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Efficacy of Trunk Balance Exercises for Individuals With Chronic Low Back Pain: A Randomized Clinical Trial

Chronic low back pain (CLBP) is one of the most common clinical conditions in Europe and the United States,[21] and in Italy it is the leading cause of absenteeism from work and the second most frequent cause of permanent disability.[26] The etiology of CLBP is complex and not yet fully understood. One possible factor may be the trunk musculature, which, during functional activities, ensures the mobility and stability of the lumbopelvic region.[20,27,36] Individuals with acute and CLBP show changes in trunk muscle activity, particularly in the transversus abdominis and multifidi.[18,19,30] A consistent finding is delayed activation of the trunk muscles during both unpredictable and predictable trunk perturbations.[18,19,29,35,40,41]

STUDY DESIGN: Randomized clinical trial.

OBJECTIVES: To determine the efficacy of trunk balance exercises for individuals with chronic low back pain.

BACKGROUND: The majority of exercises focusing on restoring lumbopelvic stability propose targeting the feedforward control of the lumbopelvic region. Less attention has been paid to feedback control during balance adjustments.

METHODS: Seventy-nine patients were randomly allocated to 2 different groups. The experimental group performed trunk balance exercises in addition to standard trunk flexibility exercises. The control group performed strengthening exercises in addition to the same standard trunk flexibility exercises. The primary outcome measures were pain intensity (visual analogue scale), disability (Roland-Morris Questionnaire), and quality of life (12-Item Short-Form Health Survey). Secondary outcomes were painful positions, use of analgesic drugs, and referred pain. Analysis of variance and relative risk were used to analyze the data for the primary and secondary outcome measures, respectively. The number of participants reaching the minimal clinically important difference in the 2 groups for each outcome measure was compared using relative risk.

RESULTS: A significant difference in scores on the Roland-Morris Questionnaire ($P = .011$) and the physical component of the 12-Item Short-Form Health Survey ($P = .048$), and in the number of participants reaching the minimal clinically important difference for the Roland-Morris Questionnaire (relative risk, 1.79; 95% confidence interval [CI]: 1.05, 3.04) and the secondary outcome of painful positions (relative risk, 1.37; 95% CI: 1.03, 1.83) were found in favor of the experimental treatment.

CONCLUSIONS: Trunk balance exercises combined with flexibility exercises were found to be more effective than a combination of strength and flexibility exercises in reducing disability and improving the physical component of quality of life in patients with chronic low back pain.

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This delayed activation has been described as an important impairment of the "neural control unit" of the spine stabilizing system.[36-38] The trunk muscles, providing spinal stability, act through feedforward and feedback control mechanisms that modulate the stiffness of the spinal muscles to control internal and external forces generated during body movements.[17,42] The reasons leading to motor control dysfunctions of the spine following an initial back injury are not clear. Leinonen[24] reports that delayed response of trunk muscles could be related to inaccurate information processing from higher centers of the central nervous system related to motor control. Others[41] emphasize a spinal reflex deficit and report that, during a sudden load-release protocol, individuals with low back pain have longer reflex latencies compared to healthy controls. These longer latencies would appear to be a preexisting risk factor and not a result of low back pain.[8]

The functional consequence of a delayed response of the trunk muscles to sudden external loads is a deficit in trunk balance, as demonstrated with a sitting test.[40] In addition, in the absence of visual feedback, poorer balance performance has been associated with longer onset times of the trunk muscles.[36] Trunk bal-

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TABLE 1	Baseline Characteristics*		
	Experimental Group	Control Group	*P* Values
Participants, n	34	45	
Gender, males/females, n	11/23	17/28	.62
Age, y	58.6 ± 13.0	57.1 ± 12.4	.62
Duration of CLBP, mo	78.2 ± 133.3	64.5 ± 97.0	.61
Participants with painful positions, n	34	45	1.00
Participants using medication, n	8	16	.25
Participants with referred pain in the lower extremities, n	24	27	.32
Visual analogue scale (0-100)	35.7 ± 26.0	43.4 ± 27.1	.20
Roland-Morris Questionnaire (0-24)	7.8 ± 4.4	8.4 ± 4.4	.55
SF-12 physical component (0-100)	39.0 ± 5.9	41.4 ± 8.5	.14
SF-12 mental component (0-100)	44.9 ± 11.7	43.3 ± 11.5	.55

Abbreviation: CLBP, chronic low back pain; SF-12, 12-Item Short-Form Health Survey.
**Data are mean ± SD unless otherwise specified. There were no significant differences between groups for all variables.*

ance deficits and muscle impairments could also originate from poor position sense, which has been reported to be present in individuals with CLBP.[3,31,32]

Clinicians are well aware that patients with CLBP have difficulty maintaining balance, especially under challenging conditions (eg, single-limb support or closed eyes[5]), and poor balance is also a frequent concern reported by patients with CLPB.[14] Balance deficits in individuals with CLBP have been demonstrated through increased displacement of the center of pressure while standing upright[6,33] and greater medial-lateral postural sway.[28]

Despite the documented balance deficits, rehabilitative protocols for improving trunk muscle activation primarily focus on the feedforward mechanism, using exercises that emphasize the maintaining of static postures (eg, squat exercises, curl-up, side and front support). These exercises, including trunk muscle strengthening exercises performed in unstable conditions, are also included in protocols using the concept of core muscle training.[1,16,44]

The authors of 4 recent systematic reviews have reported on the effectiveness of motor control exercises for the treatment of CLBP.[10,15,25,39] Comparison between motor control exercises and other rehabilitation techniques shows that the former are useful in the treatment of CLBP; however, there is no evidence of their superiority over other physiotherapy interventions. The question, therefore, remains open as to whether there is an optimum exercise program to address CLBP. More specifically, the efficacy of trunk balance training alone in individuals with CLBP has never been studied.[11] The aim of this study is to determine the efficacy of trunk balance exercises in patients with CLBP.

METHODS

Participants

Between March 2008 and October 2009, 79 individuals with a history of CLBP were enrolled in the study. The individuals were ambulatory patients who had consulted doctors regarding their CLBP, which doctors were involved in the recruitment of patients for the study. No suggestion to the participants on drug management was given. The inclusion criterion was low back pain, with or without referred pain in the lower limbs, present for at least 3 months. In all participants, lumbar pain was judged to be associated with a lumbar pathology, as documented by radiographs, CT, or MRI, and to involve the intervertebral disc, the vertebrae, or the spinal nerve roots. Exclusion criteria were inflammatory arthritis, indications for surgical intervention, contraindications to exercise, and the presence of neurological diseases. A priori sample size determination was not computed. The study was conducted at the Rehabilitation Service of San Raffaele Hospital, Milan. All participants signed an informed consent form, and the study was approved by the Internal Ethics Committee of San Raffaele Hospital.

Experimental Design

Prior to the start of the study, participants were allocated to an experimental or a control group (**TABLE 1**), using a computer-generated list of random numbers created and managed by a physiotherapist who was blinded to all information pertaining to the individuals participating in the study. Participants drawing an even number were assigned to the experimental group, and those drawing an odd number to the control group.

Throughout the study, the exercises were completed in small groups, each having a minimum of 4 to a maximum of 6 participants. Seven experimental groups (34 participants) and 8 control groups (45 participants) were created. The intervention consisted of 2 sessions per week, each lasting 60 minutes, for a total of 10 treatments over 5 consecutive weeks.

The **APPENDIX** describes the exercises performed by the 2 groups. During each treatment session, under the supervision of the same physiotherapist, all participants performed 15 minutes of walking on a treadmill and 30 minutes of flexibility exercises for the spine and lower limbs. In addition, those in the control group performed 15 minutes of strengthening exercises for the limbs and trunk. In contrast, those in the experimental group performed 15 minutes of trunk balance exercises.

The flexibility exercises for the spine were performed in supine, prone, and sitting positions. Each exercise was performed 10 times. The stretching exercises, primarily for the hip musculature, were performed with each stretching position maintained for 1 minute, followed by a 30-second rest. The strengthening exercises were performed with a load of 50% of the maximal voluntary contraction (MVC) and targeted the following muscles: quadriceps, hamstrings, and latissimus dorsi. The MVC was estimated using the formula suggested by Brzycki,[4] based on the participant performing a load that did not generate any discomfort or pain. Abdominal strengthening was also performed in the supine position.

Balance exercises were performed in the sitting, kneeling, quadruped, and supine positions. Each exercise was designed to challenge the participant; therefore, once an exercise position was easily maintained for a period ranging from 30 seconds to 2 minutes, the exercise was progressed in difficulty. For the balance exercises, participants were simply asked to maintain the requested position, without any further instructions. The progression in difficulty of the exercises was based on changing the support base (hard or soft support) and by asking participants to close their eyes or to move their heads or upper limbs. The exercises were introduced in order of increasing difficulty, tailored to the ability of each participant, and each exercise was performed for 2 to 3 minutes. If participants complained of even a slight increase in back pain, the exercise was interrupted and substituted with another one. Both groups performed their exercises at the same time of the morning but on different days.

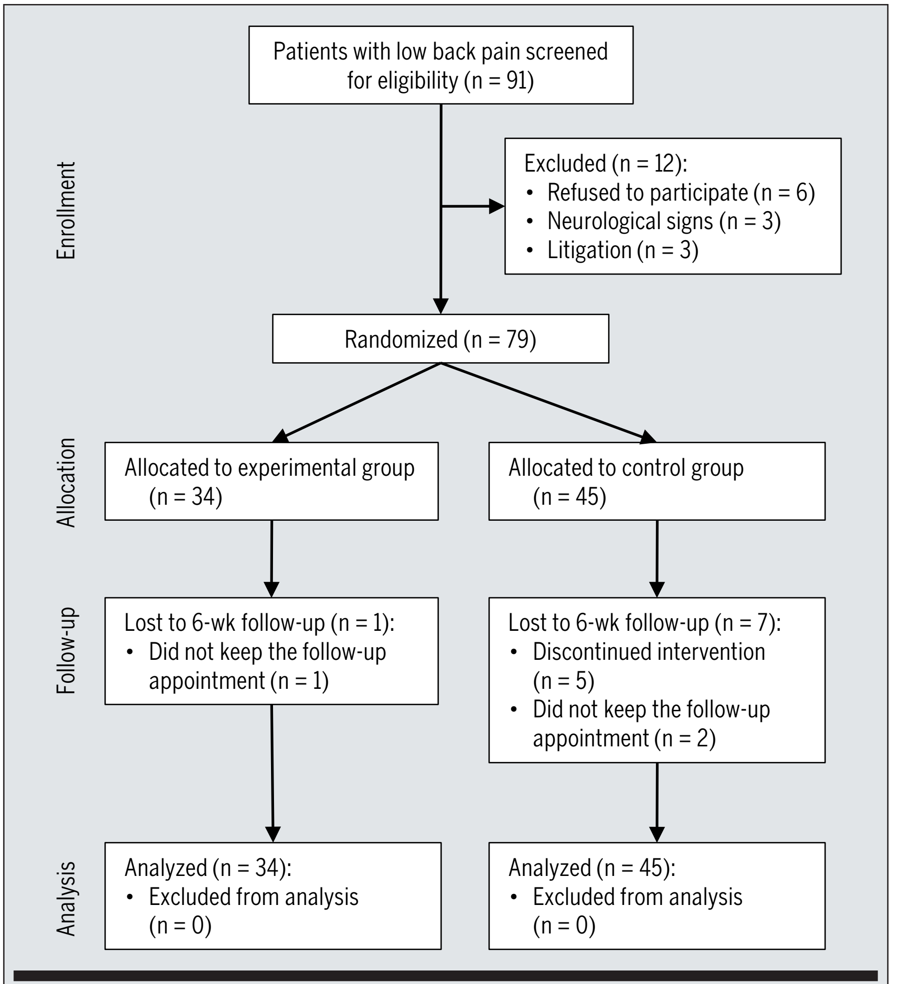

FIGURE. Flow-diagram of participants throughout the course of the study.

Outcome Measures

Primary outcome measures were pain intensity (estimated using a visual analogue scale [VAS], with scores ranging from 0 to 100, 0 representing an absence of pain and 100 very severe pain), disability (evaluated using the Roland and Morris Questionnaire [RMQ]), and quality of life (measured with the mental and physical components of the 12-Item Short-Form Health Survey [SF-12]).[43,45] Measurements were collected by a blinded assessor before the first treatment session and a week after the final session, at the time of a routine check-up. Participants were asked to indicate values based on the previous week. Standardized instructions were used to explain the scales. To obtain a broader description of the results, some variables related to the primary outcomes were also considered as secondary outcomes: painful positions, changes in medication usage, and presence of referred pain in the lower limbs. At the end of the treatment period, patients with a lower incidence of painful positions, drug usage, or referred pain in the lower limbs were considered improved. Patients with an increase or no change for these 3 variables were considered as worsened. The number of participants who improved or worsened for each secondary outcome was calculated.

Participants were asked to state if they had improved or worsened in the following positions: supine and prone position during normal activities, sitting posture for 15 minutes, standing for 5 minutes, walking, and going up and down a flight of stairs. Similarly, participants were asked to state if they had reduced, increased, or not changed their medication. The drugs of interest were those taken for pain control related to their CLBP condition. Secondary outcomes were transformed into the dichotomous variables of better or worse.

Statistical Analysis

Data were analyzed using an intention-to-treat approach. All individuals who

TABLE 2 Data for Primary Outcome Measures Preintervertion and Postintervertion*

	Experimental Group		Control Group					
	Preintervention	Postintervention	Preintervention	Postintervention	*P* Value (Time Factor)	*P* Value (Between Groups)	*P* Value (Time-by-Group Interaction)	RR (95% CI), *P* Value†
Visual analog scale (0-100)	35.7 ± 26.0	20.9 ± 18.3	43.4 ± 27.1	37.8 ± 26.1	.001	.030	.165	2.32 (0.74-7.28), .19
Roland-Morris Questionnaire (0-24)	7.8 ± 4.4	4.4 ± 3.3	8.4 ± 4.4	7.1 ± 4.5	<.001	.044	.011	1.79 (1.05-3.04), .04
SF-12 physical component (0-100)	39.0 ± 5.9	44.5 ± 8.3	41.4 ± 8.5	43.7 ± 7.9	<.001	.612	.048	1.32 (0.77-2.25), .63
SF-12 mental component (0-100)	44.9 ± 11.7	48.5 ± 11.9	43.3. ± 11.5	42.7 ± 11.2	.035	.076	.202	...

Abbreviations: CI, confidence interval; RR, relative risk; SF-12, 12-Item Short-Form Health Survey.
**Data are mean ± SD unless otherwise specified.*
†RR with 95% CI and P *value computed based on the number of participants reaching the minimal clinically important difference in both groups.*

TABLE 3 Data for Secondary Outcome Measures Preintervention and Postintervention

	Experimental Group		Control Group		
	Preintervention	Postintervention	Preintervention	Postintervention	RR (95% CI), *P* Value*
Participants with painful positions (n)	34	6	45	18	1.37 (1.03, 1.83), *P* = .03
Participants who used medication (n)	8	3	16	11	2.00 (0.81, 4.94), *P* = .20
Participants with referred pain in the lower extremities (n)	24	11	27	19	1.83 (0.92, 3.64), *P* = .08

Abbreviations: CI, confidence interval; RR, relative risk.
**RR, related 95% CI, and* P *value were based on between-group comparisons.*

met the inclusion criteria and were recruited for the study consented to participate. Missing data on the primary and secondary outcomes due to dropouts were imputed using the last observed response (carry forward). All participants who completed the study were fully compliant with the intervention program.

Between-group comparisons of baseline characteristics of the participants were analyzed using a *t* test for independent samples or a chi-square test (Fisher exact test, where appropriate). Two-way mixed-model analyses of variance (ANOVAs), with time as the within-subject variable and treatment as the between-subject variable, were used for the data analysis of the primary outcome measures. To provide an estimate of the clinical relevance of the results, the number of participants in each group reaching the minimally clinically important difference (MCID)—considered 35 mm for the VAS,[34] 3.5 points for the RMQ,[34] and 5.2 points for the SF-12 physical component[48]—was compared using relative risk (RR) ratios, with a 95% confidence interval (CI). Intragroup comparisons were performed by paired samples *t* test.

RESULTS

Ninety-one consecutive potential participants were screened for eligibility. Seventy-nine individuals (average age, 57.8 years; range, 32-85 years) met the inclusion criteria, agreed to participate, and were randomized into either the control group (n = 45) or experimental group (n = 34). One participant in the experimental group and 7 participants in the control group withdrew from the study, bringing the number of individuals who completed the study to 33 (11 men, 22 women) in the experimental group and 38 (15 men, 23 women) in the control group. Reasons for ineligibility and withdrawal are reported in the **FIGURE**. The average ± SD time from inclusion in the study and the start of the intervention was 12.3 ± 4.1 days. The 2 groups were homogeneous at the beginning of the rehabilitation period.

TABLES 2 and **3** show the results for the primary and secondary outcome measures. There was no difference in improvement for either intervention when comparing the outcomes among the smaller exercise groups within each intervention (P>.250).

Pain Intensity Postintervention, the average VAS score for the experimental group was (mean ± SD) 14.8 ± 24.5 mm (P = .001) lower than the preintervention score. The reduction in VAS score was 5.6 ± 26.9 mm (P = .115) for the control group. Decrease in pain intensity was not significantly different between the 2 groups (P = .165; mean difference, 9.2 mm; 95% CI: –2.5, 20.9). The improvement in the VAS reached the MCID for 7 participants in the experimental group and 4 in the control group (RR, 2.32; 95% CI: 0.74, 7.28; P = .19).

Disability Improvement in disability is indicated by a lower score on the RMQ. The RMQ score, from preintervention to postintervention, decreased by an average ± SD of 3.4 ± 3.2 points (P<.001) for the experimental group and 1.3 ± 3.2 (P = .005) for the control group. The improvement in RMQ score was significantly greater for the experimental group (P = .011; mean difference, 2.1; 95% CI: 0.7, 3.6). The improvement in RMQ score reached the MCID for 19 participants in the experimental group and 14 in the control group (RR, 1.79; 95% CI: 1.05, 3.04; P = .04).

Quality of Life Improvement in the SF-12 is indicated by an increased in score. From preintervention to postintervention, the SF-12 physical component score increased an average ± SD of 5.5 ± 6.6 points (P<.001) for the experimental group and 2.3 ± 7.1 points (P = .032) for the control group. The difference for the experimental group was significantly greater than for the control group (P = .048; mean difference, 3.2; 95% CI: 0.1, 5.8). The improvement in the SF-12 physical component reached the MCID for 16 participants in the experimental group and 16 in the control group (RR, 1.32; 95% CI: 0.77, 2.25; P = .63).

The mean ± SD change in score between preintervention and postintervention for the mental component of the SF-12 scale was 3.6 ± 12.2 points (P = .098) for the experimental group and –0.6 ± 5.8 points (P = .310) for the control group. This improvement was not significantly different between the 2 groups (P = .202; mean difference, 3.00; 95% CI: –1.12, 7.12).

Secondary Outcomes Twenty-eight participants in the experimental group had an improvement in their painful positions, while 6 remained unchanged or worsened. In the control group, 27 improved and 18 remained unchanged or worsened. The difference between the 2 groups was statistically significant, with an RR of 1.37 (95% CI: 1.03, 1.83).

Five of the 8 participants in the experimental group who took pain medication prior to the study reduced their use of pain medication after the intervention, while the use of pain medication was unchanged or increased for the other 3 participants. In the control group, 5 of 16 participants who took pain medication decreased their use and the remaining 11 did not change or increase their use of pain medication. The RR between groups was not significant (RR, 2.00; 95% CI: 0.81, 4.94; P = .20).

Twenty-four participants in the experimental group and 27 in the control group had referred pain in their lower extremities at the beginning of the treatment period. In the experimental group, 13 improved and 11 remained unchanged or were worse, while 8 improved and 19 remained unchanged or were worse in the control group. The RR between groups was not significant (RR, 1.83; 95% CI: 0.92, 3.64; P = .08).

DISCUSSION

The aim of this study was to determine the efficacy of trunk balance exercises in patients with CLBP. The exercise sessions provided to the experimental and control groups were conducted in small patient groups, as proposed by the San Raffaele Hospital Rehabilitation Service.

The significant improvement in RMQ and physical component of the SF-12 scores, which include items such as going up stairs and vocational activities, suggests that challenging balance exercises in this population have a potential impact on reducing disability. This is a positive result, especially in the context of CLBP as not only a clinical problem but a psychosocial and work-related one.[22,23]

In contrast, improvement in the VAS pain score was not different between the 2 groups. It is noted that the low score at baseline might have precluded the ability to identify a difference between groups, by limiting the possible magnitude of improvement for either group. However, when considering the secondary outcome variable, "painful positions," a statistically significant effect in favor of the experimental group was found. Greater improvement in this secondary outcome, although also related to pain, may reflect a more functional aspect of daily living related to disability.

The selection of exercises for the experimental intervention program was based on the hypothesis that challenging balance exercises would promote recruitment of the trunk musculature. Proper recruitment of these muscles may be lost in patients with CLBP, which may explain the poor postural control and the muscle activation delays often attributed to poor proprioception in this population.[6,18,19] The idea of training the trunk musculature is not new. Exercises to induce transverse abdominis and multifidus muscle activation to stabilize the spine are often proposed for the treatment of CLBP.[13,46,47] Evidence from randomized clinical trials shows that treatment programs aimed at improving trunk muscle control through stabilization exercises lead to significant improvements in pain and disability and quality of life in patients with CLBP.[9,12,13] In contrast to the trunk balance exercises already proposed for spine stabilization, those of the present study did not require voluntary contractions of specific muscles. Additionally, maintenance of the unstable positions and the exercises was addressed as a functional task in which the recruitment of the trunk and spine muscles would be automatic. Further studies should analyze the characteristics of the recruitment of the trunk and spine muscles during trunk balance exercises to determine if this type of treatment decreases the spinal reflex deficit and, consequently, the delayed response time of the spinal muscles.[40,41]

In this study, there were fewer withdrawals in the experimental group (1 patient) than in the control group (7 patients). We can hypothesize that this might have been due to the greater challenge of trunk balance exercises compared to the strength training exercises and the perception of some patients that strengthening exercises might be injurious. In addition, balance exercises are more easily learned by patients, do not necessitate any special equipment, and can be performed independently at home after a period of supervised training, according to individual requirements. This aspect is important, as it has been reported that a home exercise program can be effective if supervised and directed at patients who are motivated.[2] As part of the study, we tried to increase the specificity of the intervention by adjusting the difficulty of the motor skills exercises of each patient to maintain and then intensify the exercise workout. It has been reported that, if adapted in this manner, aerobic exercise provides good results in terms of decreasing pain and disability in individuals with CLBP.[7]

The primary limitation of the study is the lack of an a priori sample size analysis based on the primary outcomes. Additional patient enrollment in the study could have resulted in significantly greater improvements in the VAS scale for the experimental group, further reinforcing the efficacy of this approach in individuals with CLBP. Another limitation is the absence of a follow-up beyond the termination of the intervention period. Subsequent studies should include follow-up assessments to determine if, over time, the changes noted remain. In addition, as the 2 interventions were both performed for 45 minutes, and the individual balance or strength exercises were performed for 15 minutes, it is difficult to attribute the results to either the combination of the entire exercise program or simply the balance training component. Finally, a placebo or Hawthorne effect cannot be excluded, as it was not possible to blind the patients to the intervention, given the nature of the treatment approach, and the outcomes were self-reported by the patients, making them prone to information bias.

CONCLUSION

The use of trunk balance exercises, compared to that of muscle-strengthening exercises of the limbs and trunk, appeared to be effective in reducing disability and led to improvements on the physical component of the quality of life due to CLBP. ◉

KEY POINTS

FINDINGS: Trunk balance exercises reduced disability and led to improvements in function and quality of life in patients with chronic low back pain.

IMPLICATIONS: The use of trunk balance training should be considered as part of a rehabilitation program for chronic low back pain.

CAUTION: This study did not include follow-up beyond the period of treatment, therefore, long-term efficacy of the program is not known.

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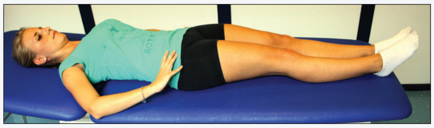
APPENDIX

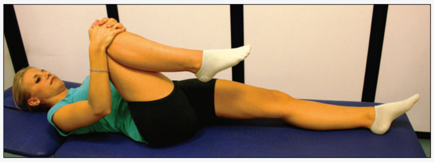
EXERCISES PERFORMED BY BOTH GROUPS

1. Walking on the treadmill for 15 minutes at a comfortable velocity.

2. Anterior and posterior pelvic tilts performed in supine, 15 repetitions.

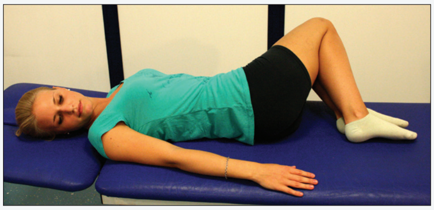


3. Single knee-to-chest exercise with the assistance of both hands, 10 repetitions each limb.

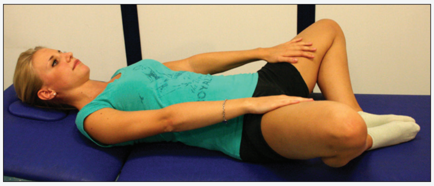


4. Double knee-to-chest exercise with the assistance of both hands, 10 repetitions.

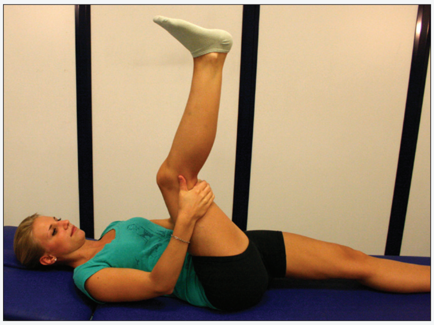
5. Lower limbs and trunk rotation with feet resting on the table, while rotating the head to other direction, 10 repetitions each direction.



6. Hip adductor stretches, while maintaining contact between the lumbar spine and the table, 2 repetitions, 1-minute hold.

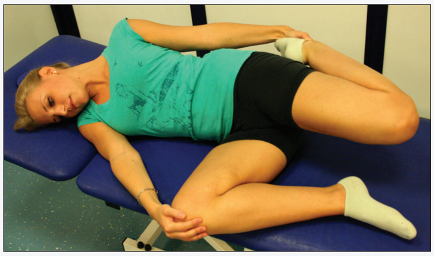


7. Hamstring stretches, first bringing the thigh toward the chest, followed by active extension of the knee. The position is maintained twice for 1 minute for each lower extremity.

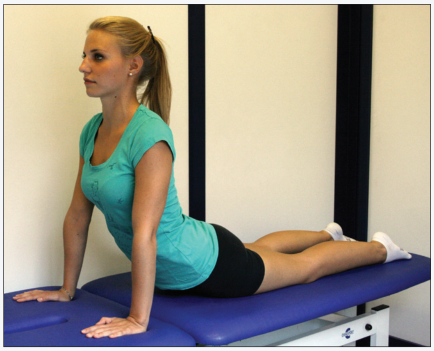


APPENDIX

8. Stretching of the quadriceps and hip flexors in a sidelying position. The limb being stretched is moved in a combination of hip extension and knee flexion, while the opposite lower extremity is kept in flexion. The position is maintained twice for 1 minute for each lower extremity.



9. Passive trunk extension, 10 repetitions.



10. Seated trunk flexion, do not provide overpressure with the hands, 10 repetitions.

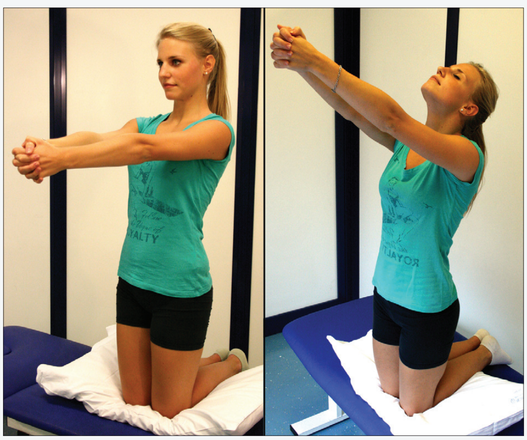
11. Trunk rotation, 10 repetitions each direction.

APPENDIX

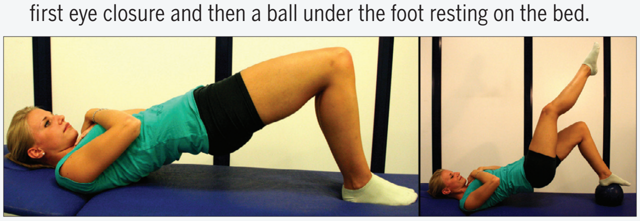
EXPERIMENTAL GROUP (BALANCE EXERCISES)

1. Kneeling on a pillow and arms abducted to 90°, rotate the trunk, head and upper limbs to 1 direction. Repeat 2 times per direction, maintaining each position for 30 seconds. The exercise is made more challenging by adding first eye closure and then head extension.

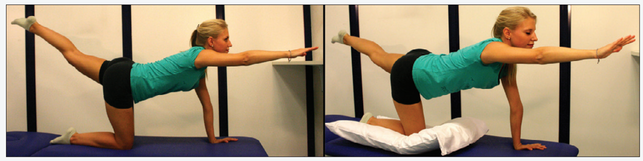
2. Kneeling on a pillow, move the upper limbs in flexion and extension, with a simultaneous movement of the head. The position is maintained for 3 minutes, performing 6 repetitions of upper limbs movement. The exercise is made more challenging by adding eye closure.



3. Supine with feet resting on the table, lifting the pelvis up, after reaching maximum hip extension, raise 1 lower limb from the table and extend the knee. This position is maintained twice for 30 seconds for each lower extremity. The exercise is made more challenging by adding first eye closure and then a ball under the foot resting on the bed.



4. From the quadruped position, extend opposite upper and lower limbs. The position is maintained for 1 minute for each combination of limbs. The exercise is made more challenging by first adding eye closure and then a pillow under the lower limb.



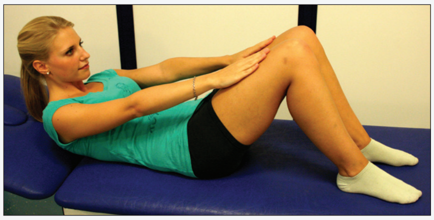
5. Sitting on the side of the table with unilateral support. This position is maintained for 1 minute each side. The exercise is made more challenging by adding eye closure, crossing the upper arms to the chest, closing the eyes, and putting a pillow under the lower limb.

6. Single-limb kneeling on the edge of the table with a pillow under the knee. The position is maintained for 30 seconds. Two repetitions for each limb. The exercise is made more challenging by first adding eye closure, then head extension, and finally arms across the chest.

APPENDIX

CONTROL GROUP (STRENGTH TRAINING EXERCISES)

1. Abdominals: curl-ups, contracting the abdominal muscles to lift the head and shoulders off the table for 3 seconds. Three sets of 6 repetitions.



2. Latissimus dorsi: shoulder extensions against resistance. Three sets of 8 repetitions at 50% maximum voluntary contraction.

3. Hamstrings: seated knee flexion against resistance. Three sets of 8 repetitions at 50% maximum voluntary contraction.

4. Quadriceps: seated knee extension against resistance. Three sets of 8 repetitions at 50% maximum voluntary contraction.