ORIGINAL PAPER

Physiotherapy Quarterly (ISSN 2544-4395)
2022, 30(1), 51–56

Effect of electromyography biofeedback training of the abdominal muscles on bladder function in paraplegic spinal cord injury patients

DOI: https://doi.org/10.5114/pq.2020.102167

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Abstract

Introduction. To investigate the efficacy of biofeedback abdominal muscles training on the bladder control and the quality of life in paraplegic patients.

Methods. Overall, 60 male and female paraplegic patients aged 20–40 years were randomly divided into 2 groups. The patients in the study group were treated with abdominal muscles biofeedback strength training, and the control group received pelvic floor biofeedback strength training 2 times per week. The subjects in both groups were evaluated before and after the treatment by (1) measuring post-void urine residual volume, (2) overactive bladder questionnaire, the Arabic version.

Results. There was a significant difference between the 2 groups. In the study group, the urine residual volume decreased to the normal range and the quality of life questionnaire score decreased, which showed good improvement. In the control group, there was no significant difference, with minimal changes: the urine residual volume was still high and the quality of life questionnaire score remained high.

Conclusions. Abdominal muscles biofeedback training must be a main point in the bladder rehabilitation program for paraplegic patients as it decreases the urine residual volume and optimizes quality of life.

Key words: spinal cord injury, overactive bladder (OAB-V8) questionnaire, urinary tract infections, intermittent catheterization

Introduction

Spinal cord injury (SCI) patients experience decreased independence as they have social and physical problems and exhibit increased mortality rates [1]. The life expectancy of individuals with SCI still remains below that of the general population [1–6].

A study showed that urogenital diseases are among the leading causes of death in Norway [5] and in Finland [7]. West et al. [8] found that urinary tract infections in SCI could lead to bladder carcinoma that needed invasive treatments. Until now, there is no simple, safe, and non-invasive method to regulate micturition in SCI patients [9].

Increased residual urine is considered to be an important risk factor for urinary tract infections [10]. Recurrent urinary tract infections are a major problem affecting SCI patients with neurogenic lower urinary tract dysfunction undergoing intermittent catheterization, even if adequate catheterization techniques are applied [11].

Catheterization remains the most accurate method of assessing residual bladder volumes. It was preferred to ultrasonography for quantitative determination of bladder volumes, particularly with low residuals; it provides good qualitative measurement of bladder capacity except at low bladder volumes [12].

The Credé manoeuvre (applying external pressure on the bladder) can be used to empty the bladder but it can lead to renal damage in a long perspective. Therefore, intermittent catheterization is the best choice till now [13]. However, Wyndaele [11] observed that intermittent catheterization could cause complications like urinary tract infections. A clean intermittent catheter can lead to high rates of urinary tract infections beside the psychosocial problems that the injury causes to the patients and their families. It is thus important to perform studies on the effect of different bladder management methods on the quality of life [14].

The aim of this study was to determine the efficacy of biofeedback training of the abdominal muscles to improve bladder control in paraplegic patients. It was hypothesized that there would be no effect of the abdominal training with electromyography biofeedback on bladder function in paraplegic SCI patients.

Subjects and methods

Subjects and study design

The current study was conducted in Eden healthcare and rehabilitation resort, in the period from March 1, 2019 to December 30, 2019, to investigate the effect of electromyography biofeedback training of the abdominal muscles on bladder function in paraplegic SCI patients. In the study group, there were 6 (20%) females and 24 (80%) males. In the control group, the sex distribution was as follows: 5 (17%) females and 25 (83%) males. There was no significant difference in sex distribution between the study and the control group ($p = 0.73$) (Table 1).

A pretest-posttest randomized controlled experimental design was used to investigate the effect of abdominal muscles biofeedback training with electromyography on bladder function in the paraplegic SCI patients, as shown in Figure 1.

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Received: 02.07.2020
Accepted: 15.09.2020

Citation: Gamal M, Latif N, Samir E, Ameen FH, Amin DI. Effect of electromyography biofeedback training of the abdominal muscles on bladder function in paraplegic spinal cord injury patients. Physiother Quart. 2022;30(1):51–56; doi: https://doi.org/10.5114/pq.2020.102167.

Table 1. Baseline demographic and clinical characteristics of the participants

	Study group	Control group	*p*
Age, mean ± *SD* (years)	30.7 ± 7.57	31.63 ± 7.3	0.62
Gender, *n* (%)			
Males	24 (80%)	25 (83%)	0.73
Females	6 (20%)	5 (17%)	
Level of injury, *n* (%)			
(ASIA C) T10–L1	19 (63.3%)	18 (60%)	0.79
(ASIA D) T10–L1	11 (36.6%)	12 (40%)	
Time after injury, *n* (%)			
4–7 months	20 (66.6%)	22 (73%)	0.57
8–12 months	10 (33.3%)	8 (26.6%)	

ASIA – classification by the American Spinal Cord Injury Association

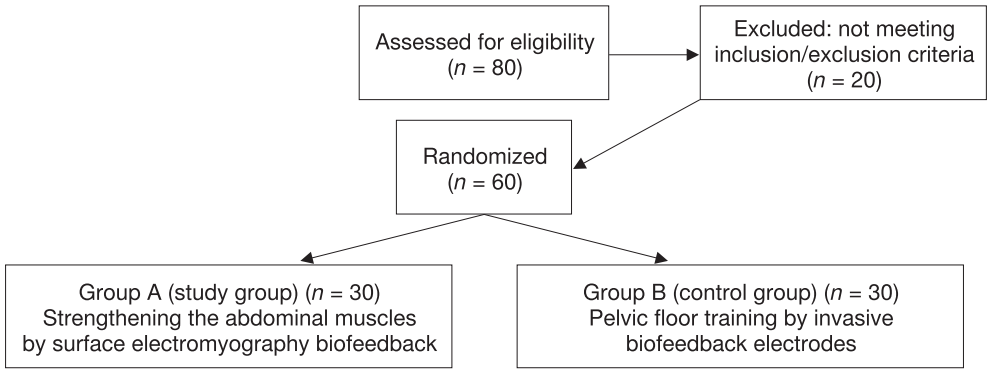

Figure 1. Study design

The 60 randomized patients suffered from urinary incontinence after traumatic partial SCI at the level of the thoracic vertebra T10 and below; the injury had occurred 4–12 months earlier. The subjects were randomly divided into 2 groups by using a random sequence generator. The 30 participants in the study group (A) were treated with abdominal muscles strengthening with electromyography biofeedback surface electrodes. The used device was Cadwell Sierra II Wedge electromyography system connected to an 8 RAM computer. The 30 subjects in the control group (B) received pelvic floor biofeedback training with invasive electrodes.

Patients were included if their age ranged 20–40 years, and if they had experienced SCI within the previous 4–12 months and were medically stable. The exclusion criteria involved impaired bladder function before SCI, any severe medical condition that might interfere with the treatment or affect the results, and anticholinergic drugs administration.

Assessment

All the participants were assessed before and after the treatment period (6 weeks) by:

(1) Measuring the post-voiding residual urine volume with an intermittent catheter (the patient tried to empty the bladder alone, without any assistive tools, and then the residual urine was measured by using intermittent catheterization).

(2) The overactive bladder (OAB-V8) questionnaire in the Arabic version, which is validated to be used in the Arabic language [15].

Treatment

The patients received the treatment program for 2 sessions per week, for 6 weeks. The study group received electromyography biofeedback training for the abdominal muscles by using surface electrodes. The surface electrodes were placed over the lower abdominal muscles and the patient was encouraged to contract the abdominal muscles from supine position by isometric contraction. The participant focused on the monitor for visual biofeedback and on the sound of the contractions as auditory biofeedback. The control group underwent pelvic floor electromyography biofeedback training by using invasive electrodes. The individuals were encouraged to contract the pelvic floor muscles as if they were trying to stop the urine flow. They also focused on the monitor for visual biofeedback and on the sound of the contractions as auditory biofeedback. Each session lasted for 30–45 minutes.

Statistical analysis

– Descriptive statistics and the *t*-test were conducted for comparison of the subject characteristics between the groups.

– The chi-squared test was performed to compare sex distribution between the groups.

– Mixed ANOVA served to compare the effect of time (pre- vs. post-treatment) and the effect of treatment (between the groups), as well as the interaction between time and treatment in the mean values of the residual volume and OAB-V8 scores.

– The level of significance for all statistical tests was set at $p < 0.05$.

– All statistical analyses were performed with the Statistical Package for the Social Sciences (SPSS), version 25 for Windows.

Sample size

The sample size estimation was based on power analysis (mean difference: 26.87, standard deviation [*SD*]: 5.64). The G*Power 3.1 software (Heinrich Heine University Düsseldorf, Düsseldorf, Germany) was used, with the power of 80% and probability of 0.05.

Ethical approval

The research related to human use has complied with all the relevant national regulations and institutional policies, has followed the tenets of the Declaration of Helsinki, and has been approved by the Ethics Committee of Faculty of Physical Therapy, Cairo University (approval No.: P.T.REC/012/001994).

Informed consent

Informed consent has been obtained from all individuals included in this study.

Results

The post-void residual urine volume decreased significantly in group A, while there was no significant decrease in the post-void residual urine volume in group B (Table 2, Figure 2). The OAB-V8 questionnaire revealed a significant difference and improvement in group A, while there was no significant difference in group B (Table 3, Figure 3).

Effect of treatment on residual volume

Study group

The mean ± *SD* residual volume in the study group was 340 ± 84.85 ml before the treatment and 53 ± 11.78 ml after the treatment. The mean difference equalled 287 ml and the percentage of change was 84.41%. There was a significant decrease in the residual volume in the study group after the treatment compared with that before the treatment ($p = 0.0001$) (Table 2, Figure 2).

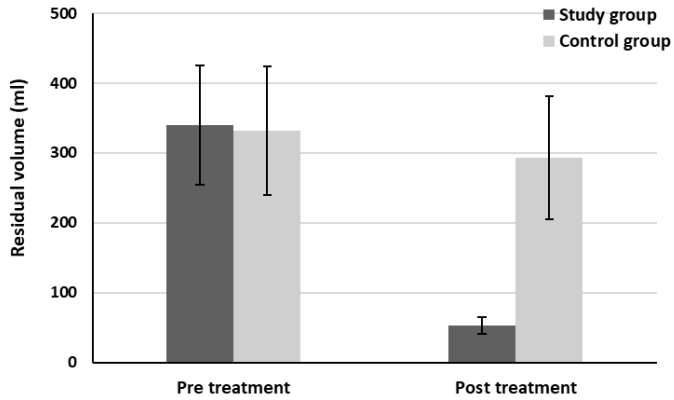

Figure 2. Mean pre- and post-treatment residual volume in the study and control groups

Table 2. Mean pre- and post-treatment residual volume in groups A and B

Residual volume (ml)			
Study group		Control group	
Mean ± *SD*		Mean ± *SD*	
Pre	Post	Pre	Post
340 ± 84.85	53 ± 11.78	331.66 ± 92.36	293.33 ± 87.82
Mixed ANOVA			
Within-group comparison (time effect)			
$F = 394.44$		$p = 0.0001$	
Between-group comparison (group effect)			
$F = 41.28$		$p = 0.0001$	
Interaction effect (time*group)			
$F = 58$		$p = 0.0001$	
Pairwise comparison (Bonferroni correction)			

		MD	% of change	*p*
Pre vs. post	Group A	287	84.41	0.0001
	Group B	38.33	11.56	0.002

		MD	*p*
Study vs. control	Pre-treatment	8.34	0.71
	Post-treatment	–240.33	0.0001

MD – mean difference

Control group

The mean ± *SD* residual volume in the control group was 331.66 ± 92.36 ml before the treatment and 293.33 ± 87.82 ml after the treatment. The mean difference equalled 38.33 ml and the percentage of change was 11.56%. There was a significant decrease in the residual volume in the control group after the treatment compared with that before the treatment ($p = 0.002$) (Table 2, Figure 2).

Comparison between groups

Before treatment. The mean difference in the pre-treatment residual volume between the study and control groups was 8.34 ml. The difference was not statistically significant ($p = 0.71$) (Table 2).

After treatment. The mean difference in the post-treatment residual volume between the study and control groups was –240.33 ml. The difference was statistically significant ($p = 0.0001$) (Table 2).

Effect of treatment on OAB-V8 scores

Study group

The mean ± *SD* OAB-V8 score in the study group was 13.36 ± 1 before the treatment and 3.43 ± 1.35 after the treatment. The mean difference equalled 9.93 and the percentage of change was 74.33%. There was a significant decrease in OAB-V8 scores in the study group after the treatment compared with that before the treatment ($p = 0.0001$) (Table 3, Figure 3).

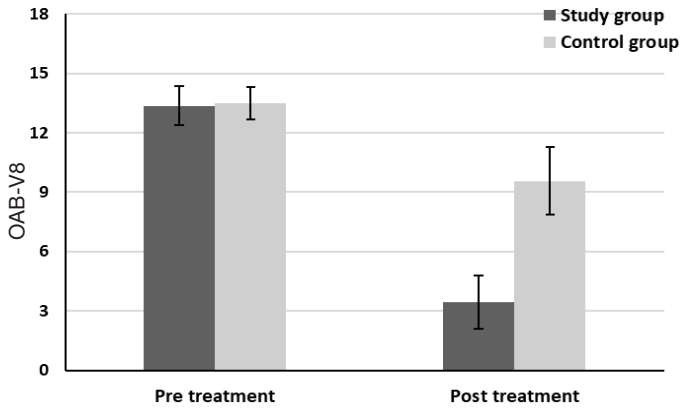

Figure 3. Mean pre- and post-treatment overactive bladder (OAB-V8) questionnaire scores in the study and control groups

Control group

The mean ± *SD* OAB-V8 score in the control group was 13.5 ± 0.82 before the treatment and 9.56 ± 1.7 after the treatment. The mean difference equalled 3.94 and the percentage of change was 29.19%. There was a significant decrease in OAB-V8 scores in the control group after the treatment compared with that before the treatment ($p = 0.0001$) (Table 3, Figure 3).

Comparison between groups

Before treatment. The mean difference in the pre-treatment OAB-V8 scores between the study and control groups

Table 3. Mean pre- and post-treatment overactive bladder (OAB-V8) questionnaire scores in groups A and B

OAB-V8 scores			
Study group		Control group	
Mean ± *SD*		Mean ± *SD*	
Pre	Post	Pre	Post
13.36 ± 1	3.43 ± 1.35	13.5 ± 0.82	9.56 ± 1.7
Mixed ANOVA			
Within-group comparison (time effect)			
$F = 1009.37$		$p = 0.0001$	
Between-group comparison (group effect)			
$F = 166.93$		$p = 0.0001$	
Interaction effect (time*group)			
$F = 188.97$		$p = 0.0001$	
Pairwise comparison (Bonferroni correction)			

		MD	% of change	*p*
Pre vs. post	Group A	9.93	74.33	0.0001
	Group B	3.94	29.19	0.0001

		MD	*p*
Study vs. control	Pre-treatment	–0.14	0.57
	Post-treatment	–6.13	0.0001

MD – mean difference

was –0.14. The difference was not statistically significant (p = 0.57) (Table 3).

After treatment. The mean difference in the post-treatment OAB-V8 scores between the study and control groups was –6.13. The difference was statistically significant (p = 0.0001) (Table 3).

Discussion

Paraplegic SCI patients prefer regaining bladder control function to regaining walking and normal sensation because of the associated psychological problems for the patients and their families [16]. The bladder control is divided into how to empty the bladder and how to close the urine pathway independently; both functions are affected after SCI, which causes a great impact on the daily routine. Different management methods are used but sometimes they can induce side effects after long-term usage [17]. Long-term management strategies like intermittent catheterization and conservative pharmacological therapy are mostly applied to increase the bladder capacity and decrease bladder overactivity in order to provide the patient's satisfaction, avoiding any medical complications as much as possible [18]. Although intermittent catheterization is the best management method for long-term use, it causes medical problems such as scarring, formation of false tracts, urinary tract infections, and some renal diseases [19]. So, a new management strategy with fewer side effects is needed to alleviate bladder disfunction, which is among the top ranked disorders affecting the quality of life [20].

The results of this study showed that the residual urine volume decreased significantly in the study group after the abdominal muscles training with electromyography biofeedback. Measuring the residual urine volume is an important point in the evaluation of the lower urinary tract dysfunction and urinary incontinence [21]. Al Afraa et al. [22] found that it was more safe and healthy for the urine post-void residual volume to decrease to 50 ml or less to avoid urinary tract infections and dysfunctions. Oh et al. [23] measured the quality of life among patients who used intermittent catheterization secondary to SCI and concluded that their quality of life was affected in all health domains. Patients empty their bladder with the Credé manoeuvre, which increases the abdominal pressure by the diaphragm or by the abdominal muscles [24]. So, the results of this study suggest a new safe, non-invasive method by training the abdominal muscles to empty the bladder without using intermittent catheterization. This may change the known medical protocol for long-term management of bladder dysfunction after this type of SCI.

Limitations

The limitations in this study were as follows: there was no financial support; some patients refused to use the invasive electrodes (which is an important cause to think about a new applicable method that does not lead to the patient's psychological problems); sometimes it was embarrassing for the patient that defecation happened during the session while using the invasive electrodes, which caused psychological problems to the patient and their family; and in some cases, the patient refused to complete the treatment program.

Conclusions

Abdominal muscles training with electromyography biofeedback for the paraplegic SCI patients injured at the level of T10 and below is effective for improving bladder function as the patients can empty the bladder voluntarily.

Acknowledgements

We would like to thank the Dar el Mona physiotherapy and rehabilitation resort, Eden healthcare resort, and Badr University in Cairo for their encouragement and providing time to complete this research.

Disclosure statement

No author has any financial interest or received any financial benefit from this research.

Conflict of interest

The authors state no conflict of interest.

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