm-supported forward-leaning position than in the other 2 positions. Similar to our study, a previous study demonstrated that the arm-supported forward-leaning position reduced the work of breathing, suggesting that this position is a comfortable posture. Because VC is a comprehensive index of ventilatory capacity for both inspiration and exhalation, an increase in inspiration increases exhalation. Therefore, the high VC in the arm-supported forward-leaning position can probably be explained by the fact that IC was the greatest in this position than in the other 2 positions.

FVC and PEF were significantly greater in the arm-supported forward-leaning position than in the other 2 positions. Unlike VC, which is measured during slow breathing, FVC is measured with maximum labored breathing within a short duration. For this reason, FVC is a comprehensive index of ventilatory capacity for both inspiration and exhalation and describes the instantaneous power of respiratory function. Therefore, similar to the implications of the results on VC measurements, the arm-supported forward-leaning position appeared to be an advantageous posture. Moreover, the arm-supported forward-leaning position had been reported to improve the contraction efficiency of the diaphragm in Chronic Obstructive Pulmonary Disease patients. In this study, this position had beneficial effects in healthy adults, in terms of the instantaneous power of respiratory function, which was probably brought about by the improved contraction efficiency.

MEP was significantly greater in the arm-supported forward-leaning position than in the other 2 positions. Previous studies have shown that respiratory muscle strength was dependent on lung volume, implying that MEP was dependent on PEF in our study. Moreover, similar to FVC, MEP requires instantaneous expiratory effort and is an index that requires abdominal muscle activity. During defecation, abdominal muscle contraction through straining and consciously increasing the abdominal pressure are necessary to increase the intraabdominal pressure. Our results suggested that, compared with the other 2 positions, the arm-supported forward-leaning position, which had the greatest MEP, was the best posture for straining.

For subjective comfort, both subjective comfort ranking and NRS showed that, compared with the upright and forward-leaning positions, the arm-supported forward-leaning position was significantly the most comfortable. The comfortable postures for inspiration in respiratory disorders had been described by several specialized textbooks. The Brompton Hospital Guide to Chest Physiotherapy defined comfortable posture as “a posture that brings maximum relaxation to the upper thorax and allows free movement of the lower thorax” and Tidy’s Physiotherapy described rest posture as “a sitting position on a chair with both forearms on the thighs, supporting the upper body with the elbows” and “forward tilting sitting position on a chair with hands and face resting on the cushion on the table.” The arm-supported forward-leaning position in our study was similar to the arm-supported posture described in these books, indicating that this position relaxes the upper thorax.

Moreover, previous studies stated that the arm-supported forward-leaning position reduced the trunk muscles’ load in maintaining posture by supporting the upper trunk weight with the arms, thereby, decreasing oxygen uptake by the muscle. In this study, the arm-supported forward-leaning position removed the upper trunk load, thereby, reducing the workload of the trunk muscles and bringing comfort. Moreover, because toilet seats do not have a backrest and are designed with a high seat, maintaining a stable sitting position may be difficult. The arm-supported forward-leaning position can address this difficulty and create stability and comfort by removing the upper trunk instability with the arm support.

Our findings demonstrated that the arm-supported forward-leaning position for defecation was a subjectively comfortable posture that increased VC by removing the weight of the shoulder girdle and preventing excessive forward leaning. Moreover, the high MEP in this position suggested greater straining, compared with that in the other 2 positions. However, this study did not investigate in detail the other possible reasons for comfort, such as the effects of respiratory function and posture-maintaining muscles. In addition, we did not investigate elderly people and patients with respiratory illness who are physically burdened. These require further investigation with continuing studies.

**Funding**
This work was supported by JSPS KAKENHI Grant Number JP19K19879.

**Conflict of interest**
The authors have no conflicts of interest relevant to this article.
REFERENCES

1) Cerveri I, Zaia MC, Fanfulla F, et al.: Reference values of arterial oxygen tension in the middle-aged and elderly. Am J Respir Crit Care Med, 1995, 152: 934–941. [Medline] [CrossRef]
2) Horsley JR, Sterling II, Waters WE, et al.: Respiratory symptoms among elderly people in the New Forest area as assessed by postal questionnaire. Age Ageing, 1991, 20: 325–331. [Medline] [CrossRef]
3) Bank S, Marks IN: The aetiology, diagnosis and treatment of constipation and diarrhoea in geriatric patients. S Afr Med J, 1977, 51: 409–414. [Medline]
4) Singer W, Oppenheimer TL, McPhee BR, et al.: Influence of posture on the Valsalva manoeuvre. Clin Sci (Lond), 2001, 100: 433–440. [Medline] [CrossRef]
5) Levison H, Cherniack RM: Ventilatory cost of exercise in chronic obstructive pulmonary disease. J Appl Physiol, 1968, 25: 21–27. [Medline] [CrossRef]
6) Takano S, Sands DR: Influence of body posture on defecation: a prospective study of “The Thinker” position. Tech Coloproctol, 2016, 20: 117–121. [Medline] [CrossRef]
7) Secker-Walker RH, Ho JE, Gill IS: Observations on regional ventilation and perfusion in kyphoscoliosis. Respiration, 1979, 38: 194–203. [Medline] [CrossRef]
8) Zacharkow D: Posture: sitting, standing, chair design and exercise. Illinois: Charles C Thomas, 1988, pp 12–64.
9) LaPier TK, Donovan C: Sitting and standing position affect pulmonary function in patients with COPD: a preliminary study. Cardiopulm Phys Ther J, 1999, 10: 8–13. [CrossRef]
10) Barach AL: Chronic obstructive lung disease: postural relief of dyspnea. Arch Phys Med Rehabil, 1974, 55: 494–504. [Medline]
11) Izumizaki M, Satake M, Takahashi H, et al.: Effects of inspiratory muscle thixotropy on the 6-min walk distance in COPD. Respir Med, 2008, 102: 970–977. [Medline] [CrossRef]
12) O’Neill S, McCarthy DS: Postural relief of dyspnoea in severe chronic airflow limitation: relationship to respiratory muscle strength. Thorax, 1983, 38: 595–600. [Medline] [CrossRef]
13) Miller MR, Hankinson J, Brusasco V, et al. ATS/ERS Task Force: Standardisation of spirometry. Eur Respir J, 2005, 26: 319–338. [Medline] [CrossRef]
14) American Thoracic Society/European Respiratory Society: ATS/ERS Statement on respiratory muscle testing. Am J Respir Crit Care Med, 2002, 166: 518–624. [Medline] [CrossRef]
15) Thomson A, Skinner A, Piercy J: Tidy’s Physiotherapy. 12th ed. Boston: Butterworth Heinemann, 1991, pp 181–195.
16) Prandi E, Couture J, Bellemare F: In normal subjects bracing impairs the function of the inspiratory muscles. Eur Respir J, 1999, 13: 1078–1085. [Medline] [CrossRef]
17) Craig AB Jr: Effects of position on expiratory reserve volume of the lungs. J Appl Physiol, 1960, 15: 59–61. [Medline] [CrossRef]
18) Kera T, Maruyama H: The effect of posture on respiratory activity of the abdominal muscles. J Physiol Anthropol Appl Human Sci, 2005, 24: 259–265. [Medline] [CrossRef]
19) Sharp JT, Drutz WS, Moisan T, et al.: Postural relief of dyspnea in severe chronic obstructive pulmonary disease. Am Rev Respir Dis, 1980, 122: 201–211. [Medline]
20) Rahn H, Otis AB, Chadwick LE, et al.: The pressure-volume diagram of the thorax and lung. Am J Physiol, 1946, 146: 161–178. [Medline] [CrossRef]
21) Cook CD, Mead J, Orzalesi MM: Static volume-pressure characteristics of the respiratory system during maximal efforts. J Appl Physiol, 1964, 19: 1016–1022. [Medline] [CrossRef]
22) Campbell EJ: The respiratory muscles: mechanics and neural control. London: Lloyd-Luke, 1970, pp 181–193.
23) Webber BA: The Brompton hospital guide to chest physiotherapy. Oxford: Blackwell Scientific Publications, 1990, pp 47–63.
24) Drutz WS, Sharp JT: Electrical and mechanical activity of the diaphragm accompanying body position in severe chronic obstructive pulmonary disease. Am Rev Respir Dis, 1982, 125: 275–280. [Medline]