

Efficacy of balance training using biodex balance system on spatial and temporal gait parameters in patients with recurrent lateral ankle sprain

Gait & balance rehabilitation

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Abstract

Aim: Ankle sprains occur in athletes that stress the joint alignment and cause stress between the articular surfaces during weight-bearing.

The purpose of this study was to explore whether the addition of Biodex Balance System balance training to a recommended physical therapy exercise program may help patients with recurrent lateral ankle sprains improve their Spatial and Temporal Gait Parameters abnormalities.

Material and Methods: Fifty voluntary patients of both genders, diagnosed with chronic recurrent lateral ankle sprain, aged from 18 to 40 years. Patients were assigned into two equal groups of twenty-five patients: study group (A) who received Biodex Balance System added to the recommended physical therapy exercise program in the form of therapeutic exercises, and control group (B): the same recommended physical therapy exercise program like the group (A). Approximately 30 minutes per session, three times a week for 6 weeks was done for all exercise modes. The recommended physical therapy exercise program was performed three times a week for six weeks.

Results: There were statistically significantly higher results in step length, stride length, and single support time ($p < 0.01$) in the study group (A) in favor of the control group (B).

Discussion: In the treatment of patients with recurrent lateral ankle sprains, it was discovered that the inclusion of the Biodex balance system into the recommended physical therapy exercise program has a directional effect on improving spatiotemporal gait parameters, which are one of the major secondary effects of recurrent lateral ankle sprains.

Keywords

Biodex Balance; Training; Recurrent; Lateral Ankle; Sprain; Spatio-temporal Gait Parameters; Walkway System

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Introduction

Both in clinical practice and in the sporting community, lateral ankle sprains are one of the various common problems of musculoskeletal injuries that require considerably more recovery time [1]. Twisting the foot in inversion and plantar flexion of the rear foot at the tibia during walking gait [2], cutting maneuvers during sports, or stepping off an uneven surface represents the most prominent causes of lateral ankle sprain [3].

The consequences of a lateral ankle sprain include damage to the lateral ankle ligaments and an impaired sensory pathway to the central nervous system. The most common initial consequences of the damage to lateral ligaments are anatomical structures. Changes in joint loading and natural movement patterns result in reduced reach distance and shifts in the kinematics of the ankle joint [4]. A functional deficiency in postural stability is thought to occur in addition to anatomical changes associated with lateral ankle sprains [4].

After an ankle sprain, there is a deterioration of the mechanical and neurological properties of the joint, resulting in gait changes. The altered gait mechanics causes unnatural loads on the musculoskeletal system [3,5]. It's necessary to consider the proper gait mechanics during rehabilitation for lateral sprains. Balance and gait are intertwined. Balance is a prerequisite for walking, and many gait disorders are in reality balance disorders [5].

One of the most common biomechanical changes in patients with lateral ankle sprain is increased inversion at the initial contact phase of gait, which is a contributing factor for chronic sprain and episodes of dysfunction, as a result of being closer to the mechanism of injury [6].

During the midstance of gait, it was found that patients with recurrent lateral ankle sprain had a more inverted rear foot of the pivot leg (affected side) [7], lower values of gait velocity [8], step length, time in single support [8,9], and a more inverted rearfoot pre- and post- initial contact compared to healthy controls [9].

One of the most common repeatable and reproducible methods for recording barefoot plantar foot measurements and gait in children and adolescents is Walkway [10]. The walkway system pioneered a non-wearable device that is now considered the gold standard for accurately capturing kinetic, kinematic, and spatiotemporal gait characteristics [11,12].

As a result, the goal of this study was to compare the effects of balance training with the Biodex Balance System in combination with a recommended physical therapy exercise program on spatial and temporal gait parameters in patients with recurrent lateral ankle sprains.

Material and Methods

Study Design

A randomized controlled trial was conducted at the outpatient clinic of the Faculty of Physical Therapy, Modern University for Technology and Information over a period of three months. The study was carried out and approved by the Ethics Committee of the Faculty of Physical Therapy, Cairo University (P.T.RE/012/002887), and all participants signed an informed consent statement before starting the study after being informed about the study's nature and purpose.

Participants

Fifty voluntary patients (forty males and ten females), aged from 18 to 40 years, whose BMI was $26 \pm 2.94 \text{ kg/m}^2$ were referred from orthopedists with chronic recurrent lateral ankle sprain. The inclusion criteria were as follows: 1- chronic unidirectional recurrent lateral ankle sprain (Grade II) [13]. 2- Written doctor's recommendation for 2nd-degree LAS with chronic onset. 3- History of inversion trauma [14]. The exclusion criteria included the following (21): (1) Previous musculoskeletal damage or operation on the lower limb or the lumbar spine (2) Individuals who experienced a sprain of the medial or interosseous (syndesmotic) ankle ligaments, concomitant fracture, lower limb nerve damage [15].

The patients were randomized using the coin toss. Twenty-five patients (twenty males and five females) in the study group (A) received biodex balance training in the form of Maze Control Training, Random Control Training, and postural stability Training, in addition to the recommended physical therapy exercise program in the form of Therapeutic exercise. Twenty-five patients (twenty males and twenty females) made up the control group (B), received the same recommended physical therapy exercise program as group A.

Procedures

Assessments

Pre-and post-study assessment procedures were elicited by the same therapist for intrarater reliability.

Walkway™ System Multi-Step Barefoot Analysis

Three Spatio-temporal parameters associated with gait parameters: (1) step length (m), (2) stride length (m), (3) single support time, were recorded by an instrumented walkway.

The patient's gait was evaluated using the Walkway™ System's multi-step barefoot analysis, which records several sequential footsteps for foot function and gait analysis. Track and record different gait-recommended parameters in high-resolution formats and use specialized computer programs to aid data processing, leading to a more thorough and accurate analysis. This strategy imposes a limit on subjectivity. Figure (1).

Interventions

Biodex Balance System™ SD

The biodex balance system is a reliable and valid device used to evaluate the participant's static and dynamic balance stability on the unstable tilting platform. One unique feature is an attached LCD monitor that provides augmented visual feedback. The monitor provides information via a screen tracing, concerning the subject's ability to balance on the platform as the subject tries to maintain the cursor in the middle of the screen grid.

Unique training modes such as Maze Control Training (Improves sensory-motor control skills), Random Control Training (improves posture sway with varying movement levels), and LOS Training (improves postural dynamics) are used through Biodex Balance System™ SD – Static and Dynamic Balance system Training. (With 2.02 Software).

Each session lasted approximately 30 minutes. For six weeks, this session was repeated twice a week and was conducted for all exercise modes. To start with, the patients performed five minutes of warm-up exercises, which consisted of moderate-speed walking. For the first two sessions, the stability level of the platform was set to level plate stability 8. After that,



Figure 1. Walkway™ System Multi-Step Barefoot Analysis

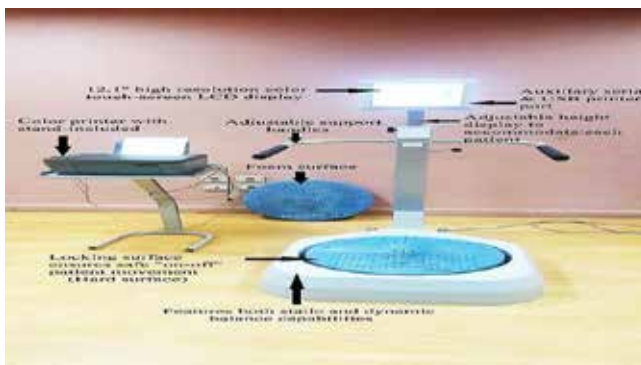


Figure 2. Biodex Balance System™ SD

every two sessions, the plate stability was reduced by one level. Each session included two repetitions of both of these exercise modes. In maze control training mode, the patient worked to follow the cursor inside these maze-like targets by following a repeatable pattern of motion on the screen. Random control training mode is suitable for motor control and vestibular training. In Random Control Training mode, tasks are displayed in random patterns, the Postural Stability Training mode is designed to emphasize particular movement patterns or techniques. The patient's score is calculated using the target approach as the number of times the patient will hit the targets by leaning and changing their postural stance during the session [16] (Figure 2).

Recommended Physical Therapy Exercise Program

The greater muscle forces and more muscle groups are necessary to gain and maintain an upright posture during weight-bearing exercises. They also concluded that weight-bearing exercises had a greater effect on physical outcome measures because of their greater level of difficulty [17].

1-Weight-bearing Exercise for Better Balance program

Weight-bearing Exercises for Better Balance were performed three times a week for six weeks. Standing with a decreased base exercise to perform a warm-up exercise, graded reaching in standing, and walking practice. Between each trial, they did not rest, but a rest period of 10 seconds was given between each exercise [24].

2-The unilateral balance training program

A single-legged stance, wobbles board exercises, steamboats, anterior hop, quadrant hop, single-legged ball catch, toe touch

down, and hops up and down were the components of the unilateral balance training program. Two times a week for six weeks, The program was performed. All exercises were done for the affected limb.

Statistical Analysis:

The mixed design MANOVA was performed to compare effects within and between groups on spatiotemporal gait parameters. For subsequent multiple comparisons, post-hoc tests using the Bonferroni correction were carried out. The level of significance for all statistical tests was set at $p < 0.05$. All statistical analyses were conducted using the statistical package for social studies (SPSS) version 25 for Windows (IBM SPSS, Chicago, IL, USA).

Results

General demographic data:

There was no significant difference between both groups in mean age, weight, height, and BMI ($p < 0.05$). Also, there was no significant difference in the distribution of sex and affected sides between groups ($p < 0.05$) (Table 1).

Effect of treatment on spatial-temporal gait parameters

Mixed MANOVA revealed that there was a significant interaction of treatment and time ($F = 5.4, p = 0.001$). There was a significant main effect of time ($F = 123.21, p = 0.001$). There was a significant main effect of treatment ($F = 1.99, p = 0.04$).

Table 1. Descriptive statistics and t-test for comparing mean age, weight, height, and BMI between groups A and B

	Group A Mean ± SD	Group B Mean ± SD	p-value
Age (years)	26.72 ± 5.89	24.92 ± 6.66	0.31
Weight (kg)	71.28 ± 7.75	73.08 ± 8.56	0.44
Height (cm)	165.72 ± 5.4	168 ± 8.77	0.27
BMI (kg/m ²)	26 ± 2.94	25.88 ± 2.26	0.87
Sex			
Male	5 (20%)	5 (20%)	1
Female	20 (80%)	20 (80%)	
Affected sides			
Right	12 (48%)	15 (60%)	0.39
Left	13 (52%)	10 (40%)	

SD, Standard deviation; p-value, the Probability value

Table 2. Mean spatial-temporal gait parameters pre- and post-treatment in groups A and B

	Pre Mean ± SD	Post Mean ± SD	MD	% of change	p- value
Step length (m)					
Group A	0.53 ± 0.08	0.7 ± 0.07	-0.17	32.08	0.001
Group B	0.52 ± 0.1	0.63 ± 0.08	-0.11	21.15	0.001
	p = 0.71	p = 0.003			
Stride length (m)					
Group A	1.03 ± 0.13	1.28 ± 0.1	-0.25	24.27	0.001
Group B	1.01 ± 0.11	1.19 ± 0.14	-0.18	17.82	0.001
	p = 0.42	p = 0.01			
Single support time (sec)					
Group A	0.43 ± 0.04	0.48 ± 0.05	-0.05	11.63	0.001
Group B	0.42 ± 0.03	0.45 ± 0.04	-0.03	7.14	0.005
	p = 0.45	p = 0.01			

SD, Standard deviation; MD, Mean difference; p-value, Level of significance

Table 2 showed descriptive statistics of spatial-temporal gait parameters and the significant level of comparison between groups, as well as a significant level of comparison between pre- and post-treatment in each group.

Between groups comparison:

There was a significant increase in step length, stride length, and single support time of group A compared with that of group B post-treatment ($p < 0.01$). (Table 2)

Discussion

The study group showed statistically significant higher results in step length, stride length, and single support time in comparison to the control group. These results are consistent with a study investigating alterations in gait parameters and the effect of a balanced 4-week comprehensive rehabilitation program. The measured step length, stride length, and single-leg stance test timings were significantly improved after 4 weeks of rehabilitation, which suggested that gait parameters are affected by recurrent lateral ankle sprain [20].

Treatments for ankle injuries include exercises to restore strength and gait mechanics. Gait is an especially important aspect of rehabilitation, as abnormal gait can have effects on other parts of the body further up the kinetic chain. Many of these treatments take time to see results and are therefore not ideal for a person who wants to return to their activity immediately [21].

The Biodex Balance System SD provides visual feedback on the position of the participant's COP on a screen at eye level. Visual feedback balance training on an uneven surface has reduced ankle injury rates [22].

The improvement in the inverted foot position post-treatment in group (A) was consistent with a researcher who used visual biofeedback, concluding that the pressure on the lateral aspect of the foot decreased. Reducing ankle inversion during walking could potentially lower the risk of subsequent lateral ankle sprains for individuals with recurrent LAS [23].

The use of immediate feedback is easier for the patient and leads to faster results. On the other hand, deviations from the center of gravity are worked better utilizing images. Technological devices, based on feedback, used by the different authors range from complex to basic. The complex group would include, for example, Biodex [24].

Future Directions

- While this study sheds some light on the effect of balance training on gait, some questions remain unanswered. The underlying mechanisms that contribute to the changes shown in this research, such as enhanced proprioception, should be investigated further.
- Further research is required about the effectiveness of various rehabilitation techniques on spatiotemporal parameters gait.
- Additionally, it is imperative to standardize efficient methods for rehabilitation of lateral ankle sprain aiming to prevent its recurrence in the community.

Limitations

Short rehabilitation time is a limitation; if the patients had a longer rehabilitation period, the treatment programs would have been more efficacious, and more evident results would have come out from this research.

Conclusion

Treatment based on feedback using innovative technology in patients with abnormal gait is mostly effective in improving gait parameters and, therefore, for the functional recovery of a patient.

Balance training using the Biodex Balance System (BBS) in combination with a recommended physical therapy exercise program may be helpful in the rehabilitation of patients with recurrent lateral ankle sprain.

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Scientific Responsibility Statement

The authors declare that they are responsible for the article's scientific content including study design, data collection, analysis and interpretation, writing, some of the main line, or all of the preparation and scientific review of the contents and approval of the final version of the article.

Animal and human rights statement

All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. No animal or human studies were carried out by the authors for this article.

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Conflict of interest

None of the authors received any type of financial support that could be considered potential conflict of interest regarding the manuscript or its submission.

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