

Relationship Between Lumbar Muscle Strength and Proprioception After Fatigue in Men with Chronic Low Back Pain

Kronik Bel Ağrılı Erkeklerde Bitkinlik Sonrası Lomber Kas Gücü ve Propriyosepsiyon Arasındaki İlişki

Bilge Yılmaz, Evren Yaşar, Mehmet Ali Taşkaynatan, Ahmet Salim Göktepe, İlknur Tuğcu, Kamil Yazıcıoğlu, Haydar Möhür

Türk Silahlı Kuvvetleri Rehabilitasyon Merkezi, GATA, Fiziksel Tıp ve Rehabilitasyon Anabilim Dalı, Ankara, Turkey

Abstract

Objective: To evaluate the relationship between lumbar position sense and trunk muscle strength, to investigate the effect of fatigue on this relationship, and the effect of fatigue on proprioception in patients with chronic low back pain (CLBP).

Materials and Methods: A cross-sectional study was conducted to determine lumbar position sense and trunk muscle strength in 19 males with low back pain and in 20 healthy controls. After neurological examination every subject was evaluated for repositioning error (RE) with Cybex Norm isokinetic dynamometer using the trunk extension-flexion modular component. Then, every subject underwent a concentric/concentric exercise program including extension and flexion exercises performed actively for 15 times with the velocity of 60° / second. Finally, the RE test was repeated.

Results: Differences in RE between the groups were significant before and after fatiguing exercise procedure. After fatigue, changes in RE were found significant in both groups. Differences in flexion peak torque and total work between the groups were significant. Second RE measurement was found to be correlated with flexion peak torque and total work in control group.

Conclusion: The results of this study reveals that flexor muscle strength is significantly lower in patients with CLBP. RE was significantly higher in patients compared to the healthy controls. We found that abdominal muscle strength was moderately correlated with position sense in healthy population after fatigue, whereas there was no correlation in patient group.

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Key words: Chronic low back pain, proprioception, muscle strength, fatigue

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Özet

Amac: Kronik bel ağrılı erkek hastalarda lomber pozisyon hissi ve paravertebral kas gücü arasındaki ilişkiyi tanımlamak ve yorgunluk sonrası propriyosepsiyon üzerindeki etkisini ortaya koymak

Yöntem ve Gereçler: Lomber pozisyon hissini (LPH) tanımlamak ve paravertebral kas gücü ile arasındaki ilişkiyi ortaya koymak üzere kronik bel ağrılı 19 erkek hasta ve sağlıklı 20 erkek değerlendirilmeye alındı. Hastaların nörolojik muayenelerini takiben, Cybex Norm İzometrik Dinamometresinin gövde aparatı kullanılarak lomber pozisyon hissi değerlendirildi. Tüm hastalar 60°/sn hızda 15 kez fleksiyon ve ekstansiyon egzersizleri konsantrik/konsantrik moda uygulandı. Bu uygulamadan hemen sonra lomber pozisyon hissi tekrar değerlendirildi.

Bulgular: LPH, yorgunluk öncesi ve sonrasında gruplararası istatistiksel olarak anlamlı ölçüde farklıydı. Yorgunluk sonrasında, LPH'deki değişim her iki grupta da anlamlı ölçüde farklıydı. Fleksiyon pik tork ve total work değerlendirilmelerinde anlamlı farklılık bulundu. Kontrol grubunda, 2. LPH ölçümleri ile total work ve fleksiyon pik tork arasında anlamlı bir korelasyon bulundu.

Sonuç: Bu çalışmanın sonuçları kronik bel ağrılı erkek hastalarda fleksör kas gücünün anlamlı ölçüde düşük olduğunu ortaya koydu. LPH, hasta grubunda kontrol grubuna oranla önemli ölçüde azdı. Yorgunluk sonrasında sağlıklı bireylerde pozisyon hissi ile abdominal kas gücü arasında orta derecede bir korelasyon var iken hasta grubunda bu ilişkinin olmadığını bulduk.

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Anahtar sözcükler: Kronik bel ağrısı, propriyosepsiyon, kas gücü, yorgunluk

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Introduction

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 (1). Position sense or repositioning error are the most widely used methods to measure proprioception.

In patients with chronic low back pain (CLBP), some structural and functional changes occur in articular and

Address for Correspondence: Dr. Bilge Yılmaz, Türk Silahlı Kuvvetleri Rehabilitasyon Merkezi, GATA, Fiziksel Tıp ve Rehabilitasyon Anabilim Dalı, Ankara, Turkey Phone: +90 312 291 16 07 E-mail: bilgeyilmaztr@hotmail.com

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periarticular structures. Hence, it has been shown that proprioception is also affected in patients with CLBP (2). Patients with CLBP frequently demonstrate difficulty adopting and maintaining a neutral or midrange position of the lumbar spine (3). 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 (2). Moreover, under stress conditions such as mechanical loading or fatigue, the ability to sense a change in lumbar position may be highly affected (4).

Newcomer et al. (5), found that lumbar flexor proprioception is impaired much more than extensor proprioception in patients with CLBP. They postulated that this might be because of the contribution of a wide range of muscles including abdominal, psoas, posterior hip group, and erector spinae and the larger excursion during lumbar flexion which challenges muscles more. In a recent study, the same author reported that rectus abdominis muscle activation pattern was changed in some positions on a force plate in patients with CLBP (6). The results of these studies pointed out that the deterioration in flexor muscle group of lumbar region is more prominent in patients with CLBP.

Although a decrease in strength of trunk muscles can be expected in chronic low back pain, there is still a lack of objective studies investigating the relationship between the changes in strength of trunk muscles and the changes in proprioception. The aim of this study was to evaluate the relationship between lumbar position sense and trunk muscle strength, to investigate the effect of fatigue on this relationship and the effect of fatigue on proprioception in patients with CLBP.

Materials and Methods

For the patient group, individuals were consecutively selected from a population of young recruits with non radicular low back pain lasting more than 3 months and not radiating below knee level. Healthy subjects who applied for periodic health examination to our outpatient clinic with no complaints were included in control group. They did not have a history low back pain for at least one year. The intensity of low back pain was assessed by 100-mm Visual Analog Scale (VAS) before testing. All volunteers had lumbar flexion of at least 90° from standing erect position without severe low back pain.

Exclusion criteria for both groups were history of radiculopathy, previous back surgery or a vertebral compression fracture, current lower extremity problems (e.g. atrophy, extremity shortness), any neurologic deficit, symptoms of dizziness, and systemic diseases that can effect proprioception (e.g. diabetes mellitus, polyneuropathy).

After neurological examination every subject was evaluated isokinetically for repositioning error and lumbar paraspinal muscle strength with Cybex Norm isokinetic dynamometer (Lumex, Ronkonkoma, NY) using the trunk extension-flexion modular component. This apparatus which has been used in some studies does not

deal with the effect of gravitational forces (7, 8). Subjects with eyes and ears covered were placed in this device and their lower limbs were stabilized by tibial and thigh pads. A belt secured the pelvis to limit the use of hip flexors. A shoulder harness and backrest provided anchorage to the moving upper section of the apparatus.

Before testing, subjects performed standardized warm-up trials consisted of 6 minutes on an ergometric bicycle followed by a thorough explanation of the test procedure. Isokinetic dynamometer moved the trunk of the participants through flexion with an angular velocity of 1° / second holding a switch in their right hand, it was stopped at 60° degree and they were told to keep this position in their mind. After that, they were brought back to the neutral position. When the device moved again, they were instructed to press the switch with the right thumb finger as soon as they sensed the right position.

The degree of deviation from 60° flexed position was calculated as repositioning error (RE). This test was performed two times for each subject. We used the mean values of two measurements to exclude the influence of learning factor that could affect test performance (1st RE Measurement). Then, every subject was joined to the concentric/concentric exercise program including extension and flexion exercises in full range of motion performed actively for 15 times with the velocity of 60° / second. Immediately after the exercise program, the repositioning error test was repeated (2nd RE Measurement). RE measurements and exercise program were performed consecutively using the same dynamometer without any resting. The isokinetic parameters used for evaluation of muscle strength were total work in joules and peak torque in Newton-meter unit.

Statistical Analysis

Comparisons between groups were analyzed by Student's t-test. Paired t test was used to analyze within-group comparisons. Correlations between variables were analyzed using Spearman's correlation test. Statistical analyses were done by using the SPSS v10.0 program.

Results

There were 19 males in the patient group and 20 males in the control group. All subjects were active persons who were involved in sports activities with irregular intervals. Comparisons between two groups are presented at Table 1. Differences in repositioning error before and after concentric exercise procedure between the groups were statistically significant ($p < 0.05$) (Table 1). After fatigue, changes in repositioning error were found significant in both groups ($p < 0.05$) (Figure 1).

While differences in flexion peak torque and total work between the groups were statistically significant ($p < 0.05$), differences in extension measures were not found significant ($p > 0.05$). Besides, there were no significant differences in mean peak torque and mean total work between two groups (Table 1). Mean flexion peak torque angle was 51.66 ± 8.7 degrees in study group and

61.4±6.9 degrees in control group. Mean extension peak torque angle was 41±11 in study group and 50.5±8.2 in control group. These differences were significant ($p<0.05$).

The correlation between 2nd RE measurement and flexion torque and total work values were found statistically significant in control group ($p<0.05$) in contrary to study group ($p>0.05$). Nevertheless, there was no significant correlation between 2nd RE measurement and extension test parameters in either group ($p>0.05$) (Table 2). When we deal with the alteration between 1st RE measurement and 2nd RE measurement, there was no significant difference between two groups ($p>0.05$).

Discussion

The results of this study revealed that flexor muscle strength is significantly lower in patients with CLBP. The RE was found to be higher in patients with CLBP compared to the healthy controls. Also, there was no relationship between abdominal muscle strength and proprioception in patients with CLBP.

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 (8-11).

Several studies demonstrated that extensor strength is affected more than flexor strength in CLBP (12, 13). Shirado et al. (14), reported that patients with CLBP had greater flexor/extensor ratios than the healthy subjects. However, there are some studies in the literature which supports the notion that involvement of extensor muscles is not more prominent in CLBP. Hultman et al. (15), studied 3 groups of middle-aged men; nonimpaired low back, intermittent LBP and CLBP. In all groups, the ratio of trunk extensor endurance to trunk flexor endurance approximated 3: 1. Similarly, we did not find a significant difference in lumbar extensor muscle strength between the patient and control groups after fatigue in this study. However, the strength of flexor muscles in the patient group was significantly lower than that of the control

group. We think that adaptation to disease process in lumbar extensor muscles is better than that of lumbar flexor muscles. A possible explanation for this may be the contribution of wider range of muscles during flexion as it was postulated by Newcomer et al. (5).

In our study, the higher flexor RE of the lumbar region in patients with CLBP compared to the healthy controls is consistent with the results of other authors (5, 16, 17). Although there are various factors affecting proprioception in CLBP, paraspinal muscles can be considered as a major factor (18, 19). 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.

Before fatigue, the patient group had significantly higher RE than the control group. After fatigue RE was improved in both groups. This improvement seems likely to be due to learning and adaptation to the procedure. On the other hand, our results have indicated that only flexor muscle strength is related with proprioception after fatigue in healthy subjects in contrary to the patient population.

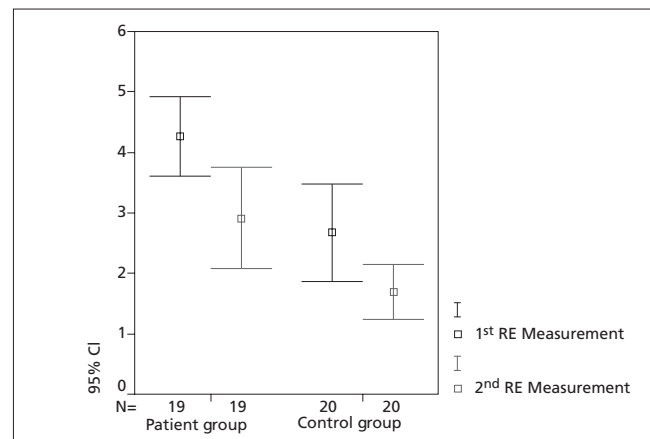


Figure 1. After fatigue, changes in repositioning error in both groups

Table 1. Comparison of demographic characteristics and clinical parameters between study and control groups

	Study group (n=19)	Control group (n=20)	p
Age (y)	25.2±8.2	24.2±5.6	0.67
VAS (mm)	55.2±13.1 mm	0 mm (No pain)	-
Body Mass Index (kg/cm ²)	22.64±0.78	23.26±0.84	0.58
1 st RE Measurement (degrees)	4.26±1.37	2.68±1.74	0.002
2 nd RE Measurement (degrees)	2.92±1.73	1.70±0.98	0.02
Flexion Peak Torque (Nm)	134.84±47.67	180.20±39.44	0.012
Flexion Total Work (Joule)	123.97±52.35	180.45±37.12	0.001
Extension Peak Torque (Nm)	108.24±49.67	118.10±27.65	0.74
Extension Total Work (Joule)	100.37±54.19	120.95±33.72	0.17
Mean Peak Torque (Nm)	133.87±32.60	170.58±93.35	0.20
Mean Total Work (Joule) (n=18)	135.43±32.74	135.46±40.66	0.65

RE; repositioning error VAS; visual analog scale

Table 2. Correlations between repositioning error measurements and isokinetic test parameters

		FPT	FTW	EPT	ETW	MPT	MTW
		Correlation Coefficient (r)					
Study Group	2 nd RE	-0.059	-0.346	-0.181	-0.184	0.109	0.067
Control Group	2 nd RE	-0.471*	-0.498*	-0.476*	-0.377	-0.069	-0.186

FPT; Flexion Peak Torque (Nm), FTW; Flexion Total Work (Joule), EPT; Extension Peak Torque (Nm), ETW; Extension Total Work (Joule), MPT; Mean Peak Torque (Nm), MTW; Mean Total Work (Joule).

* p<0.05

Flexion requires activation of abdominal, psoas, posterior hip group, and erector spinae muscles and also complex coordination of hip and pelvis (20). Extension is the direction that activates the facet joint mechanoreceptors most <http://gateway.ut.ovid.com/gw1/-82> (21).

In patients with CLBP, a particular muscle activation (gluteal etc.) pattern is inhibited, thus creating abnormal movement of the pelvis and spine leading to further deterioration in CLBP (5). Subsequently, to create an adaptive protective mechanism, an alteration of activation patterns of different muscle groups may be expected. Indeed, the literature showed us that lumbar paraspinal muscle activation patterns are different in patients with CLBP from those of the healthy controls (22). To have an idea about this alteration in activity patterns, we have checked the peak torque angles in both groups. The peak torque angles at both flexion and extension were significantly different between groups.

In a recent meta-analysis, it was shown that most of the studies dealing with the effects of exercise in patients with CLBP consist of abdominal exercise programs (23). However, it is not known how strengthening exercises affect the protective abilities of lumbar spine. Further studies are needed to determine if exercise programs not including specific proprioceptive exercises, affect the relationship between muscle strength and proprioception.

In conclusion, we believe 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. However, this needs to be verified in further studies.

Conflict of Interest

No conflict of interest is declared by authors.

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