Isokinetic Evaluation of Lifting Capacity in Healthy and non-specific low back Pain Subjects

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ABSTRACT

Background: *Low back pain (LBP) is one of the most prevalent and costly health problems in the industrial society. It accounts for the most frequent cause of physical work disability in adults with percent as much as 80%–85%. Despite intensive automation and mechanization, heavy lifting is still frequently performed in, industry and health care.* ***Objectives:*** *The purpose of this study was to compare average power, work fatigue, and agonist/ antagonist ratio during isokinetic lifting up and lowering down in healthy and LBP subjects.* ***Methods:*** *15 non-specific LBP male patients with mean age of (20.5±0.97) years and mean weight of (69.3± 3.71) kg and 15 normal male subjects as a matched control group with mean age of (20.9± 0.99) years and mean weight of (70.0 ± 2.75) kg participated in this study. Isokinetic testing is carried out with maximum effort for measuring average power, work fatigue, and agonist/ antagonist ratio during isokinetic lifting up and lowering down for all subjects.* ***Results:*** *Isokinetic lifting showed a significant difference between the normal and the LBP group in average power, work fatigue and agonist/antagonist ratio during isokinetic lifting up and lowering down.* ***Conclusion:*** *It was recommended from this study that the program of rehabilitation of LBP subjects should introduce therapeutic varieties for maintaining and/or increasing level of physical activities thereby reducing the level of functional disability.*

Key words: *Non-specific LBP, lifting capacity, Isokinetic dynamometer.*

INTRODUCTION

Low back pain (LBP) is one of the most prevalent and costly health problems in industrial society[1]. It is a phenomenon that is complex in terms of etiology, management and attending complications that arise from it, [2] as low back pain is the most frequent cause of physical work disability in people with less than 45 years of age. Epidemiological studies have shown that as many as 80%–85% of adults experience LBP once during their lives[3,4].

Despite the high prevalence of the LBP, knowledge of its causes, prevention and treatment remain unclear. Eighty-five percent of chronic low back pain (CLBP) disorders do not have a specific diagnosis. These disorders are labeled 'non-specific CLBP' disorders and represent a large group of 'tissue strains' and 'sprains' that have not resolved beyond normal tissue healing time. This group has been broadly classified based on the area of pain and defined as somatic referred or radicular in nature[5].

Because of its high prevalence, back pain is a leading reason for physicians' visits, hospitalizations and other health and social service utilizations. Literature reveals in terms of economic implications such as hours of work loss, compensation and cost of treatment for LBP. Besides the economic and hours-off work loss implications, LBP creates functional disability and reduces physical activity. All these may cause job boredom, absenteeism and poor morale[2].

On the other hand functional disability is defined as restriction from impairment whereas impairment is defined as any loss or abnormality of psychological, physiological and anatomic structure or function[6]. Functional restriction in turn due to pain, which can be regarded as physiological impairment, may be more than any anatomical or structural impairment. It has been established that prolonged avoidance of activity will lead to physical de-conditioning which will in turn reduce physical activity[7]. Physical activity itself is viewed as an actual performance that will be predicted by both physiological and psychological factors, thus Low back pain can be revealed as a disease that compromises physical activity[8].

Lifting capacity[9], physical factors[10], and vibrations[11] have been found to correlate with a high incidence of low back pain, confirming that lifting is a strong work-related factor. Patients with (CLBP) also report physical stress as well as driving as work-related factors more than healthy subjects[12].

From another perspective, work-related physical and psychosocial factors are generally acknowledged to be related to low back complaints. Among the physical risk factors, scientific evidence indicates manual lifting as a strong predictor of the development of low back complaints at work. Despite intensive automation and mechanization, heavy lifting is still frequently performed in industry and health care[13,14,15,16,17].

Manual material handling is considered to be an important risk factor for the development of low back pain leading to spinal loading that exceeds tissue tolerance. Large extensor moments about the joints of the lumbar vertebral column are produced by the paravertebral musculature during lifting. These moments result in large compressive and shear forces acting between each pair of vertebrae, which may result in injury to the intervertebral disk, muscles, and ligaments. Although lifting from a squat position with the lumbar spine maintained in lordosis is a commonly taught strategy, there is little evidence to support that this posture reduces compressive and shear forces acting on the spinal segments. Existing evidence suggests that compressive and shear forces acting on the lumbar spine are most influenced by load moment, lifting speed, and acceleration[18].

In addition, Low back pain has been found to be associated with certain anthropometric, postural, muscular and mobility characteristics.[19] Among these, poor abdominal muscle strength and an imbalance between flexor and extensor trunk muscles strength seem to be linked[20]. These factors cannot be accurately evaluated with conventional means such as non-apparatus tests which are non-discriminating or in other words nonobjective. Isokinetic apparatuses have been adapted for this purpose and are of practical interest in the follow-up of such patients. The force–velocity relationship measured by the isokinetic testing provides a general overview of the individual muscle properties[21].

The isokinetic lifting protocol enables the subject to move with optimal power at each angle-position of the muscles and joints, whereas the weight applied in conventional lift training must be adapted to the most unfavorable angle of the muscles and joints in the movement process. In an isokinetic procedure, the individual applies maximal effort against a device that will move at a fixed velocity regardless of the force. Criticism has been raised against the use of isokinetic devices, suggesting that they are not realistic or comparable with actual lifting modes. The main advantage of isokinetic testing is, however, its low risk of injury. It does not permit acceleration of a weight through a convenient part of the arc of motion to avoid strength deficits in another part of the arc[22]. Recent studies have shown that lifting capacity is influenced by the gender and age of the subjects[23,24]. In order to minimize this influence, it is important to compare the lifting capacity of the patients with CLBP with matched control groups of subjects free of low back pain. In previous evaluations[25,26], the maximal isometric leg strength of healthy subjects was higher than that of patients with CLBP. There were also differences in the results of isokinetic and gravity-iso-inertial testing in patients with CLBP and healthy subjects[12].

The problem of using the isokinetic mode in the evaluation of lifting is that it provides fixed speed whatever the load was. In other terms as the patient attempts to lift with high speed, the isokinetic mode provides more resistance to overcome the increased speed, but functionally the load remains constant not the speed of movement. In the present study, isokinetic dynamometer used in evaluation provides new software with an isotonic mode and a new specific attachment called "lifting dynamometer". In contrast to other methods of assessment used, the lifting dynamometer provides lifting in a linear motion (up and down) similar to the functional position during lifting and the isotonic mode provides fixed amount of tension against fixed amount of load where the speed is not the controlled parameter, in other words it provides a means of assessment in a dynamic loaded condition of the spine, which is more valid and reliable, and to the author's knowledge no previous studies have been conducted using the lifting dynamometer to compare isokinetic outcomes between healthy and LBP subjects therefore.

The purpose of the present study was to compare average power, work fatigue, and Agonist / Antagonist Ratio during isokinetic lifting up and lowering down in healthy individuals and LBP subjects.

METHODS

Operational definitions:

Average Power is the Total work divided by time. Power indicates how quickly a muscle can produce force and is used to provide a true measure of work rate intensity which indicates a muscle group's ability to perform work over time. Work fatigue is the ratio of difference between the first 1/3 and the last 1/3 of work in the test session. It is valuable in documenting progress during endurance training to detect the amount of fatigue throughout the test session. Agonist / Antagonist Ratio define the reciprocal flexion /extension muscle group ratio[24,25].

Methods:

Thirty male subjects volunteered to participate in this study and were assigned to one of two sub-groups: {A normal group (Number 15) and a low back pain group (Number 15)}. The subjects were accepted in the study if they had (1) pain between the area of L1 and the gluteal fold for longer than two weeks and (2) mild to moderate impairment of physical function at work or leisure demonstrated by using the Roland and Morris Disability Scale. Subjects were excluded if low back pain was so severe as to prevent co-operation with the study.

Normal subjects was accepted in the study after match them with low back pain subjects in their age, weight, height and body mass index.

Normal subjects included could not have had complaints of discomfort over the low back region for more than three months in duration and had to have been free of low back pain for at least the previous year. Subjects were excluded from either group if they fulfilled any of the following criteria: a history of previous back surgery, compression fractures of the spine, neurological disorders, symptoms of vertigo or dizziness, current lower extremity symptoms or un-medicated cardiovascular disease[27]. A proper explanation and illustration of the test procedures was given to all subjects prior to testing procedures.

This study was conducted by using the lifting simulation unit of Biodex Isokinetic Dynamometer (As shown in figure 1).The protocol of lifting of the isokinetic dynamometer was isotonic unilateral, lifting between knees, Concentric/Concentric contraction with five repetitions as 26/26, 30/30, 35/35, 40/40, 45/45 where the nominator and the denominator represents the concentric loads during the testing session. Isokinetic tester performed the test without knowing whether the subject was normal or had a low back pain. The first repetition was considered as the easiest and the fifth was the hardest. In this study all the trials except the fifth were considered as a warming up and to be familiar with the test and equipment and only the fifth trial was recorded for all subjects. To avoid fatigue, 60 seconds of rest interval between each trial was given to all subjects.

As a pre-trial warm-up, each subject performs a standardized series of passive static stretches of the lumbar spine, erector spinae muscles, hamstrings, hip flexors, and upper extremities and all subjects were instructed to maintain their back erect during the whole test. In order to determine the limit of lifting range, the subjects were positioned as stride standing on the lifting platform unit. Both feet were centered on two marked areas, with knees and hips comfortably flexed the subjects could grasp the force transducer handle positioned at mid patellar height. The subjects started to move the lifting handle down to the level that they performed complete squatting and the lifting handles were directly beneath their legs to determine the starting lifting range. The bar is then lifted up to the end limit of lifting where the subjects were in fully upright position.

Fig. (1): Isokinetic dynamometer.

The test was started by moving the lifting bar up and down through the whole pre-determined range and the subjects were asked to attempt to keep the movement smooth and rhythmic without a halt in any part of range. The process was repeated to the fifth trial and all subjects attempted to rest lying in bed after the testing protocol for at least 10 minutes.

In the fifth trial, Peak velocity, Work Fatigue and average power were collected from all subjects. The power generated is measured in Watt (W). Student t-test was used to compare between normal and LBP groups. The level of significant was set at $P < 0.05$.

RESULTS

Thirty volunteered male subjects were assigned to one of two subgroups: Normal group (Age 20.90 ±0.99, weight 70.0 ±2.75 and height 173.3 ±5.42) and low back pain group (Age 20.50 ±0.97, weight 69.3 ±3.71 and height 173.8 ±4.29). Isokinetic testing was carried out with maximum effort and Peak torque, work fatigue, average power and agonist/antagonist ratio during isokinetic lifting up and lowering down all measured for all subjects. There were no significant differences in anthropometric parameters such as age, weight, and height where t value of age was t = 0.910 and P= 0.375), weight (t= 0.479 and P= 0.638) and in height (t= -0.229 and P=0.822).

Table (1): Comparison between normal and LBP group.

	Normal (Group I)		Low Back Pain (Group II)		t-value	Sig.
	Mean	SD	Mean	SD		
age	20.90	0.99	20.50	0.97	0.910	0.375
weight	70.00	2.75	69.30	3.71	0.479	0.638
Height	173.30	5.42	173.80	4.29	-0.229	0.822
Average Power (UP)	549.81	141.43	276.36	103.43	4.935	0.00001*
Average Power (down)	571.67	123.71	278.57	64.54	6.643	0.0001*
Work fatigue (Up)	42.28	15.30	16.37	10.40	4.429	0.0001*
Work fatigue (down)	66.62	32.45	22.22	9.84	4.140	0.001*
Agonist/antagonist ratio	88.72	2.58	69.89	6.42	8.602	0.0001*

SD: Standard deviation Sig*: Significant

Unpaired t-test was performed to compare between average power, work fatigue, and agonist/ antagonist ratio during isokinetic lifting up and lowering down in healthy and LBP subjects. It revealed a significant difference in average power between normal and LBP groups during lifting up as the mean value of average power in normal individual was (549.81±141.43) and in LBP was (276.36±103.43) where t-value= 4.935 and P= 0.00001 and during lowering down as the mean value of average power in normal individual was (571.67 ±123.71) and in LBP was (278.57 ± 64.54) where t-value= 6.643 and P= 0.0001 as shown in table (1) and figure (2).

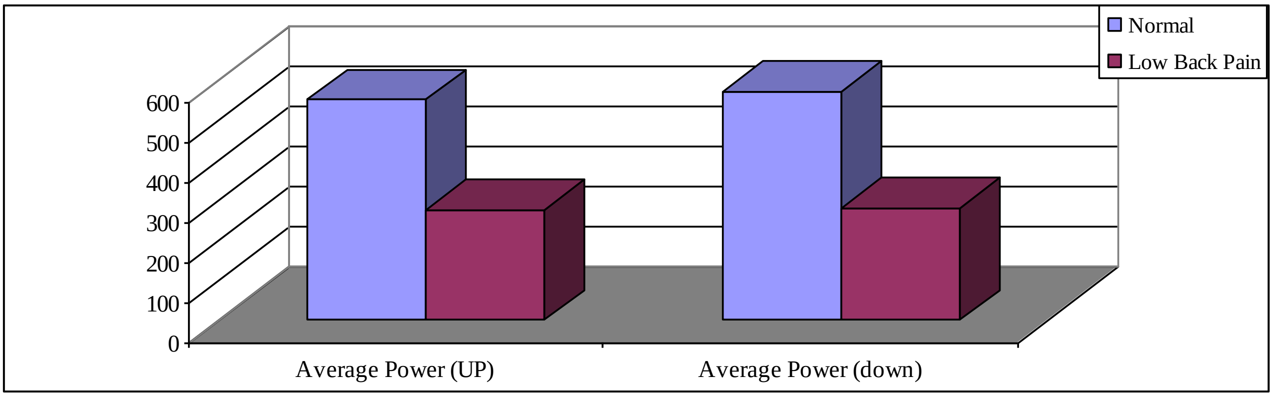

Fig. (2): Average power values during up and down in normal and LBP.

Also, there was a significant difference in work fatigue between normal and LBP groups during lifting up as the mean value of work fatigue in normal individual was (42.28 ±15.30) and in LBP was (16.37 ±10.40) where t-value = 4.429 and P value = 0.0001 and during lowering down as the mean value of work fatigue in normal individual was (66.62 ±32.45) and in LBP was (22.22 ± 9.84) where t-value= 4.140 and P= 0.001 As shown in table (1) and figure (3).

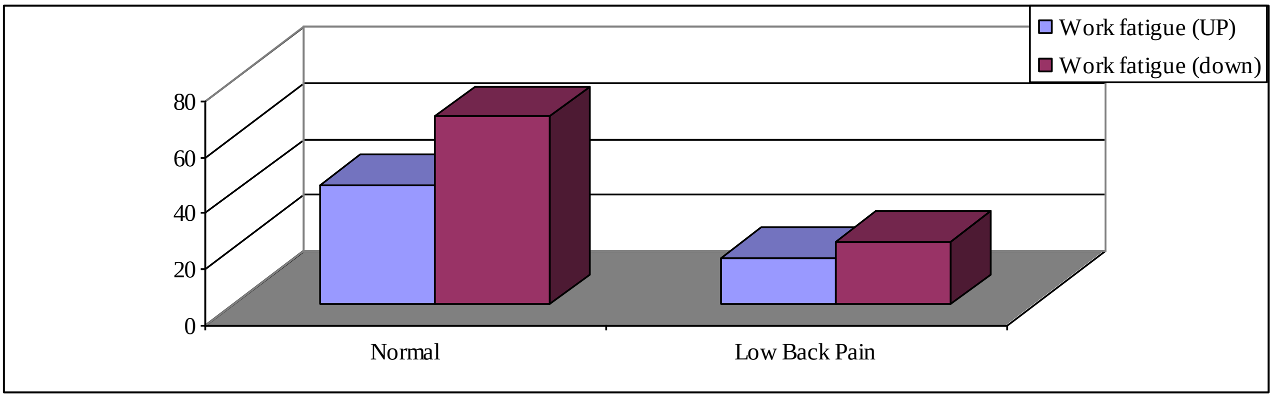

Fig. (3): Work fatigue values during up and down in normal and LBP.

There was a significant difference in agonist/antagonist ratio between normal and LBP groups as the mean value of agonist/antagonist ratio in normal individual was (88.72 ±2.58) and in LBP was (69.89 ±6.42) where t-value was 8.602 and p value was 0.0001 As shown in table (1) and figure (4).

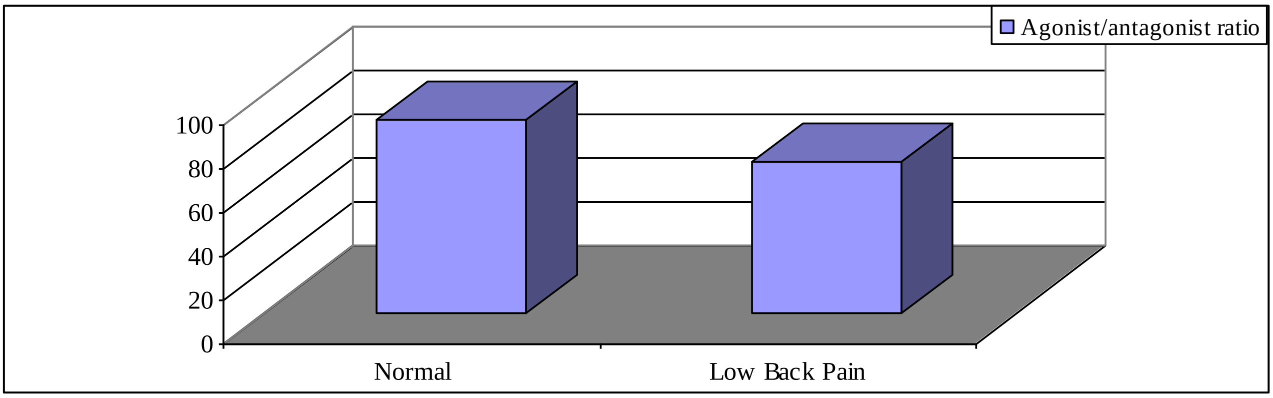

Fig. (4): Agonist/antagonist ratio in normal and LBP.

DISCUSSION

The results of this study revealed a significant difference in average power, work fatigue, and agonist/ antagonist ratio during isokinetic lifting up and lowering down in healthy and LBP subjects.

Our findings were supported by the findings of Akindele[28] who evaluated the effects of functional disabilities and physical activity in patients with low back pain (LBP) and apparently healthy individuals. It was concluded from his study that patients with low back pain have impaired physical activity when compared with apparently healthy individuals because of functional disability associated with low back pain[28].

He attributed the reason for low activity level of low back pain subjects might be due to fear of not involving themselves in physical activity (indoor or job related activities). Many LBP subjects believed that engaging in job related and indoor activities might worsen the pain they experience[28].

The results of the present study also tend to be agreed upon with those previously obtained during isokinetic movements by Ripamonti et al.[29] as LBP patients showed significantly lower torque values than normal healthy subjects for both trunk flexor and extensor muscles. They reported that torque values become non-significant when the torques were expressed relative to the body weight. These results underline the importance of body mass in trunk movement[29].

In addition our results were supported by the findings of Ripamonti et al.[30] who tend in their study to describe the torque–velocity and power–velocity relationships of the trunk muscles in chronic low back pain patients and to compare them with those of healthy subjects. The results showed that peak torque and power values were approximately 20% higher than those of the LBP for both flexor and extensor trunk muscles whereas the P_{max} significantly differed between the two groups for both flexor and extensor muscles[30].

In the present study, comparing between agonist / antagonist ratio between normal and LBP subjects reflected a significant difference for the ratio between abdominal and back muscles during lifting up and lowering down in which was greater in normal subjects than the ratio in LBP subjects possibly due to poor abdominal muscle strength, increased activity of the back muscles as a response of pain or simply due to muscle imbalance as abdominal muscles may play a more important role than the extensors in providing trunk stability; therefore, it is possible that an altered abdominal recruitment pattern may lead to deficiencies in spine stability in patients with CLBP[31].

This result was consistent with Neda al.,[1] who studied the trunk muscle activation in patients with chronic low back pain (CLBP) during load holding. The results showed that there was no significant difference in muscle activity between CLBP patients and healthy subjects when they held no load in neutral posture, so the difference in muscle activity between patients with CLBP and healthy subjects while holding loads was due to low back pain effects. Higher and lower activation of global and local abdominal muscles respectively in patients with CLBP may represent that pain changes neuromuscular control systems®. The increased activity of extensor muscles during trunk flexion is probably needed for stability and controlling of flexion[1].

Supporting our findings, Ripamonti et al.[29] reported a decrease in the agonist/antagonist ratio between healthy individuals and LBP subjects as the ratios for LBP group was lower than in normal subjects and concluded that the lower ratio described in this present study supports the poor abdominal muscle strength as well as that the flexor/extensor ratio determined from the measurement could become a reliable parameter to predict chronic low back pain[29].

In contrast to the findings of the present study Ripamonti et al.[29,30] who compared the flexor/extensor ratio of the trunk muscles to verify whether it was predictive of chronic low back pain. The results demonstrated that the flexor/extensor ratio cannot be considered as a predictive factor of low back pain. As comparing between flexor/extensor ratio between normal and LBP subjects revealed a non-significant difference between groups[30].

One explanation for this Contradiction between our results and the finding of Ripamonti et al.[29,30] could be related to the difference in age between the two groups of subjects. Also the difference may be due to the different experimental protocol (e.g. position of the subject during the movements or using different accessory tools of isokinetic dynamometer device as in the current study using a lifting simulation unit rather than the use of the dual position back extension/flexion attachment).

Another explanation to the previous difference may be due to the time of testing and the patient current status of pain as the chronic non-specific LBP represent a complex, multidimensional problem. The chronic LBP experience is characterized by vast array of physical[32] and social features[33].

The patients in this study referred to 'non-specific low back pain syndrome' without a specific diagnosis and were characterized as having moderate impairment accompanied by mild pain. For a low back pain population with a specific diagnosis it would be necessary to perform further studies.

Conclusion

It was concluded from this study that patients with LBP have impaired lifting capacity when compared with healthy individuals because of functional disability associated with LBP subjects.

Recommendations

It was recommended from this study that the program of rehabilitation of LBP subjects should introduce therapeutic varieties for maintaining and/or increasing level of physical activities thereby reducing the level of functional disability. As LBP subject were found to have a reduction in physical ability as compared with normal subjects.

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الملخص العربي

المقدمة : يعتبر آلام أسفل الظهر من المشاكل الصحية الأكثر انتشارا وتكلفة في المجتمع الصناعي حيث يعد الأكثر شيوعا للإعاقة الجسدية لدى البالغين للعمل بنسبة تصل الى 80 ٪ -85 ٪. وعلى الرغم من استخدام الميكنة الا ان الرفع الثقيل لا يزال عبئا ثقيلا في كثير من الأحيان- على سبيل المثال- في الصناعة . **الهدف :** تهدف هذة الدراسة مقارنة متوسط القوة و مقدار العمل والتعب و نسبة العضلات المنقبضة وعكسها أثناء رفع وخفض باستخدام جهاز الايزوكينيتك بين الاصحاء ومرضى الام اسفل الظهر . **طريقة البحث :** شارك في هذا البحث خمسة عشرة شخصاً لديهم الام اسفل الظهر حيث يبلغ متوسط أعمارهم 20.5 ± 0.97 عاما ومتوسط أوزانهم 69.3±3.71 كجم و خمسة عشر شخصاً أصحاء كمجموعة للمراقبة حيث بلغ متوسط أعمارهم 20.9±0.99 عاما ومتوسط أوزانهم 70.0 ±2.75 كجم. اجري اختبار الرفع والخفض بجهاز الايزوكينيتك وتم قياس متوسط القوة و مقدار العمل والتعب و نسبة العضلات المنقبضة وعكسها أثناء الرفع والخفض لجميع الأشخاص والمرضى . **النتائج :** أظهرت النتائج فروق ذات دلائل احصابية بين الاشخاص الاصحاء ومرضى الام أسفل الظهر في متوسط القوة ومقدار العمل والتعب أثناء الرفع و الخفض و نسبة العضلات المنقبضة وعكسها باستخدام جهاز الايزوكينيتك . **الاستنتاج :** يستنتج من هذة الدراسة الى وجود ضعف في القدرة على الرفع لمرضى الام اسفل الظهر عند مقارنتهم بالاشخاص الاصحاء وذلك بوجود عجوز وظيفى مصاحب لالم أسقل الظهر لدي هؤلاء الأشخاص .