ORIGINAL ARTICLE

Effect of Different Sitting Postures on Lung Capacity, Expiratory Flow, and Lumbar Lordosis

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ABSTRACT. Lin F, Parthasarathy S, Taylor SJ, Pucci D, Hendrix RW, Makhsous M. Effect of different sitting postures on lung capacity, expiratory flow, and lumbar lordosis. Arch Phys Med Rehabil 2006;87:504-9.

Objective: To investigate the effect of sitting posture on lung capacity and expiratory flow (LC-EF) and lumbar lordosis.

Design: Repeated measures on 1 group of subjects in 4 postures.

Setting: Laboratory.

Participants: Seventy able-bodied volunteers.

Interventions: Postures were assumed randomly: normal, with full ischial support and flat lumbar support; slumped, with the pelvis positioned in the middle of seat while leaning against the backrest; against the back part of the seat without ischial support (WO-BPS), with partially removed ischial support and an enhanced lumbar support; and standing.

Main Outcome Measures: For LC-EF, forced vital capacity, maximum forced expiratory flow, forced expiratory volume in 1 second, and peak expiratory flow; and lumbar lordosis.

Results: All LC-EF measures in standing were significantly superior to those in slumped and normal sitting, and 4 measures were significantly higher than in WO-BPS. In slumped sitting, LC-EF significantly decreased from that in normal sitting. WO-BPS sitting significantly increased 4 of the LC-EF measures from those in the normal sitting. Lumbar lordosis was the highest in standing and progressively decreased in WO-BPS, normal, and slumped sitting.

Conclusions: Slumped sitting significantly decreased LC-EF and lumbar lordosis. Because it increases the lumbar lordosis and promotes LC-EF, the WO-BPS posture may be a better seating option for people sitting for a prolonged time.

Key Words: Lordosis; Lung volume measurements; Posture; Rehabilitation.

PEOPLE WITH SPINAL CORD INJURY (SCI) frequently experience a range of complications. Respiratory dysfunction,[1] pain,[2,3] muscle fatigue,[4] and pressure ulcers[5-12] are among the most common complaints. A major cause of morbidity and mortality in these people is long-term respiratory complication in the form of pneumonia or atelectasis,[5] with pneumonia being the leading cause of their deaths.[13] Many factors can contribute to poor lung function, including smoking habits, surgical history, hazardous occupational or environmental exposure, asthma, allergies, chronic obstructive pulmonary disease, and obesity. Additionally, the connection between posture and lung performance has proved significant.[1,6,14-16] Studies[1,15,16] with able-bodied subjects that compared sitting and standing postures support the hypothesis that pulmonary function is optimal while standing. In SCI populations, Chen[1] and Baydur[14] and colleagues found that the supine posture produced the best spirometric recordings. Because subjects with SCI are in a sitting posture for prolonged periods of time, it is important to know how different sitting postures affect pulmonary function. To date, this information has not been reported.

A new seating system that features adjustable ischial and lumbar support[17] has been developed to suggest a new sitting posture to mimic the spine's natural curvature in the stance, and provide better postural support for seated subjects.[18] This posture has been designated as the back part of the seat without ischial support (WO-BPS),[18] that is, the back part of the seat is tilted downward 20° and the enhanced lumbar support is used (fig 1). Because the WO-BPS's design imitates standing spinal alignment, it was expected that use of this model by able-bodied subjects would result in improved sitting posture and respiratory capacity.

We tested 2 hypotheses in this study: (1) body posture affects the lung capacity and expiratory flow (LC-EF); specifically, taking the LC-EF in the standing posture as a reference value, the kyphotic, or slumped, sitting posture may compromise LC-EF more than a normal sitting posture, and a sitting posture that approximates a standing condition may improve the LC-EF over that when in the normal sitting posture; and (2) the change in LC-EF induced by body posture can be correlated to spinal curvatures, that is, lumbar lordosis. To test these hypotheses and capture the variance in pulmonary indices across the different postures that most people assume, we examined the relation between the LC-EF and body posture, between lumbar lordosis and body posture, and between LC-EF and lumbar lordosis. The selected body postures included a standing posture and 3 different seated postures—slumped, normal, and WO-BPS sitting.

METHODS

Participants

Seventy able-bodied people participated after giving their informed consent. Among them, 40 subjects (22 men, 18 women; mean age, 33.9±13.3y; mean weight, 73.3±20.3kg, mean height, 172.5±11.2cm) participated in the breathing test; 40 subjects (19 men, 21 women; mean age, 44.7±16.8y; mean

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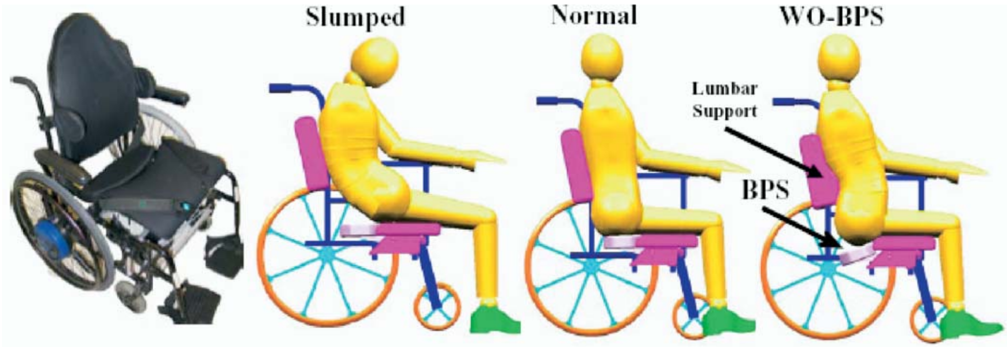

Fig 1. BPS of the wheelchair can be tilted downward 20°, and lumbar support added. Three sitting postures (ie, slumped, normal, WO-BPS) are shown here.

weight, 68.5±13.9kg; mean height, 168.0±11.2cm) took the radiologic measurement of lumbar lordosis in 3 body postures, that is, normal sitting, WO-BPS sitting, and standing. Ten subjects participated in both tests and 8 of the 10 (3 men, 5 women; mean age, 40.0±10.7y; mean weight, 72.4±17.2kg; mean height, 170.4±10.5cm) took an additional radiologic measurement of lumbar lordosis in the fourth (slumped sitting) body posture. All subjects had full range of motion (ROM) of the spine with no pain induced when assuming the testing postures. Exclusion criteria included the severe, fixed deformities of the pelvis and spine, which prevented conformity of the spinal column to the back of the chair. The study was approved by the institutional review board of Northwestern University.

Postures

The 3 sitting postures included WO-BPS, normal, and slumped sitting (see fig 1). In all seated postures, knees were flexed at 90° with feet fully supported. The WO-BPS posture included sitting with the buttocks all the way back into the seat while the BPS was tilted downward 20° with respect to the front part of the seat (see fig 1). There was a total back rest with a protruded lumbar support at the L4 area of the back. The normal sitting posture was defined as the BPS being level with the front part of the seat, with the lumbar support remaining flat. The slumped sitting posture was defined as the subject sitting in the chair, which was configured the same as in the normal posture, with the pelvis positioned in the middle of the seat, allowing it to significantly tilt posteriorly, with the trunk and spine assuming a long kyphotic posture against the backrest. The subject was instructed to keep his/her head statically flexed while performing the breathing test. This position was meant to mimic sitting without external posterior lumbar and pelvic support. The standing posture was defined as the subject standing upright, allowing for physiologic lumbar lordosis.

LC-EF Measurement

The LC-EF measures evaluated were the forced vital capacity (FVC), maximum forced expiratory flow at 25%, 50%, and 75% of the FVC, respectively ($FEF_{25\%}$, $FEF_{50\%}$, $FEF_{75\%}$), average forced expiratory flow between the 25% and 75% FVC levels ($FEF_{25\%-75\%}$), forced expiratory volume in 1 second (FEV_1), and peak expiratory flow (PEF). An SBG spirometer[a] was used to measure each subject's LC-EF and the spirometric indices were calculated with the manufacturer-supplied software WinSpiro, version 2.35.[a] A demonstration of the LC-EF definitions can been seen in the typical flow volume loop plot in figure 2.

Wheelchair

A custom-instrumented wheelchair, designed to permit the BPS to be tilted downward, and with an enhanced lumbar support, was used to configure the sitting postures (see fig 1). The tilting angle of the BPS was controlled by a motor and had a ROM of 20° downward with respect to the front part of the seat. The depth, height, and width of the seat could also be adjusted to accommodate people of different sizes. The tilting angle of the BPS and the seat depth were measured with potentiometers. The height of the lumbar support was adjustable and its shape could be changed by pumping air into or from the bladder embedded in the backrest. Pressure sensors on the lumbar support were used to gauge its strength. The threshold was set between 50 and 60mmHg. The seat and backrest of the wheelchair were parallel to horizontal and vertical lines, respectively. A programmable logic controller[b] was used to control the pump and motor to change the posture from the normal to WO-BPS sitting posture, or vice versa.

Protocol

Each subject transferred into the wheelchair. The seat depth and height were adjusted in the normal sitting posture to make the seat pan short enough for knee clearance, to give the knee a waterfall front edge, and with the ischia located as close as possible to the center of BPS. The thighs were approximately parallel to the floor, with the feet resting firmly on a footrest. Subjects were told how to properly complete 1 trial, which consisted of: (1) deepest inhalation possible (without the spi-

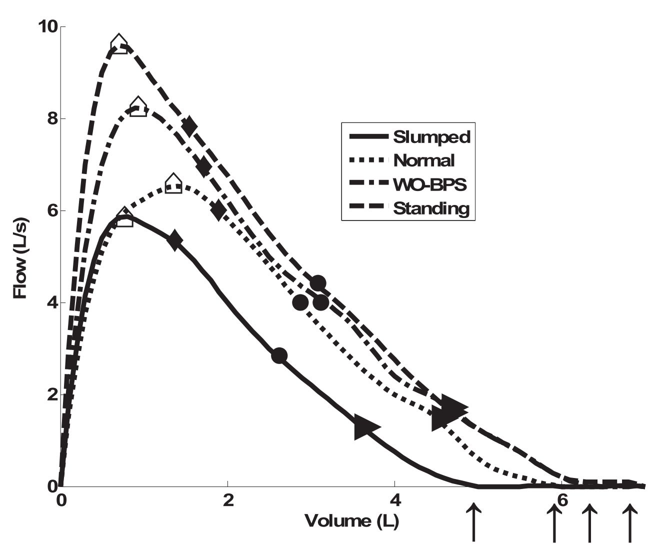

Fig 2. A typical flow volume loop from a subject for the slumped, normal, WO-BPS sitting, and standing postures. Legend: ⌂, PEF; ♦, $FEF_{25\%}$; ●, $FEF_{50\%}$; ▶, $FEF_{75\%}$; ↑, FVC.