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Original investigation

The Effect of Computer-Based Training on Postural Control in Patients with Chronic Low Back Pain: A Randomized Controlled Trial

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ABSTRACT

Objective: Chronic low back pain (CLBP) causes disability and postural control deficits. Since suffering from pain, disability and impaired postural control, patients decrease their physical activity levels. The aim of this study was to examine the effects of computer-based stability training on pain, disability, postural control and physical activity in patients with CLBP and compare them with traditional training.

Methods: Forty-two participants with a history of CLBP were recruited and divided into two groups randomly. Computer-based stability training was applied to study group by help of computer-based device two times a week for 12 weeks while traditional training was done to another group. Pain and disability were assessed by Numeric Pain Scale and Oswestry Disability Index, respectively. Limits of stability (LoS) and postural stability (PS) tests were used to evaluate postural control by Biodex Balance System and SenseWear Armband was used for physical activity assessment. All measurements were applied before and after the training.

Results: Significant improvements occurred in LoS and PS scores in both groups after interventions ($p<0.05$). However, physical activity scores for both groups did not significantly change ($p<0.05$). Statistical analyses of between-group mean differences showed that there was superiority of computer-based stability training over the traditional training in improving LoS ($p=0.023$).

Conclusion: The results of this study suggest that twelve-week computer-based stability training might be beneficial to reduce pain and improve postural control in patients with CLBP. On the other hand, computer-based stability training showed superior effect over traditional training for increasing limits of stability.

Keywords: postural balance, physical activity, low back pain

INTRODUCTION

Chronic low back pain (CLBP) is one of the most common disorder that results in disability in daily living activities (1). Deep muscles of trunk are affected by late activation patterns and become weak in CLBP (2). Additionally, involvement of glutes and hip muscles causes imbalance of muscle strength in the lumbal and sacral spine (3). Together, these changes could trigger instability and reduced motor control in patients with CLBP (4).

The existing evidence suggests that, patients with CLBP showed excessive centre of pressure (CoP) displacement and postural sway when compared to healthy individuals. Postural control can be decreased by declined sensory feedback to the spinal or limb muscles, inefficient motor control or altered in the strength and mechanical instability of the back and lower extremity. By reason of long-term neuromuscular adaptations, the choice of daily postural control strategies is predetermined in patients with CLBP (5).

Dynamic stability of the spine is maintained by the central nervous system relies on accurate lumbar proprioceptive inputs, combined with feedforward and feedback motor responses (6). Static and dynamic tasks such as sitting, standing and walking are maintained by anticipatory and reactive postural responses. Patients with CLBP demonstrate insufficient muscle co-contraction in response to unexpected perturbations (7). There is evidence that decreased postural control in patients with CLBP and alteration of limits of stability (LoS) make patients to reduce hip control strategy during quiet standing which causes the gluteus maximus muscle to contract, creating a self-locking mechanism, thereby providing stability to the sacroiliac joint and favouring the ankle strategy, which was not effective in demanding conditions (8). On the other hand, pain and postural control deficits affect daily activities of the patients and they become more disabled and inactive to perform static or dynamic functional tasks (7). The daily function of the patients reduces due to chronic pain, disability and impaired postural control, therefore physical activity of the patients gradually decreases and they become more disabled and immobile (9, 10).

Recently, lots of stabilization programs applied to patients with CLBP which include Pilates exercises, specific lumbar stabilization exercises, etc. are being conducted (11). Research focusing on improvement of the dynamic postural control which aimed to ameliorate hip and ankle strategy is insufficient, although these strategies which required for postural control could positively affect patients with CLBP. Stabilization training on balance indices could be effective to improve postural control by activation of trunk muscles and hip and ankle strategies. In addition, computer -based rehabilitation program could be beneficial to improve postural control through providing essential visual feedbacks to the patients during the training. Accordingly, the purpose of the study was to determine the effects of stability training on pain, disability, postural control and physical activity. We hypotized that computer-based stability training would significantly decrease pain and improve postural control and physical activity in patients with CLBP when compared with traditional training.

METHODS

Design

We conducted a prospective, randomized, sham-controlled study with a parallel design having an allocation ratio of 1:1, which was carried out between February and September in 2015. Minimum sample size was calculated with 95% confidence interval and 80% power analysis in Open Source Epidemiologic Statistics for Public Health (Open Epi Version 3.1) program using the data from a previous study which reported an increase in stability index (8) and 18 participants were required for each group.

All participants signed an written informed consent form. Procedures followed were in accordance with the ethical standards of Dokuz Eylül University Ethics Committee with the Helsinki Declaration. Participants were fully briefed on all testing procedures. Ethical approval code of the study was GOA-2011/05–25.

Participants

Forty-two people with CLBP aged between 30 and 60 years participated in the study from local hospital. We randomly allocated participants to two groups: the experimental (computer-based training) group and the control (traditional training) group and used block randomization (AABB, ABAB, ABBA, BBAA, BABA, BAAB paradigm). A was experimental group and B was sham group. Participants were assigned to one of two groups using this paradigm by an independent investigator. To ensure blinding, we concealed the paradigm in a sealed envelope and gave it to each participant. Participants were then asked to give the sealed envelope only to the researcher who would be performing training before the intervention.

All participants were screened by physiotherapist and neurosurgeon. The inclusion criteria encompassed patients with low back pain who have had chronic pain for at least 3 months. The exclusion criteria included the presence of neurological diseases, nerve root pain, history of spinal surgery, severe spinal deformities, history of visual impairment, vestibular or respiratory disorders, cognitive deficits, diabetes, recent lower limb injuries or using any medicine that could affect their balance.

Procedures

For computer-based training group, we asked the patients to perform postural balance training for approximately 30 minutes per session, 2 times a week for 12 weeks using postural stability, limits of stability, weight shift and maze control training parameters on Biodex Balance System (BBS) under physiotherapist supervision. BBS has static and unstable platform that moves in response to changes in the subject's centre of mass; it also has 12 stability levels. In postural stability training patients were asked to stand stable on the platform. In limits of stability training, targets on the screen blinked in random order and patients were asked to reach all 8 directions (forward, backward, right, left, forward-right, forward-left, backward-right, backward-left) up to test completion time. For weight shift training, patients tried to transmit their body weight forward, backward, right and left sides with up to 50% of indicator on each side by following the instructions of the physiotherapist. In maze control training, circular indicator in the screen moved different sides and patients were asked try to catch the movement with keeping their CoP in the indicator during the session. Three trials with a rest period of 10 seconds were performed in each condition. During the first 4 weeks of training, patients were given 10 minute warm up consisting of tracing predictable patterns and then static weight shift, postural stability and limits of stability training for 20 minutes. During the second 4 weeks subjects were trained with static limits of stability training on BBS, but the stability level of platform was progressively decreased from static to level 9 for postural stability and weight shift. The stability level of the platform was decreased from level 9 to level 6 during final 4 weeks for postural stability, the same static limits of stability training with maze control and weight shift training were given to subjects. Skill level of each training was set to moderate. The widest target box area was required the lowest skill level.

Pain, disability, postural control and physical activity were re-assessed after training.

To simulate computer-based training with an eliminated effect for the traditional training (control) group, we applied the training by physiotherapist supervision in the same manner but without computer-based system. We used traditional postural control exercises by giving them visual, vestibular or proprioceptive stimulus under the cues of a physiotherapist in close resemblance to the computer-based training group. The same training as balance exercises in limits of stability of individuals, static postural stability exercises and weight shift training was applied to control group.

Outcome measures

The level of resting pain on the day of investigation was determined by Numeric Rating Scale (12). Self reported disability was assessed by Oswestry Disability Index (ODI). Zero was equated with no disability and 100 was the maximum disability according to ODI (13).

The Biodex Balance System (BBS; SD 12.1"Display 115 VAC) was used to assess postural control. Biodex Balance System measures stability indexes and these indexes represent the variance of foot platform displacement in degrees, from level, for motion in different planes. Limits of stability (LoS) overall index and postural stability tests (overall, mediolateral and anteroposterior indexes) were used to evaluate postural control in firm surface and eyes open during a period of 20 seconds. To eliminate learning effect, three familiarization test trials, each consisted of 20 seconds, were applied to individuals one day before the first assessment day. Participants stood barefoot and were not permitted to touch the handrails during the tests. The foot position was recorded using the platform rail. The platform locked and the patients were asked to control themselves keeping the indicator in the centre of target on the screen for postural stability test. For LoS test, targets on the screen blinked in random order and patients were asked to reach all 8 directions (forward, backward, right, left, forward-right, forward-left, backward-right, backward-left) up to test completion time. Three trials with a rest period of 10 seconds were performed in each condition. Postural tasks were explained to each participant before starting the measurements. Lower postural stability scores and higher LoS scores reflect better postural control (14).

Physical activity was assessed using BodyMedia SenseWear Armband and reflected as total energy expenditure in kcal. Armband was placed over the triceps muscle of right arm at the midpoint between the acromion and olecranon process of all participants (15). Subjects were asked to wear armband 24 hours a day except during water-based activities (like having bath) for 4 consecutive days (including 1 day of the weekend).

Statistical analysis

We analysed all data using Statistical Package for Social Sciences software (IBM Corporation, version 20.0 for Windows). While descriptive statistics were summarized as frequencies and percentages for categorical variables, continuous variables were presented as mean and standard deviation. The variables were investigated using visual (histograms, probability plots) and analytical methods (Shapiro-Wilk's test) to determine whether or not they were normally distributed. We reported results as baseline, post-intervention and change (Δ) values. The distribution of demographic and clinical characteristics between groups were analysed using Chi-Square Test. Since the normality assumption was violated, we used non-parametric tests for statistical analysis. Mann-Whitney U Test and Wilcoxon Test were used for between group and within group analyses, respectively. A 5% type-I error level was used to infer statistical significance ($p<0.05$).

RESULTS

Twenty-one individuals in the computer-based group and 21 individuals in the traditional training (control) group were analysed in terms of all outcomes. The analyses were by original assigned groups. Post hoc power analysis with 5% type-I error was performed.

A large number of patients completed exercise trainings. Therefore, exercise adherence rate was calculated as 87.5%. There were no statistically significant differences in the distribution of gender and clinical characteristics between the groups ($p>0.05$). No significant differences were also found between the groups in terms of baseline values of measured variables after the initial assessment ($p>0.05$) (Table 1).

NRS scores decreased significantly in both groups with 2.0 points median change ($p<0.05$). Beside that, ODI scores increased with 28.0 points median change in experimental group while they increased with 26.00 points median change in control group. On the other hand, LoS and PS scores for both groups did significantly change in both groups after interventions ($p<0.05$). However, physical activity score showed a significant improvement neither experimental nor control group ($p=0.02$). (Table 2).

Table 1. Demographic and clinical characteristics of the groups

	Computer-based group (n=21) *Median IQR (25–75%)*	Control group (n=21) *Median IQR (25–75%)*	p value[a]
Age (year)	46.00 (40.05–50.50)	45.00 (44.00–48.00)	0.772
BMI (kg/m^2)	28.34 (24.77–29.76)	24.94 (23.99–27.19)	0.116
NRS score	7.00 (4.00–9.00)	6.00 (3.00–9.00)	0.268
ODI score	56.00 (38.00–70.00)	59.00 (36.00–67.00)	0.645
LoS overall score	58.00 (47.50–62.50)	56.00 (52.50–63.00)	0.801
PS overall score	0.40 (0.25–0.55)	0.30 (0.30–0.40)	0.133
Physical Activity score (kcal)	8076.00	8669.00	0.754
Total energy expenditure	5498.50–9445.50	5644.50–9144.50	

[a]Mann-Whitney U test analysis.
BMI: body mass index, **NRS:** numeric rating scale, **ODI:** Oswestry disability index, **LoS:** limits of stability, **PS:** postural stability.

Table 2. Changes in pain, disability, postural control and physical activity

		Computer-based group (n=21) *Median IQR (% 25–75)*	**Control group (n=21)** *Median IQR (% 25–75)*	***p value*** *(between group)* [b]
NRS score	**Pre-intervention**	7.00 (4.00–9.00)	6.00 (3.00–9.00)	0.268
	Post-intervention	3.00 (2.00–5.00)	4.00 (2.00–7.00)	**0.041***
	Δ	2.00 (3.00–7.00)	2.00 (2.00–6.00)	0.866
p value (within group) [a]		**0.021***	**0.038***	
ODI score	**Pre-intervention**	56.00 (38.00–70.00)	59.00 (36.00–67.00)	0.645
	Post-intervention	32.00 (28.00–53.00)	36.00 (30.00–52.00)	0.035*
	Δ	28.00 (16.00–31.00)	26.00 (21.00–38.00)	0.568
p value (within group) [a]		**0.030***	**0.044***	
LoS score	**Pre-intervention**	58.00 (47.50–62.50)	56.00 (52.50–63.00)	0.801
	Post-intervention	63.00 (56.50–76.50)	58.00 (42.00–65.00)	0.042*
	Δ	7.00 (3.50–12.00)	6.50 (2.00–10.75)	0.023*
p value (within group) [a]		**0.012***	0.024*	
PS overall score	**Pre-intervention**	0.40 (0.25–0.55)	0.30 (0.30–0.40)	0.133
	Post-intervention	0.35 (0.84–1.32)	0.30 (0.22–1.40)	**0.022***
	Δ	-0.10 (-0.67–0.40)	-0.15 (-0.47–0.20)	0.708
p value (within group) [a]		**0.014***	**0.026***	
Physical Activity (kcal)	**Pre-intervention**	8076.00 (5498.50–9445.50)	8669.00 (5644.50–9144.50)	0.754
	Post-intervention	11658.00 (8750.00–13986.00)	12023.00 (9001.00–14365.00)	0.184
	Δ	4678.00 (2587.00–1024.00)	4211.00 (3004.00–9122.00)	0.533
p value (within group) [a]		0.422	0.488	

[a] Wilcoxon signed rank test analysis; [b] Mann-Whitney U test analysis; *p<0.[05]
NRS: numeric rating scale, **ODI:** Oswestry disability index, **LoS:** limits of stability, **PS:** postural stability.

Statistical analyses of between-group mean differences showed that there was no superiority of one intervention over the other in improving pain, disability, postural stability and physical activity (p>0.05). However, computer-based training made superior effect in improvement of LoS score over control training (p=0.023) (Table 2).

DISCUSSION

The aim of this study was to investigate the effects of computer-based stability training on pain, disability, postural control and physical activity in patients with chronic low back pain.

Our findings showed that both computer-based and traditional training could be useful to decrease pain and disability and also increase postural control in participants with CLBP. Neither computer-based nor traditional training are effective to improve physical activity. Computer-based training showed better enhancement in limits of stability when compared with traditional training.

There are only a few available studies that investigated postural control in CLBP patients but none of these studies reported how stability training affects aforementioned parameters (16, 17). In one study that investigated the effects of supervised stability training on postural balance in CLBP, postural stability was evaluated with Biodex Balance System. Stability exercises for transversus abdominus and multifidus were performed for 10 days. The results of the study suggested that supervised stability training might improve muscle co-contractions and postural control of the patients (18). Postural stability was assessed by Biodex Balance System in our study and contrary to previous study our results showed both computer-based training and traditional training had positive effects on postural stability (static postural control) and limits of stability (dynamic postural control). In another study that investigated the efficacy of a perceptive rehabilitation on postural control in patients with LBP, participants randomized into perceptive rehabilitation and back school group and were assessed using stabilometry and pain questionnaire. Training sessions were held 3 times for week for 1 month. Results of their study showed that perceptive rehabilitation was useful for reducing pain and postural instability (19). Kim et al., examined the effect of stabilization exercises with using the sling on postural balance in CLBP patients, measured center of pressure for postural balance and revealed lumbar stabilization exercises that applied 4 times per week reduce pain and improve postural balance (20). Parallel to our study static postural stability of CLBP patients assessed by Biodex Balance System and 12-week whole body vibration therapy was found feasible to decrease pain and improve postural stability in patients with non-specific low back pain (21).

In addition to different exercise research papers that investigated the effects of training programs on postural control, there are also a few studies that use computer-based training like Biodex Balance System to improve postural control in patients with CLBP. Hosseinifar et al. compared the effect of balance and stabilizing trainings on balance indices with Biodex Balance System in patients with nonspecific chronic low back pain. Patients enrolled exercise groups and did exercises for 6 weeks and four sessions per week. In conclusion, results of their study showed that balance training and stabilizing training have the same impact on postural stability indices measured, while stabilizing training were more effective in reducing pain and disability compared to balance trainings (22). In another study, researchers showed that the use of postural training with anodal transcranial direct current stimulation compared to postural training alone induced significant improvement in the postural stability indices, especially during dynamic condition (23). Both computer-based training and traditional training improved postural stability and limits of stability in our study. However, only computer-based training showed superior effect on limits of stability when compared to traditional training. Two factors might have contributed to that. One of them might be kinesiophobia or fear of movement. This fear might results in narrow-bordered limits of stability in traditional training group. The second reason might be that the decreased pain scores in computer-based group when compared to the control group. Therefore, patients in computer-based group might become more comfortable and independent in dynamic activities that required wide-ranged limits of stability. In addition, being a familiar to the device could be affected the results in computer-based training group. Sham controlled trials should be planned in future studies to investigate this effect.

LBP is a condition not only results in impaired postural control but also decreased physical activity. Wearable armband was showed as objective device that can be used for physical activity feedback for last few days in many studies for different populations as adolescents, children, elderly individuals or neuromuscular disorders, cerebral palsy, chronic obstructive pulmonary disease, sleep apnea (24–26). Armband wearing time varied 4 to 7 days a week in these studies and measurements were done over a period of several minutes to 24 hours a day. There was only one available study that used armband in CLBP patients in the literature (27). In this study researchers evaluated sleep disturbance/quality by using armband for 7 consecutive days and demonstrated there was a relationship between sleep and pain intensity in patients with LBP. In a systematic review it was found that patients with CLBP with high levels of disability were likely to have low levels of physical activity (9). We did not evaluate sleep quality of patients, instead, we want to investigate if computer-based stability training and traditional training could increase recent physical activity level of the patients with decreased pain and disability. Our results showed that both computer-based stability training and traditional training did not increase physical activity level (in terms of total energy expenditure in kcal). The one reason for this other factor or factors might also affect physical activity regardless of pain and disability. Secondly, both trainings appeared to be ineffective to increase physical activity because we evaluated recent level (physical activity in last week).

The major strength of our study was that to the best of our knowledge, ours is the first study that has investigated the effectiveness of computer-based stability on postural control with details (static and dynamic postural control that evaluated postural stability and limits of stability, respectively) and physical activity. Another strength that we evaluated postural control and physical activity with an objective instruments and the devices. Beside that these instruments have shown to perform well in categorising postural control (in terms of postural stability and limits of stability) and physical activity levels in this population.

There were some limitations in this study. Since fewer patients were participated in this study, the generalization of our findings could be restricted and it is one of the limitations. Another limitation is that there was no sham training group in our study. In addition to this, dynamic postural control assessment could be evaluated in different conditions (eyes open-closed etc.). Overall, since kinesiophobia may affect outcomes, its evaluation could be useful. Therefore, future research shall recruit a sufficient sample size to have a more accurate estimation of postural control and physical activity. And also the alterations in limits of stability can be explained by analysis in more challenging conditions (foam surface, dual task etc.).

In conclusion the present study showed that both computer-based stability training and traditional training were effective and could be use to improve postural control of the patients with CLBP. While both computer-based stability training and traditional training were effective in improving postural control, there were superiority of computer-based training over the traditional training for improvement of limits of stability. Computer-based stability training should be part of the treatment to improve both static and dynamic postural control in this population.

Informed Consent: From patients with low back pain

Compliance with Ethical Standards: Non-interventional Clinical Researches Ethics Committee of Dokuz Eylül University 25.02.2011

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