Relationship between Proprioception and Trunk Muscles Strength at Different Trunk Velocities in Patients with Lumbar Disc Prolapse

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ABSTRACT

Purpose: *To compare between the peak torque of trunk flexors and extensors at 60°, 120°, 180°/sec. angular velocities; to test the repositioning accuracy of the trunk proprioception and to find out if there is a relationship between proprioception and peak torque of the trunk flexors and extensors in patients with lumbar disc prolapse with sciatica.* ***Subjects:*** *Forty male and female subjects participated in the study. They were assigned into two equal groups. The control group which consists of twenty normal subjects without previous history of low back pain. Their mean age was (43.85±8.08), their mean height was (168.23±7.52) and their mean weight was 83.42 (±13.76). The experimental group consisted of twenty patients, diagnosed as chronic lumbar disc prolapsed with sciatica. Their mean age was 43.58 (±7.80), mean height was 164.3(±80) and their mean weight was 89.70(±13). Methods: The peak torque of the trunk extensors and flexors was tested at three preset angular trunk velocities of 60°, 120°, and 180°/sec using the Biodex medical system III isokinetic dynamometer. The proprioception accuracy was also tested using the active repositioning accuracy test (ARAT) by the Biodex medical system III.* ***Results:*** *SPCC package was used for analysis of data. There was a significant difference between the peak torque of the trunk flexors and extensors in the preset three angular velocities with $P<0.05$ between the control and the experimental group in favor of the control group. There was a significant difference regarding the proprioceptive error between the normal and the experimental groups in favor of the control group with $P<0.05$. There was a negative correlation between the proprioception error and the peak torque of the trunk flexors and extensors in the control group at high velocities only (120 and 180 angular velocities) but there was significant positive correlation between them at 60 angular velocity. For the experimental group, there was no correlation between the proprioceptive error and the peak torque of the trunk flexors at the three preset angular velocities and a positive correlation between the proprioceptive error and the peak torque of the trunk extensors with $P<0.01$.* ***Conclusions:*** *Lumbar disc prolapse patients with sciatica are characterized by weakness of the abdominal and back muscles that decreases more with higher velocities and with increased proprioceptive error in comparison with the normal subjects. In the experimental group, in spite of having a high proprioceptive error and with the presence of trunk muscle weakness, there was no relationship between them.*

Key words: *Low back pain, isokinetic peak torque, proprioceptive error.*

INTRODUCTION

Low back pain (LBP) is one of the most common forms of chronic pain[17] and is a significant cause of disability and cost in society[1]. Chronic LBP substantially influences the capacity to work and has been associated with the inability to obtain or maintain employment[26] and lost productivity[27].

One important risk factor for LBP is weakness of superficial back and abdominal muscles[2,8]. Another independent risk factor for chronic LBP is the weakness and lack of motor control of deep trunk muscles, such as the lumbar multifidus (LM) and transversus abdominis (TrA) muscles[9]. Reduced abdominal muscle contraction thickness is reported in cross-sectional studies of chronic LBP patients compared to healthy subjects[7], and in studies with experimentally induced pain[13].

Proprioception is one of the most important mainstays of musculoskeletal rehabilitation and is a term used to describe the complex relations between afferent and efferent pathways that are regulated by mechanoreceptors in the joints. Position sense or repositioning error is the most widely used method to measure proprioception[11]. It has been shown that proprioception is affected in patients with CLBP[21]. Patients with CLBP frequently demonstrate difficulty adopting and maintaining a neutral or midrange position of the lumbar spine[4]. Proprioceptive deficit may lead to delayed neuromuscular protective reflexes and coordination such that muscle contraction occurs too late to protect the joint from excessive joint movement[21]. Moreover, under stress conditions such as mechanical loading or fatigue, the ability to sense a change in lumbar position may be highly affected[28].

It was found that lumbar flexor proprioception is impaired much more than extensor proprioception in patients with CLBP[20]. Some investigators reported that rectus abdominis muscle activation pattern was changed in some positions on a force plate in patients with CLBP[19]. The results of these studies pointed out that the deterioration in flexor muscle group of lumbar region is more prominent than the extensor muscle group in patients with CLBP[19,20].

It has been shown that some studies[2,8,9] searched the characteristics of the trunk muscles of low back pain population. Others[4,19,20,21,28,] searches the repositioning accuracy and the proprioceptive errors in low back pain patients but the relationship between proprioception and the peak torque of the trunk flexors and extensors at different angular velocities is lacking. Thus, the purposes of this current study are to compare between the peak torque of trunk flexors and extensors at 60°, 120°, 180°/sec. angular velocities; to test the repositioning accuracy of the trunk proprioception and to find out if there is a relationship between proprioception and peak torque of the trunk flexors and extensors in patients with lumbar disc prolapse with sciatica.

MATERIAL AND METHODS

Subjects:

Forty male and female subjects participated in this study. They were distributed into two equal groups. The control group consisted of twenty normal subjects without previous history of low back pain. Their mean age was 43.85 (±8.08) years, their mean height was 168.23 (±7.52) cm and their mean weight was 83.42 (±13.76) kg. The Experimental group consisted of twenty patients, diagnosed as chronic lumbar disc prolapse L4-5, L5-S1 with sciatica from 3 month and up to 2 years. Their mean age was 43.58(±7.80) years, their mean height was 164.3(±80) cm and their mean weight was 89.70 (±13) kg. Patients were excluded if they had previous back surgery, tumors, or spinal deformities.

Instrumentations:

Biodex medical system III Isokinetic Dynamometer was used in assessment procedures of the study.

<u>Lumbar fatigue exercise</u>

Subjects assumed sitting position in the Biodex isokinetic dynamometer with their lower limbs were stabilized by tibial and thigh pads. Knee block positions was individually adjusted by two curved anterior leg pads, the feet were held in a position with no contact with the floor, both thighs were stabilized by two straps, the pelvic brace was then be applied and positioned as far down as possible to press firmly but comfortably against the superior aspect of the proximal thighs. A shoulder harness and backrest provided anchorage to the moving upper section of the apparatus. The lumbar attachment was selected. Lumbar pad was located against the lower lumbar spine. Each subject was positioned into an upright neutral starting position. This position was such that the anterior superior iliac spine and the posterior superior iliac spines were aligned in the horizontal plane[15]. The head was stabilized neutrally on adjustable head rest (figure 1).

Fig. (1): Positioning of the subject during the test protocol (starting position).

The spinal range of motion was adjusted between 80 degree flexion and 10 degree hyperextension as recorded through the Biodex system. The examiner set the parameters of the biodex system on the isokinetic mode and selected the con/con type of muscle contraction with a preset velocities of 60°/120°/180° /sec. for five repetitions in each velocity with a rest period of 10 sec. between each speed. The subject performed isokinetic lumbar flexion and extension. The subject was instructed to perform maximal effort. The average peak torque was recorded for each speed.

<u>Lumbar repositioning accuracy test</u>

Proprioception accuracy as represented by active repositioning accuracy was assessed for lumbar spine by the Biodex system isokinetic dynamometer through active repositioning test by examining the ability of subjects to reproduce actively an angle at which the joint had been placed before in a compressed seated position of the lumbar spine.

<u>Measurement procedure</u>

Each subject was asked to sit on the lumbar attachment of the Biodex system with the 90 degrees flexion of hips and knees (starting position). The subject was stabilized in the test position by straps around the trunk, pelvis and thigh and folded their arms across their chest and was blind folded to eliminate visual input during testing, Type of test was chosen (active repositioning test with speed 30^o/second). Prior to testing, each subject performed 2 trials to be familiarized with the procedures[30]. Initially the anatomical reference angle was set at 45° flexion then the subject trunk was returned to the starting position[18].

For standardization, the subject trunk was allowed to move to target angle (45°) actively[19] then was held for 10 seconds as a teaching process for the subject so the subject could memorize the position, and then the trunk was allowed to return to the starting position by the apparatus[5]. After a 5-second rest, the subject was asked to move his trunk to the target angle (45°) actively, when the subject felt that he reached the target angle actively he would stop the apparatus using the Hold/Release button. Subjects were not permitted to correct the angle[24]. Three trials were done with rest period of 30 seconds between trials[24].

The mean angular difference of the 3 trials, between the target angle position and the subject perceived end range position (absolute error) was recorded in degrees as the proprioceptive error and was used for the statistical analysis[23].

RESULTS

As variables were not normally distributed using Kolmogorov–Smirnov test except the age. The Mann-Whitney test was used to compare between variables in both groups. For the control group, the mean for the proprioceptive error was 3.36 (±1.31); the peak torque of trunk flexors at 60^0 angular velocity was 65.57 (± 8.85); the peak torque for trunk flexors at 120^0 was 39.20 (±10.67); the peak torque for trunk flexors at 180^0 was 41.34 (±19.22); the peak torque of trunk extensors at 60^0 angular velocity was 103(± 18.41); the peak torque for trunk extensors at 120^0 was 95.09 (± 24.37) and the peak torque for trunk extensors at 180^0 was 87.91(±30.49). For the experimental group, the mean for the proprioceptive error was 9.24 (± 8.89); the peak torque of trunk flexors at 60^0 angular velocity was 27.96 (± 13.38); the peak torque for trunk flexors at 120^0 was 34.61(± 22.58); the peak torque for trunk flexors at 180^0 was 26.13(±18.00); the peak torque of trunk extensors at 60^0 angular velocity was 70.79 (±28.07); the peak torque for trunk extensors at 120^0 was 65.02(±16.01) and the peak torque for trunk extensors at 180^0 was 52.36 (±18.14).

There were significant differences between the control and the experimental groups regarding all the variables with P<0.05 in the favor of the control group as shown in (table 1).

Table (1): Between groups comparison regarding the repositioning accuracy and the peak torque of trunk flexors and extensors at different trunk velocities.

	Control group	Experimental group	Mann-Whitney Z-score	P value
Proprioceptive error	3.36 (± 1.31)	9.24 (± 8.89)	-4.300	.000 (sig)
Peak tork flex60	65.57(± 8.85)	27.96(± 13.38)	-7.727	.000(sig)
Peak torque ext 60	103.63(± 18.41)	70.79(± 28.07)	-5.055	.000(sig)
Peak torque flex 120	39.20(± 10.67)	34.61(± 22.58)	-2.391	.017(sig)
Peak torque ext 120	95.09(± 24.37)	65.02(± 16.01)	-4.731	.000(sig)
Peak torque flex 180	41.34(± 19.22)	26.13(± 18.00)	-4.227	.000(sig)
Peak torque ext 180	87.91(± 30.49)	52.36(± 18.14)	-5.236	.000(sig)

Spearman's correlation coefficient (r^2) was used to find out the relationship between variables in both the control and the experimental groups. For the control group, there was a significant positive correlation between the proprioceptive error and the peak torque of the trunk flexors and extensors at 60^0 angular velocity. A significant negative correlation was found between the proprioceptive error and the peak torque of the trunk flexors and extensors at 120^0 angular velocity and the peak torque of the extensors at 180^0 angular velocity (Table-2). For the experimental group, there were significant positive correlations between the proprioceptive error and the peak torque of the trunk extensors at 60 and 80 degrees angular velocities and a significant negative correlation between the proprioceptive error and the trunk extensors at 120^0 angular velocity as shown in table 2. No correlations had been found between the peak torque of the trunk flexors and the proprioeceptive error.

Table (2): Correlation between variables in both control and experimental groups.

		r^2	Ext 60	Ext 120	Ext 180	Flex 60	Flex 120	Flex 180
Control group	Proprioception	r^2 P-value	.432* .005	-.452* .003	-.834* .000	.834* .000	-.452* .003	-.452 .003
Experimental group	Proprioception	r^2 P-value	.525** .001	-535* .000	.486 .001	-.079 .628	-.050 .852	-.286 .074

*significant relationship

DISCUSSION

This study was conducted to compare between the peak torque of trunk flexors and extensors at 60°, 120°, 180° preset angular velocities; to test the repositioning accuracy of the trunk proprioception and to find out if there is a relationship between proprioception and peak torque of the trunk flexors and extensors at preset three angular velocities in patients with lumbar disc prolapse and sciatica.

The results of this study revealed that there is a proprioceptive error in patients with lumbar disc prolapse associated with sciatica as compared to normal subjects. In addition, there is a weakness in both trunk flexors and extensors in low back pain population as compared with normal subjects. It has been widely reported that patients with low back pain develop a deconditioning syndrome that particularly influences the strength and function of the trunk muscles, with such patients being much weaker than healthy controls[6,14,12,29].

Several studies[2,18] demonstrated that extensor strength is affected more than flexor strength in CLBP. Shirado et al.,[25] reported that patients with CLBP had greater flexor/extensor ratios than the healthy subjects. The results of this study are contradictory to that done by Hultman et al.,[10] which supports the notion that involvement of extensor muscles is not more prominent in CLBP than the trunk flexor group. Hultman et al.[29], studied 3 groups of middle-aged men; nonimpaired low back, intermittent LBP and CLBP. In all groups, the ratio of trunk extensors endurance to trunk flexors endurance approximated 3:1. The results of this study found a significant difference in lumbar extensor muscle strength between the patient and control groups at different trunk velocities. Moreover, the strength of flexor muscles in the patient group was significantly lower than that of the control group. Although there are various factors affecting proprioception in CLBP, paraspinal muscles can be considered as a major factor[15].

In patients with CLBP, a gluteal muscle activation pattern is inhibited, thus creating abnormal movement of the pelvis and spine leading to further deterioration[20]. Subsequently, to create an adaptive protective mechanism, an alteration of activation patterns of different muscle groups may be expected. Indeed, the literature showed that lumbar paraspinal muscle activation patterns are different in patients with CLBP from those of the healthy controls[22].

Unfortunately, studies that searched the presence of a relationship between the peak torque of the trunk muscles and the presence of proprioceptive error are lacking. Our correlation analysis revealed that for the control group, there were significant correlations between the proprioceptive error and the peak torque of flexors and extensors at lower velocity of 60/sec while, there were significant negative correlations between the proprioceptive error and the peak torque of flexors and extensors at angular velocity of 120°/sec. Moreover, there was a negative correlation between the peak torque of trunk extensors and the proprioceptive error at 180/sec angular velocity.

On the other hand, for the experimental group there were moderate positive correlations between the proprioceptive error and the peak torque of the trunk extensors at trunk velocities of 60° and 180°/sec while there was a moderate negative correlation between the peak torque of the trunk extensors and the proprioceptive error. Although there are various factors affecting the proprioception in CLBP, paraspinal muscles can be considered as a major factor[16]. Yilmaz et al.,[31] said that Trunk muscle dysfunction may cause alterations in normal afferent input from the affected muscles. On the other hand, proprioceptive impairment may cause different activation patterns and creates new adaptive protective mechanisms. Either being a cause or a result of CLBP, it is an expected outcome.

However, there was no correlation between the flexors and the proprioceptive error in the experimental group. This comes in agreement with the results of Yilmaz et al.,[31] who concluded that there was no relationship between abdominal muscle strength and proprioception in patients with CLBP. They added that the imbalance between flexor muscle strength and proprioception may be the key factor to explain the lack of relationship between proprioception and flexor muscle strength after fatigue in CLBP patients.

Conclusions

The results of the current study showed that patients with lumbar disc prolapsed are characterized by weakness of the abdominal and back muscles that decreases more with higher velocities and increased proprioceptive error as compared with the normal subjects. In the control group, the relationship between the strength of the trunk muscles improves as the proprioceptive error decreases. Thus, we can conclude that good proprioception is important for good trunk muscle strength especially with movement at high speeds but this is not essential for trunk movement at low speeds. On the other hand, in experimental group, in spite of having a high proprioceptive error and with the presence of trunk muscle weakness, there was no relationship between them.

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الملخص العربي

العلاقة بين الإحساس العميق وقوة عضلات الجزع في السرعات المختلفة لمرضى الإنزلاق الغضروفي المزمن

الغرض من البحث : المقارنة بين أقصى عزم لعضلات ثنى و فرد الجزع عند 60 و120و 180 سرعة دائرية محددة قبلا و لاختبار دقة الرجوع للوضع الأصلي للإحساس العميق للجزع و لاكتشاف إن كان هناك علاقة بين الإحساس العميق و أقصى عزم لعضلات ثني و فرد الجزع في الثلاث سرعات المحددة قبلا في مرضى الانزلاق الغضروفي المزمن مع عرق النسا . **الأشخاص :** ثمانون رجل وامرأة شاركوا في هذه الدراسة. تم تقسيمهم إلى مجموعتين. المجموعة الحاكمة تتكون من أربعون شخص سليم بدون أي تاريخ سابق لألم أسفل الظهر والمجموعة الاختبارية تتكون من أربعون مريضا بتشخيص ألم أسفل الظهر مع عرق النسا . **الطرق :** تم اختبار أقصى عزم لعضلات ثنى و فرد الجزع عند 60 و120و 180 سرعة دائرية محددة قبلا و المرضي جالسين ب استخدام نظام أيزوكينتك بيودكس الطبي III لكلا من المرضى والأشخاص السليمة . تم اختبار دقة الإحساس العميق بلستخدام اختبار دقة الإحساس العميق الإيجابي للمجموعتين عند 45 درجة من المدى الحركي المتاح لكل من عضلات الجزع الباسطة و القابضة كما تم قياسه من جهاز الأيزوكينتك . **التحليل الإحصائي :** تم استخدام وحدة SPSS في تحليل النتائج . تم حساب متوسطات العمر و الوزن والطول . تم استخدام اختبار مان ويتني للمقارنة بين دقة الإحساس العميق وأقصى عزم لعضلات ثنى وفرد الجزع عند ثلاث سرعات دائرية المحددة قبلا بين المجموعتين الحاكمة و الاختبارية . وتم استخدام عامل سبيرمان لاكتشاف إن كان هناك علاقة بين دقة الإحساس العميق وأقصى عزم لعضلات ثنى وفرد الجزع عند ثلاث سرعات دائرية المحددة قبلا بين المجموعتين الحاكمة و الاختبارية . **النتيجة :** هناك علاقة جادة بين أقصى عزم لعضلات ثنى وفرد الجزع عند ثلاث سرعات دائرية المحددة قبلا بين المجموعتين الحاكمة والاختبارية في مصلحة المجموعة الحاكمة . وهناك فرق جوهري في خطأ الإحساس العميق بين المجموعتين الحاكمة والاختبارية في مصلحة المجموعة الحاكمة . كما أن هناك علاقة سلبية بين خطأ الإحساس العميق وأقصى عزم لعضلات ثنى وفرد الجزع في السرعات العالية فقط (120و 180 سرعة دائرية) بينما هناك علاقة إيجابية بين المتغيرين عند سرعة 60 الدائرية . في المجموعة المريضة لم توجد أي علاقة بين الإحساس العميق وأقصى عزم لعضلات ثنى الجزع ووجدت علاقة إيجابية بين خطأ الإحساس العميق وأقصى عزم لعضلات فرد الجزع . **الاستنتاج :** أظهرت نتائج الدراسة أن مرضى الإنزلاق الغضروفي المزمن مع عرق النسا يعانون من ضعف في عضلات البطن والظهر يزداد أكثر مع السرعات العالية واضطراب الإحساس العميق بالمقارنة بالأشخاص السليمة . بالنسبة للعلاقة بالمجموعة الحاكمة ، تتحسن قوة عضلات البطن والظهر كلما قل الخطأ في الإحساس العميق . لذلك يمكنا القول أن الإحساس العميق الجيد هام لقوة العضلات خاصة في سرعات الحركة العالية . ولكنه غير ضروري في السرعات المنخفضة . في مجموعة ألم أسفل الظهر لم توجد علاقة بين الإحساس العميق و قوة العضلات بالرغم من وجود خطأ عال في الإحساس العميق و ضعف شديد بعضلات البطن و الظهر.

الكلمات الدالة : ألم أسفل الظهر ، خطأ الإحساس العميق ، أقصى عزم أيزوكينتك .