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Original Article

Effects of pelvic tilt angles and forced vital capacity in healthy individuals

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Abstract. [Purpose] The purpose of this study was to investigate the effect of pelvic tilt angles and lung function in participants performing pelvic tilts on a ball. [Subjects and Methods] Eighteen subjects participated in this study. While they performed pelvic tilt on sitting at a ball, the peak expiratory flow (PEF) and forced expiratory volume in one second (FEV1) were measured at 10 degrees of anterior and posterior pelvic tilt, respectively, and neutral position. The repeated measure ANOVA was performed, and the Bonferroni correction was used for post-hoc analysis. [Results] The PEF of the participants was significantly higher at neutral position, compared with an anterior pelvic tilt at 10 degrees. The FEV1 was also higher in neutral position, compared with anterior and posterior pelvic tilt. [Conclusion] This study underlines the need for the standardization of the FVC testing protocol for positioning the pelvic angle in a neutral position in patients with respiratory disorders to promote reliable interpretation of intervention outcomes.

Key words: Peak expiratory flow, FVC, Cardiopulmonary

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INTRODUCTION

The prevalence of respiratory disease is rising amid worsening air pollution. Chemicals in dust, when swallowed, can cause respiratory problems, and chronic obstructive pulmonary disease (COPD) and chronic bronchitis and even pneumonia are particularly common[1, 2)].

Among the respiratory muscles, the expiratory muscles include the rectus abdominis, external oblique abdominis, internal oblique and transverse abdominis. These muscles are also involved in trunk motion, posture, labor, vomiting and dejection in addition to respiration[3–5)]. Although these muscles remain inactive during rest, the activity of these muscles is known to increase during exercise and forced expiration, affecting the abdominal muscles according to changes in body position[6)]. If the load to respiratory muscles is sufficient enough to augment muscle strength during contraction, breathlessness decreases and physical exercise ability increases[3–5, 7)].

One of movements affected by the abdominal muscles is pelvic tilt exercise, which can be performed with the anterior superior and posterior superior iliac spines being tilted in anterior direction in the sagittal plane, staying in line (neutral) or being titled in posterior direction. The major muscles involved with an anterior pelvic tilt include the iliopsoas, rectus femoris, erector spinae (hip flexors and lumbar extensors while the rectus abdominis, external oblique muscle, gluteus maximus, hamstring muscle (abdominal muscle and hip extensors) enable a posterior pelvic tilt[8)]. Thus, some of the pelvic muscles are also involved in thoracic movement[9, 10)]. For instance, the erector spinae and rectus abdominis control not only pelvic inclination but also the lumbar lordotic curvature[8, 10)].

Based on this anatomical evidence, we hypothesized that lung function would vary with the three pelvic positions: anterior,

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Fig. 1. Measurement of pelvic tilt angle: (a) 10° anterior tilt, (b) neutral position, and (c) 10° posterior tilt.

Table 1. General characteristics of subjects

	N (%)
Male	2 (11%)
Female	16 (88%)
	Mean ± SD
Age (yrs)	22.2 ± 3.1
Height (cm)	160.1 ± 6.3
Weight (kg)	57.7 ± 11.6
Body Mass Index (kg/m^2)	22.2 ± 3.1

Table 2. PEF and FEV1 of the different pelvic tilts on the ball

	10° ant. tilt	Neutral position	10° post. tilt
PEF (l/min)	269.5 ± 102.3[b]	297.3 ± 101.4[b]	281.2 ± 105.3
FEV1 (l)	2.2 ± 0.6[a]	2.4 ± 0.6[a,c]	2.26 ± 0.6[c]

Mean ± SD.
FEV1: forced expiratory volume in one second; PEF: peak expiratory flow
[a,b,c]Significant difference between the pelvic tilts ([a]p<0.05, [b]p<0.005 and [c]p<0.001).

neutral and posterior tilt. In addition, we addressed the fact that the studies investigating the effects of pelvic position and tilt angles are lacking and that the effects of pelvic tilt tend to be overlooked when interpreting the results of interventions related to PEF and FEV1. In other words, pelvic tilt angles can be clinically important for respiratory rehabilitation application and outcome assessment, and a proper sitting position while leaning against the backrest should be maintained during FVC tests. This study aimed to identify how the three pelvic positions (anterior, neutral and posterior) practiced on a stability ball can affect expiratory function.

SUBJECTS AND METHODS

While 18 healthy participants performed pelvic tilt in anterior (10 degrees), neutral and posterior (10 degrees) directions (Fig. 1), PEF and FEV1 were measured. All the participants voluntarily participated in the study. After being fully briefed about the study, the participants signed on the informed consent, which was approved by the Hoseo University Faculty of Human Ethics Committee (104123-170904-HR-063-02). The participants were excluded if they had respiratory diseases or severe pain in the neck and spine (VAS 5 or higher) due to prolapsed intervertebral disc and if they could not perform anterior pelvic tilt (10 degrees) on a stability ball. The general characteristics of the participants are shown in Table 1. Palpation Meter (PALM: performance attainment associates, St. Paul, MN, USA) is an inclinometer to measure the angle between two points that were selected for measurement on the body. An oval-shaped location marked moves 1 degree in a semi-circle of the inclinometer. The device can measure from 0 to 30 degrees on the basis of central alignment. The Vitalograph PEF/FEV1 Diary (Vitalograph Inc., KS, USA) was used to measure PEF and FEV1. In this study, the reliability of the Vitalograph PEF/FEV1 Diary was 77%, and the reliability of the FEV1 was high in the range of 0.97–0.99[11, 12]. The repeated measurement ANOVA was performed to compare changes in lung function (PEF and FEV1) in three different pelvic conditions on a stability ball using SPSS 20.0 (SPSS, Chicago, IL, USA). The Bonferroni correction was used for post-hoc test. The significance level was set at p<0.05.

RESULTS

The PEF measured on a stability ball was 253.28 l/min at 10° of pelvic anterior tilt, 283.42 ± 92.26 l/min in neutral pelvic position and 270.78 ± 101.00 l/min at 10° of pelvic posterior tilt, showing a significant difference (p=0.022). The FEV1 readings were also significantly different between pelvic positions, showing 2.28 ± 0.56 l at 10° of anterior tilt,, 2.41 ± 0.51 l in neutral position and 2.27 ± 0.53 l at 10° of posterior tilt (p=0.005).

Based on the changes in PEF with different pelvic tilt angles on a stability ball, there was a significant difference in the PEF readings measured at 10° of anterior tilt and in neutral position (p=0.021). However, no significant difference was observed in the PEF between anterior and posterior tilting positions (10° each) and between posterior tilt and neutral position, respectively (p=0.098, p=0.561).

According to the changes in FEV1 with different pelvic tilt, as shown in Table 2, a significantly higher FEV1 reading was found in neutral position, when compared with those at 10° of anterior and posterior tilt, respectively (p=0.010, p=0.000).

However no significant difference was observed between anterior and posterior tilt, performed at 10° each (p=1.000).

DISCUSSION

This study was conducted to identify how pelvic tile angles change FVC in healthy individuals. The results of this study revealed that the PEF was higher in a neutral pelvic position, compared with those measured from anterior and posterior pelvic tilt (10 degrees each), respectively ($p<0.05$). FEV1 was also significantly higher in a neutral pelvic position than when the pelvis was at 10 degrees of anterior tilt or 10 degrees of posterior tilt ($p<0.05$).

In this study, it was hypothesized that "FVC will change with the angles of pelvic tilt". We found that the PEF was reduced when the pelvis was tilted anteriorly or posteriorly from its neutral position. Indeed, the difference in PEF between 10° anterior pelvic tilt and neutral position was significant. However, there was no significant difference between 10° posterior pelvic tilt and neutral position. Therefore, the hypothesis is not fully supported.

At 10° of anterior pelvic degree, the abdominal muscles are extended beyond an anatomical neutral position, thereby limiting the motion of the lower thorax where the muscles are originated and such a limiting eventually makes a spatial inflation of the thoracic cage difficult although lung inflation is essential to trigger inspiration sufficiently during deep breathing performed in FVC tests. The results can be explained from biomechanical aspects as well. When the abdominal muscles are excessively extended on the wake of anterior pelvic tilt, the muscle length-tension relation occurs, meaning that the muscle is stretched beyond an anatomical resting length.

Some authors also assert that upright posture contributes to the activation of the ribcage inspiratory muscles and the diaphragm[13)], and the supine posture also assists the diaphragm to activate the abdominal muscles over the ribcage[14)]. Fang et al. suggests that the body posture has an effect on the lung capacity as well as expiratory flow. The study shows that the slumped sitting—kyphotic spinal curvatures—decreases the lung capacity, expiratory, and lumbar lordosis[15)]. O'Sullivan et al. also suggests that the different upright (thoracic, lumbo-pelvic and slumped) sitting postures alter the activation of trunk muscles and pelvic tilts.

At 10° of posterior pelvic angle, the abdominal muscles used for FVC are relaxed while the erector spinae and multifidus muscles are stretched, thereby reducing the intra-abdominal pressure, which in turn makes the contraction of the diaphragm toward the abdomen easy during inhalation. Hence, the volume of air inspired increases with a posterior pelvic tilt, compared to an anterior pelvic tilt, and PEF increases accordingly. However, the increased PEF with a posterior pelvic tilt was still lower than the PEF derived from a neutral position, although the difference was not statistically significant, because the elector spinae's strength is likely reduced in its stretched position during forced vital capacity.

When the pelvis was tilted anteriorly or posteriorly at 10°, FEV1 readings were significantly reduced, when compared with that in the neutral position. These results can be also explained from the reduced motion of the thorax and biomechanical aspects described above. Combined, pelvic tilt angles can serve as a confusing variable that can make a big difference in the results of FVC tests and it requires caution regarding posture of patients with respiratory disorders when undergoing lung function tests, in particular those who are sensitive to intervention outcomes.

This study has the following limitations: First, this study did not meet the requirement that the sitting height should be identical when measuring pelvic tilt angles with a PALM. Secondly, there were gender differences in subjects as the number of male subjects who could perform anterior pelvic tilt at 10° was fewer than their counterparts. Although the hypothesis was supported statistically, the data are limited to be interpreted as scientific results. Third, only healthy individuals participated in the study. Patients with respiratory disorders have different states of thoracic flexibility and trunk muscles as a result of pain and discomfort associated with dyspnea and chronic fatigue. To determine validity and clinical effectiveness of the findings, studies involving respiratory patients are necessary under the same design. Based on these limitations, further studies need to be conducted in more scientific design and with respiratory patients to verify clinical effectiveness.

This study presents significant differences between pelvic tilt angles and forced vital capacity. Therefore, the standardization of the FVC testing protocol for positioning the pelvic angle in a neutral position is required for valid interpretation of intervention outcomes in patients with respiratory disorders.

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