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Assessment of Isokinetic Trunk Strength in Chronic Lumbar Radiculopathy

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ABSTRACT

Background: Chronic lumbar radiculopathy, often caused by lumbosacral disc herniation, leads to significant muscle changes and back pain. Previous studies have demonstrated that specific muscles, such as lumbar multifidus (LM) and transversus abdominis (TrA), are preferentially affected in individuals with low back pain. **Objective**: This study aimed to evaluate maximal concentric isokinetic trunk extension and flexion torque in patients with unilateral chronic lumbar radiculopathy in comparison to healthy subjects. **Methodology**: Sixty-two male participants aged 35 to 45 years were included and divided into two groups: 31 male patients with chronic unilateral lumbar radiculopathy and 31 healthy matched controls. Lumbar flexion and extension muscles strength were assessed using an isokinetic dynamometer. **Results**: Patients with chronic lumbar radiculopathy exhibited a significant reduction in lumbar flexion and extension strength compared to healthy controls. **Conclusion**: There is a significant reduction in trunk muscle strength at 60˚/s and 120˚/s velocities in chronic low back pain (CLBP) patients compared to healthy controls indicating an imbalance that may contribute to the persistence of chronic back pain.

Keywords: Chronic Lumbar Radiculopathy – Muscle Strength – Lumbar Multifidus – Transversus Abdominis –Isokinetic Dynamometer.

1. Introduction

Chronic low-back pain (CLBP) is a significant healthcare challenge in developed nations. This condition is not only widespread but also challenging and time-consuming to treat. It is uncommon for a CLBP patient to experience relief after their initial visit to a doctor and the prescribed treatment. Additionally, the economic burden increases as various treatment approaches are tried. Research suggests that 80% of the population will experience low back pain at least once in their lifetime **(Fatoye et al., 2019).**

Chronic low-back pain is associated with specific body measurements, posture, muscle strength, and flexibility. Many different causes have been connected to the condition: being overweight, having excessive curvature in the lower back, weak abdominal muscles, an imbalance between the strength of the muscles that bend the trunk forward and those that extend it backward, and reduced flexibility in the spine. Regarding chronic low-back pain, there has been extensive research on the strength of the muscles in the trunk **(Tavares et al., 2020).**

Measuring trunk strength involves various methods that have been developed. The most reliable method is the isokinetic dynamometer, which includes assessing muscle strength capacity during linear or rotational movements at consistent speeds **(Stark et al., 2011)**. This approach enables a rapid assessment of multiple muscle function parameters at different positions and angular velocities, and it has been recommended for both clinical and research purposes **(Alvares et al., 2015)**.

The isokinetic dynamometer is commonly used to assess the strength of trunk muscles. Previously, researchers have utilized dynamometers to measure the strength of trunk flexion and extension at different speeds and contraction modes **(Yahia et al., 2011)**. Isokinetic measurement is known for its reliability and precision **(Mueller et al., 2011)** and is frequently employed for dynamic strength assessment to comprehend the mechanical characteristics of skeletal muscles, including those of the trunk. Furthermore, isokinetic testing has been used to study the biomechanical aspects of spinal movements during trunk flexion-extension **(Van Damme et al., 2013)**.

Patients with CLBP have been found to have abnormalities in controlling their trunk muscles. It is important to focus on addressing the trunk muscles to establish stability around the lumbar spine when carrying out daily activities. People with CLBP exhibit a delay in muscle contraction at the level of these stabilizing muscles **(Hodges & Richardson, 1998)**.

Chronic pain may result in an abnormal motor cortex reorganization, leading to less efficient control of the trunk muscles **(Tsao et al., 2011)**. Physiotherapy methods like motor control training and sensory feedback training address this reorganization and can correct the pathological changes by leveraging the brain's plasticity **(Tsao et al., 2010; Kälin et al., 2016; Foster et al., 2018)**. The lumbar multifidus muscles play a key role in stabilizing the lumbar spine, and recent magnetic resonance studies have revealed a significant link between chronic low back pain and the presence of atrophy and fat infiltration in these muscles **(Kim et al., 2007; Freeman et al., 2010).**

The strength of the muscles in the trunk plays a significant role in stability **(Barbado et al., 2016)**, in preventing injuries **(De Blaiser et al., 2018)**, and can affect performance in functional assessments (**Shahtahmassebi et al., 2017)**, it becomes crucial to measure these forces for clinical purposes. This will help guide professionals in developing rehabilitation programs and prevention strategies. Therefore, this study aims to assess the maximum concentric isokinetic torque values for trunk extension and flexion in male patients with unilateral chronic lumbar radiculopathy compared to healthy control populations to determine if these factors are linked to the occurrence of CLBP.

2. Material and methods

This is a prospective cross-sectional study conducted to evaluate lumbar flexion and extension strength in patients with unilateral chronic lumbar radiculopathy. All patients signed the consent form before the beginning of the study.

The study enrolled 62 male patients recruited from February 2023 to September 2023, from the Delta University population. The **study group** included 31 male patients with chronic unilateral L5 lumbar radiculopathy due to disc herniation, diagnosed and referred by a neurosurgeon based on a careful examination and diagnosis confirmed by magnetic resonance imaging of lumbosacral spine and electro diagnosis and the **control group** included 31 male healthy-matched subjects.

The inclusion criteria for the study were male patients aged from 35 to 45 years with chronic unilateral lumbar radiculopathy due to lumbar disc herniation, a body mass index (BMI) less than 30 kg/m^2, waist-hip ratio ≤ 0.9, and duration of pain exceeding six months. Exclusion criteria included bilateral lumbosacral radiculopathy, acute or sub-acute pain, spinal cord injury, fractures, tumors, infections, previous lumbar surgery, severe musculoskeletal diseases, peripheral mononeuropathies or polyneuropathy, and obesity.

Sample size calculation

Sample size calculation was performed using G*POWER statistical software (version 3.1.9.2) for a comparative study between two groups. Based on data on trunk flexion to extension torque ratio of derived from **Moussa et al**. (**2020**) who found a significant difference in trunk flexion to extension torque ratio between groups, the calculation revealed that the required sample size for this study was 31 subjects per group. Calculations were made using $\alpha=0.05$, power 80% and effect size = 0.66, and allocation ratio N2/N1 =1.

Instrumentation

Trunk strength assessment during flexion and extension was performed on an isokinetic dynamometer (IsoMed 2000; D&R Ferstl, Hemnau, Germany) at a speed of 60 /s, and 120 /s respectively. Isokinetic dynamometer can measure trunk flexion and extension strength at various angular velocities and contraction modes (isometric, concentric, and eccentric), and is safe, reliable, valid, and sensitive enough to detect muscle weakness (**Moussa et al., 2020).**

Procedures:

Before testing, participants performed a 10-minute warm-up of brisk walking on a treadmill (4-7 kph) **(Maud & Foster, 2006; Roussel et al., 2006)** and 1 set of 10 sub-maximum trunk flexion-extension exertions at testing angular velocity (120°/s). This warm-up helped participants become familiar with the device. The overall testing duration was approximately 15 min. Then baseline participant characteristics were collected: length (cm), weight (kg), and BMI. All the trials were performed at the same time of the day and were supervised by the same researcher. with maximal voluntary effort and a 1-minute break between trials. In addition, they were instructed to perform the maximum effort from the beginning of the first set to the end of the test. Moreover, they were verbally encouraged with the same indications and intensity across repetitions to exert maximum physical effort throughout the test protocol.

Trunk strength assessment during flexion and extension was performed on an isokinetic dynamometer (IsoMed 2000; D&R Ferstl, Hemnau, Germany) at a speed of 60 /s, and 120 /s respectively. Different angular velocities could reflect the various types of muscle contraction and facilitate the understanding of the muscular dynamics of the trunk. The low-speed tests examine muscle strength and explosive force. The type of muscle fibers involved in contraction was mainly type I slow contraction muscle fibers. The rapid muscle strength tests assess muscle power and endurance, the contraction type of muscle fibers was mainly type II fast contraction muscle fibers. Participants performed a concentric exploration of trunk flexors and extensors in two trials of five consecutive flexion-extension movements at speeds of 60°/s and 120°/s, as previously used and recommended.

Participants were fixed in a sitting position at the shanks, thighs, and shoulders fixed by shoulder support. The point of rotation of the device was verified with a laser pointing at the upper margin of the iliac crest. Each participant completed two trials with five repetitions for the isokinetic mode, starting with the trunk flexion and a subsequent trunk extension sweeping from 30° to 30°, concerning an upright trunk position, the hip angle at 90 ° (**Moussa et al**., **2020**).

The highest peak torque of the two trials was evaluated afterward and used in further analysis. Thereby, the maximal torque describes the maximal voluntary torque value captured under dynamic conditions. The Raw data was exported and processed with external software.

Statistical analysis

The statistical analysis was conducted by using the statistical SPSS Package program version 25 for Windows (SPSS, Inc., Chicago, IL). Quantitative descriptive statistics data including the mean and standard deviation for age, weight, height, BMI, flexion, extension, and flexion/extension ratio variables. Independent t-test to compare the study group and control group for age, weight, height, BMI, flexion, and extension. Statistical level All statistical analyses were significant at the level of probability less than an equal 0.05 ($P \leq 0.05$).

Results

<u>1. General characteristics of subjects:</u>

The study group included 31 patients with chronic unilateral L5 lumbar radiculopathy due to disc herniation and the control group included 31 male healthy matched subjects. The mean values of age in the study group and control group were 41.55 ±3.88 and 42.16 ±4.18year, respectively. The mean values of weight were 70.68 ±3.63 and 70.46 ±3.69 kg, respectively. The mean values of height were 163.26 ±4.32 and 161.59 ±4.47cm, respectively. The mean values of BMI were 26.52 ±1.09 and 27.00 ±1.44 kg/m^2, respectively. There were no significant differences in mean values of age, weight, height or BMI between the study and control groups. (Table 1)

Table (1): Demographic characteristics of subjects in both groups.

Items	**Age (Year)**	**Weight (kg)**	**Height (cm)**	**BMI (kg/m^2)**
Study group (n=31)	41.55 ±3.88	70.68 ±3.63	163.26 ±4.32	26.52 ±1.09
Control group (n=31)	42.16 ±4.18	70.46 ±3.69	161.59 ±4.47	27.00 ±1.44
t-value	0.597	0.236	1.490	1.482
P-value	0.553	0.814	0.141	0.144
Significance	NS	NS	NS	NS

Data are expressed as mean ±standard deviation (SD) P-value: probability value NS: non-significant

<u>Lumbar flexion strength</u>

The mean values of flexion at speed 60º/s in the study group and control group were 103.89 ±27.43 and 125.89 ±9.36, respectively, with a change and decreasing percentage of -22.00 and -17.48%, respectively. The mean values of flexion at speed 120º/s in the study group and control group were 101.44 ±26.14 and 129.10 ±11.24, respectively, with change and decreasing percentages of -27.66 and

-21.43%, respectively. There was a significant decrease in flexion at 60º/s (P=0.0001) flexion 120º /s (P=0.0001) in the study group compared to the control group (Table 2 and Figure 1).

Table (2): Comparison of mean values of lumbar flexion strength between the study and control groups.

Items	Lumbar flexion strength (Mean ±SD)	
	Flexion 60º/s	**Flexion 120º/s**
Study group (n=31)	103.89 ±27.43	101.44 ±26.14
Control group (n=31)	125.89 ±9.36	129.10 ±11.24
Change	-22.00	-27.66
Decreasing %	-17.48%	-21.43%
t-value	4.225	5.411
P-value	0.0001*	0.0001*
Significance	S	S

Data are expressed as mean ±standard deviation P-value: probability value S: significant

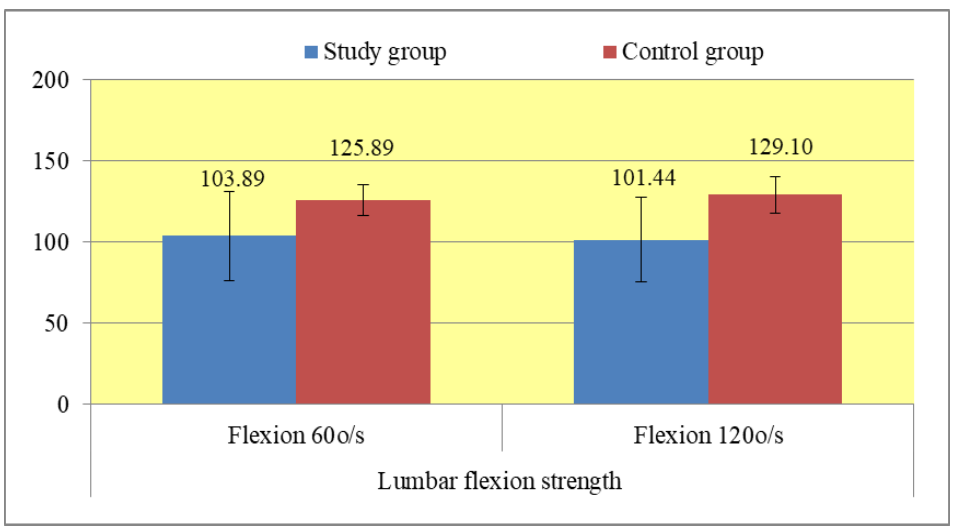

Figure (1): Mean lumbar flexion strength values in the study and control groups.

Lumbar extension strength

The mean values of extension 60˚/s in the study group and control group were 109.59 ±51.10 and 127.30 ±60.70, respectively, with change and decreasing percentages of -17.71 and -13.91%, respectively. The mean values of extension 120º/s in the study and control group were 96.50 ±41.26 and 128.89 ±61.62, respectively, with change and decreasing percentages of -32.39 and -25.13%, respectively. There was a significant decrease in extension 60º /s (P=0.018) and extension 120º /s (P=0.0001) in the study group compared to the control group (Table 3 and Figure 2).

Table (3): Comparison of mean values of lumbar extension strength between the study and control groups.

Items	Lumbar extension strength (Mean ±SD)	
	Extension 60º/s	Extension 120º/s
Study group (n=31)	109.59 ±51.10	96.50 ±41.26
Control group (n=31)	127.30 ±60.70	128.89 ±61.62
Change	-17.71	-32.39
Decreasing %	-13.91%	-25.13%
P-value	0.018*	0.0001*
t-value	2.432	3.954

Data are expressed as mean ±standard deviation P-value: probability value S: significant

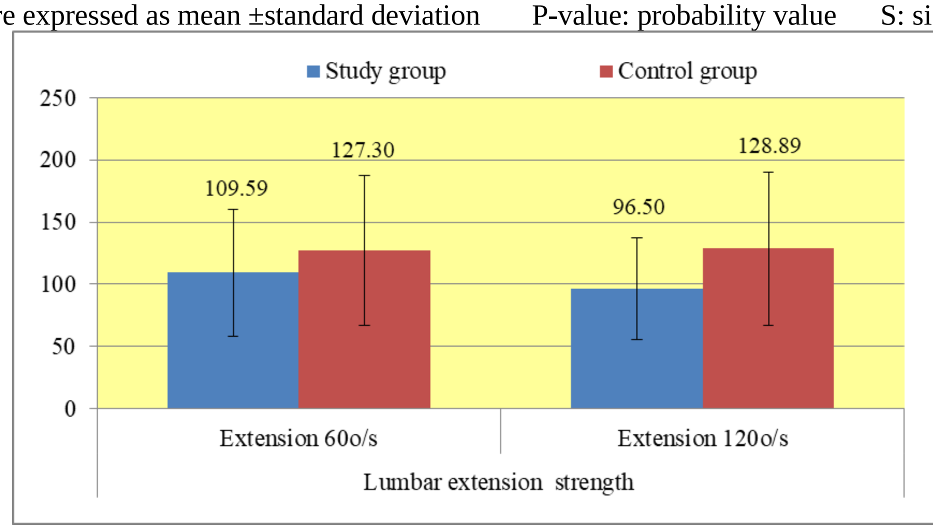

Figure (2): Mean lumbar extension strength values in the study and control groups.

Discussion

Chronic low back pain is a prevalent healthcare issue in industrialized nations, closely linked to various anthropometric, postural, muscular, and mobility characteristics **(Bayramoglu et al., 2001)**. Previous studies have suggested that an imbalance in trunk muscles strength, particularly between flexors and extensors, plays a significant role in CLBP **(Pope et al., 1985)**. However, conventional non-apparatus tests fall short of accurately evaluating these muscle properties, necessitating the use of advanced devices like isokinetic dynamometers **(Calmels et al., 2004)**.

Our study aimed to elucidate differences in flexion and extension torque at velocities of 60 and 120 degrees per second between CLBP patients and healthy controls. The findings highlighted notable differences between both groups in lumbar flexion and extension strength values. In trunk-muscle strength testing, methods, and outcomes vary widely across studies due to differences in procedures, equipment, contraction types, and contraction velocities **(Calmels et al., 2004)**. Consistent with prior research, our results demonstrated lower isokinetic flexor and extensor trunk muscle strengths at 60 and 120 degrees/sec in CLBP individuals compared to controls. These findings align with literature indicating the critical role of abdominal muscles in back pain **(Mayer et al., 1985)** and support the notion that trunk extensors are more affected than trunk flexors in CLBP patients **(Cho et al., 2014)**.

Previous research presents mixed results regarding trunk muscle strength in CLBP patients. Some studies, like those by **Suzuki et al. (1983) and Ripamonti et al. (2009)**, found no significant differences in trunk muscle performance between CLBP patients and healthy individuals. Conversely, other studies align with our findings, demonstrating a significant reduction in trunk muscle strength among CLBP patients. For example, **Pope et al. (1985)** found weaker trunk flexor and extensor muscles in CLBP patients, and **Mayer et al. (1985)** noted that trunk extensors were more affected than flexors in these patients. Our study adds to this body of evidence by confirming a significant reduction in trunk muscle strength at 60 and 120 degrees/sec in CLBP patients. These findings emphasize the presence of muscle imbalances in CLBP patients and underscore the importance of targeted therapeutic interventions to address these dysfunctions. Further research should explore broader testing parameters and diverse populations, incorporating various contraction modes and postures, to deepen our understanding of trunk muscle dynamics in CLBP.

Conclusion

In our research, we observed a noteworthy decrease in the strength of the muscles in the trunk area at speeds of 60˚/s and 120˚/s in individuals with CLBP in comparison to healthy individuals. These results indicate the existence of muscle imbalances in CLBP patients, emphasizing the need for specific interventions. These holistic methods will improve our comprehension and treatment of trunk muscle irregularities in CLBP.

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Disclosure

No financial interest or benefit has been gained from this research.

Conflict of interest

No conflict of interest has been declared by the authors of the current research.

References

Alvares, J. B. D. A. R., Rodrigues, R., de Azevedo Franke, R., da Silva, B. G. C., Pinto, R. S., Vaz, M. A., & Baroni, B. M. (2015). Inter-machine reliability of the Biodex and Cybex isokinetic dynamometers for knee flexor/extensor isometric, concentric and eccentric tests. Physical Therapy in Sport, 16(1), 59-65.

Barbado, D., Lopez-Valenciano, A., Juan-Recio, C., Montero-Carretero, C., van Dieën, J. H., & Vera-Garcia, F. J. (2016). Trunk Stability, Trunk Strength and Sport Performance Level in Judo. PloS one, 11(5), e0156267.

Bayramoglu, M., Akman, M. N., Klnç, S., Çetin, N., Yavuz, N., & Özker, R. (2001). Isokinetic measurement of trunk muscle strength in women with chronic low-back pain. American journal of physical medicine & rehabilitation, 80(9), 650-655.

Calmels, P., & Rimaud, D. (2004). Physiotherapy in patients with chronic low back pain. Preliminary results. In Annales de readaptation et de medecine physique.

Cho, K. H., Beom, J. W., Lee, T. S., Lim, J. H., Lee, T. H., & Yuk, J. H. (2014). Trunk muscles strength as a risk factor for nonspecific low back pain: a pilot study. Annals of rehabilitation medicine, 38(2), 234-240.

De Blaiser, C., Roosen, P., Willems, T., Danneels, L., Bossche, L. V., & De Ridder, R. (2018). Is core stability a risk factor for lower extremity injuries in an athletic population? A systematic review. Physical therapy in sport : official journal of the Association of Chartered Physiotherapists in Sports Medicine, 30, 48–56.

Fatoye, F., Gebrye, T., & Odeyemi, I. (2019). Real-world incidence and prevalence of low back pain using routinely collected data. Rheumatology international, 39, 619-626.

Foster, N. E., Anema, J. R., Cherkin, D., Chou, R., Cohen, S. P., Gross, D. P., ... & Woolf, A. (2018). Prevention and treatment of low back pain: evidence, challenges, and promising directions. The Lancet, 391(10137), 2368-2383.

Freeman, M. D., Woodham, M. A., & Woodham, A. W. (2010). The role of the lumbar multifidus in chronic low back pain: a review. Pm&r, 2(2), 142-146.

Hodges, P. W., & Richardson, C. A. (1998). Delayed postural contraction of transversus abdominis in low back pain associated with movement of the lower limb. Clinical Spine Surgery, 11(1), 46-56.

Kälin, S., Rausch-Osthoff, A. K., & Bauer, C. M. (2016). What is the effect of sensory discrimination training on chronic low back pain? A systematic review. BMC musculoskeletal disorders, 17, 1-9.

Kim, C., Gottschalk, L., Eng, C., Ward, S., & Lieber, R. (2007). 160. The multifidus muscle is the strongest stabilizer of the lumbar spine. The Spine Journal, 7(5), 76S.

Maud, P. J., & Foster, C. (2006). Physiological assessment of human fitness. Human kinetics.

Mayer, T. G., Smith, S. S., Keeley, J. A. N. I. C. E., & Mooney, V. E. R. T. (1985). Quantification of lumbar function: part 2: sagittal plane trunk strength in chronic low-back pain patients. Spine, 10(8), 765-772.

Moussa, A. Z. B., Zouita, S. B. S. F., Salah, F. B., Behm, D. G., & Chaouachi, A. (2020). Isokinetic trunk strength, validity, reliability, normative data and relation to physical performance and low back pain: A review of the literature. International journal of sports physical therapy, 15(1), 160.

Mueller S, Mayer P, Baur H, Mayer F. Higher velocities in isokinetic dynamometry: a pilot study of new test mode with active compensation of inertia. Isokinet Exerc Sci 2011;19:63-70.

Pope, M. H., Bevins, T. H. O. M. A. S., WILDER, D. G., & Frymoyer, J. W. (1985). The relationship between anthropometric, postural, muscular, and mobility characteristics of males ages 18–55. Spine, 10(7), 644-648.

Ripamonti, M., Colin, D., Schmidt, D., Ritz, M., & Rahmani, A. (2009). Isokinetic evaluation of trunk muscles in healthy and low back pain subjects. Computer Methods in Biomechanics and Biomedical Engineering, 12(S1), 215-216.

Roussel, N., Nijs, J., Truijen, S., Breugelmans, S., Claes, I., & Stassijns, G. (2006). Reliability of the assessment of lumbar range of motion and maximal isometric strength. Archives of physical medicine and rehabilitation, 87(4), 576-582.

Shahtahmassebi, B., Hebert, J. J., Hecimovich, M. D., & Fairchild, T. J. (2017). Associations between trunk muscle morphology, strength and function in older adults. Scientific reports, 7(1), 10907.

Stark, T., Walker, B., Phillips, J. K., Fejer, R., & Beck, R. (2011). Hand-held dynamometry correlation with the gold standard isokinetic dynamometry: a systematic review. PM&R, 3(5), 472-479.

Suzuki l, N., & Endo, S. (1983). A quantitative study of trunk muscle strength and fatigability in the low-back-pain syndrome. Spine, 8(1), 69-74.

Tavares, J. M., Rodacki, A. L., Hoflinger, F., dos Santos Cabral, A., Paulo, A. C., & Rodacki, C. L. (2020). Physical performance, anthropometrics and functional characteristics influence the intensity of nonspecific chronic low back pain in military police officers. International Journal of Environmental Research and Public Health, 17(17), 6434.

Tsao, H., Danneels, L. A., & Hodges, P. W. (2011). ISSLS prize winner: smudging the motor brain in young adults with recurrent low back pain. Spine, 36(21), 1721-1727.

Tsao, H., Galea, M. P., & Hodges, P. W. (2010). Driving plasticity in the motor cortex in recurrent low back pain. European journal of pain, 14(8), 832-839.

Van Damme BB, Stevens VK, Van Tiggelen DE, Duvigneaud NN, Neyens E, Danneels LA. Velocity of isokinetic trunk exercises influences back muscle recruitment patterns in healthy subjects. J Electromyogr Kinesiol 2013; 23:378-386.

Yahia, A., Jribi, S., Ghroubi, S., Elleuch, M., Baklouti, S., & Elleuch, M. H. (2011). Evaluation of the posture and muscular strength of the trunk and inferior members of patients with chronic lumbar pain. Joint Bone Spine, 78(3), 291-297.