ASSOCIATION BETWEEN POSTURE AND PULMONARY FUNCTION IN MIDDLE AGE AND OLDER ADULTS

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ABSTRACT

Berens AR, Doro KJ, Heiman MR, Bredle D, Ishikawa S. Association between Posture and Pulmonary Function in Middle Age and Older Adults. Journal of Undergraduate Kinesiology Research 2014; (9)2:11-19. Purpose: It is widely assumed that a hunched sitting position will impede airflow. The purpose of this study was to determine whether posture would indeed impact airflow in middle-age and older adults. We hypothesized that poorer posture would negatively impact the pulmonary capacity, especially in high risk individuals: BMI > 30 kg/m² or BMI > 25.0 kg/m² with a waist circumference ≥ 102 cm (men) or ≥ 88 cm (women). Methods: Twenty-two Caucasian adults (age 62 ± 9 yrs.) volunteered, blinded to the postural aspect of this study prior to testing to avoid any biased effort between postures. Several trials of slow vital capacity (SVC) were performed on each individual using electronic spirometry in three different postures (their normal, poor, and ideal) assessed using Dartfish 5.0 software. A two-way (risk category x posture) repeated measures ANOVA using SPSS 19.0 was performed, with an alpha level of .05. Results: Demographic characteristics include: mean BMI 29 ± 6 kg/m², mean waist circumference 98 ± 19 cm, 50% male and 50% high risk. Mean SVC for normal, poor, and ideal posture were 3.90 ± 1.23 L, 3.67 ± 1.37 L, 3.77 ± 1.38 L, respectively. Though no comparisons reached significance, normal posture yielded the highest SVC, and there was a tendency for poor posture to reduce SVC (p = .076). Furthermore, no statistical significance was found when SVC was analyzed by risk category. Conclusions: Neither posture nor high risk body composition significantly affected SVC. These findings demonstrate that a subject’s naturally chosen posture can be their most efficient way to breath, and adjusting posture to improve breathing may not be as important as once believed.

Key Words: slow vital capacity, geriatrics, obesity, lung capacity, breathing, position
INTRODUCTION

According to the Department of Health and Human Services, 20% of the population will be over the age of 65 by 2030, twice the number of adults over 65 in 2000 (1). The deterioration of the body is a natural part of this aging process and can contribute to gradually poorer posture. Two-thirds of elderly women and men already have thoracic kyphosis, or severe curvature of the upper back (2). This disease reduces thoracic cage size which in turn can reduce lung capacity (2,3). Vaz Fragoso and Gill show aging contributes to a natural decrease in pulmonary function (4). Elderly populations, therefore, have both a decrease in posture and lung capacity but to our knowledge no research has been completed to see if improving posture could lead to improvement in breathing. Proper posture is emphasized to improve breathing ability, even without the scientific research, in therapy departments, exercise tests, and everyday life. A scientifically proved correlation would be the evidence needed to help improve breathing in sedentary, diseased and aging populations.

Though to date no correlation between lung function and posture has been clearly demonstrated, several studies have examined the effects of obesity, asthma, and aging on pulmonary function. A study completed by Santamaria and colleagues demonstrated a connection between duration of a person’s obesity and a decrease in vital capacity (VC) (5). The researchers used forced vital capacity (FVC) lung tests to demonstrate that the longer a person was obese the greater the decline in VC (5). FVC is just one of the spirometry or pulmonary function tests (PFT) utilized by researchers to measure pulmonary function. Spirometry is a physiological test that measures how an individual inhales and exhales volumes of air as a function of time that can be used as a diagnostic, monitoring, disability/impairment evaluation and public health (6).

A pulmonary study using elderly populations utilized the slow vital capacity (SVC) spirometry test because they found that some older adults cannot handle the energy requirements needed to complete the FVC test, especially multiple trials (7). SVC was also utilized by Kotur et al. in a study conducted with obese populations to show there was not a significant change in VC when compared to control groups (8). When comparing FVC, SVC, and inspiratory vital capacity (IVC) tests in normal populations and populations with asthma, little difference was seen between the three tests in healthy and mildly asthmatic populations (9). These several studies show that SVC can be an adequate measure of pulmonary function for normal populations as well as populations who are obese, have asthma, or are elderly. Furthermore, SVC would be a better representation of every day breathing habits than FVC. Recent research has shown that ethnicity is not as impactful on pulmonary function amongst white, African-American, and Mexican American individuals as traditionally assumed (10). For this reason, ethnicity was not considered an exclusion criteria in this study.

The purpose of this study is to determine whether posture significantly impacts pulmonary function in middle-age and older adults. Since there have been no studies that have investigated the correlation between posture and lung function, this study hypothesizes middle-age and older adults will have lower pulmonary function scores with poor posture
compared to ideal posture, linking posture to lung function. If this hypothesis is correct, it will reveal an important connection between posture and pulmonary function that could increase the quality of lives for many middle-age and older adults. It will create the opportunity for further research on posture interventions and exercise programs that could increase pulmonary function.

**METHODS**

**Subjects**
A total of 22 Caucasians, age 45 or older, were recruited using convenience sampling from the University of Wisconsin-Eau Claire’s Community Fitness Program. All measurements are presented as mean ± standard deviation: age 62 ± 9, BMI 29 ± 6 and 50% male. Of the sample, 41% had a BMI ≥ 30 kg/m² another 9% had a BMI ≥ 25 kg/m² plus a waist circumference ≥ 102 cm (men) or ≥ 88 cm (women). They were asked a brief health history questionnaire that examined for any underlying lung condition or smoking habits; 5 of the participants had sleep apnea. BMI was determined through height and weight measurements (170.84 ± 11.43 cm and 86.67 ± 24.31 kg, respectively). All participants read a cover letter explaining the study and had the opportunity to ask any questions. An informed consent was signed prior to data collection and kept on file for each participant. Participants were debriefed on the purpose of the study via e-mail after completion of data collection. This study was approved by the University of Wisconsin Internal Review Board.

**Instrumentation**
*Slow Vital Capacity Test.* Calibration of Medgraphics BreezeEx V 3.06 (Med Graphics Corporation, St. Paul, MN) and the Cardiorespiratory Diagnostics software included inputting the current temperature, humidity, barometric pressure, and calibrating the pneumotachometer using a 3 Liter syringe. A single primary investigator conducted all of the pulmonary function testing. The participant breathed into a pneumotachometer and wore nose clips to prevent breathing through the nose. The SVC test begins with the participant taking 3-4 normal breaths. When indicated by the computer system, the investigator instructs the participant to slowly inhale as much as possible and then slowly exhale until they cannot exhale any further. The computer system analyses the test and shows SVC values.

*Anthropometric Measurements.* Height was measured to the nearest 0.1 cm recorded by a Seca Model 220 Stadiometer (SECA, Hamburg, Germany) and weight was measured to the nearest 0.1 kg with a Tanita Electronic Scale (Tanita, Tokyo, Japan) Minimal clothes and no shoes were worn for the recording of height and weight. Weight and height were measured twice and were averaged to compute BMI. BMI was used to categorize the participants into risks classifications (see Table 1). Waist circumference was measured once using a flexible tape measure and recorded to the nearest half centimeter. These anthropometric measures were conducted by the second principal investigator.
Table 1. Body Mass Index categorization.

<table>
<thead>
<tr>
<th>Waist Girth</th>
<th>Normal (18.5-24.9 kg \cdot m^2)</th>
<th>Overweight (25 – 29.9 kg \cdot m^2)</th>
<th>Obese (30 – 34.9 kg \cdot m^2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Men: &lt; 102 cm</td>
<td>Least risk</td>
<td>Increased risk</td>
<td>High risk</td>
</tr>
<tr>
<td>Women: &lt; 88 cm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Men: ≥ 102 cm</td>
<td>Increased risk</td>
<td>High risk</td>
<td>Very high risk</td>
</tr>
<tr>
<td>Women: ≥ 88 cm</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Applying BMI and waist girth measurements to risk for health and longevity and medical problems in adult men and women (11).

Posture. Three neon stickers were placed on the subject to improve the ability to analyze posture using the motion analysis software, Dartfish 5.0 (Dartfish, Switzerland); one on the acromion process, one on the greater tubercle of the femoral head, and one on the lateral epicondyle of the tibia. The first trial was completed without instruction on posture thus considered their “normal” posture (NP). Ideal posture (IP) was instructed as sitting as straight as possible with shoulder blades pulled back, and chest out. Poor posture (PP) was instructed as resting elbows on knees in a hunched over position. SVC was taken several times in each position and the best trial from each position was noted to be analyzed. Using the motion analysis software, angles for each of the three postures were recorded.

Procedures
Data was collected over a 3-week time period from 5:30 am to 7:30 am in the Exercise Physiology Lab. The testing procedure took approximately 30 minutes to complete for each subject. Several pilot tests were done prior to the experimental testing to demonstrate the validity of the equipment and testing procedure. To ensure consistency
between trials and testing days, measures were taken to standardize the procedure including calibration and positioning of the camera equipment in relation to the participant.

Testing Protocol. Participants rested for at least 15 minutes prior to testing to ensure that their breathing was normal. Each participant was instructed on proper SVC test technique using a prepared script of verbal cues and a visual demonstration. A nose clip was used to prevent air leakage through the nostrils. The subject was instructed to wet their lips to form an airtight seal around the pneumotachometer mouthpiece. After breathing normally for 4 to 5 breaths, the subject was told to take a deep inhale at a natural pace to completely fill their lungs, then to completely empty their lungs to their best ability through the mouthpiece. After resuming normal breathing, the subject was able to take a full minute break until the start of the next trial. The number of trials performed was dependent on the subject's level of understanding on the technique in fully inhaling and exhaling to produce relatively similar results. After several trials were performed with no posture instruction (NP), the subject was instructed to change posture to either IP or PP depending on randomized group assignment. All of the groups performed NP first without instruction on position. Subsequently, half of the participants (Group 1) performed PP then IP while the other half (Group 2) performed IP then PP. The order of testing was counterbalanced across participants to account for possible fatigue or improvement through practice.

Statistical Analyses
The mean and standard deviation of the baseline characteristics of the subjects including age, height, weight, BMI and waist circumference were determined by a descriptive analysis and risk classification was expressed in percentages. Two-way repeated measures ANOVA was used to compare the SVC scores across NP, PP, and IP between risk classifications. The level of significance was determined as alpha = 0.05 (5%). Data was analyzed using the Statistical Package for the Social Sciences (SPSS) software version 19.0.

RESULTS
Descriptive Statistics
A total of 22 participants completed the study. Fifty percent of the participants were male and fifty percent of the participants were considered to be low/moderate risk classification (table 2).

Mean NP SVC values for all participants, males, and females were $3.90 \pm 1.23$, $4.87 \pm 0.81$ and $2.94 \pm 0.69$, respectively (table 3). Mean difference in angle of hip flexion from NP to PP was 50 degrees; mean difference in SVC from NP to PP was 0.23 L, not significant.

Table 2. Participant Demographics
Parameter | Male (n = 11) | Female (n = 11) | Total (n = 22)
--- | --- | --- | ---
Age (years) | 61.36 ± 5.78 | 62.09 ± 12.30 | 61.73 ± 9.39
Height (cm) | 180.18 ± 7.15 | 161.50 ± 6.02 | 170.84 ± 11.43
Weight (kg) | 103.76 ± 21.35 | 69.58 ± 11.95 | 86.67 ± 24.31
Body mass index (kg/m²) | 31.96 ± 6.44 | 26.68 ± 4.43 | 29.32 ± 6.03
Waist Circumference (cm) | 110.59 ± 15.92 | 84.91 ± 11.77 | 97.75 ± 18.96

Risk Classification

- Low/Moderate: 45.5% (n = 5) 54.5% (n = 6) 50% (n = 11)
- High/Very High: 54.5% (n = 6) 45.5% (n = 5) 50% (n = 11)

Note: Values are presented in mean ± standard deviation for continuous variables and in percentage for categorical variable(s). Risk classification categories obtained from Douketis, J.D., 2005 (11).

**Table 3.** Descriptive Statistics of Slow Vital Capacity by Posture and Risk Classification

<table>
<thead>
<tr>
<th>SVC Posture</th>
<th>Mean</th>
<th>Standard error</th>
</tr>
</thead>
<tbody>
<tr>
<td>All subjects</td>
<td>NP</td>
<td>3.90</td>
</tr>
<tr>
<td></td>
<td>PP</td>
<td>3.67</td>
</tr>
<tr>
<td></td>
<td>IP</td>
<td>3.77</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Risk Level</th>
<th>SVC Posture</th>
<th>Mean</th>
<th>Standard error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low/Moderate</td>
<td>NP</td>
<td>3.97</td>
<td>0.379</td>
</tr>
<tr>
<td></td>
<td>PP</td>
<td>3.80</td>
<td>0.420</td>
</tr>
<tr>
<td></td>
<td>IP</td>
<td>3.82</td>
<td>0.427</td>
</tr>
<tr>
<td>High/Very high</td>
<td>NP</td>
<td>3.84</td>
<td>0.379</td>
</tr>
<tr>
<td></td>
<td>PP</td>
<td>3.53</td>
<td>0.420</td>
</tr>
<tr>
<td></td>
<td>IP</td>
<td>3.72</td>
<td>0.427</td>
</tr>
</tbody>
</table>

Note: NP = Normal posture; PP = Poor posture; IP = Ideal posture

**Posture and Risk Classification on Vital Capacity**

Using an alpha level of .05, a two-way ANOVA indicated there was not a significant interaction between posture and risk classification on SVC values among middle-age adults.
males and females, $F(1.73, 34.64) = 0.42$, $MSE = 0.12$, $H-Fp = .63$, $\eta^2 = .020$. The main effect of posture on SVC values was not significant, $F(1.73, 34.64) = 2.89$, $H-Fp = .076$, $\eta^2 = .126$. The main effect of risk classification on SVC values was not significant, $F(1, 20) = 0.09$, $MSE = 5.31$, $p = .770$, $\eta^2 = .004$. See Table 2 for descriptive statistics for SVC values by posture and risk classification.

DISCUSSION

The pulmonary function data of our sample population aligns with values from a large normative study (n > 1,000) (12). Normative FVC values include: males $4.46 \pm 0.93$ L with a mean age of $64 \pm 10$ years and females $3.00 \pm 0.70$ L with a mean age of $69 \pm 10$ years (12). Within our sample population, the average SVC for males was $4.87 \pm 0.81$ with a mean age of $61 \pm 6$ years and females $2.94 \pm 0.69$ with a mean age of $62 \pm 12$ years. Although the normative study measured pulmonary function using FVC, according to Allen et al, FVC values can be comparable to SVC values in the older adult population (7).

It was hypothesized that poorer posture would result in a decline in SVC. However, the analysis showed no significant difference in SVC with a change in posture. The lack of significant results do not support the theory that posture plays a key role in pulmonary function testing in older individuals. There was a tendency for the normally selected posture to produce a larger SVC than the poorer posture. Additionally, some participants saw a decrease in vital capacity from normal to ideal posture. This could be explained by an individual’s natural efficiency of breathing in normal posture. Upon adjusting to ideal posture, one’s breathing may be not as efficient. SVC, as a measure of pulmonary capacity, may not have accurately reflected the compensatory mechanisms of respiratory muscles resulting in a lack of significant decrease in SVC during PP (13, 14).

When considering body composition, a study conducted in 2011 showed an inverse relationship between increasing BMI and pulmonary function (15) but the present data lacks both a main effect of obesity on breathing ability as well as an interaction effect of body composition and posture on SVC. Thus, our findings do not support the assumption of an additional burden from abdominal adiposity on breathing. This outcome is likely due to the body’s ability to adjust breathing mechanics with changing posture. According to Segizbaeva et al, complex interactions between several muscle groups allow for effective breathing with changing body position (13).

Strengths and Limitations

This study is unique in that no previous studies have compared posture differences on SVC. In addition, the objective measurements of height and weight for each subject were taken to estimate BMI rather than self-reported. The risk classification of each subject was categorized based on both waist circumference and BMI (11). To account for improvements due to a learning curve or detriments due to fatigue, posture order was randomized. Dartfish was used to confirm the difference in the trunk flexion during the breathing test. Lastly, when looking at the demographics of this study, there was an equal distribution in males and females and low-moderate to high-very high risk classifications.
Limitations of this study include a small sample size (n = 22), preexisting lung conditions in some subjects, and the use of a single spirometry measure. A larger sample size could show a more statistically significant impact on SVC from posture. When broken down by gender and risk classification, the even smaller sample sizes limited our power to detect statistically significant differences. Additionally, 5 of our subjects had sleep apnea which may or may not have impacted the results. Finally, utilizing other spirometry measures when conducting the pulmonary function testing could reveal differences between postures. This study utilized SVC for a variety of reasons mentioned earlier; however, FVC, Forced Expiratory Ventilation in one second (FEV1) or the 12 second Maximum Voluntary Ventilation (MVV) could also be used.

CONCLUSIONS AND FUTURE DIRECTIONS

The results showed no significant difference in SVC with a change in posture in middle age to older adults. In addition, higher BMI and waist circumference showed neither lower SVC nor a greater posture effect on SVC. Regardless of the lack of significance, the subjects’ normal posture tended to produce the best SVC demonstrating an inherent characteristic of each individual to optimize breathing mechanics. Further research in this field of study is needed to look at the impact of posture in clinical populations with pulmonary diseases.

ACKNOWLEDGEMENTS

We would like to thank all of the participants for volunteering for our study. We also recognize the Department of Kinesiology, University of Wisconsin-Eau Claire for the use of the equipment and supplies necessary to complete this study. Finally, we greatly appreciate the guidance of faculty mentors Dr. Donald Bredle and Dr. Saori Ishikawa.

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