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ORIGINAL ARTICLE

Evaluation of influence of stretching therapy and ergonomic factors on postural control in patients with chronic non-specific low back pain

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Abstract

Introduction and objectives. The vertical orientation of the body in the upright standing position is maintained by keeping the body's centre of gravity (COG) upright, above the base of support, by a dynamic interplay of visual, vestibular, and somatosensory control systems. The objectives of this study were: to compare the postural control strategy between people with and without low back pain (LBP), to estimate the influence of the stretching therapy on the postural control strategy, and to discover the relationship between the restriction of spine mobility and occurrence of some ergonomic factors.
Materials and methods. The study consisted of 32 patients with LBP and 25 healthy controls. Postural characteristics of the subjects were measured with the use of a computerized force platform. The software programme filters and measures COG sway velocity in different conditions. Additional measurements and tests were conducted in patients after stretching therapy. Based on survey research, all individuals were selected and evaluated from the aspect of ergonomics.
Results. The results of the COG sway velocity vary under the testing conditions. From the aspect of ergonomic attitude and influence of the rehabilitation, results varied in the groups.
Conclusions. Ergonomic factors are often accompanied by the appearance of LBP. The restrictions within the musculoskeletal system cause disorders in muscle synergies, which is expressed by an increase in the angular velocity of the COG. In patients with chronic back pain syndrome, selected stretching therapy techniques improves the range of motion of the spine and reduces pain.

Key words

low back pain, centre of gravity, body balance, postural control, force platform, risk factors

INTRODUCTION

Low back pain (LBP) is becoming an epidemiological problem in western countries and one of the most common reasons for visits to a doctor's surgery, generating enormous social costs. It is estimated that about two-thirds of adults in the USA may be affected by some form of low back pain in their lifetime [1, 2]. Direct and indirect costs related to this condition in the US exceed $100 billion per year [3]. In Poland, sciatica represents approximately 2% of all medical diagnoses and ranks in 4th place in the list of the main causes of work absenteeism [4]. Paradoxically, nowadays the increase in the pace of life is not accompanied by increased physical activity. On the contrary, in the era of the automotive industry and digital technology which bear most of the responsibilities, as well as relaxing time people spend in front of the computer/TV screen or behind the wheel, but do not care about the condition of the musculoskeletal system, including the spine. Meanwhile, compensatory mechanisms within it cause chronic tension of myofascial structures which, in turn, leads to restricted mobility and pain.

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Only in about 10% of the patients the specific cause of LBP, such as hernia nucleus pulposus, fracture, or tumour, can be identified. The great majority of patients are labelled as having non-specific LBP without a clear reason. According to the duration, non-specific LBP is classified as acute (less than 6 weeks), subacute (between 6 – 12 weeks) or chronic (longer than 12 weeks) LBP [5]. Epidemiological studies have identified some risk factors for the occurrence of non-specific low back pain which may be considered in 3 groups:

1) individual risk factors, such as: age, body weight, physical fitness, strength of back and abdominal muscles;
2) psychosocial risk factors, e.g. stress, anxiety, emotional instability;
3) occupational risk factors, e.g. physically heavy work, lifting, bending, twisting, pulling and pushing, body vibration, job dissatisfaction, and monotonous tasks [6].

Some of these risk factors, such as lower age and higher pain intensity, obesity, distress or a job requiring lifting, may play a role in the transition from acute to chronic low back pain [6]. Identification of people remaining under the influence of risk factors is very important as it enables implementation of primary as well as secondary prevention.

Many types of treatment for low back pain have been recommended [2, 6, 7]. Exercise therapy is widely used and recommended as a conservative therapy for chronic non-specific but not for acute LBP. This type of treatment strategy is individually designed and often includes stretching exercises. It may be effective in improving function and reducing pain in patients with chronic LBP [5, 8, 9, 10].

Clinical observations show that persons with LBP demonstrate a greater postural sway compared with healthy controls [11, 12, 13]. The exponent of musculo-fascial balance is the ability to maintain proper posture, which can be measured objectively using a computerized posturographic measurment of the body's center of gravity (COG), which is linearly dependent on the centre of pressure (COP) [14]. The vertical orientation of the body in the upright standing position is maintained by keeping the body centre of gravity (COG) upright, above the base of support, by a dynamic interplay of visual, vestibular, and somatosensory control systems [14, 15]. The control of upright stance can change during conditions of increased postural tension which limits the synergy of musculofacial system. No part of the human body should be considered in isolation from the others when trying to understand the balance strategies in subjects.

Since COG is located at the level of S1-S2 and is separated from the support plane by 3 pairs of joins: hips, knees and ankles, there are 2 basic correction strategies. In the ankle strategy, COG is repositioned by moving the whole body as a single-segment inverted pendulum by production of torque at the ankle. The hip strategy moves the body as a double-segment construction with counterphase motion at the ankle and hip [16]. The force platform technique is one of the most frequently used quantitative techniques for postural control assessment that enables the measurement of the COG sway velocity (Fig. 1) [14, 17].

OBJECTIVES

The aims of the presented study were to compare:
1) the postural control strategy and range of the spine movement between people with and without LBP;
2) the postural sway velocity and range of the spine movement between people with LBP before and after stretching therapy.

The study also attempts to discover the relationship between restriction of the lumbosacral spine region and occurrence of some ergonomic factors.

MATERIALS AND METHODS

The study included 32 patients (20 male, 12 female) with persistent symptoms of mild chronic low back pain (LBP) and 25 age- and gender- matched healthy control subjects. Clinical test of spine mobility (Schober test) and treatment were carried out at the Medical Centre Orto-Optymist in Lublin, Poland. Postural sway characteristics of the standing subject were measured with the use of a computerized force platform – Balance Master (NeuroCom, USA) (Fig. 1) in the Department of Physiotherapy and Rehabilitation Department of Nursing and Health Sciences, at the Medical University in Lublin, during the period from October 2012 – July 2013. The subjects were also required to grade their level of back pain on a visual analogue scale (VAS). The following cut points on the pain VAS were recommended for inclusion of subjects in the study: 0–4 mm – no pain, 5–44 mm – mild pain. The demographic characteristics of the subjects are given in Table 1. Patients with neurological conditions associated with balance disorders or taking analgesics or other drugs or stimulants that may cause increased body sway were excluded from the study group. The Balance Master system consists of mobile equipment with dual static force plates and a computerized monitor. Each footplate rests on 2 force transducers, with the sensitive axes oriented vertically. The transducers in turn provide input to the computer. The software programme filters the centre of pressure data and then calculates, tracks, and displays the centre of gravity (COG) on the monitor.

Test of Sensory Interaction on Balance (mCTSIB). The mCTSIB assesses a person's ability to use sensory inputs for balance, and distinguishes between normal and abnormal balance performance. The test measures the centre of gravity (COG) sway velocity while standing on firm and foam surfaces with eyes open (EO) and closed (EC).

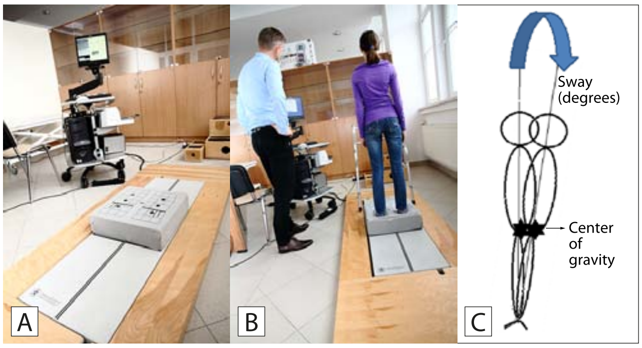

Figure 1. The Balance Master System enabling computerized posturographic measurements: (A) equipment which consists of platform and computer, (B) measurement of the sway velocity of COG of the body on foam surface, (C) diagram explaining the principle of the System action: the sway angle of COG is the angle between vertical line projecting upward from the centre of the area of feet support and the second line projecting from the same point to the subject's COG. The COG sway velocity is the ratio of the distance travelled by the COG (degrees) to the time (sec) of the trial [14]

Furthermore, the patients were assessed by a routinely used clinical test of spine mobility, the Schober test.

All evaluations were compared in 2 groups – control (C) and patients (LBP). Further, additional measurements were conducted in patients after a 2-week rehabilitation with use of stretching techniques. Each subject underwent a series of 6 therapy sessions over a period of 2 weeks. Twenty minutes soft tissue therapy included mobilization of the thoraco-lumbar fascia, and massage lengthening the back extensor muscles. Additionally, the subjects were supposed to do some stretching exercises of iliopsoas, back extensor and ilio-tibial band in accordance with the standards of physiotherapy (on their own) at a frequency of once a day, of 30 minutes each, for a period of two weeks.

Based on survey research, all individuals were selected into 2 subgroups, taking into consideration the aspect of work condition, as well as taking up physical activity. Each of the variables assigned a score: ergonomic work – 1 point, non-ergonomic – 2 points, regular activity – 1 point, irregular activity – 2 points, and no physical activity – 3 points. These variables were specified into the ergonomic attitude (EA) and non-ergonomic attitude (NEA). EA was specified on the point scale below 4 points (EA <4) while NEA≥ 4. All evaluations were compared in those 2 groups (EA vs. NEA).

Statistical methods. Kolmogorov-Smirnov and Shapiro-Wilk normality tests were used to determine if the dependent variables had normal distribution. All variables had normal distribution and were analyzed with parametric statistical tests. The differences of continuous variables among patients' groups were determined with the T test. Fisher exact test was used to test the association for categorical data. Results with p-values <0.05 were regarded as statistically significant. Significant p values are indicated in bold characters in the Tables. Data in plots are shown as mean values (height of rectangles) ± standard deviations (whiskers). Results were analyzed using statistical software packages SPSS ver. 14PL (SPSS, Inc.) and Statistica ver. 9 (StatSoft, Inc.).

RESULTS

In comparing the 2 groups (control and LBP), no significant differences were found in age, gender weight, and height, but the groups differed in BMI (Tab. 1).

Table 1. Demographic characteristics of subjects

Characteristics	Control group (n=25)	Patient group (LBP) (n=32)	p
Age (years)	42.6 ± 6.93	41.75 ± 6.58	0.64 (NS)
Males	16 (64%)	20 (62.5%)	NS
Females	9 (36%)	12 (37.5%)	NS
Body weight (kg)	75.32 ± 11.83	80.00 ± 10.77	0.13 (NS)
Height (m)	1.72 ± 0.09	1.73 ± 0.07	0.85 (NS)
BMI (kg/m²)	25.27 ± 2.11	26.86 ± 2.91	0.021 (SS)
Duration of pain (months)	N/A	17.69 ± 4.45	N/A

Values are means ± SD
p – comparison of control and LBP groups

Significant differences were found in the range of spine mobility measured by the Schober test (Fig. 2) as well as pain intensity on VAS scale (Tab. 2). The results of the centre of gravity (COG) sway velocity were significantly different under the 4 testing conditions. In both the eyes open and eyes closed conditions, mean postural sway of the controls was significantly lower than mean postural sway of the LBP patients (Tab. 2). As far as the results of the rehabilitation treatment are concerned significant differences were found in the range of spine mobility (Fig. 2) as well as pain intensity on VAS scale. The results of the centre of gravity (COG) sway velocity were not significant different in the pre-rehabilitation and after rehabilitation groups, except for the values under the condition of Foam-EC and of Foam-EO. Individuals with LBP before treatment showed a significantly higher mean COG sway velocity under the condition of foam surface, compared to individuals with LBP after treatment (Tab. 2).

Considering the aspect of ergonomic and non-ergonomic attitude, spine mobility was higher in the EA group than the NEA; furthermore, the influence of the rehabilitation was significantly higher in the EA group than the NEA (Tab. 3). Results of the centre of gravity (COG) sway velocity were not significantly different in the pre-rehabilitation and after rehabilitation groups, except for the values under the condition of Foam-EC. In the eyes closed conditions, mean postural sway of the EA group was significantly lower than mean postural sway of the NEA group.

Table 2. Comparison of spine mobility measured by Schober test, pain intensity on VAS scale and balance parameters between control and LBP group

	Control group (n=25)	LBP group (n=32)		p	
		before	after	p_1	p_2
Schober test (cm)	5.51 ± 0.64	4.47 ± 0.77	5.15 ± 0.8	< 0.001	< 0.001
VAS (mm)	2.64 ± 0.95	31.5 ± 9.36	23.47 ± 11.82	< 0.001	< 0.001
Firm Eo (⁰/sec)	0.29 ± 0.03	0.33 ± 0.02	0.32 ± 0.02	< 0.001	NS
Firm EC (⁰/sec)	0.3 ± 0.03	0.36 ± 0.03	0.34 ± 0.03	< 0.001	NS
Foam Eo (⁰/sec)	0.5 ± 0.05	0.66 ± 0.05	0.6 ± 0.05	< 0.001	< 0.001
Foam Ec (⁰/sec)	1.56 ± 0.06	1.92 ± 0.1	1.62 ± 0.13	< 0.001	< 0.001

Values are means ± SD
p_1 – comparison of control and LBP groups before rehabilitation
p_2 – comparison of LBP group before and after 2-weeks rehabilitation

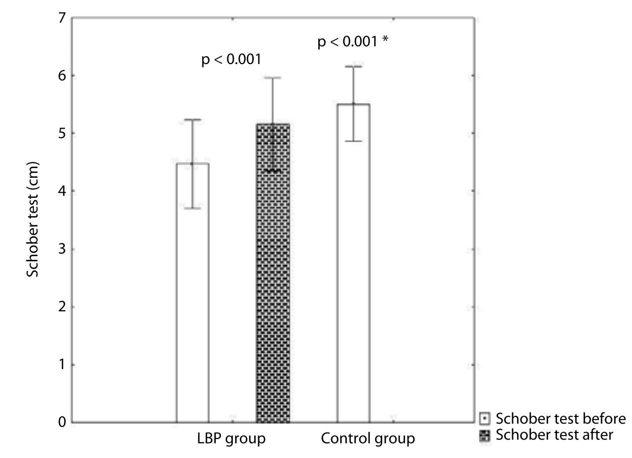

Figure 2. Comparision of spine mobility measured by Schober test between the Control and LBP Group and between LBP patients before and after a 2-week rehabilitation (p – comparison of LBP group before and after a 2-week rehabilitation, p* – comparison of control and LBP groups before rehabilitation)

Table 3. Comparison of spine mobility measured by Schober test and balance parameters between EA and NEA groups

	EA group (n= 11)		NEA group (n=21)		p	
	Before	After	Before	After	p_1	p_2
Schober test (cm)	4.99 ± 0.5	5.7 ± 0.64	4.2 ± 0.75	4.87 ± 0.74	0.004	0.003
Firm Eo (⁰/sec)	0.32 ± 0.02	0.31 ± 0.02	0.33 ± 0.02	0.32 ± 0.02	NS	NS
Firm EC (⁰/sec)	0.36 ± 0.03	0.34 ± 0.04	0.36 ± 0.02	0.34 ± 0.02	NS	NS
Foam Eo (⁰/sec)	0.64 ± 0.06	0.6 ± 0.05	0.66 ± 0.04	0.63 ± 0.04	NS	NS
Foam Ec (⁰/sec)	1.85 ± 0.08	1.58 ± 0.14	1.95 ± 0.1	1.64 ± 0.12	0.004	0.03

Values are means ± SD
p_1 – comparison of EA and NEA groups before treatment
p_2 – comparision of EA and NEA groups after treatment

DISCUSSION

The current study compared postural control in LBP patients and healthy controls. The results obtained revealed a significant increase in the postural sway velocity in the patient group compared to control. Significant differences were found in the range of spine mobility measured by the Schober test – the range of movement was higher in healthy controls. As far as the results of the influences of the stretching techniques are concerned, significant differences were found in the range of spine mobility. The results of the centre of gravity (COG) sway velocity were not significantly different in the pre-rehabilitation and after rehabilitation groups except, for the values under the condition of Foam-EC and of Foam-EO. Individuals with LBP before treatment showed a significantly higher mean COG sway velocity under the condition of foam surface, compared to individuals with LBP after treatment (Tab. 2). From the aspect of ergonomic and non-ergonomic attitude, spine mobility was higher in the EA than NEA group, furthermore the influence of the rehabilitation is significantly higher in EA group than in the NEA. Results of the centre of gravity (COG) sway velocity were not significantly different in the pre-rehabilitation and after rehabilitation groups, except for the values under the condition of Foam-EC. In the eyes closed conditions, mean postural sway of the EA group was significantly lower than mean postural sway of the NEA group.

Some previous studies have demonstrated that postural sway is increased in patients with LBP, which is confirmed by the presented study. However, the other authors observed no effect, nor even a negative effect, of LBP on postural sway [17]. Clinical observations indicate that subjects with mild LBP show impairments of postural control and dynamic stability, which affect the relative utilization of hip and ankle strategies [18]. First, studies of people with LBP have indicated changes in position of the centre of pressure (COP) which is linearly dependent on COG in quiet standing on a flat surface. For example, the COP is more posterior in people with LBP than in those who are pain-free, which probably results from adoption of a lordotic posture to relieve pain. Second, patients with LBP exhibit proprioceptive deficits which involve kinematic changes for stability of the lumbopelvic region. This causes an increase in the COG sway velocity [18]. Several studies have indicated the incidence of balance disorders in patients with LBP based on the results of clinical balance and mobility tests. The results demonstrated that, in general, the individuals with LBP have lower levels of body balance control compared to healthy controls [11, 12, 13, 18]. The results of the presented study also support this observation under the 4 testing conditions. In foam surface, firm surface, eyes open and eyes closed conditions, mean postural sway of the controls was significantly lower than mean postural sway of the LBP patients.

Since restriction of spine mobility itself is a known cause of balance disturbances [19, 20], the influence of stretching therapy on postural control and on the level of pain was analysed in the current srtudy. After rehabilitation, an increase in spine mobility was noticed, while a decrease in pain intensity on the VAS scale was observed. The results of the centre of gravity (COG) sway velocity test were not significantly different in the pre-rehabilitation and after rehabilitation groups except, for the values under the condition of Foam-EC and of Foam-EO. Individuals with LBP before treatment showed a significantly higher mean COG sway velocity under the more challenging conditions (Foam EC), where somatosensory inputs were compromised, compared to individuals with LBP after treatment. Considering the influence of the therapy on postural control, differences in the COG sway velocity values became more evident with increased difficulty of the experimental conditions.

Many experimental studies have investigated the link between non-ergonomic work and LBP [20, 21]. These findings led to the general belief that prolonged sedentary work is harmful to the lumbar spine. Interestingly, sitting was even classified as a risk factor for LBP; however, the postulated harmful effect of prolonged sitting has not been fully supported by epidemiological data. Recently, Lis et al. [22], in their systematic review, found that sitting itself does not increase the risk of LBP, but sitting for more than half a workday, combined with awkward postures and no physical activity, does increase the likelihood of having LBP – it is the combination of those risk factors that leads to the greatest increase in LBP. Evidence of the contribution of physical activity to the prevention and management of LBP is also unclear. In the presented study, those two factors were combined. Based on survey research, all patients with LBP were selected into 2 subgroups from the aspect of work conditions, as well as performing physical activity, the first group with the ergonomic attitude (EA) and the second group with non-ergonomic attitude (NEA). Comparing those 2 groups, higher spine mobility was observed in the EA group than the NEA. Furthermore, the influence of rehabilitation on the clinical course of LBP (pain intensity, spine mobility) was significantly higher in the EA group than the NEA (Tab. 3). Results of the centre of gravity (COG) sway velocity were not significantly different in either group, except for the values under the condition of Foam-EC. In the eyes closed condition, mean postural sway of the EA group was significantly lower than mean postural sway of the NEA group.

Despite the risk of activity-related injuries, some experts [23] have found an association between physical activity and lower risk of musculoskeletal disorders to be plausible. Randomized trials and epidemiological studies on exercise as a means of strengthening back and/or abdominal muscles, and of improving fitness, have resulted in only limited evidence of a positive effect on low back morbidity. Empiric evidence of the long-term effects of exercise is still lacking [24]. Toroptsova et al. [25], in their cross-sectional study of 800 machine-building factory workers, found a significant association between the absence of sports activity and LBP.

In the presented study, the ergonomic attitude dependent on work conditions and physical activity was associated with higher levels of body balance control, compared to non-ergonomic attitude. It is possible that despite non-ergonomic work conditions, regular physical activity may prevent episodes of low back pain among workers, and vice versa – work in ergonomic conditions without further increased physical activity protects them against this health problem. Further studies are needed to investigate the influence of ergonomic factors on postural control in patients with LBP.

CONCLUSIONS

Un-ergonomic life factors result in reduced mobility of the spine, and are often accompanied by the appearance of pain, especially lower back pain (LBP). The restrictions within the musculoskeletal system cause disorders in muscle synergies and consequently increase the energy cost of maintaining postural stability, which during measurements on the platform is expressed by an increase in the angular velocity of the centre of gravity. In patients with chronic pain syndrome of the lumbosacral spine, appropriately selected rehabilitation treatment with using stretching techniques improves the range of motion of the spine and reduces pain.

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