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Relationship between Core Muscles Endurance and Functional Lower Limb Performance in Patients with Chronic Mechanical Low Back Pain

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Abstract:
Purpose: The purpose of this cross-sectional, correlation study was to investigate the correlation between core muscles endurance and functional lower limb performance in patients with mechanical chronic low back pain. **Materials and methods:** Twenty-six subjects with chronic mechanical low back pain were included in this study. Their mean age was 31.27 ±6.75 years, and mean body mass index was 25.89 ± 1.82 kg/m^2. Researchers measured core muscles endurance with core endurance tests, and lower limbs` functional performance with hops tests. Spearman rank correlation coefficient was conducted to investigate the correlation between core muscles endurance and functional testing. **Results:** The findings of this study indicate that there was a correlation between right limb single hop and right-side trunk endurance; left leg single hop and trunk extension endurance; left leg triple hop and trunk extension endurance; percentage of improvement between right and left lower extremity triple hop and trunk prone endurance; and percentage of limb symmetry index during both lower limbs triple hop and trunk prone endurance ($p<0.05$). **Conclusion:** The findings of this study allow us to draw the conclusion that functional lower limb performance and core muscular endurance should be taken into consideration when planning exercise programs for patients with mechanical chronic low back pain.

Keywords: low back pain, mechanical chronic low back pain, core muscles endurance, functional performance.

1.Introduction:

Chronic mechanical low back pain (CMLBP) is a complicated, diverse medical condition that covers a wide range of symptoms in clinical settings and places a significant financial burden on the healthcare, social, and welfare systems (1).

The most common symptom of CMLBP, a functional aberration with no underlying cancer, is throbbing or excruciating pain in the thighs and buttocks. In terms of the severity of painful diseases, it is second only to headaches and frequently results in severe morbidity and impairment (2).

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Although the exact cause of CMLBP is unknown, there is growing evidence that it is complex in nature and may be exacerbated by dysfunction in the back and pelvic muscles (3,4).

The data available show that the current prevalence of CMLBP is 11.9%, the 1-year prevalence is 38%, and the lifetime prevalence is almost 80% among people under the age of 45 (3,1). Physical symptoms of CMLBP include tight hamstrings, paravertebral muscle spasm, and limited spinal motion. There can also be spinal pain that has persisted for at least a year (5-12).

The core muscle group relate the upper and lower extremities together, acting as the functional hub of the kinetic chain (13). Most people agree that the torso is the center of the body. The torso's core muscles are crucial for functional movements. The core musculatures are the 29 musculoskeletal pairs that support the lumbo-pelvic-hip complex to maintain the spine, pelvis, and kinetic chain during functional movement (14). The primary core muscles are situated in the mid- and lower back, around the abdomen, but peripheral structures like the hips, shoulders, and neck are also considered to be a part of the core (15).

According to the authors' knowledge, there haven't been enough studies looking at the connection between core muscles endurance and the functionality of the lower limbs in people with CMLBP. The authors believe this study may benefit Egyptian health care society, also it might benefit physical therapists by providing an evidence-based approach in assessment and treating patients with CMLBP using valid and reliable assessment and functional training exercise. Therefore, the aim of this study was to look into the correlation between the functional performance of the lower limbs and the endurance of the core muscles in CMLBP patients. Researchers predicted that in individuals with CMLBP, there would be no statistically significant correlation between the strength of the core muscles and the functionality of the lower limbs.

2.Patients and Methods

2.1.Study participants and recruitment criteria:

Twenty-six subjects with CMLBP met the inclusion criteria. The inclusion criteria were males and females with age between 20 and 45 years old with CMLBP for at least three months Their mean age was 31.27 ±6.75 years, and mean body mass index was 25.89 ± 1.82 kg/m^{2}.

Subjects were excluded if they had ever undergone surgery on their backs or lower extremities, or if their back pain was caused by a known pathology (such as an infection, tumor, osteoporosis, fracture, structural deformity, or inflammatory disorder like ankylosing spondylitis). Additionally, subjects who had red flags such as fever, unexplained weight loss, growing weakness, radiation to the lower leg, bowel or bladder problems, or who were pregnant were excluded from the study.

2.2. Study Design :

This was a cross-sectional correlation. This study was carried out in the physical therapy outpatient clinic of El sheikh Zayed specialized hospital in Cairo to investigate the relationship between core muscles endurance and functional assessment of lower limbs in patients with CMLBP. The study ran between august 2022 and April 2023. The study protocol was approved by the research ethical committee of the Faculty of Physical Therapy (NO. P. T. REC/012/003949). The study was registered as on clinicaltrials.gov, registration number(NCT05860218). The participants signed an informed consent form prior to the data collection.

2.3. Assessment procedure:

The subjects' eligibility to participate was checked once they had submitted their signed consent forms. Then, demographic information about them was gathered. The assessment of core muscles endurance and functional performance of both lower limbs was done after eligibility screening in order to rule out any red flags.

2.3.1. Core muscles endurance assessment:

The subject was then assessed for core musculatures stability via core stability tests involving trunk flexion/ McGill`s test (**figure 1-A**), trunk extension/ Sorenson test (**figure 1-B**), side (**figure 1-C**) and prone plank tests (**figure 1-D**). Core stability tests have been reported to be highly reliable (ICC ≥ 0.98) and showed moderate to high correlation with one another (correlation coefficient ranged from 0.4 to 0.8) (16).

a) For the McGill test, the participant's back leaned against a jig in a sit-up position that was 60 degrees (degrees) off the ground, their knees bent 90 degrees, their hips folded over their chests, their hands on the shoulder across from them, and their feet fastened. The patient was instructed to maintain isometric posture for the longest period of time feasible before the researcher pushed the jig back 10 centimeters. Thus, when the patients' backs touched the jig, it was considered a failure. The researcher also noted how long the subjects maintained an isometric stance, which is typically between one and two minutes (17).

b) The Sorenson test was carried out with the individuals' upper bodies off the end of the test bench and their pelvises, knees, and hips restrained. Hands were placed on opposite shoulders while the

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subjects' upper bodies were held across their chests. Failure was defined as the moment that a subject's upper body deviated from the horizontal position, and the researcher noted the amount of time that a subject typically maintained a straight posture for between one and two minutes (17).

c) Side plank test was conducted with subjects lied on side, then researcher asked to lift body on elbow, forearm, and feet were stacked to create a straight line from head to toes. Thus, failure was determined when subjects` body dropped; and researcher has recorded time that subjects has hold body straight with normal range of one and two minutes (17).

d) Prone plank test was conducted with subjects prone, then the researcher asked to support upper body off by elbow, forearm, and to take own weight by toes with legs straight via hip lifted off to create a straight line from head to toes. Thus, failure was determined when subjects` body dropped and hip was lowered; and researcher has recorded time that subjects has hold body straight with normal range of one and two minutes (18).

(A)

(B)

(C)

(D)

Figure (1): The 4 core endurance tests performed: A: McGill's flexion test, B: Sorenson's extension test, C: side plank test, D: prone Plank test.

2.3.2. Functional lower limbs performance assessment:

Subjects were assessed via one-legged hops tests involving single limb-single hop test for distance, and single limb-triple hop test for distance through recording the forward distance that subject travelled. The sensitivity of single (49%) (**figure 2-A**), triple (50%) (**figure 2-B**), and specificity was 94% for single hops. Side-to-side comparisons of hop performance calculated and 80% to 85% was considered normal. The minimum detectable change for each component; single hop test (8%), triple hop test (10%) (19-21).

a) single-limb, single-hop test was done to measure how far the patient could go while standing on one leg with the toes on the beginning line. The subject hopped as far ahead as she could and came to rest on the same limb. Over the course of two practice sessions, the hop distance was measured in cm. The test was repeated on the other limb (19).

b) single-limb, triple-hop test was done to measure how far the patient could go while standing on one leg with the toes on the beginning line. The patient made three successive, maximal hops as far forward as she could and came to rest on the same leg. Over the course of two practice sessions, the hop distance was measured in cm. The test was repeated on the other limb (19).

(A) **(B)**

Figure (2): The 2 one-legged hops tests: A: Single limb single hop test for distance, B: Single limb triple hop test for distance.

3. Data Analysis:

In order to detect an effect size of Cohen's d= 0.80 with 80% power (alpha= 0.05), G*power software (version 3.1.9.7; Franz Faul, Universitat Kiel, Germany) suggests we will need 26 participants . A flow diagram for assessment eligibility is presented in **figure 3**.

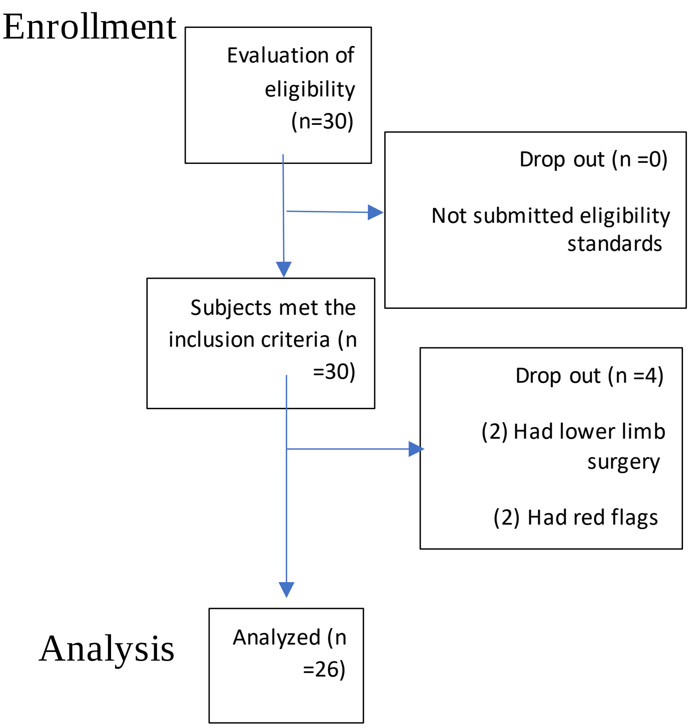

Figure 3: Flow diagram of the participants throughout the study

Statistical Analysis:

The statistical package for social sciences (SPSS) computer application for Windows, version 25 (IBM SPSS Inc., Chicago, IL, USA), was used to analyze the data. For continuous data, descriptive statistics were expressed as mean standard deviation, and for categorical variables, as frequency distribution (%). Shapiro-Wilk test was used to determine whether the data had a normal distribution. Since the data were not normally distributed, nonparametric statistics were used to examine the correlation between trunk endurance and functional testing using the Spearman rank correlation coefficient. All statistical tests had a significance threshold of p 0.05.

4. Results:

A total of 26 participants with CMLBP completed the study. There distribution revealed that there were 14 (53.8%) males and 12 (46.2%) females. The Shapiro-Wilk test revealed a mixture of normal and not normally distributed variables. Correlation coefficient for Spearman revealed the following correlations between core muscles endurance and functional lower limb assessment:

4.1. Trunk flexors endurance:

Table 1 showed The correlations between trunk flexors endurance and functional testing were weak positive non- substantial association with right single hop ($r = 0.052$, $p > 0.05$), moderately positive substantial association with left single hop ($r = 0.405$, $p < 0.05$), weak positive no significant correlation with right triple hop ($r = 0.129$, $p > 0.05$), weak positive no substantial association with left triple hop ($r = 0.185$, $p > 0.05$), a weak negative no substantial association with RT-LT single hop ($r = -0.267$, $p > 0.05$), a weak negative no substantial association with RT-LT triple hop ($r = -0.245$, $p > 0.05$), weak positive substantial association with LSI- single hop ($r = 0.267$, $p > 0.05$) and weak positive no substantial association with LSI- triple hop ($r = 0.245$, $p > 0.05$).

4.2. Trunk extensors endurance:

Table 1 showed The correlations between trunk extensors endurance and functional testing were weak positive no substantial association with right single hop ($r = 0.010$, $p > 0.05$), moderately positive substantial association with left single hop ($r = 0.481$, $p < 0.05$), moderately positive no substantial association with right triple hop (r =

0.332, p > 0.05), moderately positive substantial association with left triple hop (r = 0.463, p < 0.05), a weak negative no substantial association with RT-LT single hop (r = -0.254, p > 0.05), moderate negative substantial association with RT-LT triple hop (r = -0.371, p > 0.05), weak positive no substantial association with LSI-single hop (r = 0.254, p > 0.05) and moderately positive no substantial association with LSI-triple hop (r = 0.371, p > 0.05).

4.3. Right lateral flexors endurance:

Table 1 showed The correlations between right lateral flexors endurance and functional testing were moderately positive substantial association with right single hop (r = 0.413, p < 0.05), weak positive no substantial association with left single hop (r = 0.004, p > 0.05), moderately positive no substantial association with right triple hop (r = 0.004, p > 0.05), a weak negative no substantial association with left triple hop (r = -0.032, p < 0.05), weak positive no substantial association with RT-LT single hop (r = 0.227, p > 0.05), weak positive no substantial association with RT-LT triple hop (r = 0.272, p > 0.05), a weak negative no substantial association with LSI- single hop (r = -0.227, p > 0.05) and a weak negative no substantial association with LSI-triple hop (r = -0.272, p > 0.05).

4.4 Left lateral flexors endurance:

Table 1 showed The correlations between left lateral flexors endurance and functional testing were weak positive no substantial association with right single hop (r = 0.080, p > 0.05), a weak negative no substantial association with left single hop (r = -0.011, p > 0.05),a weak negative no substantial association with right triple hop (r = -0.039, p > 0.05),a weak negative no substantial association with left triple hop (r = -0.014, p < 0.05), weak positive no substantial association with RT-LT single hop (r = 0.093, p > 0.05), weak positive no substantial association with RT-LT triple hop (r = 0.216, p > 0.05), a weak negative no substantial association with LSI- single hop (r = -0.093, p > 0.05) and a weak negative no substantial association with LSI-triple hop (r = -0.216, p > 0.05).

4.5. Prone endurance:

Table 1 showed The correlations between prone endurance and functional testing were weak negative no substantial association with right single hop (r = -0.205, p > 0.05), moderately positive no significant correlation with left single hop (r = -0.316, p > 0.05), weak positive no substantial association with right triple hop (r = 0.011, p > 0.05), weak positive no substantial association with left triple hop (r = 0.270, p < 0.05), a weak moderate negative no substantial association with RT-LT single hop (r = -0.329, p > 0.05), moderate negative substantial association with RT-LT triple hop (r = -0.469, p > 0.05), moderately positive no substantial association with LSI- single hop (r = 0.329, p > 0.05) and moderate negative substantial association with LSI- triple hop (r = 0.469, p > 0.05)

5. Discussion:

The findings of this study can help medical professionals better understand The correlation between functional testing and core strength in people with mechanical persistent low back pain by providing them with additional evidence-based knowledge. Participants with chronic low back discomfort that is mechanical performed less effectively in terms of core muscle endurance, as indicated by the statistically significant between the two groups connection.

significant correlations between the endurance tests and the right single hop and right-side plank, the left single hop and extension endurance, the left triple hop and extension endurance, the percentage of improvement between the right and left lower extremity triple hop and prone endurance, and the percentage of limb symmetry index during both lower limbs triple hop and prone endurance, show the necessity of core strength for the proper function of both lower limbs. It may also be a sign that weak core muscles will negatively or positively impact both lower limbs' ability to function.

Lack of significant correlation between the other variables could be explained by the characteristics of the individuals or by their ability to perform well under pressure.

Table 1. correlation between core endurance and functional testing in the study group

	RT single hop	LT single hop	RT triple hop	LT triple hop	RT-LT single hop %	RT-LT triple hop %	LSI- single hop %	LSI- triple hop %
Flexors endurance	0.052	0.405*	0.129	0.185	-0.267	-0.245	0.267	0.245
extensors endurance	0.010	0.481*	0.332	0.463*	-0.254	-0.371	0.254	0.371
Right lateral flexors endurance	0.413*	0.004	0.004	-0.032	0.227	0.272	-0.227	-0.272
Left lateral flexors endurance	0.080	-0.011	-0.039	-0.014	0.093	0.216	-0.093	-0.216
Prone endurance	-0.205	0.316	0.011	0.270	-0.329	-0.469*	0.329	0.469*

***Correlation is significant at p-value ≤ 0.05 (2-tailed)**
Abbreviations: RT: right, LT: left ,LSI: limb symmetry index for distance , %:percent .

The examiner made sure the exams were given as accurately as possible and gave the participants clear instructions, despite the possibility that there would be some variation in how each participant performed. A trial was conducted for each test position prior to the recording of the real test trial (19).

Although this is the first study to look at the connection between core strength and functional assessment in people with CMLBP to author's knowledge, core endurance findings in this study are comparable to other published data in other body locations. Reid et al. and Ellenbecker (20.21) reported lower performance in core endurance in younger and older peoples with low back pain that is nonspecific Zazulak et al. (22) Tennis players with nonspecific LBP showed reduced extensor muscle activation (erector spinae and longissimus thoracis), fewer co-contraction patterns, and lower abdominal musculature endurance compared to asymptomatic healthy tennis players.

6.Study limitations:

There are several restrictions on this study that should be taken into account. Firstly, Due to differences in kinematics and muscle activation patterns between males and females, enrolling individuals of both sexes may not produce appropriate results (22). Secondly, a Since there was no reliability evaluation performed amongst the investigators who completed the assessment, it is challenging to guarantee that the outcomes are comparable. Although assessing inter- or intra-rater reliability was not the goal of this study, using such a process will enhance the results' internal and external validity. Thirdly, The slightly non-homogenous sample size and features may restrict how broadly the study's findings can be applied. We ended up with 26 individuals because of things like scheduling issues and/or reluctance to participate after completing the consent form.

Conclusion:

The findings of this study allow us to draw the conclusion that functional lower limb performance and core muscular endurance should be taken into consideration when planning exercise programs for patients with mechanical chronic low back pain.

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Declaration of competing interest;

The research was not specifically funded by any public, private, or nonprofit organizations, thus the writers say they don't have any conflicts of interest.

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