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Relation between corset use and lung function postural variation in spinal cord injury

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ABSTRACT: **Corsets are widely used to improve trunk stability in patients with spinal cord injury (SCI) and can improve respiratory function. The aim of the present study was to identify predictors of respiratory benefits from wearing a corset in SCI patients.**

In a prospective observational study, respiratory function was tested in the 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 users on sex, injury level and severity.

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

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

KEYWORDS: **Abdominal binding, corset use, diaphragm, paraplegia, tetraplegia**

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

Corsets are widely used in SCI patients. Although 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 ribcage improved respiratory function, diaphragm performance and perceived breathing difficulties during usual activities [13, 14]. However, the corset is abandoned over the time-course of SCI by most 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, consecutive SCI outpatients who used a corset and were referred to the Physiology – Functional Testing department of Raymond Poincaré Teaching Hospital (Garches, France) for pulmonary function testing (PFT) were studied, and, during the same period, data were collected on nonuser SCI patients.

METHODS

Population

Over 4 yrs, patients referred for routine PFT in the Raymond Poincaré 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, data were collected 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

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severity (following American Spinal Injury Association criteria [15]) and SCI level (C4 or higher, C5–C6, C7–C8, T1–T4 and 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 French Language Society for Critical Care (Paris, France) approved this observational study as research on standard or usual care [16] that required oral informed consent, which was obtained from all of the patients.

Measurements

Corset users were tested randomly in the supine position and in the wheelchair, with and without the corset, on 3 days consecutively. Flow–volume curves and lung volumes were recorded according to standard guidelines [17]. Maximal expiratory static mouth pressure and the highest value between sniff inspiratory nasal pressure and maximal inspiratory mouth pressure was recorded [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 ⩾1 day with and ⩾1 day without the corset), assessed at home using the modified Borg Scale (range 0–10; 0: no dyspnoea; 10: worst possible dyspnoea).

Statistics

Data are reported as mean±SD. Comparisons used the Friedman's repeated-measures, Wilcoxon and Mann–Whitney tests. Spearman's rank correlation and step-by-step regression analysis were computed to assess correlations. A p-value of <0.05 was considered significant.

RESULTS

Among the 182 SCI patients referred for PFT, 99 had an injury level of C8 and above, and 83 an injury level of between T1 and T8. Among them, 36 (23% of tetraplegic patients and 16% of paraplegic patients; eight females and 28 males) were corset users (table E1 of online supplementary material). Their mean±SD age was 37±12 yrs, and the time since SCI was 7.0±9.8 yrs (range 2 months to 36 yrs; median 18 months). The matched controls (table E2 of online supplementary material) did not differ regarding age (39±9 yrs; p=0.3 (Wilcoxon test)), body mass index (BMI) (22.3±4.7 kg·m^{-2} in users *versus* 22.7±4.9 kg·m^{-2} in nonusers; p=0.9 (Wilcoxon test)) or proportion of nonsmokers (18 out of 36 users *versus* 19 out of 36 nonusers). However, 11 nonusers were current smokers compared to none of the users, and the time since SCI was significantly longer in the nonusers (16±12 yrs; range 0.5–40 yrs; median 14 yrs; p=0.003 (Wilcoxon test)).

Spirometric lung volumes are presented in table 1, and other detailed respiratory parameters are shown in the online supplementary material. Vital capacity (VC) and inspiratory capacity (IC) did not differ between the two groups in the supine position, whereas they were significantly higher in nonusers than in users in the seated position (table 1). Expiratory residual volume (ERV) was higher in nonusers than in users in both positions (table 1).

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

The VC change with position (in proportion to the seated position) was correlated with the SCI duration (ρ=-0.47; p=0.0001 (Spearman's test)) and the level of the lesion (S5 was denoted 1, and 1 point was added for each vertebral level above this; ρ=0.28; p=0.02 (Spearman's test)), but not with the BMI (ρ=-0.21; p=0.08 (Spearman's test)). The stepwise regression analysis including corset use, SCI duration and the level of the lesion gave an R^2 of 0.34; corset use contributed 29%, whereas the inverse of SCI duration contributed 5% to the VC change variance.

The corset induced significant improvements in seated IC and VC (table 1), and the VC change with position change correlated significantly with the VC change induced by the corset in the seated position (ρ=0.64; 95% confidence interval 0.47–0.83; p<0.0002 (Spearman's test)) (fig. 1).

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

DISCUSSION

Although healthy individuals exhibit better respiratory function in the upright position [20], SCI patients show improved

TABLE 1 Effect of supine position and wearing the corset on spirometric lung volumes in corset users and nonusers

	Supine	Seated		p-value#	
		No corset	Corset	Position	Corset
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	
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	
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	
p-value¶	<0.02	<0.02			

Data are presented as mean±SD unless otherwise indicated (n=36 each for users and nonusers). The Friedman's repeated-measures analysis performed on corset users (supine, seated without corset and seated with corset) was significant for the three parameters. VC: vital capacity; IC: inspiratory capacity; ERV: expiratory residual volume. #: Wilcoxon test; ¶: Mann–Whitney test (corset users *versus* nonusers).

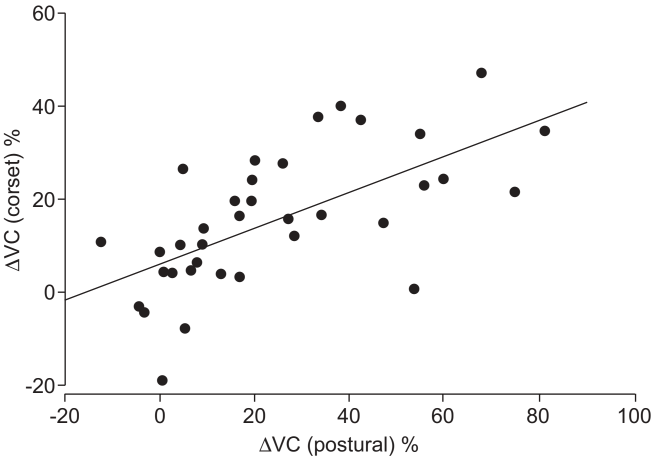

FIGURE 1. Relationship between vital capacity changes (ΔVC) induced by lying supine and ΔVC induced by wearing the corset while sitting upright, both compared to sitting upright with no corset, in the 36 corset users.

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 ribcage, thereby reducing its ability to elevate the ribcage [23, 24]. The supine position places the diaphragm in a more advantageous position for ventilation [8, 22]. A similar effect is obtained with abdominal binding, which increases VC and decreases functional residual capacity and residual volume 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, a significant correlation was found between the improvement in VC induced by lying supine and the improvement in VC induced by wearing a corset.

In addition, it was observed that corset nonuse was an independent factor for no change in VC with position.

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

The nonusers differed from the users in term of duration of SCI. During the time-course of the post-injury period, the problem of orthostatic hypotension decreases and the patients find other technologies (mounted on a wheelchair, for example) to maintain truncal stability. In SCI, VC generally increases during the first months following injury [27–29], ascribable to the improvement in diaphragmatic function [28–30], neck accessory muscles [31] and reflex activity of both intercostal muscles [32] and last but not least abdominal muscle [7, 33, 34]. Therefore, it seems obvious that the benefits of corset use decrease as the post-injury period progresses. Nevertheless, this does not explain the independent relationship between corset nonuse and the absence of VC change with position.

It was not possible to determine the moment at which a nonuser stopped corset use because this was progressive and poorly remembered by them. The reasons were also unclear, since they were many and various, including illogical reasons. Nevertheless, when corset nonuse was associated with no negative effect of being upright on VC, we are confident that corset reuse would not improve respiratory function.

It is probable that the reduction in dyspnoea with the 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 descriptions [14]. Although dyspnoea perception is impaired in tetraplegic patients [23], its prevalence is greater in higher levels of injury, independent of 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 position may predict the effects of corset use on respiratory function. Thus measuring the improvements induced by the supine position may constitute a simple means of predicting whether or not corset use would be beneficial. The introduction of these measurements into the management strategy of SCI patients could be useful, and the long-term effect of corset use needs to be evaluated prospectively in a randomised clinical trial.

STATEMENT OF INTEREST

None declared.

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