



ORIGINAL ARTICLE

# Time-varying Changes in Pulmonary Function with Exposure to Prolonged Sitting

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**Abstract**

**Objectives:** The purpose of this study was to quantify the time-varying changes in pulmonary function with exposure to prolonged sitting.

**Methods:** Twenty-one healthy volunteers were recruited. The pulmonary function of all participants was measured three times in order to assess changes over time; pulmonary function was measured before sitting, after participants had been seated for 1 hour, and after they had been seated for 2 hours. A spirometer was used to measure pulmonary function. The recorded values were forced vital capacity, forced expiratory volume in 1 second, ratio of forced expiratory volume in 1 second to forced vital capacity (forced expiratory volume in 1 second/forced vital capacity), and peak expiratory flow.

**Results:** All measured values were significantly different before sitting and after 1 hour of sitting. There were also significant differences between all measurements taken before sitting and after 2 hours of sitting. However, the measurements taken after 1 hour and 2 hours of sitting did not significantly differ.

**Conclusion:** These findings suggest that significant changes in pulmonary function occur relatively quickly when human beings are seated.

## 1. Introduction

Sedentary behavior is characterized as any waking behavior involving low energy expenditure, usually done while in a sitting or reclining posture [1]. Sitting is the most common sedentary posture; many people sit for long periods of time, whether they are at school/work, in the car, watching television, etc. [2]. Prolonged sitting is associated with a number of poor health factors, such as cardiovascular disease, obesity, type 2 diabetes, and premature mortality [3–5]. In addition, previous studies reported that prolonged sitting has an adverse influence on musculoskeletal functions. For example, it brings

about decreases in intervertebral disk health, active lumbar range of motion, and spinal musculature activity, and an increase in passive stiffness [6–9].

Pulmonary function is related to age, sex, and race, and may also vary depending on body position [10,11]. Posture (e.g., sitting, standing, supine, and prone) is known to influence pulmonary function because postural changes influence the position of the diaphragm and alter the effects of gravity on the contents of the abdomen [11]. A previous study reported that lung capacity and expiratory volume differ when individuals adopt various sitting postures, such as slumped, kyphotic, and normal sitting [12]. This may be because

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certain postures impede movement of the diaphragm, thereby having deleterious effects on spinal movement and stability. Sustained lumbar flexion caused by prolonged sitting may adversely influence the spinal nerves and muscles and cause lower back issues.

Prolonged sitting, which is inherent in desk work, has become the norm in many work environments. However, there is little information on the effects of prolonged sitting on pulmonary function. Therefore, the aim of this study was to quantify changes in pulmonary function over time with exposure to prolonged, uninterrupted sitting.

## 2. Materials and methods

### 2.1. Study participants

The participants consisted of 21 healthy volunteers from Yeungnam University College in South Korea (5 men and 16 women). The characteristics of the participants (mean  $\pm$  standard deviation) were as follows:  $23.14 \pm 3.21$  years old,  $163.78 \pm 7.21$  cm tall, and  $56.33 \pm 10.45$  kg in weight. Informed consent was voluntarily obtained from all volunteers before participation in the study. Volunteers were included if they had had no experience of lower back pain within the past 6 months, had no orthopedic spinal diseases, and could sit on a stool without experiencing pain. Volunteers who had any kind of respiratory dysfunction, current smokers, and those who had quit smoking cigarettes within the previous 5 years were excluded.

### 2.2. Procedure

The pulmonary function of all participants was measured three times. Measurements were taken at the beginning of the experiment, after 1 hour of sitting, and after 2 hours of sitting. A stool that could be adjusted for height was used. It had no armrest or back support. Participants sat on the stool such that the backs of their knees comfortably rested on the seat and their feet touched the floor. They were instructed to sit with their feet at hip width. The participants watched a monitor while seated. The monitor was at eye level, and a movie was shown on the monitor.

### 2.3. Spirometer measurement

A spirometer (Spiropalm, COSMED, Italy) was used to measure pulmonary function. The values we recorded were forced vital capacity (FVC), forced expiratory volume in 1 second (FEV1), ratio of FEV1/FVC, and peak expiratory flow (PEF). These values have been used to assess the extent of lung disease, but they can also be used to test the pulmonary function of a normal person [13]. Participants blew into a mouthpiece connected to the spirometer each time a measurement was taken. When doing so, they were informed that they should look straight ahead and fixate on a clip placed on

their nose. The participants inhaled and exhaled normally three times, and then inhaled and exhaled deeply.

### 2.4. Data analysis

Statistical analyses were done using PASW 22.0 (SPSS Korea DataSolution, Chicago, IL, USA) for Windows. One-way repeated measures analysis of variance was used to examine changes in pulmonary function over time. Bonferroni's measure was used as a *post hoc* test. Statistical significance was set at  $p < 0.05$ .

## 3. Results

Repeated measures of analysis of variance showed that there were significant changes in the main effect. *Post hoc* testing revealed significant differences in FVC, FEV1, FEV1/FVC, and PEF before sitting and after 1 hour of sitting. Also, *post hoc* testing revealed significant differences in FVC, FEV1, FEV1/FVC, and PEF before sitting and after 2 hours of sitting. There were no significant differences between 1 hour and 2 hours of sitting.

## 4. Discussion

The aim of this study was to quantify time-varying changes in pulmonary function with exposure to prolonged sitting. Our results indicate that pulmonary function is significantly decreased when individuals remain seated for prolonged periods of time. However, all the changes we found took place within the 1<sup>st</sup> hour of sitting. This indicates that it would be better to take a rest after sitting for at least 1 hour. These findings suggest that changes in pulmonary function occur relatively quickly upon exposure to sitting (Table 1).

Our results indicated that participants have decreased lung volume during inspiration, perform muscle contraction less efficiently upon expiration, and experience more air flow obstruction in airways of all sizes when seated for a long period of time. Sustained lumbar flexion, a consequence of prolonged sitting, has been shown to alter conditions in the spinal system. Our results are in agreement with those of several previous studies that reported that biomechanical changes, such as muscle stiffness and alterations in the range of motion of the torso, can take place after exposure to prolonged sitting [6,7]. Adoption of a posture that causes the spine to be flexed, such as when one sits at a computer and does desk work, has become unavoidable in many working environments. When slumping, the lumbar and pelvic spinal segments become dependent on passive structures to maintain their positions against gravity [14,15]. Thus, sustaining a posture with a flexed spine might cause stiffness and reduce the elastic properties of muscles. Similarly, Beach et al reported that stiffness of the lumbar spine increased after prolonged sitting. A

**Table 1.** Time-varying changes in pulmonary function.

	Before sitting	1 h sitting	2 h sitting
FVC* <sup>†</sup>	2.58 ± 0.90	2.33 ± 0.90	2.22 ± 0.86
FEV1* <sup>†</sup>	2.39 ± 0.74	2.11 ± 0.77	2.00 ± 0.81
FEV1/FVC* <sup>†</sup>	95.92 ± 1.16	91.17 ± 1.97	90.08 ± 2.20
PEF* <sup>†</sup>	4.49 ± 1.40	3.72 ± 1.60	3.53 ± 1.59

Values are given as mean ± standard deviation. There were no significant differences between 1 hour and 2 hours of sitting. \* Significant difference between before sitting and 1 hour of sitting. † Significant difference between before sitting and 2 hours of sitting. FEV1 = forced expiratory volume in 1 second; FEV1/FVC = ratio of forced expiratory volume in 1 second to forced vital capacity; FVC = forced vital capacity; PEF = peak expiratory flow.

decreased range of lumbar motion after exposure to prolonged sitting was also reported in previous studies [6,15]. Callaghan and McGill [15] reported that a decreased range of lumbar motion was induced by structures that provide passive resistance to lumbar flexion, such as posterior ligaments and intervertebral discs. Taking into consideration a stiffened abdomen and decreased range of lumbar motion, diminished pulmonary function may be induced by impeded diaphragm movement caused by normally inactive muscles acting to move the ribcage more inefficiently.

Our findings showed that pulmonary function was decreased while participants sat for a prolonged period of time. Although our study has a marked limitation in that the sample size was small, we expect our results to provide an index for other studies on the effects of prolonged sitting. Further studies are required to investigate whether more changes in pulmonary function occur when individuals are seated for long periods of time each day, over a period of weeks or months.

When humans are exposed to a sitting position for a long time, pulmonary function changed relatively quickly. The change was significant after 1 hour. It would be better for humans to take a rest after sitting for at least 1 hour.

## Conflicts of interest

The authors declare that there are no conflicts of interests.

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