SYSTEMATIC REVIEW

Effectiveness of Lumbar Stabilization Exercise on Pain, Disability and Functional Performance among Older People with Low Back Pain: A Systematic Review

Zarina Zahari[1], Siti Aishah Shaiful Azan[2], Naim Faiz Ahmad Imran[1]

[1] Centre for Physiotherapy, Faculty of Health Sciences, Universiti Teknologi MARA Puncak Alam Campus, Selangor, Malaysia
[2] Klinik Kesihatan Telok Datok, Jalan Pegawai, 42700 Banting, Kuala Langat, Selangor, Malaysia

ABSTRACT

Introduction: Lumbar stabilization exercises may improve core stability and reduce low back pain among older persons. However, the evidence is scarce. The objective of this study was to update evidence on the effectiveness of lumbar stabilization exercises on pain, disability, and functional performance among older persons with low back pain. **Methods:** This systematic review retrieved articles from PubMed, MEDLINE (via EBSCO), PEDro, Google Scholar, and ScienceDirect published from 2005 to 2020. The selected articles were scored using the McMaster Critical Review Form for Quantitative Studies for quality assessment. The data was extracted based on the study design, sample size, inclusion criteria, intervention, outcome, and conclusion. **Results:** A total of 2349 articles were found but only two articles met the inclusion criteria with both showing excellent scores on the McMaster Critical Review Form for Quantitative Studies. The findings showed lumbar stabilization exercises alone or combined with other interventions were effective in reducing pain intensity, and improving disability, and gait functional performance among older persons with low back pain. **Conclusion:** The current study suggests lumbar stabilization exercise is effective for pain, disability, and functional performance among older persons. However, further investigation is needed to gain more conclusive evidence for clinical practice.
Malaysian Journal of Medicine and Health Sciences (2023) 19(4):307-314. doi:10.47836/mjmhs19.4.43

Keywords: Lumbar Stabilization, Older Persons, Low Back Pain, Disability, Functional Performance

Corresponding Author:
Zarina Zahari, PhD
Email: zarinazahari@uitm.edu.my
Tel: +603-3258 4368

INTRODUCTION

Low back pain is a musculoskeletal problem commonly associated with ergonomically incorrect posture and working conditions (1). Several risk factors are also contributing to the persistent recurrence of low back pain. These risk factors include a previous history of low back pain, a family history of low back pain, cigarette smoking, nightmare frequency, sleep quality, and self-perceived fitness (2). Low back pain is reported as a worldwide concern, with high incidences involving particularly males aged 35 to 50 years (3). Studies have reported that low back pain prevalence in a lifetime is as high as 84%, and chronic low back pain has a prevalence of about 23%. Of this percentage, 11-12% of the population is affected with different disabilities due to back pain (4).

The United Nations (2010) has stated that in 2050, the number of older persons above the age of 60 years would rapidly rise threefold which could be due to better healthcare services thus increasing the quality of life. However, low back pain is the most common health issue affecting older persons which results in pain and disability (5). It is reported that low back pain affects at least 12-42% of individuals above age 65 years old (6). Meanwhile, it is the most common musculoskeletal disease experienced by older persons over the age of 75. Additionally, low back pain results in other consequences among older persons, including withdrawal from social and leisure activities, sleep disturbances, psychological distress, malnutrition, cognition disruption, falls, and deterioration of functional ability (7).

Low back pain among older persons is categorized into three phases, which are acute, sub-acute, and chronic which is similar to younger age people. Acute low back pain is defined as pain in the low back for less than a month, while the sub-acute phase may continue from a month to 6 months and the chronic phase may persist for more than 7 months (8). Low back pain in older persons is currently managed through conservative approaches rather than surgery which could be more

vulnerable due to the aging process and a greater risk of developing complications following the operative procedure. The common approaches include massages, spinal manipulation, exercises, self-management, and patient education (9). A previous study reported three recommended non-invasive low back pain management treatments for older persons (10).

The first recommendation is for patients with the acute and sub-acute phases. This approach involves the administration of non-pharmacologic interventions such as superficial heat, acupuncture, massage, and spinal manipulation, but, if pharmacologic treatment is needed, nonsteroidal anti-inflammatory drugs or skeletal muscle relaxants are recommended. This approach is recommended because clinicians should prevent costly and possibly harmful prescriptions for patients with low back pain, especially narcotics, as stated by the American College of Physicians (11). If low back pain does not much improve and turns to chronic then the second recommendation should be the choice for management.

The second recommendation is for patients with chronic low back pain. This approach involves the administration of non-pharmacologic interventions including exercises, acupuncture, rehabilitation, mindfulness-based stress therapy, yoga, tai chi, progressive relaxation, motor control training, operant therapy, cognitive-behavioral training, or spinal manipulation. This recommendation is aligned with guidelines from the National Institute for Health and Care Excellence (12)¬¬¬¬, to reduce pain and improve function. However, when these choices are failed then the third recommendation may become the choice for the management.

The third recommendation is for patients with chronic low back pain who are less responsive to non-pharmacologic therapy which could be due to interference of behavioral or psychological factors or central mechanisms rather than physical factors which is more complex. As the first line of therapy, patients can be administered pharmacologic interventions, particularly non-steroidal anti-inflammatory drugs. The second line of therapy may be prescribed with other pharmacologic interventions such as tramadol or duloxetine which provide greater analgesic effects to combat pain (12-13). Patients who have failed to respond to the aforementioned medications may be considered for opioids that offer further greater analgesic effects. However, this is only an option if the benefits far outweigh the patient's risks and after careful consideration. Caution is, however, included as opioid abuse may result in death (13).

Lumbar stabilization exercises using McGill and Sahrmann regimes focus on multifidus and transverse abdominis muscle control have been shown to have positive effects on self-support ability in older persons living fitness (increased strength and muscle endurance, improved flexibility), dynamic balance, and agility and activities of daily living (14). However, this particular study investigated women only and with a small sample size (N= 41). Furthermore, lumbar stabilization exercises result in a reduction in pain level (15-17), improved disability (15-20), enhanced gait velocity (18), gait in Time Up and Go, improved cadence, and increased velocity among stroke patients (21). However, most studies did not include older persons with LBP. The majority of the available literature investigated chronic low back pain in adults but not older persons. This has shown limited information on the effect of lumbar stabilization management in the older person population.

A meta-analysis (22) found that core stabilization exercises reduce pain and improve disability in adults with chronic low back pain. However, their study also involved the adult population and not older persons. Thus, these findings are heterogeneous due to the different populations involved. The results might be different when investigated among older persons which could be interfered with by the aging process. Recent studies also found that exercises help to delay the process of aging and improve pain and disability.

There are numerous studies reported on the effects of stabilization exercises in older persons however, fewer investigations were found in low back pain. There is limited evidence on the effects of lumbar stabilization exercises among older persons with low back pain thus, make the results inconclusive. Therefore, this paper aims to review studies on the effect of lumbar stabilization exercises on pain intensity, disability, and functional performance among older persons with low back pain. The finding of this study is crucial to improve the current practice involving lumbar stabilization exercises, to treat low back pain among older persons.

METHODOLOGY

Study Design

This study used a systematic review method and followed the PRISMA (Preferred Reporting Items for Systematic Review and Meta-Analyzes) guidelines. This design can detect methodological flaws and identify knowledge gaps (23) for better-quality studies. This review was not registered on PROSPERO or another registration body.

Search Strategies

Searches were performed by one reviewer (SASA) using the available online databases through PubMed, MEDLINE (via EBSCO), PEDro, Google Scholar, and ScienceDirect, and ranged from the year 2005 to 2020. The keywords used in the search were done by constructing synonyms of the clinical research question. The keywords were combined and searched using the Boolean Operators 'AND' and 'OR' to narrow down and

specify the search results that were relevant to the study. Finally, the keywords used were (("lumbar stabilization" OR "co-contraction" OR "drawing in") AND ("low back pain" OR "back pain" OR "lumbar pain" OR "backache" OR "lumbago pain") AND ("older person*" OR "elderly" OR "older adult*" OR "senior geriatric*" OR "older population*" OR "elder")). The search was not included either for the grey literature or pearling of the literature because they may be at high risk of bias for a number of reasons.

Eligible Criteria and Selection Process

For this review, the inclusion criteria used the PICO principle where, the study must include (i) Population (older persons with low back pain: age > 60 years old), (ii) Intervention (lumbar stabilization exercises), (iii) Comparison (other treatments), and (iv) Outcome (pain, disability, and functional performance) (Table I). The article must also be full text, in English, and an interventional randomized or non-randomized type of study. The article was excluded when (i) Population (low back pain involving pregnant women, surgery, chronic severe osteoarthritis, and rheumatoid arthritis), (ii) Intervention (no specific lumbar stabilization exercises), and (iii) Outcome (psychological involvement, depression, sleep disturbance).

Table I: Inclusion criteria

Parameters	Items
Design	• Randomised or non-randomised controlled trial
Participants	• Older people aged above 60 years old • Experiencing lower back pain
Intervention	• Lumbar stabilization exercise
Comparison	• Other treatment
Outcome measures	• Pain intensity (VAS / NRS) • Disability (RODI / RMDQ / ODQ) • Functional performance (example: gait, balance)

Data Extraction Processes

One reviewer (SASA) screened the studies for titles and full texts. Data were then extracted from relevant studies by one reviewer (SASA) and then discussed and checked by three reviewers (ZZ, SASA, NFAI). Multiple reviewers are required for these processes to minimize bias during data extraction.

Quality Appraisal

Studies that met the inclusion criteria were critically appraised for methodological quality using the Modified Guidelines for use of the McMaster Critical Appraisal Form for Quantitative Studies (24) by two reviewers (ZZ, SASA). The instrument consists of sixteen items, namely; purpose, literature review, study design, blinding, sample description, sample size, ethics and consent, the validity of outcome, reliability of outcomes, intervention description, statistical significance, statistical analysis, clinical importance, conclusion, clinical implications, and study limitations. All of the items were given a score of "yes" = 1, "no" = 0, or "not addressed". The total score is 16 points with interpretation as poor (score 0-8), fair (9-10), good (11-12), very good (13-14), and excellent (15-16).

Data Analysis

The data from the reviewed articles were extracted based on the study design, sample size, inclusion and exclusion criteria, intervention, outcome, and conclusion. The effects of lumbar stabilization exercises for older persons with LBP on pain intensity (VAS, NRS), disability (RMDQ / ODQ), and functional performance (gait speed, static/ dynamic balance) were analyzed. Later, the descriptive analysis of the McMaster score was analyzed for mean, median, and standard deviation. Ethical approval was not required for conducting a systematic review.

RESULTS

Included studies

Through the search of published articles from the year 2005 to 2020 through PubMed, MEDLINE (via EBSCO), PEDro, Google Scholar, and ScienceDirect, a total of 2349 articles were found. However, after the removal of duplication, and screening for full-text English articles, titles, and abstracts using the PRISMA Flow Diagram (Figure 1), only 2 articles (25-26) were eligible for the review. The quality appraisal score for the selected articles is demonstrated in Table II.

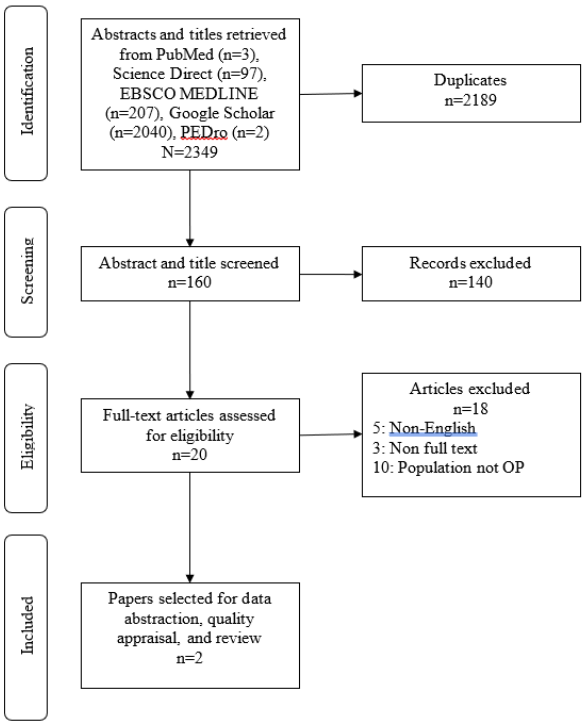

Figure 1: PRISMA flow diagram of search strategies

Table II: Quality Appraisal Score

Study	Mc Master Criteria Score																Total score	Quantitative description
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16		
Ozsoy et al. 2019 (25)	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	15/16	Excellent
Kim et al. 2018 (26)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	16/16	Excellent

Note:
1=yes, 0=No, Q = Question

Risk of Bias

The results of the assessment of the bias risks determined the possibility of biases in the design, conduct, and analysis through the "risk of bias" evaluation for each of the two reviewed articles. The results demonstrated a high risk of bias in both articles (Table III).

The Articles That Support the Effectiveness of Lumbar Stabilization Exercise Among Older Persons with Low Back Pain

The study design of the two reviewed articles was a randomized control trial (RCT) (25) and a quasi-experimental study (26). The study design, sample, inclusion and exclusion criteria, interventions, outcomes measured, and result from both studies are presented in Table IV.

Effect of Lumbar Stabilization Exercise on Pain

Ozsoy et al. (25) reported that lumbar stabilization exercises improved pain intensity in low back pain among older persons ($p<0.001$). The pain intensity and pain pressure threshold between pre-and post-intervention were statistically significant ($p<0.001$). However, the pain intensity at rest showed no significant difference ($p>0.05$). Nevertheless, Kim et al. (26) did not evaluate and report pain intensity.

Table III: Risk of bias

Articles / criterion	Ozsoy et.al. 2019 (25)	Kim et. al. 2018 (26)
Random sequence generation (selection of bias)	Low	High
Allocation concealment	High	High
Blinding participants and personnel (performance bias)	Low	High
Blinding outcome assessment (detection bias) self-reported outcome	High	High
Blinding of outcome assessment (detection bias) objective measure	High	High
Incomplete outcome data (attrition bias)	Low	Low
Selective reporting	Low	Low
Other bias	Unclear	Unclear

Effect of Lumbar Stabilization Exercise on Disability

Both articles reported the significant effect of lumbar stabilization exercise on disability among older persons with low back pain, with $p=0.001$ and $p<0.001$, respectively. Ozsoy et al. (25) used the Oswestry Disability Index (ODI) and showed a statistically significant reduction in ODI scores between pre-and post-intervention in both groups ($p<0.001$). In contrast, the time interaction between groups showed no significant difference in their ODI scores ($p>0.05$). On the other hand, Kim et al. (26) used the Korean Oswestry Disability Index (K-ODI) and Korean Roland Morris Disability Questionnaire (K-RMDQ) as assessment tools in their study. The authors reported that both hollowing lumbar stabilization and bracing lumbar stabilization exercises showed significant differences within each group ($p=0.001$), but no significant differences between groups ($p=0.20$).

Effect of Lumbar Stabilization Exercise on Functional Performance

Only Ozsoy et al. (25) reported improvement in functional performance among older persons with low back pain through assessment of patients' gait characteristics, for ambulation index using Biodex Gait Trainer 2. A core stabilization exercise combined with the myofascial release technique showed a significant difference in ambulation index between pre-and post-intervention ($p=0.047$), compared to the myofascial release technique alone ($p>0.05$). The researchers conducted the myofascial relaxation technique with a roller massager along the superficial backline (from the plantar surface of the toe phalanges to the occiput) bilaterally. The roller massage application was carried out along four separate myofascial tracks (plantar fascia and short toe flexors, gastrocnemius/Achilles tendon, hamstrings, and sacrolumbar fascia/erector spinae) of the superficial back line. However, there was no significant difference between the myofascial release technique group and core stabilization exercise combined with the myofascial release technique group, specifically on walking speed, step cycle, step length, coefficient of variation, and time on foot (all $p>0.05$). Nevertheless, Kim et al. (26) did not investigate functional performance.

Methodological Quality of the Studies

Both articles scored excellent for their methodological quality based on the Modified Guidelines for use of

Table IV: Study Design, Sample, Inclusion and Exclusion Criteria, Intervention, Outcome Measures, Result and Conclusion

Author	Ozsoy *et al.* 2019 (25)	Kim *et al.* 2018 (26)
Study design	RCT	Quasi- Experimental Study
N	45 older people divided into two groups	38 older adult women with non-specific LBP
Inclusion	Patients older than 65 years with ongoing LBP for at least 3 months, having no neurological or orthopedic problems, and Standardized Mini-Mental State score equal to or greater than 24 points	Elderly women aged 60 or older, diagnosed with chronic non-specific LBP by a doctor, could participate in intervention 3 times a week or more, and e living in Seongbuk-gu
Exclusion	Patients who had LBP originating from various pathologies, such as presence of cord compression, radiculopathy, osteo- porosis or osteopenia (t score>-1), as well as those who received any treatment for their LBP using long-term anticoagulant or corti-costeroid drugs	Has previous spinal surgery or spinal pathologic conditions such as lumbar herniated intervertebral disk, spondylolysis, spondylolisthesis, or nerve root pain signs
Intervention	Exp = Core stabilization exercise with Myofascial Release Technique Hold 5-10s x 8-15reps x 1-3sets x 3/wk x 6 wk Hot pack 15 mins TENS Con = Core stabilization exercise Hold 5-10s x 8-15reps x 1-3sets x 3/wk x 6 wk Hot pack 15 mins TENS	Exp = Group 1 Hollowing Lumbar Stabilization Exercise Hold 3/5/8s Ч 1hour x 3/wk x 12 wk Group 2 Bracing Lumbar Stabilization Exercise Hold 3/5/8s x 1hour x 3/wk x 12 wk Each group performed 5 lumbar stabilization exercises, including side plank exercise, bridge exercise, 4-kneeling exercise, prone plank exercise, and prone back extension exercise with hollowing and bracing strategy
Outcome measures	• Pain = VAS • Pain Pressure Threshold = Algometer commander • Disability = ODI • Lower body flexibility = chair sit and reach test • Kinesiophobia = Tampa Scale of Kinesiophobia • Core stability endurance = supine bridge test • Spinal mobility assessment = the Spinal Mouse System • Gait characteristic = Biodex Gait Trainer 2 • Quality of life = WHOQOL-OLD • Follow-up = 0, 16, 22 wk	• Disability = K-ODI, K-RMDQ • Trunk muscle strength = dynamometer • Balance = 1-leg standing test • Follow-up = 3, 9, 12 wk
Results	Both groups had reduced pain, improved disability, increased lower body flexibility, reduced kinesiophobia, improved gait characteristics, and quality of life but no significant differences between both groups. CSE+MRT was found to improve core stability endurance and spinal mobility compared to the CSE group.	In low back disability, K-ODI for HLSE and BLSE had significant differences (p= .001) within-group but no significant difference (p= .02) between groups.

Exp = experimental group, Con = control group, etc

the McMaster Critical Appraisal Form for Quantitative Studies. Only Ozsoy et al. (25) used blinding of participants and a randomization method on age and gender, to assign participants into two groups. Blinding of the participants was crucial to exclude the placebo effect (27). Blinding of assessors was important to exclude assessors' biases on the measured outcomes. Blinding of therapists was essential to prevent the therapist's attitude which may influence the intervention chosen for the tested group.

DISCUSSION

Effects of Lumbar Stabilization Exercises on Low Back Pain among Older Persons

This study aimed to review articles on the effects of lumbar stabilization exercise on pain, disability, and functional performance among older persons with low back pain. The findings of this study revealed that lumbar stabilization exercises comprise of abdominal drawing-in / hollowing and bracing techniques improved pain intensity, disability, and functional performance.

The study by Ozsoy et al. (25) showed that lumbar stabilization exercises (core stabilization) significantly ($p<0.001$) improved pain intensity at rest and during activity value between pre-and post-intervention among older persons with low back pain. This finding was consistent with other studies (28-30) which found that lumbar stabilization exercise was able to reduce pain intensity among older persons with low back pain. Unfortunately, although those three articles (28-30) investigated lumbar stabilization exercises among the older person population, they were excluded from the review and analysis because they were not written in full-text English language which caused a barrier for the researchers to completely understand the writing. The improvement in pain in Ozsoy et al. (25) can be explained that when the multifidus and transversus abdominis control improved, this helped increase the stability surrounding the lumbar spine thus alleviating the pain (31). Nevertheless, Ozsoy et al. (25) was unable to demonstrate a significant ($p>0.05$) reduction in pain intensity between core stabilization exercise alone and core stabilization exercise combined with myofascial release. This could be because the pain among the sufferers is more affected by the deep stabilizer muscles than the superficial structures, thus when core stabilization exercises were applied in both groups regardless of additional superficial myofascial

release, the effect would be similar. Hence, the results unable to show which intervention was better than the other.

This finding was inconsistent with Smith et al. (32), who stated that lumbar extension exercise with pelvic stabilization resulted in significant ($p<0.05$) improvement in pain intensity when compared with non-pelvic stabilization. The method of pelvic stabilization was different from core stabilization in Ozsoy et al. (25) but maintained the pelvis in a neutral position while performing back extension. If core stabilization is combined together with pelvic stabilization as in Smith et al. (32) to work on the back muscle strength, the results in pain intensity might be further improved. This is because when emphasizing the pelvis in a neutral zone position, the core muscles are activated more and able to provide a greater stability function thus allowing the back extensor muscles to work more efficiently towards improving their strength in extension and ultimately reducing pain intensity. Following this, the older person has a better ability to move and perform activities, thus will improve overall function and disability.
However, core muscle recruitment is slower in older persons than the younger persons due to the physiological changes when aging (33). The reduction in muscle mass might cause a reduction in the motor unit which cause the slow firing of impulse. This will interfere the muscle strength and if neglected can progress to disability. Therefore, recommendations for consistent optimal core muscle stabilization and resistance training may be beneficial to retain and improve the functional performance of older persons with low back pain (34).

This study demonstrated both articles (25-26) showed a significant improvement effect of lumbar stabilization exercise on the level of disability among older persons with low back pain. This finding is consistent with other studies (28, 32), which used ODI as a disability assessment tool. However, a study (35) on a specific spinal stabilization exercise, showed no significant effect compared to conventional physiotherapy. Cairns et al. (35) particularly evaluated disability, pain intensity, and the physical component of quality of life among normal adults aged 18 to 60 years old.

Ozsoy et al. (25) showed improvement in gait characteristics of older persons with low back pain on the ambulation index, using the Biodex Gait Trainer 2. This finding was consistent with other studies which reported that lumbar stabilization exercise enhanced gait among older persons, as assessed using the Timed Up and Go (TUG) (36) and Dynamic Gait Index (37). This can be explained by improving core muscle strength and back extensor strength, it will enhance pelvis stability which indirectly assists to improve the strength and coordination of the lower limbs (38). Hence, provide support for improving balance and speed in gait performance. However, this finding was inconsistent with Bagheri et al. (39), who found that core stabilization exercise on trunk-pelvis three-dimensional kinematics (angular displacement, waveform pattern, and offset variability) had no significant outcome on angular displacement and offset variability in gait between healthy individuals and non-specific chronic low back pain. This could be due to similar increase trunk–pelvis kinematic pattern variability in both groups following the core stabilization program which specifically increases transverse and frontal plane variability, showing enhanced motor pattern performance through the movement. However, pain intensity and disability showed significant improvements after intervention on the non-specific chronic low back pain among patients.

Limitations of the Study

There are various limitations faced including the majority of the studies involved younger age groups with less vulnerability and risk compared to older people. We did not search for grey literature or unpublished work. These limitations may reflect the shortage of selected articles.

CONCLUSION

Lumbar stabilization exercise provides a positive effect on improving pain intensity, disability, and gait functional performance among older persons with low back pain, regardless of a combined treatment. These might benefit patients for a better life with manageable pain, disability, and optimized functional performance during daily living. However, our findings should be interpreted with caution due to the small number of studies included and that lumbar stabilization exercise was combined with other treatment modalities.

ACKNOWLEDGEMENTS

We would like to thank the Faculty of Health Sciences, UiTM, and Research Management Centre, UiTM for the support via MyRA Grant (600-RMC/GPM ST 5/3 (035/2021)).

REFERENCES

1. Kim D, Cho M, Park Y, Yang Y. Effect of an exercise program for posture correction on musculoskeletal pain. Journal of Physical Therapy Science. 2015;27(6):1791-4. doi: 10.1589/jpts.27.1791
2. Wei G, Li H, Wang B, Wu J, Wu F, Lin Z. A retrospective cross-sectional survey of non-specific lower back pain among a cohort of Chinese army soldiers. International Journal of Surgery. 2018 Aug 1;56:288-93. doi: 10.1016/j.ijsu.2018.06.023
3. Hoy D, Bain C, Williams G, March L, Brooks P, Blyth F, Woolf A, Vos T, Buchbinder R. A systematic review of the global prevalence of low back pain. Arthritis & Rheumatism. 2012 Jun;64(6):2028-37. doi: 10.1002/art.34347
4. Balagué F, Mannion AF, Pellisй F, Cedraschi

C. Non-specific low back pain. The Lancet. 2012;379(9814):482-91. doi: 10.1016/S0140-6736(11)60610-7
5. Prince MJ, Wu F, Guo Y, Robledo LM, O'Donnell M, Sullivan R, Yusuf S. The burden of disease in older people and implications for health policy and practice. The Lancet. 2015;385(9967):549-62. doi: 10.1016/S0140-6736(14)61347-7
6. Rosa N, Queiroz BZ, Lopes RA, Sampaio NR, Pereira DS, Pereira LS. Risk of falls in Brazilian elders with and without low back pain were assessed using the Physiological Profile Assessment: BACE study. Brazilian journal of physical therapy. 2016 Sep 22;20:502-9. doi: 10.1590/bjpt-rbf.2014.0183
7. Molton IR, Terrill AL. Overview of persistent pain in older adults. American Psychologist. 2014;69(2):197. doi: 10.1037/a0035794
8. Foster NE, Thomas E, Bishop A, Dunn KM, Main CJ. Distinctiveness of psychological obstacles to recovery in low back pain patients in primary care. PAIN®. 2010;148(3):398-406. doi: 10.1016/j.pain.2009.11.002
9. Shipton EA. Physical therapy approaches in the treatment of low back pain. Pain and therapy. 2018 Dec;7(2):127-37. doi: 10.1007/s40122-018-0105-x
10. Qaseem A, Wilt TJ, McLean RM, Forciea MA, Clinical Guidelines Committee of the American College of Physicians*. Noninvasive treatments for acute, subacute, and chronic low back pain: a clinical practice guideline from the American College of Physicians. Annals of internal medicine. 2017 Apr 4;166(7):514-30. doi: 10.7326/M16-2367
11. McCarthy M. Non-drug therapies should be a line first-line treatment for low back pain, US guidance says. BMJ 2017 Feb 15; 356 DOI: https://doi.org/10.1136/bmj.j840
12. National Guideline Centre (UK). Evidence review for pharmacological management of sciatica: Low back pain and sciatica in over 16s: assessment and management: Evidence review A. London: National Institute for Health and Care Excellence (NICE); 2020 Sep. (NICE Guideline, No. 59.)
13. Manchikanti L, Kaye AM, Knezevic NN, McAnally H, Trescot AM, Blank S, Pampati V, Abdi S, Grider JS, Kaye AD, Manchikanti KN. Responsible, safe, and effective prescription of opioids for chronic non-cancer pain: American Society of Interventional Pain Physicians (ASIPP) guidelines. Pain physician. 2017 Feb;20(2):S3-92. doi: 10.36076/ppj.2017.s92
14. Hong Y, Kim YK, Park SH. The effects of lumbar stabilization exercise program using McGill and sahrmann on living fitness and activities of daily living in elderly women. J Korean Assoc Certif Exerc Prof 2013;15(2):23–33. doi: doi:10.15758/jkak.2013.15.2.23
15. Chung S, Lee J, Yoon J. Effects of stabilization exercise using a ball on multifidus cross-sectional area in patients with chronic low back pain. Journal of sports science & medicine. 2013 Sep;12(3):533.
16. Rhee HS, Kim YH, Sung PS. A randomized controlled trial to determine the effect of spinal stabilization exercise intervention based on pain level and standing balance differences in patients with low back pain. Medical science monitor: international medical journal of experimental and clinical research. 2012;18(3):CR174. doi: 10.12659/msm.882522
17. Parveen A, Nuhmani S, Hussain ME, Khan MH. Effect of lumbar stabilization exercises and thoracic mobilization with strengthening exercises on pain level, thoracic kyphosis, and functional disability in chronic low back pain. Journal of Complementary and Integrative Medicine. 2021;18(2):419-24. doi: 10.1515/jcim-2019-0327
18. Kang JI, Jeong DK. The effect of lumbosacral stabilization exercise on Oswestry Disability Index and gait velocity of patients with chronic low back pain. Journal of Digital Convergence. 2013;11(8):243-50. doi:10.14400/JDPM.2013.11.8.243
19. Jeong UC, Sim JH, Kim CY, Hwang-Bo G, Nam CW. The effects of gluteus muscle strengthening exercise and lumbar stabilization exercise on lumbar muscle strength and balance in chronic low back pain patients. Journal of physical therapy science. 2015;27(12):3813-6. doi: 10.1589/jpts.27.3813
20. Ma SY, Kim HD. The efficacy of spinal decompression via DRX3000 combined with a spinal mobilization and a lumbar stabilization exercise program for patients with discogenic low back pain. Journal of Physical Therapy Science. 2010;22(4):345-54. doi: 10.1589/jpts.22.345
21. Chung EJ, Kim JH, Lee BH. The effects of core stabilization exercise on dynamic balance and gait function in stroke patients. Journal of physical therapy science. 2013;25(7):803-6. doi: 10.1589/jpts.25.803
22. Wang XQ, Zheng JJ, Yu ZW, Bi X, Lou SJ, Liu J, Cai B, Hua YH, Wu M, Wei ML, Shen HM. A meta-analysis of core stability exercise versus general exercise for chronic low back pain. PloS one. 2012 Dec 17;7(12):e52082. doi: 10.1371/journal.pone.0052082
23. Mallett R, Hagen-Zanker J, Slater R, Duvendack M. The benefits and challenges of using systematic reviews in international development research. Journal of development effectiveness. 2012 Sep 1;4(3):445-55. doi:10.1080/19439342.2012.711342
24. Wells C, Kolt GS, Marshall P, Hill B, Bialocerkowski A. The Effectiveness of Pilates Exercise in People with Chronic Low Back Pain: A Systematic Review. PLoS ONE. 2014 9(7): e100402. doi:10.1371/journal.pone.0100402.

25. Ozsoy G, Ilcin N, Ozsoy I, Gurpinar B, Buyukturan O, Buyukturan B, Kararti C, Sas S. The effects of myofascial release technique combined with core stabilization exercise in elderly with non-specific low back pain: a randomized controlled, single-blind study. Clinical interventions in aging. 2019;14:1729. doi: 10.2147/CIA.S223905
26. Kim M, Kim M, Oh S, Yoon B. The effectiveness of hollowing and bracing strategies with lumbar stabilization exercise in older adult women with nonspecific low back pain: a quasi-experimental study on a community-based rehabilitation. Journal of manipulative and physiological therapeutics. 2018 Jan 1;41(1):1-9. doi:10.1016/j.jmpt.2017.06.012
27. Karanicolas PJ, Farrokhyar F, Bhandari M. Blinding: Practical tips for surgical research: blinding: who, what, when, why, how? Can J Surg. 2010 Oct; 53(5): 345-348. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2947122/
28. Hyoung HK. Effects of a strengthening program for lower back in older women with chronic low back pain. Journal of Korean Academy of Nursing. 2008 Dec 1;38(6):902-13. doi: 10.4040/jkan.2008.38.6.902
29. Yu SH, Sim YH, Kim MH, Bang JH, Son KH, Kim JW, Kim HJ. The effect of abdominal drawing-in exercise and myofascial release on pain, flexibility, and balance of elderly females. Journal of Physical Therapy Science. 2016;28(10):2812-5. doi: 10.1589/jpts.28.2812
30. Larooee Z, Shojaodin SS, Sokhankoy Y. The effects of core stabilization exercise on Reduce pain, physical function and risk of falling in elderly women with chronic non-specific low back pain (Persian). J Anesth Pain. 2021;11(4):68-79. Available from: https://sid.ir/paper/416539/en
31. Wang H, Fan Z, Liu X. et al. Effect of Progressive Postural Control Exercise Versus Core Stability Exercise in Young Adults with Chronic Low Back Pain: A Randomized Controlled Trial. Pain Ther. 2022. doi:10.1007/s40122-022-00458-x
32. Smith D, Bissell G, Bruce-Low S, Wakefield C. The effect of lumbar extension training with and without pelvic stabilization on lumbar strength and low back pain. Journal of Back and Musculoskeletal Rehabilitation. 2011 Jan 1;24(4):241-9. doi: 10.3233/BMR-2011-0301
33. Hunter SK, Pereira HM, Keenan KG. The aging neuromuscular system and motor performance. Journal of Applied Physiology. 2016; 121(4): 982-995. doi:10.1152/japplphysiol.00475.2016
34. Izquierdo M, Merchant RA, Morley JE et al. International Exercise Recommendations in Older Adults (ICFSR): Expert Consensus Guidelines. J Nutr Health Aging 2021; 25: 824–853. doi:10.1007/s12603-021-1665-8
35. Cairns MC, Foster NE, Wright C. Randomized controlled trial of specific spinal stabilization exercises and conventional physiotherapy for recurrent low back pain. Spine. 2006 Sep 1;31(19):E670-81. doi: 10.1097/01.brs.0000232787.71938.5d
36. Kim TH, Choi HS. Effects of 4 weeks bridging stabilization exercise using swiss ball and whole-body vibration on balance and gait function in elderly women. Physical Therapy Korea. 2011;18(3):49-58.
37. Hosseini SS, Asl AK, Rostamkhany H. The effect of strength and core stabilization training on physical fitness factors among elderly people. World Appl Sci J. 2012;16(4):479-84.
38. Willson JD, Dougherty CP, Ireland ML, Davis IM. Core stability and its relationship to lower extremity function and injury. Journal of the American Academy of Orthopaedic Surgeons September 2005; 13(5): 316-25. doi: 10.5435/00124635-200509000-00005
39. Bagheri R, Parhampour B, Pourahmadi M, Fazeli SH, Takamjani IE, Akbari M, Dadgoo M. The effect of core stabilization exercises on the trunk–pelvis three-dimensional kinematics during gait in non-specific chronic low back pain. Spine. 2019 Jul 1;44(13):927-36. doi: 10.1097/BRS.0000000000002981