Isolated Lumbar Stabilization Exercises Versus Dynamic Lumbar Strengthening Exercises in Patients with Spondylolisthesis

MOHAMMAD F. ALI, Ph.D.*; SHEREEN H. ELWARDANY, M.Sc.** and REHAM M. ABDALRAHEEM, M.Sc.***

The Departments of Orthopedic Physical Therapy*, Basic Science of Physical Therapy** and Physical Therapy***, Faculty of Physical Therapy October 6 University*, Cairo University Hospitals**, Al Haram Hospital, Curative Health Organization***

Abstract

Background: Spondylolisthesis is one of back disorders that may cause pain and can produce lumbar curvature changes due to decreased extensor muscles strength. In later stages, it may result in straightened lumbar curvature (flattening), complaining from low back pain, hamstring muscle tightness, pain, numbness, or tingling in the thighs and buttock and lower limb muscles weakness.

Purpose: To compare between the effects of lumbar stabilization exercises and lumbar dynamic strengthening exercises on the maximal isometric strength of the lumbar extensors and pain severity level in patients with spondylolisthesis.

Subjects and Methods: Forty patients suffering from spondylolisthesis; their age (45-57) years for more than 3 months were included in this study. They were randomly assigned into 2 groups; the first group received lumbar isolated stabilization exercises by using medx machine (n=29) and the second group received lumbar dynamic strengthening exercises (n=11). The treatment session was 30 minutes twice a week for 3 weeks in both groups. The strength of the lumbar extensors was measured by isometric torque, at various angles; (12º, 24º, 36º, 48º and 60º) flexion to extension at intervals using the medx machine. The severity of low back pain was measured by visual analog scale (VAS) before and after the two different exercises methods.

Results: Compared with the baseline, lumbar extensors strength at all angles were improved significantly in both groups. The improvements were significantly greater in the isolated lumbar stabilization exercise group at angles (12º, 36º, 48º and 60º) but not significantly greater at angle (24º). Pain severity level as determined by VAS was significantly decreased after treatment in the isolated muscles lumbar stabilization exercise group than the second group. Initial and final VAS “back pain” results were 76.20±18.05mm and 34.5±22.09 (p=0.007) respectively.

Conclusion: Both isolated lumbar stabilization and dynamic strengthening exercises programs can strengthen the lumbar extensors and help in relieving LBP in patients with spondylolisthesis.

Key Words: Spondylolisthesis – Medx – Back exercises.

Introduction

DEGENERATIVE spondylolisthesis is one from five types of spondyloysis (dysplastic, isthmic, traumatic and pathologic spondylolisthesis). It is the acquired displacement of one vertebra over the subjacent vertebra, associated with degenerative changes, without an associated disruption or defect in the vertebral ring [1]. This entity is common in patients over 50 and is four times more common in women. The most commonly affected level of the spine is L4-L5 [2,3]. Degenerative spondylolisthesis has been shown to be related to multiple risk factors such as pregnancy, ligaments laxity, as posterior longitudinal ligament [4], facets orientation, and an increase in the angle between facets and pedicles [5,6]. Symptoms of Spondylolisthesis include lower back or leg pain, hamstring tightness, and numbness and tingling in the legs later. The occurring degenerative changes subsequently lead to tendency to restabilize the segment [7]. Spondylolisthesis is easily identified using plain radiographs. A lateral X-ray (from the side view) will show if one vertebra has slipped forward compared to the adjacent vertebrae. Spondylolisthesis is graded according the percentage of slip of the vertebra compared to the neighboring vertebra [4]. Grade I is a slip of up to 25%, grade II is between 26%-50%, grade III is between 51%-75%, grade IV is between 76% and 100%, and Grade V, or spondyloptosis occurs when the vertebra has completely fallen off the next vertebra. If the patient has complained of pain, numbness, tingling or weakness in the legs, these symptoms could be caused by stenosis or narrowing of the space for the nerve roots to the legs. CT scan or MRI scan
can help in identifying compression of the nerves associated with spondylolisthesis [8].

Treatment of spondylolisthesis depends on how severe the slippage is. The patient is recommended for pain relief medication, physical therapy treatment. Most patients get better with exercises to strengthen lower back muscles as a whole including lumbar flexion, extension, isometric flexion, passive extension, and intensive dynamic back exercise regimens [2,9].

For years, flexion-extension exercises (Williams-McKenzie) were tried in patients with low back pain, while other methods of exercises are being used [8]. These exercises called stabilization. These exercises are done in the neutral position where the segmental forces between disc and facet joints are best balanced and the most effective stability is obtained in axial tension strength. The neutral position is conserved during exercises and lumbar stability is not disturbed even in motion. While muscle strength is increased, improper tension is avoided in these exercises.

There has been a focus on exercises that aim to maintain/improve lumbar spine stability [10]. Although no formal definition of lumbar stabilization exercises exists, the approach is aimed at improving the neuromuscular control, strength, and endurance of the muscles that are central to maintain the dynamic spinal and trunk stability. Several groups of muscles particularly targeted the transversus abdominis and lumbar multifidi, but also other paraspinal, abdominal, diaphragmatic, and pelvic muscles are improved in strength exercises [11].

Medx is advanced computerized testing of back strength and advanced spinal rehabilitation equipment. Medx is patented and offers the unique technology to test and quantify spine muscle strength which no other assessment or intervention does. Medx rehabilitation program is appropriate for patients who have recurrent low back pain or those who are still experiencing pain 8 to 10 weeks after an injury. Patients with degenerative disc disease, bulging discs, stenosis, non-specific back pain, sciatic pain, and low grade spondylolisthesis (grade 1 or 2) have had positive results with this program [12]. Medx is the first and only machine capable of isolating the lumbar extensor muscles, and producing an objective measurement of a patient’s lower back strength and range of motion. It is highly reliable, safe, valid, and can be used for the quantification of isometric lumbar extension strength through a range of motion. Also measure changes in strength and range of motion in patients with a variety of lumbar disorders (e.g. lumbar strain, herniated discs, degenerated discs and spondylolisthesis) [13]. Medx resistance exercises allow the user to choose the resistance in 2 pound increments which is a very safe way for resistance training. Research has shown that pelvic stabilization is indispensable when strengthening the lumbar extensor muscles [14]. Medx may also be used to measure voluntary isometric torque of the lumbar extensor muscles at 7 positions through a 72° ROM. The 7 positions are (0°, 12°, 24°, 36°, 48°, 60°, and 72°) of lumbar flexion. A load cell attached to the movement arm of the machine measures isometric torque [15]. Using medx Lumbar Extensor Machine as specific exercise for isolated lumbar extensor muscles substantially increased low-back strength in chronic low back pain patients. The majority of studies on lumbar stabilization exercises use mixed groups (including patients with disc lesions, osteoarthritis, or leg pain) of subjects with nonspecific chronic LBP. These studies cannot determine whether a specific subgroup of patients may be more responsive to lumbar stabilization exercises [16]. Also, no randomized controlled trials have measured the maximal isometric contraction strength of lumbar extensors at different angles of lumbar flexion in patient with spondylolisthesis. Therefore, the aim of this study was to compare between the effects of lumbar stabilization exercises and lumbar dynamic strengthening exercises on the maximal isometric contraction strength of the lumbar extensors and LBP severity level in patients with spondylolisthesis.

**Subjects and Methods**

Forty patients (26 females and 14 males) suffering from degenerative spondylolisthesis with grade I & II; their age were ranged from 45-57 years for more than 3 months. They were randomly assigned into 2 groups by a computer-generated random number sequence. Group (A) consisted of (20 females & 9 males). They received lumbar isolated stabilization exercises by using Medx machine (n=29). Group (B) consisted of (6 females & 5 males). They received lumbar dynamic strengthening exercises (n=11). All the patients were recruited from the rehabilitation outpatient-clinic in Dallah hospital in Kingdom of Saudi Arabia (KSA).

**Inclusive criteria:**

Patients in the current study had, only grades 1 and 2 degenerative spondylolisthesis were selected. They were referred by orthopedists mainly or neurosurgeons and confirmed by X-ray.
Exclusion criteria:
Subjects who had previous back surgery, grade 3, 4, 5 spondylolisthesis, lumbar disc herniation, sciatica and any nerve root entrapment at any level and patients with structural lesions with spondylolisthesis, vertebral bone fracture, scoliosis, and kyphosis on X-ray and spinal cord injury were also excluded.

Pre and post experimental design was applied. This study included 2 groups (A&B); Group (A) received lumbar isolated stabilization exercises by using Medx machine (n=29). Group (B) received lumbar dynamic strengthening exercises (n=11). Lumbar stabilization exercises done by group (A) by using Medx and Lumbar dynamic strengthening exercises done by group (B) were performed for 30 minutes, twice weekly, for 3 weeks. The torque of the lumbar extensors of both groups was measured at various angles (12º, 24º, 36º, 48º and 60º) using a Medx testing. The severity of LBP was evaluated using a visual analog scale (VAS). The VAS consists of line ranged from 0 to 10 (10cm in length) with the left extremity indicating “no pain” and the right extremity indicating “unbearable pain”. Participants were asked to mark the line to indicate their level of pain [17]. Higher values suggest more intense pain. This scale showed good reproducibility for assessing pain levels [18]. All patients were evaluated before and after the treatment 3 week exercises program. All patients signed a written informed consent.

Medx exercises and testing can be done at various angles (0º, 12º, 24º, 36º, 48º, 60º, and 72º) of lumbar flexion but in the current study at (0º and 72º) exercises and testing were not done because most of patients could not do the full range of motion at these angles. All patients in both groups performed warm-up stretching exercises for 10 minutes before the main exercises. The exercises were in the form of stretching of back, abdominal and hamstring muscles. All exercises were performed in the treatment room under the supervision of physical therapist with technical knowledge. The therapist put each patient into the appropriate position to achieve the correct posture and muscle contraction. Hot pack wrapped in 4 towels for 10 minutes was placed over the lumbar region after exercises in both groups.

Lumbar stabilization exercises consisted of 9 exercises, which were aimed to strengthen the deep lumbar stabilizing muscles: The transversus abdominis, lumbar multifidi, and internal obliques. All 9 stabilization exercises were performed once, consecutively, and in the same order (Fig. 1). Before each exercise, the physical therapist gave detailed verbal explanation and visual instructions (pictures), regarding the start and end positions. All exercises were conducted according to the following specific principles: Breathe in and out, gently and slowly [19].

Lumbar extension strength was assessed using Medx (Medx Holdings Inc., Ocara, FL, USA) lumbar extension machine, which fixes the pelvis, thigh, and knee, to ensure complete stabilization allowing measurements of lumbar extension strength. In the current study lumbar extension strength was measured at flexion angles (12º, 24º, 36º, 48º and 60º) only. The strength tests were conducted at each angle with an approximately 10 seconds rest between tests. Differences in the maximal isometric strength at a given angle of flexion were compared between the two groups, before and after the exercises.

The lumbar extensors muscles are isolated in the following manner:

1- Feet rest: Force imposed against the bottom of the feet is transmitted by the lower legs to the femurs at an angle of approximately 45 degrees.

2- Femur restraint: Large pads located above the lower thighs limit upward movement of knee.

3- Pelvic belt: A heavy belt prevents upward movement of the upper thighs and pelvis.

4- A round pad prevents movement of the pelvis in the direction of extension. Properly restrained in this machine, the pelvis cannot rotate. It is the clinician’s duty to check for pad rotation, and tighten restraints until it does not occur. Without total restraint of the pelvis, force from the muscles of the hips and thighs would contribute to torque readings, making it impossible to determine the true force-production capability of spinal muscles as well as range of isolated lumbar-spinal movement [12]. The starting position was at 60º of lumbar flexion for all exercises done by group (A). At the first session maximum isometric contraction and muscle torque is determined by the dynamometer which is connected to the back of the seat for both groups. The patients of group (A) were exercised by fifty percent of the maximum torque determined at the first session. When patient could do twenty repetitions of this resistance (fifty percent of the maximum torque), ten percent of weight stack resistance was added at next session.

The second group (B) received exercises program in the form of flexion and extension (Wiliams-McKenzie). Anterior and posterior pelvic tilt exercises from crock lying position. Bridging from with maximum flexion both knees in crock lying position then bridging exercises from semi extended
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knees. Right knee to chest, left knee to chest then both knees to chest exercises at the same time. Prone on elbow, prone on hand with extended elbows. Leaning backward from standing position. Strengthening abdominal and trunk muscles were demonstrated by physiotherapist in the form of getting up from crock lying with cross hands. Patients received a written outline and description of the exercise program. For all exercises done by groups, the final static position was held for 10 seconds, and each exercise was performed for 10 repetitions. There was a pause of 3 seconds between repetitions and a 60-second rest between each exercise. Exercise intensity (holding time and number of repetitions) was increased gradually, based on the tolerance of each patient.

All evaluations were conducted by an examiner who was the treating therapist.

Statistical analysis:

Descriptive statistics (mean and SDs) were derived for demographic data and strength variables. Peak isometric strength (torque) was evaluated within each group using paired $t$-test pre and post treatment for angle 12º, 24º, 36º, 48º and 60º extension to flexion at intervals. $p$-value is determined for each case and significance was accepted at the 0.05 alpha level. All data are reported as means±SDs unless otherwise noted. Independent sample $t$-test used to compare means post treatment for group (A) and group (B). All statistical analysis were performed using SPSS ver. 18 (SPSS Inc., Chicago, IL, USA).

Results

There were no significant difference in the general characteristics in age, height, or body weight between group (A) and (B) shown in (Table 1). There were no significant differences in the baseline VAS scores between the lumbar stabilization exercise group and the dynamic lumbar strengthening exercise group.

Compared with that of the baseline, lumbar extension strength at all angles of lumbar flexion improved significantly in group (A) shown in (Table 2) and Fig. (2). Lumbar extension strength at all angles of lumbar flexion improved significantly in group (B) shown in (Table 3) and Fig. (3). The difference in maximal isometric contraction strength at each angle of lumbar flexion before and after the exercise shown in Fig. (4). Improvements were significantly larger in the lumbar stabilization exercise group than in the dynamic strengthening exercise group at 12º, 36º, 48º and 60º but not significant at angle 24º of lumbar flexion after the treatment for 3 weeks shown (Table 4). The VAS reported by all subjects decreased significantly after the treatment in both groups. The difference between the two groups was significant. The pain severity level decreased significantly in the stabilization exercise group than dynamic lumbar strengthening exercise group shown in Fig. (5). Statistical significance was defined as a $p$-value <0.05. Initial and final VAS “back pain” results were 76.20±18.05mm and 34.5±22.09 respectively.

Table (1): Baseline characteristics of the subjects.

<table>
<thead>
<tr>
<th>Group (A):</th>
<th>N</th>
<th>Age(y)</th>
<th>Height(cm)</th>
<th>Weight(kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>20</td>
<td>45.75±2.19</td>
<td>162.5±5.66</td>
<td>83.95±7.27</td>
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<tr>
<td>Male</td>
<td>9</td>
<td>50.33±1.65</td>
<td>170.77±5.07</td>
<td>85.89±5.42</td>
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<tr>
<td>Total</td>
<td>29</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group (B):</td>
<td>N</td>
<td>Age(y)</td>
<td>Height(cm)</td>
<td>Weight(kg)</td>
</tr>
<tr>
<td>Female</td>
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<td>56.2±0.84</td>
<td>170±6.04</td>
<td>77.8±6.42</td>
</tr>
<tr>
<td>Male</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>11</td>
<td></td>
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</tbody>
</table>

* Means±SD.

Table (2): Changes in maximal isometric strength of the lumbar extensors after exercise group (A) (unit, ft-lb).

<table>
<thead>
<tr>
<th>Angle</th>
<th>Pre tt group (A)</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>t</th>
<th>Sig</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>Post tt group (A)</td>
<td>60.8621</td>
<td>83.2759</td>
<td>16.85338</td>
<td>21.96897</td>
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<tr>
<td>24</td>
<td>Post tt group (A)</td>
<td>66.3793</td>
<td>82.5862</td>
<td>16.57755</td>
<td>32.88564</td>
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<tr>
<td>36</td>
<td>Post tt group (A)</td>
<td>71.3793</td>
<td>85.3448</td>
<td>12.23990</td>
<td>15.69412</td>
</tr>
<tr>
<td>48</td>
<td>Post tt group (A)</td>
<td>91.2069</td>
<td>104.6552</td>
<td>20.85902</td>
<td>21.46139</td>
</tr>
<tr>
<td>60</td>
<td>Post tt group (A)</td>
<td>126.2069</td>
<td>138.7931</td>
<td>37.45605</td>
<td>46.36145</td>
</tr>
</tbody>
</table>

* Significant difference before and after exercise, $p$<0.05.
Table (3): Changes in maximal isometric strength of the lumbar extensors after exercise group (B) (unit, ft-lb).

<table>
<thead>
<tr>
<th>Angle</th>
<th>Pre tt group (B)</th>
<th>Post tt group (B)</th>
<th>t</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>60.4545</td>
<td>64.5455</td>
<td>4.500</td>
<td>0.001*</td>
</tr>
<tr>
<td>24</td>
<td>67.2727</td>
<td>73.6364</td>
<td>9.037</td>
<td>0.000*</td>
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<td>36</td>
<td>65.4545</td>
<td>70.4545</td>
<td>3.708</td>
<td>0.004*</td>
</tr>
<tr>
<td>48</td>
<td>86.3636</td>
<td>91.8182</td>
<td>4.353</td>
<td>0.001*</td>
</tr>
<tr>
<td>60</td>
<td>129.0909</td>
<td>135.4545</td>
<td>5.369</td>
<td>0.009*</td>
</tr>
</tbody>
</table>

* Significant difference compared with before and after exercise, p<0.05.

Table (4): Comparison of the improvements in lumbar extensor strength at different angles of lumbar flexion in two groups (unit, ft-lb)

<table>
<thead>
<tr>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>t</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
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<td>29</td>
<td>83.2759</td>
<td>21.96897</td>
<td>2.517</td>
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<td>Angle 12 post tt (B)</td>
<td>11</td>
<td>64.5455</td>
<td>18.09068</td>
<td>0.859</td>
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<tr>
<td>Angle 24 post tt (A)</td>
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<td>83.2759</td>
<td>21.96897</td>
<td>0.859</td>
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<tr>
<td>Angle 24 post tt (B)</td>
<td>11</td>
<td>73.6364</td>
<td>16.13860</td>
<td>3.02</td>
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<tr>
<td>Angle 36 post tt (A)</td>
<td>29</td>
<td>85.3448</td>
<td>15.69412</td>
<td>3.02</td>
</tr>
<tr>
<td>Angle 36 post tt (B)</td>
<td>11</td>
<td>70.4545</td>
<td>6.87552</td>
<td>6.87552</td>
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<tr>
<td>Angle 48 post tt (A)</td>
<td>29</td>
<td>104.6552</td>
<td>21.46139</td>
<td>2.184</td>
</tr>
<tr>
<td>Angle 48 post tt (B)</td>
<td>11</td>
<td>91.8182</td>
<td>19.00957</td>
<td>2.117</td>
</tr>
<tr>
<td>Angle 60 post tt (A)</td>
<td>29</td>
<td>138.7931</td>
<td>46.36145</td>
<td>2.117</td>
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<tr>
<td>Angle 60 post tt (B)</td>
<td>11</td>
<td>135.4545</td>
<td>34.16537</td>
<td>34.16537</td>
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</table>

* Significant difference after exercises in group (A) and (B), p<0.05.

**Discussion**

Up to the authors’ knowledge, no previous study mentioned the effect of the isolated lumbar exercises using Medx in patients with spondylolisthesis. Exercises done by Medx improve lumbar muscles strength and reduce the need for spinal surgeries.

Over 100 published medical journal articles showed that the Medx Medical Lumbar Machine
is the best way to rehab back and it is very effective in relieving chronic back pain, decreasing osteoporosis, and preventing surgery [14].

Not everyone gets relief of low back pain using the Medx Machine, but about 76% of people do, according to a study of 895 consecutive patients followed for one year. However, if the Medx Machine used once or twice a week, the strength of the lumbar extensor muscles would be rebuilt [9].

In cases where surgery is a possibility, studies have shown that significant improvements can be achieved with the Medx, and thereby avoiding surgery. A recent study followed the progress of a group of 38 patients who had been recommended by their doctor for surgery but first completed a course of treatment using the Medx Lumbar Extensor Machine. The study reported that at 16 month follow-up 81% of patients reported themselves to be “excellent” or “good” and that 92% of the patients were able to avoid surgery because of gaining strength and rebuilding lumbar muscles extensors and stabilizers [20].

Among the abdominal muscles, the transverse abdominal, multifidus, and internal oblique muscles help to increase the intra-abdominal pressure, thereby contributing to the spinal and pelvic stability [18,21,22]. Lumbar stabilization exercise group included some lumbar dynamic exercises, which may have strengthened the lumbar extensors at the large lumbar flexion angle in this group of patients. However, lumbar extensor strength at low lumbar flexion angles was better in the stabilization exercise group, suggesting that this improvement was due to the stabilization exercises. In terms of length-tension relationships, the lumbar extensors are at their shortest at the flexion angles of 0° and 12°, thereby minimizing the isometric strength [23]. These findings are supported by other studies in which stabilization exercises translated into pain and functional capacity improvements [10]. A multicenter randomized controlled trial by Ferreira et al. [10] compared general exercises and lumbar stabilization exercises in patients with chronic LBP. The lumbar stabilization exercises groups showed marginally better outcomes than the general exercise group after 8 weeks in VAS and score of the Roland Morris Disability Questionnaire [10,24] but there was no significant difference between the two groups. These results were consistent with the results of the current study. This was a high-quality study and clinically relevant, however, the study enrolled a mixed group of subjects (including patients with disc lesions, osteoarthritis, and leg pain), which makes comparison difficult. This may be an explanation of the difference in significance between both groups in both studies.

The findings of the current study are in agreement with the findings of Graves et al. [15] the study compared resistance training with and without pelvic stabilization in a group of 47 men and 30 women. The results showed that post training isometric torque values describing isolated lumbar extension strength improved only for the group that trained with pelvic stabilization and not at all for the group without pelvic stabilization (using systems such as Cybex and Nautilus) when compared to the (no exercise) control. Several studies have documented outcomes for groups of chronic low back pain patients treated using intensive specific exercise using a firm pelvic stabilization (Medx Lumbar Extensor Machine).

In several studies [16,24,25], Medx exercises and testing can be done at various angles (0°, 12°, 24°, 36°, 48°, 60°, and 72°) of lumbar flexion but in the current study at (0° and 72°) exercises and testing were not done because most of patients could not do the full range of motion at these angles. The explanation of this may be due to the difference of subjects; the subjects of the previous studies had LBP with non specific origin but in the present study had spondylolisthesis.

The results of the current study showed that lumbar stabilization exercises (using medx) increased the strength of the lumbar extensor muscles than lumbar dynamic strengthening exercises significantly in all measuring angles (12°, 36°, 48°, and 60°) except the angle (24°). At angle (24°), there is no significant difference between both groups. The explanation of this due to the constant weight stack of resistance during the whole range of movement (from maximum possible flexion to the maximum extension) applied during medx exercises done by group (A). Even when the movement was in pro-gravity direction, the counter weight of the patient’s torso in the machine is substituting it. At angle (24°), the movable seat back (which is attached with weight stack) is completely balanced vertically over the horizontal plain. So, this position is considered typically like the position of practicing the dynamic exercises group (B). So, there was not a significant difference in strength of lumbar extensor muscles between both groups at this angle (24°). The middle of the lumbar range is at (24°), so both groups (A&B) had no significant difference at that angle after the two different ways of exercises. For the subjects who performed general exercises only, exercises activating the extensor (paraspinals) and flexor
(abdominals) muscle groups were done because muscle contraction occurring with exercises impose extra loading on the spinal tissues.

In the current study, lumbar stabilization exercises could be an effective treatment option in controlling pain and improving low back muscles strength which is responsible for decreasing pain especially during the functional activities in patients with degenerative spondylolisthesis. Further investigation with randomized controlled trials is necessary to obtain confirmation of these results in other causes of low back pain.

The present study has some limitations, including the patients limited age and short follow-up periods; therefore, the results cannot be generalized to all patients with spondylolisthesis. Also, the long-term effects of these exercise protocols cannot be predicted; further studies are needed with wider sample sizes including different age groups and longer follow-up periods. The strength of the deep lumbar muscles was not monitored directly, using ultrasound measurements of deep muscle thickening, or muscle hypertrophy [26]. As the current study measured only the maximal isometric strength of the lumbar extensors, the results may not reflect the overall strength of the deep lumbar stabilization muscles.

Conclusion:

Both lumbar stabilization and lumbar dynamic strengthening exercises increased the strength of the lumbar extensor muscles and reduced LBP in patients with spondylolisthesis. But lumbar stabilization exercises were more effective than lumbar dynamic strengthening exercises for strengthening lumbar extensors and decreasing the LBP in patients with spondylolisthesis.

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References


