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Original research

Attention-demand effects on respiration in chronic low back pain patients

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ABSTRACT

Increasing attention is being drawn towards the involvement of systems other than the musculoskeletal one in the presence of low back pain (LBP). Recent evidence suggests both cognitive and respiratory functions to be affected in LBP patients. The aim of this study was to compare the effect of performance of a cognitive task on the respiratory function in LBP patients with that in control participants. Capnography and spirometry parameters of 48 participants (24 in each group) were assessed under 3 cognitive loading conditions (no, easy and difficult cognitive task). The results showed that in both groups the respiratory function was significantly affected by the introduction of the cognitive task ($p < 0.05$) and in the same manner ($p > 0.05$). Capnography and spirometry variables alterations were significantly correlated in the no-LBP group ($p < 0.05$) but there was no significant relationship between respiratory parameters and capnography and disability indices in the LBP group ($p > 0.05$). The findings of the current study suggest that while performing a cognitive task affects respiratory function, the possible differences of LBP patients and control participants may not be elicited under simple non-physically demanding postural conditions.

1. Introduction

Low back pain (LBP) with the prevalence of 80% worldwide (O'Sullivan, 2000) is the major cause of disability before the age of 45 (Ong and Seymour, 2004). Few studies on the prevalence of LBP in the Iranian population have shown LBP not to be less prevalent in Iran than in the industrial countries (Ghaffari et al., 2008; Mohseni-Bandpei et al., 2007). Chronicity of LBP and the secondary consequences play a major role in the establishment of permanent disability (Plowman, 1992). Motor control approach towards recognition and treatment of LBP is gaining increasing popularity (Panjabi, 1992). LBP has shown to be accompanied by several alterations in motor control. These alterations may lead to muscular imbalance, loss of coordination, movement impairment and several secondary deficits exacerbating the symptoms (McGill et al., 1995).

The diaphragm muscle function and thereupon the breathing pattern have been proposed to play a crucial role in spinal stability (McGill et al., 1995; Hodges et al., 2001). The diaphragm with its attachment to the lumbar spine has been found to have a synergistic role with the transverse abdominis muscle and they have both shown altered activation pattern in the presence of chronic LBP (CLPB) (Hodges et al., 2001). The malfunction of the diaphragm as the primary ventilator muscle will lead to breathing pattern disorder (BPD). Hyperventilation and the resultant hypocapnia have been introduced as consequences of BPD which will in turn result in respiratory alkalosis adversely affecting muscular activity (Hastreiter et al., 2001).

Respiration, although performed automatically without the need for attention, can also be voluntarily controlled (Levitzky, 2003). This basic function of the body thus needs specific amount of attention and might be affected by any other (secondary) attention demanding task (Denot-Ledunois et al., 1998). Attention has been defined as the information processing capacity of the individual (Woollacott and Shumway-Cook, 2002). The limited resource of attention approach claims that performing concurrent

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tasks may adversely affect the performance of each or all tasks if the total needed attention exceeds that of the individual's capacity. Besides the mechanical components, the information processing and the attention resources have found to be affected in the presence of CLBP (Smith et al., 2006; O'Sullivan and Beales, 2007; Chaitow, 2004).

On the other hand, stress and anxiety have proven to affect breathing pattern mostly in terms of hyperventilation (Zvolensky and Eifert, 2001; Klein, 1993). CLBP has been found to include multiple psychological aspects and consequences such as fear of pain, fear-avoidance and pain memory. It thus seems probable that CLBP patients showing higher levels of activity-related stress and anxiety and altered diaphragm activity pattern might be at risk of BPD (Vasudevan Crombez et al., 1999; Vlaeyen and Crombez, 1999).

Although BPD has been shown to be associated with musculoskeletal disorders such as CLBP, the response of the respiratory function to a secondary task challenging the busier attention resources and the limited information processing capacity in these patients has not been compared to that in no-LBP individuals. We hypothesized that: i) CLBP patients show altered respiratory function in terms of volumetric and temporal spirometry and capnography variables; ii) performance of a secondary attention demanding task will affect the respiratory function in both CLBP and no-LBP groups and iii) CLBP patients will respond differently in terms of respiratory function to the introduction of the secondary task. The aim of this study was thus to compare the response of the respiratory function of the CLBP patients with that of no-LBP subjects.

2. Methods

2.1. Subjects

Twenty four CLBP patients (with mean age, weight and height of 33.75 ± 8.46 years, 74.04 ± 13.46 $_{kg}$ and 171.13 ± 8.60 $_{cm}$, respectively) and 24 no-LBP participants matched with the CLBP group patients (mean age, weight and height of 33.04 ± 8.25 years, 73.58 ± 12.62 $_{kg}$ and 171.54 ± 8.11 $_{cm}$, respectively) were recruited into this two-factor mixed model (a within group (cognitive task level) and a between group factor (health status)) cross-sectional study. The sampling of the CLBP participants was performed by the simple non-probability method while the members of the no-LBP group were chosen as to be matched with those of CLBP patients according to their age, body weight and height. For each of these variables an acceptable range was defined to meet the matching criteria (±2 years, $\pm 3_{kg}$ and $\pm 5_{cm}$ for age, weight and height variables). The inclusion criteria for the CLBP patients were as follows: age between 18 and 50, experience of pain in the low back region without radiation into the lower extremities during the past year lasting for three months or at least two episodes of LBP lasting more than one week. The pain intensity of the patients at the time of testing had to be between 35_{mm} and 64_{mm} on the $0–100_{mm}$ scored visual analogue scale (VAS) which is categorized as the moderate interference with functioning (Boonstra et al., 2014). The participants in the no-LBP group did not report any episode of LBP at least within the last year. Both groups participants were included if they had no difficulty in breathing and no fear of the spirometer and capnography equipment which could affect the test results. The ability to follow the reaction time test orders was another inclusion criterion for both groups. The participants with any of these criteria would be excluded from the study: history of asthma or any upper respiratory tract disorder affecting breathing, any cardio-pulmonary, neurologic rheumatic or metabolic disease, any symptom of lumbosacral nerve roots involvement, any observable deformity in the spine or lower limbs, stress or anxiety disorders, alcohol or sedative consumption affecting the respiratory or cognitive status, scores less than 30 on the mini mental status examination (MMSE) indicative of cognition or memory deficit (Choe et al., 2014). Oswestry disability index (ODI) and Roland-Morris disability questionnaire (RDQ) were used to assess the LBP related disability in the CLBP patients (Smeets et al., 2011).

All participants were familiarized with the content and aim of the study and were recruited after signing an informed consent form approved by the human ethics committee of the USWR.

2.2. Procedure

The background variables including the participants' sex, age, weight, height and MMSE score were recorded and the participants entered the main tests phase of the study. In this phase two sets of tests were performed to assess the respiratory (spirometry and capnography) and cognitive (reaction time task (RTT)) function of the participants.

The spirometry test was performed using Quark b^2 spirometer (COSMED, Italy) capable of measuring the volumetric, temporal and ratio parameters and gas analysis. The Capno True device (Blue Point, Germany) was used for capnography. The capnography cannula passing through the spirometer mask would be located close to the mouth. Both these systems were calibrated at the beginning of each testing session according to the manufactures' instructions. The tests would be initiated after the participants got acquainted with the instruments making sure there were no instrument induced stress or anxiety. The spirometry measured parameters were inspiratory time (IT), expiratory time (ET), total respiratory cycle time (TRT), inspiratory time to total respiratory cycle time ratio (IT/TRT), minute volume (MV), tidal volume (TV) and respiratory rate (RR). The carbon dioxide pressure (P_{CO2}) in the expiratory flow called end tidal $P_{CO2}$was measured by capnography.

To assess the cognitive function, simple and difficult reaction time tasks were used. Custom made software was designed to measure the accuracy of test performance. Four off lights were shown on each side of a monitor in front of the participant. One of the lights would be lit up randomly on one side and the other 7 lights would be lit up 1 s later. The participants were asked to press a pre specified key on the right or left side corresponding to the side of the first lit up light. For the difficult cognitive task, the participants were asked to press the key on the opposite side of the first lit up light. The interval between the trials in the difficult condition was also randomly variable between 1 and 5 s. Each test condition (easy and difficult) included 4 trials the average score of which was used for statistical analysis. The number of true and false clicks and the total number of clicks were recorded by the software. The key board was situated in such a position that participants did not need to move their upper extremity above the wrist level for pressing the keys. This would prevent involvement of the muscles which might affect respiration. To assure the cognitive performance was not affected by the presence of the instruments, there was another isolated cognitive function test without any spirometry and capnography instruments as the baseline performance.

The spirometry tests were performed in two cognitive task conditions (simple and difficult) the order of which was randomly defined. All tests were performed on two independent sessions being 5–7 days apart for reliability assessment purpose.

2.3. Statistical analysis

The relative and absolute between and within session reliability of the measurements were assessed by intra class correlation (ICC) and standard error of measurement (SEM) tests, respectively. The normality of the distribution of the data was tested by Kolmogrov-