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ORIGINAL ARTICLE

EFFECTS OF WHEELCHAIR USE ON PULMONARY FUNCTION AND MUSCULAR RESPIRATORY STRENGTH IN SUBJECTS WITH SPINAL CORD INJURY: A CASE SERIES

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Introduction: People who suffer from spinal cord injuries (SCI) have a high prevalence of respiratory diseases. Their level of respiratory compromise depends on the degree of the injury, whether is complete or incomplete, and on the age of the individual. Because these patients remain seated for extended periods of time, it is essential to evaluate how a wheelchair affects their lung function. Our objective was to compare pulmonary function and respiratory muscle strength in patients with SCI evaluated while seated in a wheelchair with lumbar concavity (WLC) and while seated in a static chair with lumbar convexity (SLC). **Methods:** Forced vital capacity (FVC), forced expiratory volume during the first second (FEV_1), peak expiratory flow (PEF), maximal inspiratory pressure (MIP), and maximal expiratory pressure (MEP) were assessed in subjects with SCI seated in WLC and SLC. For the statistical analysis, STATA 11.1 software was used. We applied t-test to compare the results, and a difference of <0.05 was considered significant. **Results:** We recruited seven male subjects, with a mean age of 42.4 ± 15.5 years (range 19 – 61) and level of injury between C7 and T10. The FVC was 4.21 ± 0.91 and 4.39 ± 0.89 L, for WLC and SLC, respectively, showing a significant difference (p=0.04). FEV_1, PEF, MIP, and MEP did not show any significant difference. **Conclusion:** The use of WLC diminished the FVC in subjects with SCI. The PEF, MIP, and MEP did not have a statistically significant difference but showed a marked tendency to the diminution.

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INTRODUCTON

Spinal cord injury (SCI) is a pathological process that produces alterations of the motor, sensory, and/or autonomous systems. It is therefore a serious disability with several psychological and social consequences[1]. SCI also affects the respiratory musculature producing alterations in its mechanics, thereby causing possible complications of the respiratory function[2].

The SCI may disrupt the function of certain muscles depending on the level of the injury. The inspiratory muscles will be affected if the lesion is on the T11 level, while the expiratory muscles will be affected if the lesion is on L3[2]. From this injury, subjects may have an ineffective cough and difficulty in eliminating secretions, which predisposes them to recurrent lung infections[3].

Several authors have described how people with tetraplegia and high levels of paraplegia show a restrictive type pattern due to their neuromuscular weakness[2,4]. This fact has been affirmed by a significant reduction in forced vital capacity (FVC), forced expiratory volume at one second (FEV_1), peak expiratory flow (PEF), and total lung capacity (TLC)[4].

Several other factors also affect lung function, such as body mass index, packet cigarette consumption/year, obesity, thoracic surgeries, and age[5].

Patients with SCI use a wheelchair for mobility, so they remain in a seated position for a prolonged time while performing their activities. Several studies have concluded that lung function varies in different corporal positions[6,7]. However, there is little evidence to show if there are differences in the assessment of lung function among different seated positions. The objective of this research is to evaluate pulmonary function and respiratory muscle strength in a seated position in a wheelchair with lumbar concavity (WLC) and in a static chair with lumbar convexity (SLC).

METHODS

A descriptive cross-sectional study was carried out from August 2013 to November 2013. The inclusion criteria were: Patients over 18 years of age with traumatic SCI, who smoked less than one pack of cigarette a year and signed an informed consent form. Exclusion criteria were: Patients with high tetraplegia (C1-C5), those who were tracheostomized, and those with sacral pressure ulcers. This study was approved by the Ethics Committee for Human Research at the University of Chile (No. 080-2013).

Measures

A portable PONY FX device (COSMED, Rome, Italy) was used for the evaluation of spirometry, according to international guidelines[8]. FVC, FEV_1, and PEF were obtained from this test. Knudson reference values[9] were used.

For the assessment of MIP, we used a negative pressure manometer (DHD Healthcare. New York, USA) graduated in cmH_2O, and for the evaluation of the MEP we used a positive pressure gauge graduated in cmH_2O (VBM Medizintechnik GmbH. Sulz, Germany). For both assessments, the maneuver was performed three times until a difference of <10% between each reading[10]. All evaluations were performed by a trained physiotherapist (RTC).

All evaluations were performed in two situations: a) seated in a wheelchair with posterior concavity (MEYRA, Kalletal-Kardof, Germany) and b) seated in a static chair with posterior convexity (HCS, Santiago, Chile). The order of the evaluations was randomly assigned through simple randomization.

Statistical analysis

Statistical program STATA 11.1 (Stata Corp. College Station, USA) was used. The descriptive statistics were presented as mean and standard deviations. The Shapiro-Wilk test was used to determine the normality of the sample. With data that had a normal distribution, a t-test was used, and a difference of <0.05 was considered significant.

RESULTS

We recruited seven male patients with SCI. The mean age was 42.4 ± 15.5 years, the mean height was 176.1 ± 6.1 cm, the mean weight was 76.9 ± 6.2 kg, and the mean BMI was 24.6 ± 2.4. According to the AIS classification, there were four subjects with SCI: one AIS A, two AIS B, and one AIS D (Table 1).

Table 1. Baseline patients characteristics.

Subject	Age (years)	Height (m)	Weight (Kg)	BMI	Level of injury	Time of injury (months)
1	16	1.78	69	21.7	T4 AIS D	2
2	25	1.73	70	23.3	T10 AIS B	2
3	61	1.71	81	27.7	C7 AIS B	6
4	44	1.72	82	27.3	T7 AIS A	4
5	42	1.89	82	22.9	T7 AIS A	6
6	56	1.75	72	23.1	T1 AIS A	8
7	50	1.75	82	26.4	T4 AIS A	2
Mean SD	42.4 15.5	1.76 0.06	76.8 6.2	24.6 2.4		4.3 2.4

Abbreviations: BMI, Body mass index: AIS, Association Impairment Scale.

The FVC was 4.21 ± 0.91 L in the WLC and 4.39 ± 0.89 L in the SLC, with a significant difference between both groups (p=0.04). FEV_1 was 3.49 ± 0.83 L in the WLC and 3.55 ± 0.76 L in the SLC, with no statistical significance (p = 0.49). The PEF was 7.53 ± 1.44 L/s in the WLC and 7.81 ± 0.84 L/s in the SLC, with no statistical significance (p = 0.44) (Table 2). The MIP was 93.57 ± 18.75 cmH_2O in the WLC and 98.14 ± 14.81 cmH_2O in the SLC (p = 0.07). MEP was 62.14 ± 26.11 cmH_2O in the WLC and 66.57 ± 26.67 cmH_2O in the SLC (p = 0.06) (Table 2).

Table 2. Pulmonary function and respiratory muscle strength values.

	FVC (L)			PEF (L/s)			MIP (cmH			MEP (cmH		
n	WLC	SLC	Δ	WLC	SLC	Δ	WLC	SLC	Δ	WLC	SLC	Δ
1	4.44	4.46	+0.02	8.25	8.54	+0.29	92	98	+6	108	116	+8
2	4.82	4.87	+0.05	8.99	8.40	-0.59	85	90	+5	73	80	+7
3	3.10	3.12	+0.02	6.93	6.56	-0.37	126	121	-5	70	64	-6
4	3.41	3.73	+0.32	5.74	7.12	+1.38	75	78	+3	45	46	+1
5	5.69	5.76	+0.07	9.60	8.75	-0.85	105	110	+5	68	74	+6
6	3.51	3.82	+0.31	7.06	8.10	+1.04	72	86	+14	30	38	+8
7	4.52	5.00	+0.48	6.18	7.21	+1.03	100	104	+4	41	48	+7
Mean	4.21	4.39	+0.18	7.53	7.81	+0.28	93.6	98.1	+4.5	62.1	66.6	+4.5
SD	0.91	0.89		1.44	0.84		18.8	14.8		26.1	26.7	
	p=0.04*			*p*=0.44			*p*=0.07			*p*=0.06		

Abbreviations: FVC, Forced vital capacity; PEF, Peak expiratory flow; MIP, Maximal inspiratory pressure; MEP, Maximal expiratory pressure; WLC, Wheelchair with lumbar concavity; SLC, static chair with lumbar convexity

DISCUSSION

Our results show that FVC is greater while seated in the static chair with posterior convexity than in the wheelchair with posterior concavity.

The main difference between both chairs lies in the curvature of the backrest, in which one is concave and the other is convex. Therefore, it can be determined that the position of the muscles for respiration can vary depending on the curvature of the backrest.

Lin et al (2006) evaluated differences in lung function while seated in a collapsed posture (with the pelvis in the center of the chair and trunk in flexion), normal posture (flat back), and with lumbar support (backrest with lumbar support)[11]. This research shows that there is a significant increase of FVC in the seated position with lumbar support when compared with seated position in normal and collapsed posture. The study concludes that lung volume is increased in the seated position with lumbar support. The change in lumbar lordosis could be the cause of changes in lung function. Because the modification of lumbar curvature creates compensatory adjustments in the alignment of the spine, an increase in lumbar lordosis decreases thoracic kyphosis, providing greater space for the expansion of the rib cage during inspiration[11].

This is corroborated by Baydur et al., who compared lung function in different body positions and identified differences between the seated and bipedal positions, determining that there is a significant decrease in the parameters of lung function in the seated position[12]. The cause of this is attributed to the fact that in the biped position the diaphragm acts more efficiently[13].

In our study, only one variable of lung function, FVC, showed a statistically significant difference ($p=0.04$) between the WLC-seated and SLC-seated position.

This agrees with the results found previously, since there was also a marked increase of the FVC in the posture with lumbar support compared with FVC in the posture in normal seated position, although the sample is different because Lin et al. studied healthy subjects[11].

Another study in subjects with SCI compared FVC, FEV_1, $FEF_{25\text{-}75\%}$, and PEF in the normal seated position in a wheelchair with the position with a lumbar support in a wheelchair[7]. The results concluded that FVC, FEV_1, and PEF are statistically significant in the position with lumbar support. Also, the $FEF_{25\text{-}75\%}$ increased, but without statistical significance[7].

Our research does not fully agree with the results of this study, since differences in FEV_1 ($p = 0.49$) and PEF ($p = 0.44$ were not statistically significant. However, there was a similarity in statistical significance in FVC variation with the Prajapati Namrata study[7]. The differences in the results may be because the method for achieving lumbar curvature is different in both studies. Prajapati Namrata adapts lumbar support to the backrest of a wheelchair, while in our research a static chair is used. Hence, the final angle of lumbar lordosis between both studies may be different.

Regarding respiratory muscle strength, it has been determined that there is an alteration in the displacement of the rib cage in the seated position, indirectly reducing the efficiency and strength of some respiratory muscles[14]. Another study evaluated MEP in different positions, which significantly decreases in the seated compared with the standing position[15]. Both studies used healthy subjects.

One of our limitations is the small sample size. Although the small number of patients demonstrated a significant difference in FVC, it was not sufficient to show statistically significant differences in PEF, MIP, and MEP. A second limitation was the use of the chair. Standard chairs provided by the health system are not always adapted to the characteristics of individual patients. Therefore, these chairs may not have ensured maximum functionality. Additionally, the study was limited because it was not a randomized clinical trial. However, the antecedents provided by this report serve as the basis for a better methodological design.

Finally, we concluded that the use of WLC decreased FVC in subjects with spinal cord injury due to lumbar concavity. The PEF, MIP, and MEP variables were not significantly altered but a marked tendency to decline was observed.

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