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Relation between Corset Use and Lung Function Postural Variation in Spinal Cord Injury

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Abstract

Rationale: Corsets are widely used to improve trunk stability in patients with spinal cord injury (SCI) and can improve respiratory function.

We sought to identify predictors of respiratory benefits from wearing a corset in SCI patients.

Methods: In a prospective observational study, respiratory function was tested in supine and upright seated position with and without a corset in 36 SCI patients who regularly used a corset. SCI patients who no longer used a corset were matched to the users on sex, injury level and severity.

Measurements and Main Results: Vital capacity (VC) did not differ between users and nonusers in supine position. In users, contrary to nonusers, VC increased significantly in supine position compared to seated position (increase, 0.43±0.39 L vs. -0.05±0.32 L in nonusers, $P<0.0001$). Corset use was associated with a significant VC increase in upright position (2.13±0.71 L without vs. 2.41±0.69 L with the corset, $P<0.001$). The VC increase with the corset in upright position correlated significantly to the VC increase induced by supine, compared to sitting without the corset.

Conclusion: VC increase induced in SCI patients by lying supine may predict the effects of wearing a corset. The long term effects of corset using should be evaluated.

Key Words: Paraplegia, tetraplegia, diaphragm, abdominal binding**,** corset use

Respiratory dysfunction is a major source of morbidity and mortality in patients with spinal cord injury (SCI)[1-3] resulting from weakness not only of several inspiratory muscles, but also of most of the expiratory muscles, including the abdominal muscles[4,5]. Stiffening the abdominal wall by lying supine[6-8] or abdominal binding[9,10] improves diaphragm efficiency and therefore respiratory function.

Corsets are widely used in SCI patients. While preliminary studies found no beneficial effects on respiratory function in seated SCI patients[11,12], a flexible custom-made corset covering the abdomen without overlying the lower rib cage improved respiratory function, diaphragm performance, and perceived breathing difficulties during usual activities[13,14]. However, corset is abandoned in the time-course of SCI by most of the patients.

In order to evaluate whether, in SCI patients, respiratory function improvements induced by wearing a corset in the seated position were proportional to respiratory function improvements induced by lying supine and whether SCI patients using a corset differed in some way from nonusers, we studied consecutive SCI outpatients who used a corset and who were referred to our laboratory for pulmonary function testing (PFT), collecting during the same period, data on nonusers SCI patients.

Methods

Population

Over four years, patients referred for routine PFT in our teaching hospital were included if they met the following criteria: SCI, stable clinical condition, wheelchair-bound, and use of a custom-made abdominal corset. Meanwhile, we collected data on patients who met the first three criteria but were not corset users. Among these patients, controls for the corset users were matched according to sex, SCI severity (following American Spinal Injury Association (ASIA) criteria[15]), and SCI level (C4 or higher, C5-C6, C7-C8, T1-T4, T4-T8). When more than one control was found, the patient whose age was closest to that of the corset user was selected.

The ethics committee of the *Société de Réanimation et de Langue Française* approved this observational study as research on standard or usual care[16] that required oral informed consent which was obtained from all patients.

Measurements

Corset users were tested randomly in the supine position and in the wheelchair with and without the corset, on three consecutive days. Flow-volume curves, and lung volumes were recorded according to standard guidelines[17]. Maximal expiratory static mouth pressure (Pe_{max}) and the highest value between sniff inspiratory nasal pressure and maximal inspiratory mouth pressure was taken[18,19].

The controls underwent the same measurements in the seated position and spirometry in the supine position.

Corset users completed a questionnaire on perceived dyspnoea severity during their usual activities (based on at least 1 day with and 1 day without the corset), assessed at home using the modified Borg Scale (0, no dyspnoea; to 10, worst possible dyspnoea).

Statistics

Data are reported as means±SD. Comparisons used the Friedman repeated-measures, the Wilcoxon and the Mann Whitney tests. Spearman rank correlation and step by step regression analysis were computed to assess correlations. P values <0.05 were considered significant.

Results

Among the 182 SCI patients referred for PFT, 99 had an injury level C8 and above and 83 an injury level between T1 and T8. Among them 36 (23% of tetraplegic patients and 16% of paraplegic patients) were corset users (Table E1 of the online depository). Mean age was 37±12 years, female/men was 8/28, time since SCI was 7.0±9.8 years (range, 2 months to 36 years; median, 18 months). The matched controls (Table E2 of the online depository) were not different regarding age (39±9 years, Wilcoxon test, *P*=0.3), body mass index (22.3±4.7 kg/m² in users vs. 22.7±4.9 kg/m² nonusers; Wilcoxon test, *P*=0.9) or proportion of nonsmokers (18/36 users vs. 19/36 nonusers). However, 11 nonusers were current smokers compared to none of the users, and time since SCI was significantly longer in the nonusers (16±12 years; range, 6 months to 40 years; median, 14 years) (Wilcoxon test, *P*=0.003).

The spirometric lung volumes are presented in the Table 1, and all the others detailed respiratory parameters are into the on-line depository. Vital capacity (VC) and inspiratory capacity (IC) were not different between the two groups in the supine position whereas they were significantly higher in non users than in users in the seated position (Table 1). Expiratory residual volume (ERV) was higher in non-users than in users in both positions (Table 1).

The transition from lying to seated position was associated by significant decrease of IC and increase of ERV in both groups and the resultant was a decrease of VC for only the corset users (Table 1). VC change with position between users and nonusers was significantly higher in users than in nonusers (0.43±0.39 L vs -0.05±0.32 L, Wilcoxon, *P*<0.0001).

The VC change with position (in proportion to seated position) was correlated with the SCI duration (Spearman test, ρ=-0.47; *P*=0.0001), the level of the lesion (S5 was quoted 1, and 1 point was added for each vertebral level above, Spearman test, ρ=0.28; *P*=0.02) but not with the BMI (Spearman test, ρ=-0.21; *P*=0.08). The stepwise regression analysis including

corset using, SCI duration and the level of the lesion observed a R^2 value of 0.34; corset using contributed 29% whereas inverse of SCI duration contributed 5% to the VC change variance.

The corset induced significant improvements of seated IC and VC (Table 1) and the VC change with the position change correlated significantly with the VC change induced by the corset in the seated position (Spearman test, ρ=0.64; P<0.0002; 95% confidence interval, 0.47 to 0.83) (Figure 1).

Among the corset users, 19 accepted to compare the seated position in real life with and without the corset. Wearing the corset was associated with a significant Borg-score drop, from 2.4±1.8 to 0.8±0.8 (P<0.0002).

Discussion

While healthy individuals have better respiratory function in the upright position[20], SCI patients improve VC in the supine position[6-8,13,21,22]. SCI induces abdominal muscle weakness which increases abdominal compliance and promotes descent of the diaphragm with a proportional decrease in the area of apposition of the diaphragm to the rib cage, therefore reducing its ability to elevate the rib cage[23 ,24]. Supine position places the diaphragm in a more advantageous position for ventilation[8,22]. A similar effect is obtained with abdominal binding which increased VC and decreased FRC and RV in tetraplegics[9,10]; although it is associated with an increase in the diaphragmatic load, this effect is counterbalanced by the improvement in diaphragm efficiency[14]. In agreement with these mechanisms, we found a significant correlation between the improvement in VC induced by lying supine and the improvement in VC induced by wearing a corset.

In addition we observed that the corset non-using is an independent factor of no change in VC with position.

At the acute period of tetraplegia, abdominal binding is used with leg contention to manage orthostatic hypotension[25], to maintain an upright trunk position[26] and to improve the respiratory function[9,10]. Because orthostatic hypotension[25], truncal instability[26] and the negative effects of upright on respiratory function are also present in paraplegia[13,21,22] a corset is also often prescribed in paraplegia, and because its effect on respiratory function has not been extensively evaluated in paraplegics, we chose to include all corset users.

The non-users were different from users in term of duration of SCI. During the time-course of post-injury the problem of orthostatic hypotension decreases and the patients find other technologies (mounted on a wheelchair for example) to maintain truncal stability. The vital capacity in SCI generally increases during the first months after injury[27-29] ascribable

to the improvement of the diaphragmatic function[28-30], the neck accessory muscles[31], and the reflex activity of both intercostal muscles[32] and last but not least abdominal-muscle[7,33,34]. Therefore, it seems obvious that benefices of corset decrease as the postinjury period increases. Nevertheless this does not explain the independent relationship between the corset non using and the absence of VC change with position.

We were not able to determine at which moment the nonuser stopped the corset using because it was progressive and not well reminded by them. The reason was also unclear, because it was multiple and manifold including non logical reasons. Nevertheless, when the corset non-using was associated with no negative effect of upright on VC, we are confident that the corset reusing would not improve the respiratory function.

It is probable that reduction of dyspnoea with corset in users constitutes a strong reason to continue wearing the corset and corset users reported significantly less dyspnoea with than without the corset in agreement with previous description[14]. While dyspnoea perception is impaired in tetraplegic patients[23], its prevalence is greater in higher levels of injury independently from weight, age, smoking status, and time since injury[35], but has also been observed in up to 28% of low-level paraplegics[36].

In conclusion, this prospective observational study of respiratory function in SCI patients who use a corset on a regular basis suggests that the differences in VC between the supine and seated positions may predict the effects of corset use on respiratory function. Thus, measuring the improvements induced by the supine position may constitute a simple mean of predicting whether corset use will be beneficial. The introduction of these measurements in the management strategy for SCI patients could be useful, and the long term effect of the corset using needs to be evaluated prospectively in a randomized clinical trial.

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Table 1: Effect of supine position and wearing the corset on spirometric lung volumes in users (n=36), and comparison with nonusers (n = 36).

		Supine position	Seated without corset	Seated with corset	Position effect *P* value*	Corset effect *P* value*
VC (L)	Corset users	2.56 ± 0.67	2.13 ± 0.71	2.41 ± 0.69	< 0.0001	< 0.0001
	Nonusers	2.83 ± 0.86	2.83 ± 0.87	/	0.86	/
Corset users vs Nonusers *P* value§		0.12	< 0.0005	/	/	/
IC (L)	Corset users	2.32 ± 0.58	1.79 ± 0.51	2.11 ± 0.58	< 0.0001	< 0.0001
	Nonusers	2.49 ± 0.75	2.23 ± 0.71	/	< 0.0001	/
Corset users vs Nonusers *P* value§		0.25	< 0.007	/	/	/
ERV (L)	Corset users	0.23 ± 0.17	0.33 ± 0.29	0.31 ± 0.24	< 0.01	0.83
	Nonusers	0.34 ± 0.24	0.52 ± 0.36	/	< 0.0001	/
Corset users vs Nonusers *P* value§		< 0.02	< 0.02	/	/	/

The Friedman repeated-measures analysis performed on corset users (supine, seated without corset, seated with corset) was significant for the 3 parameters.

Abbreviations: VC : Vital Capacity ; IC : Inspiratory Capacity ; ERV : Expiratory Residual Volume. *: Wilcoxon test. § : Mann Whitney test.

Figure 1: Relationship between VC changes induced by lying supine and VC changes induced by wearing the corset while sitting upright, compared to sitting upright with no corset, in the 36 corset users