ALSALAM UNIVERSITY
International Journal of Physical Therapy Alsalam University
Journal Home Page: https://ijtau.journals.ekb.eg
ALSALAM UNIVERSITY FACULTY OF PHYSIOTHERAPY

IMPAIRED MOTOR CONTROL IN ROWERS WITH NON-SPECIFIC LOW BACK PAIN: A COMPARATIVE ANALYSIS WITH HEALTHY CONTROL

Mostafa Mohamed Atifab[1], Manal Mohamed Ismaila[2], Mohammed Moustafa Aldosouki Hegazyac[3], Nesreen Fawzy Mahmouda[4].

[1]*Department of Physical Therapy for Musculoskeletal Disorders and its Surgery, Faculty of Physical Therapy, Cairo University and Ahram Canadian University*

[2]*Department of Physical Therapy for Musculoskeletal Disorders and its Surgery, Faculty of Physical Therapy, Cairo University.*

[3] *Department of Physical Therapy for Musculoskeletal Disorders and its Surgery, Faculty of Physical Therapy, Cairo University and Department of health and rehabilitation Sciences, College of applied medical sciences, Prince Sattam bin Abdulaziz University, Saudia Arabia.*

[4-]*Department of Physical Therapy for Musculoskeletal Disorders and its Surgery, Faculty of Physical Therapy, Cairo University.*

Mostafa Mohamed Atif. Email: mostafa.atif64@yahoo.com
Manal Mohamed Ismail. Email: mfarrag@cu.edu.eg
Mohammed Mostafa Aldousoki Hegazy. Email: mohamed.mostafa@pt.cu.edu.eg
Nesreen Fawzy Mahmoud. Email: dr_nesreenfawzy@cu.edu.eg

ABSTRACT

Background: Non-specific low back pain (NSLBP) is prevalent among athletes, particularly rowers, affecting performance and quality of life.
Understanding motor control deficits (MCDs) in this context is crucial.
Objectives: To assess MCDs in rowers with NSLBP and compare the results with healthy rowers.
Methods: Eighty-four active rowers were included: those with NSLBP (n=42) and healthy controls (n=42).
Motor control deficits were evaluated using four motor control tests (MCTs) with a pressure biofeedback unit.
Results: Significant differences were observed between rowers with NSLBP and healthy controls across all MCTs ($p < 0.05$).
Conclusion: Motor control deficits are evident in rowers with NSLBP. Addressing these deficits is critical for reducing pain risk and improving performance. Keywords: Motor Control Deficit, Low Back Pain, Rowing, Athletes, Muscle recruitment.
Keywords: *Motor Control Deficit, Low Back Pain, Rowing, Athletes, Muscle recruitment.)*

1. Introduction

Low back pain (LBP) is one of the most prevalent musculoskeletal conditions worldwide, leading to significant activity restrictions, work absences, and imposing substantial medical and economic burdens (1). Athletes, particularly those engaged in sports requiring repetitive spinal loading, are at an increased risk of developing LBP, which can negatively impact their performance and long-term musculoskeletal health (2).
Post-retirement, athletes with a history of LBP may encounter significant disability. Therefore, identifying modifiable risk factors is essential to reduce the occurrence of LBP in athletes. For example, athletes engaged in sports that involve repetitive back rotation, such as skiing and gymnastics, often exhibit a high incidence of spinal instability.

Previous research has highlighted that risk factors for LBP in athletes are multifaceted, involving factors such as sport type, repetitive loading, and training frequency. However, many of these risk factors are based on expert opinions, case studies, and unpublished clinical data, lacking robust evidence directly linking them to LBP in athletes (3). Rowers are among athletes particularly prone to LBP, as rowing is primarily a strength-endurance sport. The repetitive motion involved in rowing can lead to soft tissues undergoing creep, resulting in decreased tissue stiffness throughout the range of motion and an overall increase in lumbar segment range of motion. This process has been suggested as a potential contributor to spinal instability (4). Recent research suggested that MCD, characterized by impaired muscle recruitment and movement patterns, may be a key factor in the development and persistence of LBP (5).

The relative flexibility theory posits that movement follows the path of least resistance, potentially resulting in compensatory strategies that exacerbate pain and performance limitations (6). While movement-based diagnostic frameworks have been proposed as effective tools for managing chronic and recurrent LBP, their application in rowing remains underexplored (7). There was a lack of literature concerning assessing MCD in rowers with NSLBP. Hence, this study aims to compare between rowers with NSLBP and healthy controls. While some experts suggest that motor control training may help alleviate LBP in rowers, there is limited solid evidence supporting this claim (8). While numerous studies have examined motor control deficits in individuals with low back pain, few have investigated these impairments in high-demand athletic populations like rowers.
This study addresses this gap by evaluating lumbopelvic control in symptomatic vs. asymptomatic rowers using validated movement control tests.The findings will provide clinicians with valuable insights to design effective rehabilitative programs targeting MCD to improve both rowers' performance and reduce pain levels.

2. Material and methods

2.1. Study design, Setting and Participants:

Participants were recruited using a convenience sampling method. The study included 84 active rowers from 4 rowing Egyptian clubs, dividing into two: Group A, consisting of 42 rowers diagnosed with NSLBP (participants), and Group B, the control group comprising 42 healthy rowers (also 42 participants), matched for age, weight, and training characteristics. All participants underwent motor control deficit assessments using four motor control tests (MCTs) with a pressure biofeedback unit (PBU). Ethical approval for the study was obtained from the Cairo University Ethics Committee (Approval No: P.T.REC/012/005063)

2.2. Sample size calculation:

A priori power analysis using G*Power 3.1.9.7 for an independent t-test (effect size d=0.697, α=0.05, power=0.80, two-tailed) indicated a required total sample size of 68 (34 per group). The study enrolled 84 participants (42 per group) to enhance statistical precision and reduce Type II error risk.

2.3. Inclusion Criteria:

Active male rowers practicing for at least one year, training 3 to 6 times per week; lightweight rowers (<75 kg males, <62.5 kg females) and heavyweight rowers (>75 kg males, >62.5 kg females); aged 18 to 26 years (2,9,10, 11)

2.4. Exclusion Criteria:

Specific back pain causes (e.g., tumor-related, radicular pain, fracture), recent skeletal injuries or tendinopathy, and para-rowers due to differing disability profiles (9).

2.5. Assessment Procedures

Motor Control Deficit Assessment Using Pressure Biofeedback Unit

Before the evaluation began, participants were asked to provide the following information: name, age, sex, weight, height, occupation, telephone number, duration of rowing, training sessions. Then, before testing, all participants were briefed about the assessment procedures and required to sign a consent form.
Four validated and reliable motor control tests (MCTs) were administered: Active Straight Leg Raising (ASLR), Knee Lift Abdominal Test (KLAT), Bent Knee Fallout Test (BKFO), and Prone Abdominal Drawing-in Test (7,11,12).

Active Straight Leg Raising (ASLR):
Participants lay supine with the PBU placed under the lumbar spine, inflated to 40 mmHg. Each leg was raised to 20 cm above the mat and held for 20 seconds. The maximum absolute deviation from 40 mmHg was recorded (13).

Pressure variations were indicative of compromised lumbopelvic stability, reflecting inadequate motor control during the movement task. This testing protocol and outcome measurement approach have been previously described by(13).

Knee Lift Abdominal Test (KLAT):
While the participants were in a supine position, the PBU is positioned horizontally under the lumbar spine, aligning the lower edge with the level of the posterior superior iliac spines and inflated to 40 mmHg. The participants lifted one foot off the mat until they attained a hip and knee flexion of 90° while the other leg was stable on the bed in 45° hip flexion and 90° knee flexion. At the same time, they were challenged to keep their lumbar spine in a neutral position. The test was done for both lower limbs. The maximum pressure deviation from 40 mmHg was recorded (13).
Pressure variations were indicative of compromised lumbopelvic stability, reflecting inadequate motor control during the movement task (11,14) .

Bent Knee Fallout Test (BKFO):
Participants assumed a standardized supine modified crook-lying posture with one knee flexed at 120° while the opposite limb remained neutral. They executed controlled hip movements of about 45° in combined abduction and lateral rotation, keeping foot contact next to the stationary knee. Dual interconnected PBU sensors were placed longitudinally at L3 to provide lumbar tactile feedback, initially stabilized at 40 mmHg. Only data from the PBU of the moving limb were analyzed, as the contralateral unit acted as a control for posture. The test was done for both lower limbs (13,14). The primary outcome measure was the maximum deviation (mmHg) from the 40 mmHg baseline, indicating lumbopelvic stability and motor control during movement tasks (5,11,14).

Prone Abdominal Drawing test:
Participants lay prone on a mat with arms alongside their trunks and an inflatable bag placed between the anterior superior iliac spine and the navel. The bag was initially inflated to 70 mmHg, and after two normal breaths, the pressure was reset. Upon a verbal cue, participants performed three contractions by drawing in their abdomen without shifting their lumbar spine or pelvis, maintaining that position for about 10 seconds each. The examiner ensured no movement occurred during these contractions (13)

Statistical analysis:
Descriptive statistics (mean, standard deviation) were calculated. The Shapiro-Wilk test assessed normality. Independent t-tests compared MCT scores between groups; Mann-Whitney U test was used for non-normally distributed variables (e.g., age). Statistical significance was set at $p \leq 0.05$. Analyses were conducted using IBM SPSS Statistics v25.

Results

The Shapiro–Wilk test revealed that age was not normally distributed; thus, the Mann–Whitney U test was used to compare age between the groups. Other continuous variables (weight, height, BMI) demonstrated normal distribution and were analyzed using independent samples t-tests.

Demographic Characteristics

There were no statistically significant differences between the healthy and NSLBP groups in age, weight, height, or BMI (all $p > 0.05$). The median age was 21 years in the healthy group and 23 years in the NSLBP group ($p = 0.11$). Mean (± SD) weight was 80.59 ± 6.47 kg for healthy rowers and 81.52 ± 7.83 kg for the NSLBP group ($p = 0.14$). Mean height and BMI were also comparable between groups (height: 183.73 ± 5.54 cm vs. 183.19 ± 7.16 cm, $p = 0.14$; BMI: 23.85 ± 1.37 kg/m² vs. 24.31 ± 2.16 kg/m², $p = 0.07$) (Table 1).
Regarding limb dominance, 90.5% of healthy rowers and 88% of NSLBP rowers reported right-side dominance.

Table 1: Weight, Height and BMI difference between the two groups

Variable	Group	N	Mean	Std. Deviation	t-value	p-value	Mean Difference
Weight(kg)	Healthy	42	80.59	6.47	-5.92	.14	-0.93
	NSLBP	42	81.52	7.83			
Height(cm)	Healthy	42	183.73	5.54	-0.39	0.14	0.55
	NSLBP	42	183.19	7.16			
BMI(kg\m2)	Healthy	42	23.86	1.37	-1.16	0.07	0.45
	NSLBP	42	24.32	2.16			

N: number of participants , STD : standard deviation ,t value : paired t test ,p value : probability value , NSLBP :non specific low back pain

Motor Control Test (MCT) scores:

Significant differences were observed between groups across all MCT variables (Table 2, Figure 1).

Active Straight Leg Raise (ASLR):
The NSLBP group exhibited significantly higher pressure deviations in both right and left legs (10.09 ± 4.61 mmHg and 10.78 ± 4.97 mmHg, respectively) compared to healthy controls (2.88 ± 2.12 mmHg and 2.95 ± 2.09 mmHg). These differences were statistically significant ($p < 0.001$ for both limbs).

Knee Lift Abdominal Test (KLAT):
Mean pressure deviations in the NSLBP group were significantly greater for both the right (15.88 ± 4.14 mmHg) and left (16.00 ± 4.99 mmHg) legs than in the healthy group (6.54 ± 3.91 mmHg and 5.92 ± 3.63 mmHg; $p < 0.001$ for both).

Bent Knee Fallout (BKFO):
Significant increases in pressure deviation were also noted in the NSLBP group (right: 15.85 ± 4.66 mmHg; left: 16.76 ± 5.66 mmHg) compared to healthy rowers (right: 7.52 ± 6.86 mmHg; left: 7.45 ± 4.83 mmHg; $p < 0.001$ for both).

Prone Abdominal Drawing Test:
Interestingly, the healthy group demonstrated higher pressure scores (12.00 ± 2.12 mmHg) than the NSLBP group (8.92 ± 2.15 mmHg), again with statistical significance ($p < 0.001$), indicating better deep muscle activation in healthy participants.

Table 2: Comparison between both groups regarding MCT scores.

MCT Tests (mmHg)	Group	N	Mean	St. deviation	t-value	p-value	Mean difference
ASLR RT	Healthy	42	2.88	2.12	-9.21	< 0.001*	-7.21
	NSLBP	42	10.09	4.61			
ASLR LT	Healthy	42	2.95	2.09	-9.40	< 0.001*	-7.83
	NSLBP	42	10.78	4.97			
KLAT RT	Healthy	42	6.54	3.91	- 10.58	< 0.001*	-9.33
	NSLBP	42	15.88	4.14			
KLAT LT	Healthy	42	5.92	3.63	-10.55	< 0.001*	-10.77
	NSLBP	42	16.00	4.99			
BKFO RT	Healthy	42	7.52	6.86	- 6.50	< 0.001*	-8.33
	NSLBP	42	15.85	4.66			
BKFO LT	Healthy	42	7.45	4.83	-8.01	< 0.001*	-9.30
	NSLBP	42	16.76	5.66			
Prone Test	Healthy	42	12.00	2.12	6.56	< 0.001*	3.07
	NSLBP	42	8.92	2.15			

N: number of participants , STD : standard deviation ,t value : paired t test ,p value : probability value , ASLR : active straight leg raising , BKFO : bent knee fallout , KLAT : knee lift abdominal test , RT : right side , LT : lift side, NSLBP :non specific low back pain, *:significant

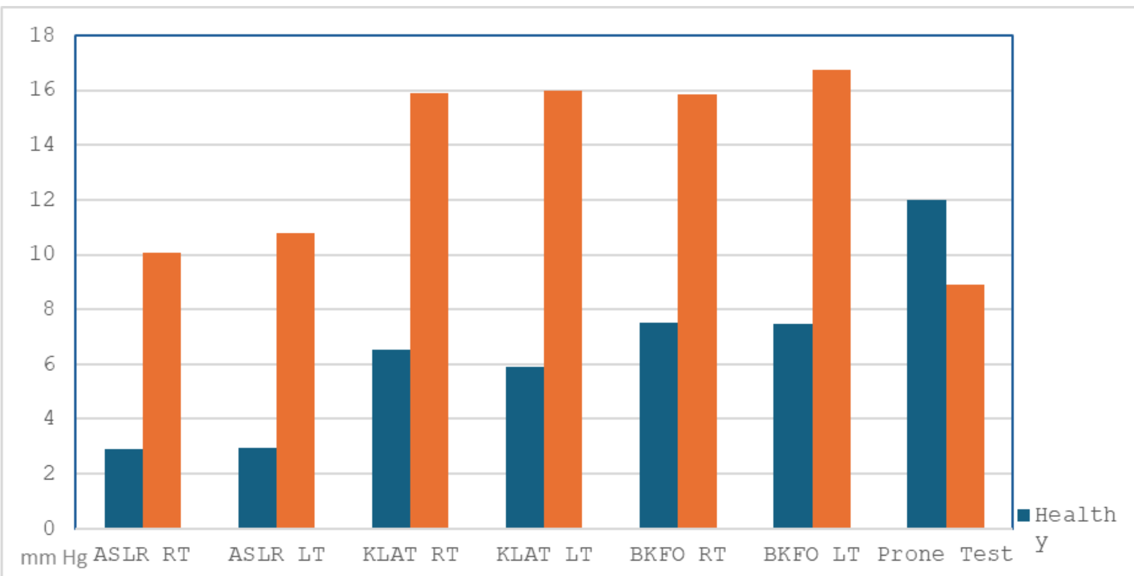

Fig 1: Comparison between both groups regarding the mean of the MCT scores.

Discussion

This study aimed to compare rowers with NSLBP to a healthy control group, the investigation focused on assessing the MCD. Rowers with NSLBP consistently performed worse on all MCTs compared to healthy controls.

This finding is consistent with previous researches that investigate MCDs in athletes suffering from LBP regardless of the type of sports that they practice. (15) Grosdent et al reported similar deficits in the performance of the KLAT and BKFO among soccer players with LBP compared to asymptomatic players. Similarly, (16) Roussel et al. identified significant differences in MCTs (KLAT and BKFO) between dancers with a history of LBP and those without. More recently, (17) Grosdent et. al observed comparable lumbopelvic MCD among tennis players using the KLAT, BKFO and three additional standardized tests: sitting knee extension test, waiter's bow, and transversus abdominis activation test. Also, Watanabe(19), reported that baseball players without LBP performed better in stability tests. These findings further highlight the relevance of motor control assessments in identifying movement deficiencies associated with LBP across diverse athletic populations.

These MCD observed in rowers may be attributed to abnormal movement patterns that exacerbate these impairments.(19) Athy et al.observed increased lumbar flexion and limited hamstring flexibility in rowers with NSLBP. Individuals with impaired motor control often rely on compensatory or inefficient strategies, such as excessive activation of superficial muscles (e.g., rectus abdominis and erector spinae). Moreover, restricted hip or pelvic motion may force the lumbar spine to compensate, thereby increasing strain on the lower back and surrounding tissues. Over time, such maladaptive patterns may contribute to the development and persistence of chronic pain (6).

Altered activation patterns of the transversus abdominis—a key muscle involved in motor control—have also been documented in individuals with NSLBP (21). Notably,21 Leonard et al. found that this abnormal activation pattern can persist even after symptom resolution.

Deficits in deep stabilizer muscles, such as the transversus abdominis and multifidus, can undermine spinal support and alignment. These muscles are critical for maintaining spinal stability and a neutral position during movement. Impaired activation or timing may result in excessive or uncontrolled spinal motion, thereby increasing stress on the vertebrae, discs, and ligaments. Over time, such dysfunctions can lead to repeated microtrauma or abnormal loading, ultimately contributing to back pain and injury (14).

Strength of the Study: This study demonstrates several methodological strengths. First, its focus on rowers—a population at high risk for NSLBP due to repetitive spinal loading—enhances the clinical relevance of the findings. The inclusion of 84 participants (42 per group) with matched age, weight, and training characteristics minimizes confounding variables and improves statistical power, reducing the likelihood of Type II errors. The use of validated MCT (e.g., ASLR, KLAT, BKFO with pressure PBU ensures methodological rigor, as these tests are standardized and have established reliability in assessing lumbopelvic stability.

Limitation of The Study:

Despite its strengths, the study has notable limitations. Its cross-sectional design precludes causal inferences, as it cannot determine whether MCDs precede or result from NSLBP. The absence of longitudinal follow-up also limits insights into whether MCDs persist or resolve with pain alleviation or targeted training. Results may not generalize beyond athletic populations.

Recommendations and Clinical Implementation:

This study underscores the importance of addressing MCD in rowers with NSLBP. Clinicians should prioritize early screening using PBU tests to identify athletes at risk and establish baseline deficits. Rehabilitation programs should be structured in phases, beginning with isolated motor control activation and progressing to dynamic stability drills. Integrating real-time PBU during training helps athletes maintain neutral spinal alignment. Physiotherapists should design individualized programs focusing on neuromuscular re-education of deep stabilizers and dynamic hip-pelvis dissociation to reduce compensatory lumbar motion.

Conclusion

The study concluded that MCDs were observed in rowers with NSLBP. Addressing these deficits is crucial for reducing pain.

Disclosure Statement:

No author has any financial interest or received any financial benefit from this research.

Conflict of Interest:

The authors stated there was no conflict of interest.

Funding:

This study did not receive any form of funding.

References

1. Wu, A., March, L., Zheng, X., Huang, J., Wang, X., Zhao, J., Blyth, F. M., Smith, E., Buchbinder, R., & Hoy, D. (2020). Global low back pain prevalence and years lived with disability from 1990 to 2017: estimates from the Global Burden of Disease Study 2017. Annals of Translational Medicine, 8(6), 299–299. https://doi.org/10.21037/ATM.2020.02.175
2. Moradi, V., Memari, A.-H., ShayestehFar, M., & Kordi, R. (2015). Low Back Pain in Athletes Is Associated with General and Sport Specific Risk Factors: A Comprehensive Review of Longitudinal Studies. Rehabilitation Research and Practice, 2015, 1–10. https://doi.org/10.1155/2015/850184
3. Noormohammadpour, P., Rostami, M., Mansournia, M. A., Farahbakhsh, F., Pourgharib Shahi, M. H., & Kordi, R. (2016). Low back pain status of female university students in relation to different sport activities. European Spine Journal, 25(4), 1196–1203. https://doi.org/10.1007/S00586-015-4034-7,
4. Reid, D. A., & McNair, P. J. (2000). Factors contributing to low back pain in rowers. British Journal of Sports Medicine, 34(5), 321–322. https://doi.org/10.1136/BJSM.34.5.321,
5. Luomajoki, H., Kool, J., De Bruin, E. D., & Airaksinen, O. (2007). Reliability of movement control tests in the lumbar spine. BMC Musculoskeletal Disorders, 8(1), 1–11. https://doi.org/10.1186/1471-2474-8-90/TABLES/3
6. Sahrmann, S., Azevedo, D. C., & Dillen, L. Van. (2017). Diagnosis and treatment of movement system impairment syndromes. Brazilian Journal of Physical Therapy, 21(6), 391–399. https://doi.org/10.1016/J.BJPT.2017.08.001,
7. Luomajoki, H., Kool, J., de Bruin, E. D., & Airaksinen, O. (2010). Improvement in low back movement control, decreased pain and disability, resulting from specific exercise intervention. Sports Medicine, Arthroscopy, Rehabilitation, Therapy and Technology, 2(1). https://doi.org/10.1186/1758-2555-2-11,
8. Wilson, F., Ng, L., O'Sullivan, K., Caneiro, J. P., O'Sullivan, P. P. B., Horgan, A., Thornton, J. S., Wilkie, K., & Timonen, V. (2021). "You're the best liar in the world": A grounded theory study of rowing athletes' experience of low back pain. British Journal of Sports Medicine, 55(6), 327–335. https://doi.org/10.1136/BJSPORTS-2020-102514,
9. Maher, C., Underwood, M., & Buchbinder, R. (2017). Non-specific low back pain. The Lancet, 389(10070), 736–747. https://doi.org/10.1016/S0140-6736(16)30970-9
10. Trompeter, K., Fett, D., & Platen, P. (2017). Prevalence of Back Pain in Sports: A Systematic Review of the Literature. Sports Medicine, 47(6), 1183–1207. https://doi.org/10.1007/S40279-016-0645-3,
11. Biele, C., Möller, Di., Von Piekartz, H., Hall, T., & Ballenberger, N. (2019). Validity of increasing the number of motor control tests within a test battery for discrimination of low back pain conditions in people attending a physiotherapy clinic: A case-control study. BMJ Open, 9(11). https://doi.org/10.1136/BMJOPEN-2019-032340,
12. Roussel, N. A., Nijs, J., Mottram, S., Van Moorsel, A., Truijen, S., & Stassijns, G. (2009). Altered lumbopelvic movement control but not generalized joint hypermobility is associated with increased injury in dancers. A prospective study. Manual Therapy, 14(6), 630–635. https://doi.org/10.1016/J.MATH.2008.12.004,
13. Solana-Tramunt, M., Ortegón, A., Morales, J., Nieto, A., Nishishinya, M. B., & Villafañe, J. H. (2019). Diagnostic accuracy of lumbopelvic motor control tests using pressure biofeedback unit in professional swimmers: A cross-sectional study. Journal of Orthopaedics, 16(6), 590–595. https://doi.org/10.1016/J.JOR.2019.06.002,
14. Comerford, M. and Mottram, S. (2012) Kinetic Control The Management of Uncontrolled Movement. Elsevier, Amster-dam. - References - Scientific Research Publishing. (n.d.). Retrieved April 30, 2025, from https://www.scirp.org/reference/referencespapers?referenceid=2203051
15. Grosdent, S., Demoulin, C., Rodriguez de La Cruz, C., Giop, R., Tomasella, M., Crielaard, J. M., & Vanderthommen, M. (2016). Lumbopelvic motor control and low back pain in elite soccer players: a cross-sectional study. Journal of Sports Sciences, 34(11), 1021–1029. https://doi.org/10.1080/02640414.2015.1085077,
16. Roussel, N. A., Nijs, J., Meeus, M., Mylius, V., Fayt, C., & Oostendorp, R. (2013). Central sensitization and altered central pain processing in chronic low back pain: Fact or myth? Clinical Journal of Pain, 29(7), 625–638. https://doi.org/10.1097/AJP.0B013E31826F9A71,
17. Grosdent, S., Grieven, L., Martin, E., Demoulin, C., Kaux, J. F., & Vanderthommen, M. (2023). Effectiveness of resisted training through translation of the pelvis in chronic low back pain. Journal of Back and Musculoskeletal Rehabilitation, 36(2), 493–502. https://doi.org/10.3233/BMR-220119
18. Watanabe, Y., Kato, K., Otoshi, K., Tominaga, R., Kaga, T., Igari, T., Sato, R., Oi, N., & Konno, S. ichi. (2022). Associations between core stability and low back pain in high school baseball players: A cross-

sectional study. Journal of Orthopaedic Science, 27(5), 965–970. https://doi.org/10.1016/J.JOS.2021.05.010,

19. Athy, V., Hach, S., Anderson, H., & Mason, J. (2023). Examining the Peer-Reviewed Published Literature Regarding Low Back Pain in Rowing: A Scoping Review. International Journal of Sports Physical Therapy, 18(1), 55–69. https://doi.org/10.26603/001C.67836,
20. Hu, H., Meijer, O. G., van Dieën, J. H., Hodges, P. W., Bruijn, S. M., Strijers, R. L., Nanayakkara, P. W., van Royen, B. J., Wu, W., & Xia, C. (2010). Muscle activity during the active straight leg raise (ASLR), and the effects of a pelvic belt on the ASLR and on treadmill walking. Journal of Biomechanics, 43(3), 532–539. https://doi.org/10.1016/J.JBIOMECH.2009.09.035,
21. Leonard, J. H., Paungmali, A., Sitilertpisan, P., Pirunsan, U., & Uthaikhup, S. (2015). Changes in transversus abdominis muscle thickness after lumbo-pelvic core stabilization training among chronic low back pain individuals. Clinica Terapeutica, 166(5), 312–316. https://doi.org/10.7417/T.2015.1884,