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ORIGINAL RESEARCH ARTICLE

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Effects of 6 weeks of ankle stability exercises on pain, functional abilities, and flexibility in patients with chronic non-specific low back pain: a randomized controlled trial

Mahmoud D. Abdelhaleem[1*], Mohamed I. Abdelhay[2], Sobhy M. Aly[3], Ehab A. Abdallah[4] and Neama H. Neamat Allah[3]

Abstract

Background Due to delayed activation of the deep trunk muscles, patients with chronic non-specific low back pain use different adjustment strategies to maintain postural control. Patients with chronic non-specific low back pain maintain a quite standing posture during pain episode and challenging activities by using signals from other joints, mainly the ankle joint. Since proprioceptive signals from the ankle joint reduce postural control variability in patients with chronic non-specific low back pain, this study explored whether ankle stability exercises added to traditional physical therapy exercises would improve the intensity of pain, functional disabilities and lumbar flexion range of motion in patients with chronic non-specific low back pain.

Methods Sixty patients with chronic non-specific low back pain participated in the current study. Patients were randomly assigned into two groups: group A and group B. Patients in group A received traditional physical therapy exercises for low back pain. Patients in group B received the same traditional physical therapy exercises as patients in group A, plus ankle stability exercises. The intensity of pain, functional disability, and lumbar flexion range of motion were assessed twice before and after a 6-week period during which each group received their interventions.

Results Mixed design MANOVA revealed a significant decrease in visual analog scale and Oswestry Disability Index in group B compared to group A post treatment ($p < 0.05$). Moreover, there was a significant increase in the lumbar flexion range of motion in group B compared with group A post treatment ($p < 0.05$).

Conclusion The findings of this study revealed that adding ankle stability exercises to the traditional physical therapy exercises significantly improved pain, Oswestry Disability Index, and lumbar flexion range of motion in patients with chronic non-specific low back pain. Thus, ankle strengthening and proprioceptive exercises may be beneficial in the management of chronic non-specific low back pain.

Keywords Low back pain, Ankle stability, Visual analog scale, Oswestry Disability Index, Range of motion

*Correspondence:
Mahmoud D. Abdelhaleem
mahmoud.diab@pt.cu.edu.eg
Full list of author information is available at the end of the article

Introduction

Despite its high prevalence, the cause of low back pain (LBP) cannot be clinically diagnosed in 85 to 90% of cases. Movement and positional deviations are the most common causes of non-specific LBP due to disruption of the kinetic chain from the feet to the back [1]. Additionally, it has also been suggested that patients with chronic non-specific LBP have trunk muscle control dysfunction and rely mainly on ankle proprioception to maintain upright posture. A different muscle recruitment pattern, improper variability in postural control, and decreased postural stiffness have also been reported in patients with chronic non-specific LBP which leads to increase reliance on distal segments' proprioception due to decreased proximal proprioception [2].

Previous literature has shown that ankle proprioception signals were significantly higher in patients with chronic non-specific LBP compared to healthy controls due to delayed activation of the deep trunk muscles [3]. Consequently, patients with chronic non-specific LBP depend more on proprioceptive signals from ankles and other joints for postural control due to decreased proprioceptive acuity in the lumbar region during painful episodes and when postural demands increase [4]. Furthermore, there is moderate evidence that patients with chronic non-specific LBP displayed greater dependency on the ankle strategy to maintain a quite standing posture [5]. In addition, younger adults with chronic non-specific LBP are more likely to use ankle strategies than older adults who use hip joint strategies more often to improve postural stability [6].

The ankle proprioceptive information is largely responsible for regulating balance in patients with chronic non-specific LBP since lumbar and hip strategies are restricted in high demand tasks [5]. Furthermore, ankle proprioception has been shown to be reduced in elderly patients with chronic non-specific LBP compared with healthy controls, which increases the risk for falls in these patients. Additionally, previous studies have indicated a higher level of posture repositioning errors with generalized proprioceptive impairment in patients with chronic non-specific LBP compared to healthy controls [7]. These findings suggest that chronic non-specific LBP impacts ankle proprioception and therefore achieving optimal proprioception of the ankle could be helpful in managing chronic non-specific LBP [8, 9].

Recently, neuromuscular rehabilitation interventions that enhance sensory deficiencies by increasing proprioceptive challenges have received increased therapeutic attention [2]. As far as the authors are aware, no previous study has examined the effects of ankle stability exercises in conjunction with traditional physical therapy exercises on pain, functional disabilities, and lumbar flexion ROM in patients with chronic non-specific LBP. Thus, the purpose of this study was to investigate the effects of adding ankle stability exercises to the traditional physical therapy exercises on pain, functional disability, and lumbar flexion range of motion (ROM) in patients with chronic non-specific LBP.

Materials and methods

Participants

Sixty patients diagnosed with chronic non-specific LBP, referred by an orthopedic surgeon participated in this study. To be eligible for the current study, patients had to be between 20 and 50 years old, had a professional diagnosis of chronic non-specific LBP, and had a history of persistent LBP for more than 3 months [9, 10]. Patients were excluded from the study if they had an acute episode of LBP; received physical therapy treatment in the last 3 months; had spinal surgery or neurological symptoms; had skeletal muscle degenerative disease; had infections, tumors, or rheumatoid arthritis; and had serious heart, renal, or liver insufficiency [11]. Patients provided an informed consent to be able to participate in the study and were refrained from using any topical or non-steroidal anti-inflammatory drugs during the study.

Sample size

A priori sample size for variance between two independent means was calculated based on visual analog scale (VAS) data collected in a pilot study conducted on ten patients, five patients in each group, using G* power (version 3.1.9.2, Franz Faul, Universitat Kiel, Germany). Accordingly, the required sample size was 30 subjects in each group with alpha level set at 5%, type II error set at 90% and effect size set at 0.86.

Design

An ethical approval was obtained from the Institution Review Board of the Faculty of Physical Therapy at Cairo University (P.T.REC/012/003519). Additionally, this study complied with all pertinent national regulations, institutional policies, and the principles of the Declaration of Helsinki. Sixty patients diagnosed with chronic non-specific LBP participated in the current study. Patients were randomly assigned into two groups (group A and group B). A computer-generated randomization table was used to implement randomization using the SPSS program (version 25 for Windows). Each patient was assigned a unique identification number, which was used to divide the patients into two equal groups. The number index cards were then sealed in opaque envelopes and a blinded researcher opened the sealed envelopes and assigned the patients to their groups. Patients in group A ($n = 30$) received traditional physical therapy exercises for LBP 3 times/week for 6 weeks. Patients in group B ($n = 30$) received the same traditional physical therapy exercises as patients in group A, plus ankle stability exercises 3times/week for 6 weeks. Throughout the study, there was no drop out among the patients (Fig. 1). This study complies with all CONSORT standards and was registered in the Pan African Clinical Trial Registry (PACTR202203839885707).

Evaluation

Patients in each group were tested twice, pre- and post 6 weeks of receiving the assigned treatment interventions. Once arrived, the treatment interventions were explained to each patient, and the consent form was taken as approved by Cairo University's Supreme Council of Postgraduate Studies and Research and Human Research Ethics Committee. Patients' demographic data including age, gender, weight, and height, pain intensity Oswestry Disability Index (ODI), and lumbar flexion ROM were collected from each patient. A researcher who was blinded to group assignment measured pain, ODI, and lumbar flexion ROM before treatment and after 6 weeks.

Outcome measures

1. Pain intensity

   Pain intensity was assessed using visual analog scale (VAS). Patients determined their level of pain at that time on a 10-cm VAS, where zero indicates no pain and 10 indicates the worst pain imaginable [12].
2. Lumber flexion ROM
   The Modified-Modified Schober test (MMST) was used to assess lumbar flexion ROM. Upon assuming a standing position, the examiner located and drew a horizontal line between the two posterior superior iliac spines. An additional point was then marked 15 cm above this line. Following this, patients were instructed to bend forward as much as possible while keeping their knees straight. ROM of lumbar flexion was calculated by measuring the distance between the previously marked points [13].
3. Functional performance assessment
   Oswestry Disability Index was used to assess the patients' functional disabilities. ODI is the gold standard for evaluation of quality of life and functional disability in patients with LBP. It consisted of 10 questions on pain intensity, ease of personal care,

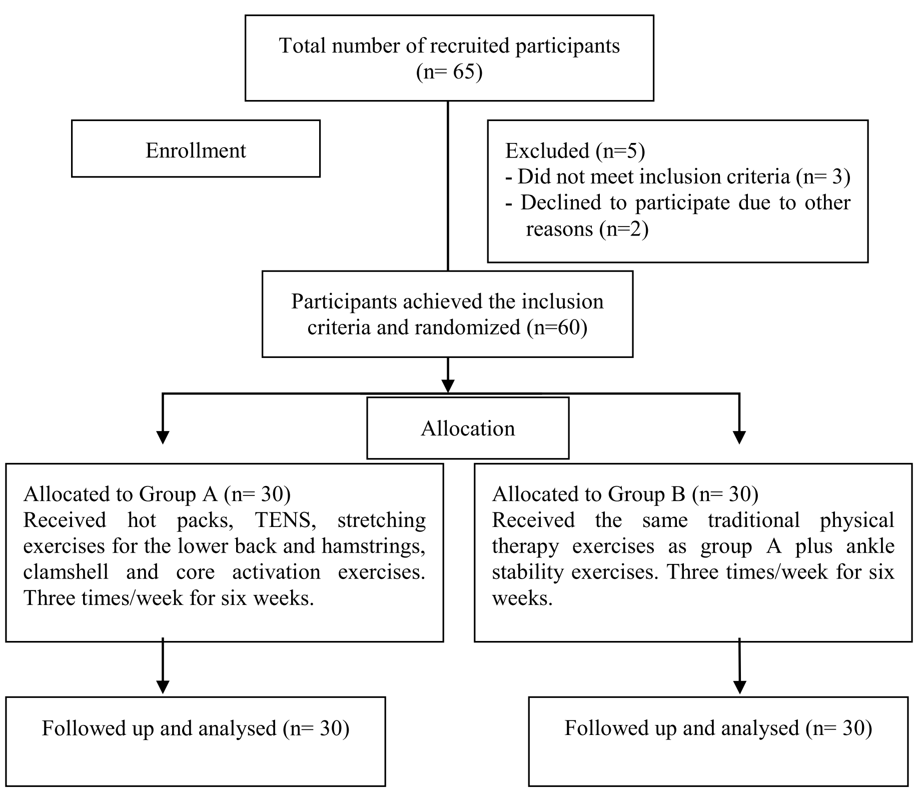

Fig. 1 Flow of patients through the trial

lifting, working, sitting, standing, sleeping, sex life, social life, and traveling that assess the functional disability of the patients. Each question is scored from 0 to 5 [14]. The ODI was filled in before and after a 6-week period.

Intervention

Patients in group A received traditional physical therapy exercises 3 times/week for 6 weeks. The traditional physical therapy treatment program consisted of hot packs, transcutaneous electrical nerve stimulation (TENS) [15], stretching exercises for the lower back and hamstrings, clamshell exercise for activation of gluteus medius muscles in bilateral lower extremities, and core activation exercises.

The hot packs were applied for 15 min on both sides of the painful area. TENS was applied for 15 min at a frequency of 80–100 Hz, a wave duration of 50–100 μs, and low intensities on both sides of the painful area [15]. A knee to chest stretching exercise was used to stretch back muscles. Patients performed 3 sets of knees to chest and bilateral hamstring stretches, each held for 30 s. Patients were then asked to perform three sets of 15 repetitions of clamshell and core activation exercises. Core activation exercises included supine extension bridge, side bridge, curl up, and bird dog exercises [6, 16]. In all core activation exercises, the final position was maintained for 10 s with a 3-s pause between repetitions and a 60-s rest between each core activation exercise [17].

Patients in group B received the same traditional physical therapy exercises as patients in group A, plus ankle stability exercises 3 times/week for 6 weeks. The ankle stability exercise program consisted of ankle strengthening exercises, calf raises, single leg standing, lower limb squats, double leg, and single leg balance board proprioceptive exercises [18]. For ankle strengthening exercises, patients were instructed to perform 3 sets of 15 repetitions of ankle strengthening exercises with a 30-s rest interval between each set using theraband resistance in four directions of ankle movements (Fig. 2). Afterward, patients were asked to perform 3 sets of 15 repetitions of calf raises (Fig. 3A), single leg standing (Fig. 3B), and lower limb squat (Fig. 3C), with a 30-s rest period between each set. Proprioceptive exercises were then performed on a balance board, where patients stood on both feet during double leg exercises (Fig. 4) and on one foot during single leg exercises (Fig. 5) and moved in a continuous path [19].

Statistical analysis

Unpaired t-test was conducted to compare the subject characteristics between groups. Chi-squared test was

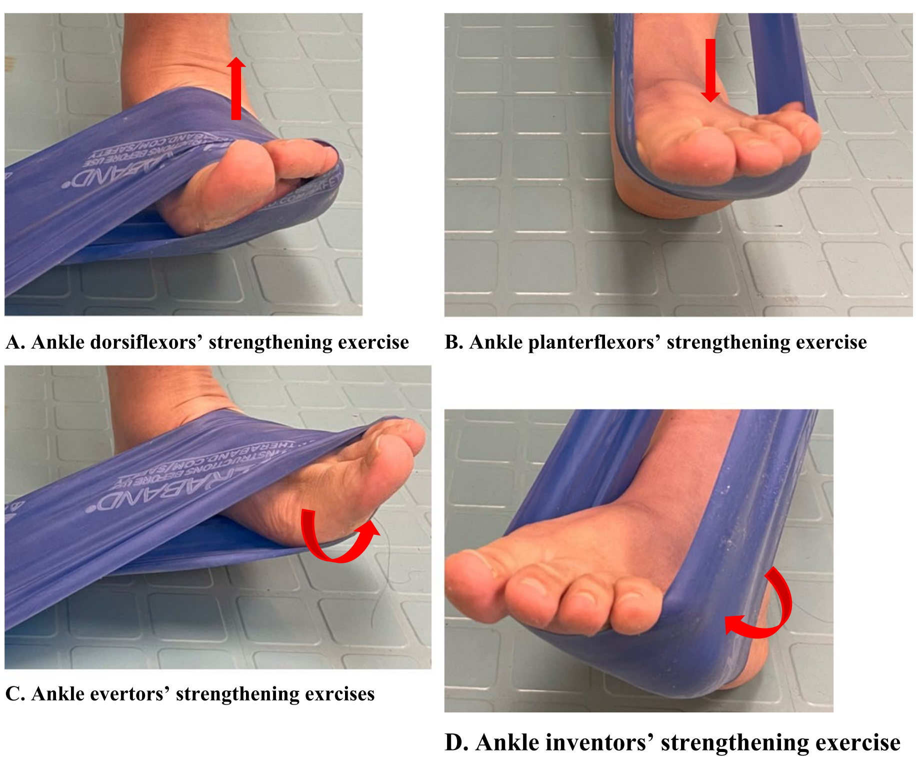

Fig. 2 Ankle strengthening exercises using theraband

A. Calf raises **B. Single leg standing** **C. Lower limbs squat**

Fig. 3 Calf raises, single leg standing, lower limb squat

Fig. 4 Double leg ankle proprioceptive exercises

Fig. 5 Single leg ankle proprioceptive exercises

used to compare the sex distribution between groups. Normal distribution of the data was checked using the Shapiro–Wilk test. Additionally, Levene's test for homogeneity of variances was performed to ensure the homogeneity between groups. Mixed design MANOVA was used to compare between both groups (between subject effect) for pain, ODI, and ROM pre and post treatment, compare between the "pretest" and "posttest" conditions (within subject effect) for the tested variables in each group, and examine the interaction effect. Post hoc tests using the Bonferroni correction were carried out for subsequent multiple pairwise comparison. The level of significance for all statistical tests was set at $p < 0.05$. All statistical analysis was conducted through the statistical package for social studies (SPSS) version 25 for windows (IBM SPSS, Chicago, IL, USA).

Results

There were no significant differences in age, weight, height, and BMI (Table 1) between group A and group B ($p > 0.05$). Additionally, there was no significant difference in the sex distribution between group A and group B ($p > 0.05$).

Mixed design MANOVA revealed a significant interaction effect of treatment and time ($F = 16.27$, $p = 0.001$). Additionally, there was a significant main effect of treatment ($F = 3.39$, $p = 0.02$) and time ($F = 184.68$, $p = 0.001$). The interaction effect was significant for VAS ($F = 8.96$, $p = 0.004$), ODI ($F = 21.64$, $p = 0.001$), and lumbar flexion ROM ($F = 17.84$, $p = 0.001$).

Mixed design MANOVA indicated no significant differences between groups for all the tested variables before treatment ($p > 0.05$). However, there were significant differences between them for all the tested variable post treatment ($p < 0.05$). Multiple pairwise comparisons revealed no significant differences between groups for all the tested variables before treatment ($p > 0.05$). However, there was a significant decrease in VAS and ODI in group B compared to group A post treatment ($p < 0.05$). The percentage of change in VAS and ODI was 35.57 and 32.08% respectively in group A and 53.67 and 60.89% respectively in group B. Moreover, there was a significant increase in the lumbar flexion ROM post treatment in group B compared with group A ($p < 0.05$). The percentage of change in the lumbar flexion ROM was 5.02 and 10.52% respectively (Table 2) in group A and group B.

Table 1 Basic characteristics of participants

	Group A $n = 30$ $X \pm SD$	Group B $n = 30$ $X \pm SD$	*t*-value	*p*-value
Age (years)	48.9 ± 6.87	49.1 ± 6.53	− 0.11	0.91
Weight (kg)	75.66 ± 6.79	77.6 ± 5.91	− 1.17	0.24
Height (cm)	170.53 ± 6.02	173 ± 7.52	− 1.4	0.16
BMI (kg/m^2)	26.06 ± 2.51	25.99 ± 2.17	0.11	0.91
Sex distribution				
Females	7 (23.3%)	4 (13.3%)	($\chi^2 = 1.01$)	0.32
Males	23 (76.7%)	26 (86.7%)		

SD Standard deviation, χ^2 Chi squared value, *p* value Probability value

Discussion

Neuromuscular rehabilitation interventions focused on improving sensory deficiencies by adding proprioceptive challenges have received more therapeutic attention in the past few years [2]. This study aimed to investigate whether ankle stability exercises in conjunction with traditional physical therapy exercises would provide greater improvements on pain, functional disabilities, and lumbar flexion ROM than the traditional physical therapy exercises in patients with chronic non-specific LBP.

The findings of this study revealed significant improvements in the intensity of pain, ODI, and lumbar flexion ROM in both groups. However, the percentage of change for all the tested variables was significantly higher in group B compared to group A. The improvement in pain following treatment was evident by a decreased VAS score. Additionally, the ROM increased two points in group B and one point in group A after treatment. Moreover, more significant differences in the ODI were observed in group B compared with group A.

This improvement in pain, functional abilities, and lumbar flexion ROM in group B can be attributed to improved muscular performance, decreased stiffness, and enhanced proprioception sense after ankle stability training [6]. Maintaining proper proprioceptive integration is crucial to pain free activities. In addition, ankle strengthening and proprioceptive exercises may stimulate the distal muscles and facilitate earlier activation of the transversus abdominals which is responsible for neuromuscular dysfunction in patients with chronic non-specific LBP [20]. Further, improving neuromuscular function of the trunk has been reported to be more important than trunk strengthening in patients with chronic non-specific LBP [2]. Additionally, ankle strengthening may improve the force generation as well as spinal stiffness, thereby reducing pain and improving physical abilities in these patient populations [10].

The findings of this study are consistent with the previous results of You JH et al. [10], who examined the effects of ankle dorsiflexion combined with drawing in the abdominal wall on pain, physical disability, and spinal stiffness in 40 patients with chronic non-specific LBP (20 experimental and 20 control). Findings showed that adding ankle dorsiflexion to core stability significantly

Table 2 Mean ± SD VAS, ODI, and lumbar flexion ROM in the pre and post-test conditions for group A and group B, between and within groups MD and *p*-value, and percentage of change

	Group A ($n = 30$) Mean ± SD		**Group B ($n = 30$) Mean ± SD**	**MD (95% CI)**	**Between subject *p*-value**
VAS	**Pre-test**	7.76 ± 1.61	7.9 ± 1.54	− 0.14 (− 0.94:0.68)	0.74
	Post-test	5 ± 2.18	3.66 ± 1.47	1.34 (0.37:2.29)	0.007*
MD (95% CI)	2.76 (2.07:3.46)		4.24 (3.54:4.92)	-	
Percentage of change	35.57		53.67	-	
Within subject *p*-value	0.001*		0.001*	-	
ODI (%)	**Pre-test**	49.56 ± 11.17	50.96 ± 11.07 19.93 ± 9.45	− 1.4 (− 7.15:4.35)	0.62
	Post-test	33.66 ± 11.66		13.73 (8.24:19.22)	0.001*
MD (95% CI)	15.9 (11.29:20.50)		31.03 (26.43:35.63)	-	
Percentage of change	32.08		60.89	-	
Within subject *p*-value	0.001*		0.001*	-	
MMST for lumbar flexion ROM (cm)	**Pre-test**	19.31 ± 1.11	19.21 ± 1.09	0.1 (− 0.46:0.68)	0.7
	Post-test	20.28 ± 1.03	21.23 ± 1.03	− 0.95 (− 1.47: − 0.42)	0.001*
MD (95% CI)	− 0.97 (− 1.33: − 0.61)		− 2.02 (− 2.38: − 1.66)	-	
Percentage of change	5.02		10.52	-	
Within subject *p*-value	0.001*		0.001*	-	

SD Standard deviation, *MD* Mean difference, *CI* Confidence interval, *p-value*, level of significance, *MMST* Modified-Modified Schober test, *ROM* Range of motion

* The significant level was set at $p < 0.05$

reduced pain, improved core stability, and increased functional abilities in patients with chronic non-specific LBP. It should be noted that they examined the combined effect of two exercises only on pain and physical disability. But in our study, we used a traditional physical therapy treatment program plus an ankle stability exercise program. The traditional physical therapy treatment program consisted of hot packs, TENS, stretching exercises for the lower back and hamstrings, clamshell exercises for activation of gluteus medius muscles in bilateral lower extremities, and four core activation exercises. The ankle stability exercise program involved ankle strengthening exercises using theraband resistance in the four directions of ankle movements, calf raises, one leg standing, lower limb squats, and double and single leg proprioceptive exercises on a balance board.

Similarly, these findings are in line with those of Yoon K-S et al. [21] who examined the effect of active stretching and mobilization of the ankle on pain, flexibility, and weight distribution in 16 patients with chronic non-specific LBP (8 experimental and 8 control). Patients in the experimental group received ankle mobilization and active stretching of the calf muscle three times a week for 4 weeks. Researchers found a significant improvement in lumbar flexion and extension ROM in the ankle mobilization group when compared to the control group. It should be noted that they used only two types of exercises (active stretching and ankle mobilization) three times a week for 4 weeks. In our study, patients received traditional physical therapy exercises for LBP as well as ankle stability exercises three times a week for 6 weeks.

Furthermore, our findings were also consistent with the previous results of Chon SC et al. [20], who examined the effects of cocontraction of ankle dorsiflexors and transversus abdominus on pain intensity, Pain Disability Index, and LBP rating scale in 20 patients with mechanical LBP and 20 healthy controls. After performing the abdominal drawing in maneuver, patients were instructed to cocontract their tibialis anterior and rectus femoris muscles against static resistance. A total of ten 30-min sessions of abdominal drawing in maneuver and cocontraction of tibialis anterior and rectus femoris muscles were scheduled over 2 weeks for each patient. According to this study, patients with mechanical LBP experienced a significant reduction in pain by cocontracting of dorsiflexors and transversus abdominis muscles.

There were some limitations to this study, including the fact that patients were included irrespective of their upper limits for pain chronicity. Additionally, ankle joint proprioception was not measured in the current study. Furthermore, the pattern and sequence of muscle activation were not measured in this study. Future studies should include EMG data to display accurate information about the sequences and patterns of muscle activations before and after treatment.

Conclusion

The findings of this study indicated that pain, ODI, and lumbar flexion ROM were significantly improved in patients who received traditional physical therapy exercises plus ankle stability exercises compared to patients who received traditional physical therapy exercises only. However, prospective longitudinal studies are needed to assess the long-term effect of adding ankle stability exercises to the traditional physical therapy exercises in patients with chronic non-specific LBP.

Abbreviations

LBP	Low back pain
MMST	Modified-Modified Schober Test
ODI	Oswestry Disability Index
ROM	Range of motion
TENS	Transcutaneous electrical nerve stimulation

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Disclosure statement

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

Authors' contributions

The study's idea, data collection, design, statistical analysis, data interpretation, and the study's writing and critical editing were done in collaboration by all authors. The author(s) read and approved the final manuscript.

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Availability of data and materials

All the data and materials of this research are available for any interested researchers and journals upon request by email to the corresponding author.

Declarations

Ethics approval and consent to participate

The study was approved by faculty of physical therapy Cairo University supreme Council of post graduate studies and research and human research ethics committee under number (P.T.REC/012/003519). All participants signed a written informed consent before starting the study.

Consent for publication

The authors of this research consent that is research has not been sent for any journal for publication and it is not considered for publication for any other journals.

Competing interests

The authors declare competing interests.

Author details

[1]Department of Orthopedic Physical Therapy, Faculty of Physical Therapy, Cairo University, 7 Ahmed El Zaiat St., Bein El Sarayat, Giza 12612, Egypt. [2]Department of Basic Science, Faculty of Physical Therapy, Cairo University, 7 Ahmed El Zaiat St., Bein El Sarayat, Giza 12612, Egypt. [3]Department of Biomechanics, Faculty of Physical Therapy, Cairo University, 7 Ahmed El Zaiat St., Bein El Sarayat, Giza 12612, Egypt. [4]Department of Orthopedic Physical Therapy, Faculty of Physical Therapy, Horus University, International Costal Road, New Damietta, Egypt.

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