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Core Stability Based Corrective Exercise Program on Improving and Functional Movement Patterns in Male Adults with Lumbar Hyper-Lordosis

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ABSTRACT

Aims: Lumbar hyper-lordosis may affect the stability, disfunction of suffered people and leading to injury and postural disorders. Therefore, the aim of this study was to investigate the effects of a core stability based corrective exercise program on improving functional movement patterns in male adults with lumbar hyper_ lordosis.

Method and Materials: Thirty four adult male ed(age 18-25 years) with lumbar hyper -lordosis were participated in this study and randomly assigned into experimental and control groups. Lumbar lordosis was measured by flexi-curve and functional movement patterns was assessed with Functional Movement Screening (FMS) tests.

Findings: The results of this study showed significant decrease in the mean lumbar lordosis curvature Furthermore, after exercise intervention, the total FMS scores and its subsets of the experimental group were significantly improved compared to control group. According the results, the post-test measurements were improved compared to their pre-test.

Conclusion: It can be concluded that targeted core stability based corrective exercise program, not only can improve lumbar hyper-lordosis curvature, but it can also improve functional movement patterns.

Keywords: Lumbar Hyper-Lordosis, Core Stability, Functional Movements Screen.

Introduction

The posture of the spinal column and its curvatures are extremely important in lowering the pressure as well as maintaining a good posture [1]. The lumbar sagittal curvature is one of the most important spinal curvatures which connects to the pelvis through the sacrum. As a result, any changes in the posture of the pelvis can affect the lumbar curvature and increasing or decreasing in the lumbar hyper lordosis which can be resulted in balance impairments and further deformation and disorders in the lumbo-pelvic area as well [2]. Hyper lordosis is known as a condition in which the lumbar lordosis increases, the pelvic tilts anteriorly by which the pelvic mal-alignment syndrome happens [2]. These changes in the lumbo-pelvic area may result in compensatory deformation in adjacent segments and affect the soft tissue dysfunction [2, 3]. These deformations change the dynamics of the pelvic girdle and disrupts the length-tension relationships and timing of the muscles activation [2, 3]. Core stability is known to have an essential role in proper function of the muscles [4]. Studies indicated that the core muscles contract prior to any movement in extremities, in order to provide a stable base for supporting the motion independent from the direction of the movement [5, 6]. Each dysfunction or weakness in the activity of these muscles, disrupt the summation of the forces of the muscles of the peripheral segments and efficient movements cannot be performed [7]. Additionally, considering the concept of the muscle slings and interrelation of the connecting muscles in the kinetic chains, dysfunction of the muscular slings in the core of the body lead to non-optimal load transfer strategies [8] and control of the motions of the joints and exert excessive forces in the lumbar spine [9, 10]. Studies have investigated the effects of the hyper lumbar lordosis on different variables, but commonly focusing on the correcting the spinal alignment [4, 5]. In addition to the alignment, muscle lengths and pattern of activity have been investigated as well [11]. However, based on the supporting evidence, lumbo-pelvic malalignment will not only cause soft tissue adaptions and decrease the function of the segment [12], but it may lead to impairment in the function of the adjacent segments and the integrity of the neuro-musculo-skeletal systems as well [8, 13, 14]. Functional Movement Screening (FMS) system is one of the easiest and useful tests for assessing the functional activity patterns introduced by Cook et al. (1998) [15]. It includes seven movement tests, which can be performed in 5 to 10 minutes and therefore is widely used by sport coaches. These series of tests include deep squat, hurdle step, in-line lunge, shoulder mobility, active straight leg raise, trunk stability push-up and rotatory stability [15]. Lower performance in these tests is known to be a risk factor for the injury and pain in the lumbar region [16, 17]. Considering the integrity of the musculoskeletal system of this area and the concepts of kinesio pathology model and chain reactions, it can be concluded that core muscle function can be affected by the mal alignment of the lumbo-pelvic region, specifically the lumbar hyper- lordosis and cause further injury and dysfunction in the daily activities. Therefore the aim of this study was to investigate the effects of a core stability based corrective exercise program on improving functional movement patterns in male adults with lumbar hyper -lordosis.

Method and Materials

Based on employing the corrective exercise as an intervention for correcting the hyper-lordiosis and purposive selection of the participants based on the inclusion and exclusion criteria, the present study had a semi-experimental design with pre- and post-test and with control and experimental groups. Informed consents obtained from the participants. The statistical population was and non-athletic male adults (18-25 years old) who suffered from lumbar hyper- lordosis. Inclusion criteria were 18-25 years old males with lumbar hyper-lordosis (more than 51 degrees [18], normal BMI (18.5 to 24.9), being able to perform the Functional Movement Screening (FMS) test and weakness in performing FMS test (score less than 14)[19], being satisfied to participate in the study by providing, written voluntary consent for participation in the study. In this study the males with no any pathologic symptoms, history of fracture, surgery, joint diseases in spinal column, shoulder or pelvis girdle [19], malalignment or musculoskeletal disorder such as upper crossed syndrome [11], spinal rotation no more than 5 degrees in Adams test using scoliometer [20], musculoskeletal injury in the past 6 months [21], surgery or orthopedic diseases which can affect the test results [22] were excluded from the study. Furthermore, the participants experienced pain during the tests, not being able or not willing to complete the tests or the training protocol (missing two consecutive or three training sessions in total) were removed from the study. For sampling, firstly fifty candidates were selected as the sampling frame through screening tests, and finally 34 participants were recruited based on the inclusion and exclusion criteria and assigned randomly to the experimental and control groups. Participants in the control group were continuing their daily life activities with no intervention while the experimental group participated in the corrective exercises between pre- and post-tests. It should be mentioned that 4 out of 34 participants were unable to complete the study and were excluded from the study (2 participants of the control group due to personal problems and 2 participants of the experimental group due to missing training sessions).

In this study, the designed corrective exercise program included stretching exercises, resistance exercises with emphasis on endurance and functional stability exercises and were performed for eight weeks under the direct supervision of the researcher. Three training sessions per week were performed. Progress in the program was gradually adjusted based on the individual characteristics of each participant and according to the principle of gradual overload by increasing the time of the exercises where each session lasted between 30 to 70 minutes. The corrective exercise protocol (Fig. 1), included the stretching exercises (1- extended child's pose; 2- kneeling lunge), the resistance exercises with emphasis on endurance (3- bridging; 4- abdominal pulse ups) and the functional stability exercises (5-side plank; 6-plank) which were performed for eight weeks. Special attention was paid to the participants' breathing techniques during exercises. In exercises 3, 5 and 6, due to the nature of these exercises (functional stability with emphasis on the core muscles), the participants were asked to hold their breath for two second before the exhale.

In this study for measuring of lumbar lordosis angle, a 60 cm flexible ruler was used to measure lumbar lordosis using the method described by Seidi et al. [20]. Using palpation method, the spinous process of T12 and S2 were determined [23-25]. Then the flexible ruler was gently molded to the lumbar spine and then the curvature and the position of the bony markers were transferred to a white paper. The angle of lumbar lordosis was then calculated using the arch formula: where L is the length of the line connecting T12 and S2 and H is the depth of the deepest point of the curvature to the line connecting T12 and S2 [26].

Figure 1. Corrective exercises

Performing functional movement screening test

Participants were asked to perform a 5 minutes warmup before the tests. Then they performed seven FMS tests according to the instructions [15]. The scoring system is presented in Table 1.

For statistical methods, the raw data were analyzed using SPSS software version 26. After checking for the normality of the data using the Shapiro-Wilk test, the demographic characteristics (such as height, weight, age, BMI, and physical activity) were compared between two groups using the Mann-Whitney U test. The lumbar lordosis angle were compared between the two groups using independent sample t-test and within the groups using the paired t-test.

Table 1) Functional movement screening tests and the scoring system

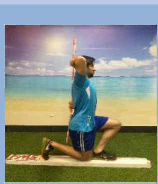
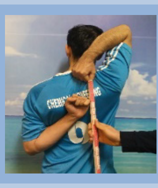
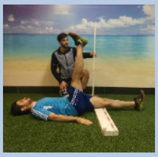
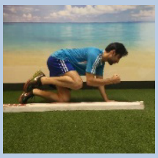
Test		Score 3	Score 2	Score 1
Deep Squat		Trunk is parallel to the shank or in a vertical position. Hips are lower than knees and knees are above the ankles.	Performing the whole test on a board.	Trunk is not parallel to the shank or in a vertical position or the spine is flexed. Hips are higher than knees or Knees are not above the ankles.
In-Line Lung		The bar should touch the head, back and sacrum. Bar and the lower extremities should remain in the sagittal plane. The rear knee should touch the plate.	The bar does not touch the head, back and sacrum. Bar and the lower extremities are not in the sagittal plane or the rear knee is not touch the plate. Movement is seen in the trunk.	Losing balance while performing the task.
Hurdle Step		Hips, knees and ankles should remain in the sagittal plane. Lumbar spine should have no movement (or near zero). Bar should be parallel to the hurdle. Ankle must be dorsa flexed.	Hips, knees and ankles are not in the same sagittal plane. Movement are seen in the lumbar spine or the bar is not parallel to the hurdle.	Feet touching the hurdle or losing balance while performing the task.
Shoulder Mobility		The distance between two hands is equal to the length of the palm or less.	The distance between two hands is between one to one and half length of the palm.	The distance between two hands is more than one and half length of the palm. The clearing exam is painful.
Active Straight Leg Raise		The ankle passes the bar. The lower leg remains neutral and its knee should touch the plate.	The knee passes the bar.	Only the mid-thigh passes the bar.
Trunk Stability Push-Up		Performing one push-up while the head is above the thumbs. Ankles should remain dorsa flexed and the whole body should move as one piece with no flexion or extension.	Performing while the chin is above the thumbs.	Unable to perform while the chin is above the thumbs of the clearing test is positive.
Rotary Stability		Performing one trial on one side while keeping the trunk horizontal. The knee and the elbow should reach to each other with no trunk rotation.	Performing one contralateral trial on one side with horizontal trunk. The knee and the elbow reach to each other.	Unable to perform a contralateral trial or the clearing test is positive.

Table 2) Comparison of demographic characteristics of the participants between both groups

Variable	Experimental group Mean±SD	Control group Mean±SD	P (Leven's Test for Equality of Variances)	U test	Z score	P value
Age(year)	20.73±2.31	21.13±2.26	0.79	99.00	-0.566	0.572
Height (m)	176.47±7.43	176.93±6.3	0.38	110.50	-0.083	0.943
Weight (kg)	70.49±7.87	69.61±6.28	0.46	111.50	-0.041	0.967
BMI(m/kg2)	22.58±1.51	22.22±1.46	0.86	94.00	-0.767	0.443

Table 3) Comparisons between groups in terms of the lumbar lordosis angle and FMS score at two time points

Variable	Time	Experimental Mean ± SD	Control Mean ± SD	Mean difference	Statistics	P value
Lumbarlordosis angle	Pre-test	59.4±4.6	60.3±4.9	1.03	t=0.66	0.51
	post-test	51.4±9.2	59.3±9.5	8.03	t=6.00	0.001
The FMS score	Pre-test	11.3±1.7	11.5±1.6	0.2	u=104.5 z=-0.34	0.73
	post-test	17.3±1.3	11.7±1.5	5.6	u=0.0 z=-4.71	0.001

Table 4) Within groups' comparisons of the lumbar lordosis angle and FMS score in both groups

Variable	Group	Pre-test Mean±SD	Post-test Mean±SD	Mean difference	Statistics	P value
lumbar lordosis angle	Experimental	59.4±4.6	51.4±9.2	7.54	t=10.65	0.001
	Control	60.3±4.9	59.3±9.5	0.53	t=1.75	0.10
The FMS score	Experimental	11.3±1.7	17.3±1.3	7.0	z=-3.4	0.001
	Control	11.5±1.6	11.7±1.5	0.2	z=-1.1	0.27

The total FMS score were then compared between the two groups using the Mann-Whitney U test and within the groups using the wilcoxon test as well. The alpha level was considered as 0.05 during the statistical tests.

Findings

Functional movement screening tests and the scoring system has been shown in Table 1. The results showed no significant difference between the demographic characteristics of the subjects participants the two groups are presented in Table 2. No significant difference was found between the two groups in pre-tests in terms of the lordosis angle and FMS score, but lower lordosis angle and higher FMS score were observed in the post-test of the experimental group compared with the control group (Table 3).

The results also indicated that there were improvements in both lordosis angle and FMS score of the post-test of the experimental group compared to their pre-test (Table 4).

Discussion

The results of this study showed that corrective exercises can have a positive and significant effect on the lumbar lordosis angle and patterns of functional movements. These findings are consistent with previous studies in terms of significant reduction in lumbar lordosis following exercise program [27-31] but inconsistent with the results of other two previous studies [32, 33]. One of the possible reasons for the inconsistency of these results can be the difference in the subjects of this study. The participants of the above-mentioned evidences were people with increased lumbar lordosis who suffered from low back pain, while the participants of the present study were not experiencing any pain in the low back. Another possible reason is that the method of measuring lumbar lordosis angle in the mentioned studies was radiography, which is not consistent with the present study.

One of the advantages of this study comparing to the consistent previous studies is that, in most of the previous studies, the effectiveness of corrective exercises was based only on observed improvements and statistically significant improvements and not on the amount of clinically important improvement of the disorder [28]. It should be noted that except for two cases [11, 34] no standard error of measurements has been reported in any of the previous studies [35]. In the present study, the measurement error of the tester in the measurement of lumbar lordosis with a flexible ruler was 3.85 degrees and the average improvement of lumbar lordosis angle was 7.54 degrees. Therefore, this rate of improvement is beyond the calculated error rate and as a result, it can be concluded that the observed differences were due to the training intervention.

On the other hand, in most previous researches, the effect size of the improvements have not been mentioned. While comprehensive review studies have suggested that future studies shall report the effect size of the corrective exercises for correction of postural disorders [35-37].

The human body functions as an integrated system that includes a set of chain reactions in the form of muscular and neurological chains. These chains work together and the success of each chain is related to the others [36]. Therefore, having an integrated and comprehensive overview of the body is essential for designing corrective exercises, which can be one of the reasons for the high effectiveness of corrective exercises in the present study. In this study, the emphasis was on central endurance and stability which were implemented regularly and under the direct supervision of the researchers. It has been also indicated that the minimum duration of the exercise intervention needed for neuromuscular adaptations is an important factor and it should last for 6-8 weeks [38], which can be another reason for the observed effect in this study compared to the previous studies [39].

The position of the pelvis in the center of the body creates a functional chain on both the lower limb and the position of the spine. Normal pelvic function is achieved by maintaining a functional balance between the mobility and the stability provided by muscle activity. The balance of the pelvis at the optimal angle depends mainly on the normal function of the various muscles. The lower fibers of back extensors, along with the rectus femoris and psoas muscles, cause anterior pelvic tilt, which increases lumbar lordosis in the spine [40]. In other words, a change in muscle activity in hyperlordosis causes muscle imbalance. One group of musclesbecome hyperactive (lumbar extensors and hip flexors) while another group become hypoactive and inhibited (thigh extensors and abdominal muscles) and therefore itteriorate the stability of the lumbopelvic region. In a previous study, Hodges et al. (1997) Stated that core muscles are activated prior to any movement of extremities independent from the direction of movement [41]. Therefore, it seems that improving the function of the core stabilizers can lead to improving the activation of the lower extremity muscles and balance function as a result.

On the other hand, in lumbar hyperlordosis, the rectus femoris muscle and psoas, are become hyperactive and their activation pattern and timing changes. Therefore, the proper stretching exercises imbedded in the training protocol of this study (exercise #2), made it possible to lower the tension in these muscles and the inhibition effects they had on the hip extensor muscles and abdominal muscles. The exercise #3 also strengthened the core muscles focusing on hip extensors (gluteus maximus). The exercises #3, #5 and #6 were designed to improve core stability with special focus on co-contraction of the lumbopelvic muscles and their proper activation timing as well. These can be other reasons for the effectiveness of the corrective exercises in this study. To increase the activity of inhibited muscles, exercises 3 and 4 were used with an emphasis on the endurance of these muscles (for example in exercise 4, the main focus was on increasing activity in the distal part of the right abdominal muscle to control the anterior pelvic tilt).

Conclusion

It can be concluded that performing core stability based corrective exercises can be effective in correcting lumbar hyper lordosis and improving the functional movement patterns in males with thoracic hyper lordosis. Based on the results of this study, since the function is affected by lumbar alignment, it is suggested that the functional movements should be screened and monitored during the assessment and correction of the lumbar hyper lordosis.

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Authors Contribution: All the authors has been contributed to the study. MR designed the study design, training protocol, collected and analyzed the data and also wrote the first draft of the manuscript. ShZ and HM helped for study designing, data analysis, and drafting the manuscript. All authors read the final version of the manuscript.

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