REVIEW

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Core stability exercise for the impact of weightlifting and deadlifting on herniated nucleus pulposus (HNP): a systematic review

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ABSTRACT

Background: Herniated nucleus pulposus or disc herniation is a serious medical condition, the common cause of sciatic pain, and the most common indication for spine surgery. People doing athletic sports, especially weightlifting and deadlifting, may face significant acute and overuse spinal injuries that can cause HNP. Core stability exercise (CSE) improves athletes' sports performance and can prevent injury. This systematic review aims to determine the impact of core stability exercises on weightlifting and deadlifting on herniated nucleus pulposus.

Method: According to PRISMA recommendations, a systematic review using an online database was carried out. The inclusion criteria set includes studies regarding the impact of core stability exercise on deadlifting and weightlifting to prevent HNP, using adult samples≥18 years old and providing the type of CSE exercise. In contrast, the exclusion criteria were studied not available in full text and not available in Bahasa or English. Study quality assessments were done using a checklist for the Joanna Briggs Institute.

Result: Ten studies are included in this systematic review, consisting of six randomized controlled trials, two review articles, one case-control study, and one prospective cohort study. The CSE effectively improves the endurance, strength, mobility, and dynamic balance of core muscles, especially spinal muscles, which can prevent back injury, especially for weightlifters and dead lifters. Core stability exercises should be incorporated into athletes' training programs to improve sports performance and reduce the risk of back injury, especially HNP.

Conclusion: The CSE effectively improves the endurance, strength, mobility, and dynamic balance of core muscle, especially spinal muscle, which can prevent back injury in athletes, especially weightlifters and dead lifters.

Keywords: core stability exercise, deadlift, herniated disc, herniated nucleus pulposus, weightlift.
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INTRODUCTION

One of the frequent health issues among adults is low back pain (LBP). The prevalence of LBP globally was estimated at 7.5% of the global population or around 577 million people. The highest incidence of LBP is around age 45-60.[1] There are several causes of LBP, such as musculoskeletal, nervous system, vascular, visceral, and psychogenic disorders. One of them is herniated nucleus pulposus (HNP).[2] Herniated nucleus pulposus or disc herniation is a serious medical condition where a soft gel disc or nucleus pulposus of the intervertebral is pressed and ruptured, resulting in narrowing and pinching of the nerves that pass through the spine. Herniated nucleus pulposus is the common cause of sciatic pain and the most common indication of spine surgery worldwide. The most often impacted levels are L4/5 and L5/S, with an estimated global frequency of HNP of 1% to 3%. The highest incidence was observed in 30 to 50-year-olds and was more frequent in men than in women. Athletic sports or training, especially weight training sports, could increase the HNP incidence.[3]

The popularity of weight training, including weightlifting and deadlifting, has increased over the past years. As the number of people who did weight training increased, it also affected the risk of injury. People doing athletic sports, especially weightlifting and deadlifting, may face significant acute and overuse spinal injuries that can cause HNP. It happened due to the postural stress of joint and soft tissue structures. Lifting with a heavy burden also causes spinal torsion and spinal cord compression, resulting in

HNP. Weightlifting activities can also lead to lumbar spine instability, which results in mechanical lesions and aches in the lumbar spine, diminishing stability and causing functional degeneration by expanding the range of motion.[4-6]

Recent studies on weight training athletes showed that approximately one-quarter of their injuries involve the trunk, including the back part of the intervertebral, indicating problems with the core muscle.[5,6] Therefore, rehabilitation exercise is needed to prevent back injury and HNP incidents in weight training athletes. One rehabilitation program that helps to prevent HNP or back injury in athletes is core stability exercise.[3] Exercises for core stability help the body's center to maintain stability and control movement. This exercise aids in stabilizing the trunk and positioning the pelvis for the best possible movements. Exercises for core stability, according to several studies, are highly beneficial in reducing back injuries since they improve balance and provide localized strength.[3,7,8] Previous studies also stated that core stability exercise could potentially improve spinal stability that can prevent injury. The core stability exercises include seated abdominal contractions, oblique twists, leg lifts, bridge exercises, and lying spinal rotation.[9,10] Studies regarding the role of core stability exercise's impact on deadlifting and weightlifting on HNP are still limited. Thus, this systematic review gathered a study about core stability exercises and provided concise information regarding the impact of this exercise on preventing HNP in deadlifting and weightlifting sports.

METHODS

Study eligibility

The inclusion and exclusion criteria were used to establish the study's eligibility requirements. The inclusion criteria set includes studies regarding the impact of core stability exercise on deadlifting and weightlifting to prevent HNP, using adult samples≥18 years old, and providing the type of ore stability exercise to prevent HNP or disc injury or disc herniation or back injury. The exclusion criteria were studied, and they were not available in full text and not available in Bahasa or English. The PICO Criteria used in this systematic review are as follows:

P (Population) = subject doing athletic sports, especially deadlifting and weightlifting

I (Intervention) = core stability exercise

C (Comparison/Control) = non-core stability exercise or control group

O (Result) = herniated nucleus pulposus, herniated disk, prolapsed disk, or back injury.

Search strategy and study selection

The search strategy study was conducted using keywords and Boolean operators in the form of [(core stability exercise) AND (impact OR role) AND (herniated nucleus pulposus OR herniated disc OR disc degeneration OR back injury) AND (athlete OR weightlift OR deadlift)]. The study search was conducted on three electronic databases: Google Scholar, Cochrane Library, and PubMed. Duplicated studies were excluded from the search results. Furthermore, the study conducted abstract screening to assess its relevance to the research topic. Two researchers carried out literature screening to avoid bias. The studies that made it past the abstract screening were then carefully read to check for compliance with the requirements for eligibility. The studies that met the eligibility criteria were then analyzed to obtain a summary of the literature. The Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) diagram, as seen in **Figure 1**, was used to choose the studies.

Study quality assessment

A critical assessment checklist from The Joanna Briggs Institute (JBI), which was customized for each study's design, was used to evaluate the quality of the studies. Each item on the checklist is worth one point if it satisfies the requirements, and the study is deemed to be of acceptable quality if it earns at least half of the maximum possible points. Study quality assessments were done independently by two authors to avoid bias.[11-14]

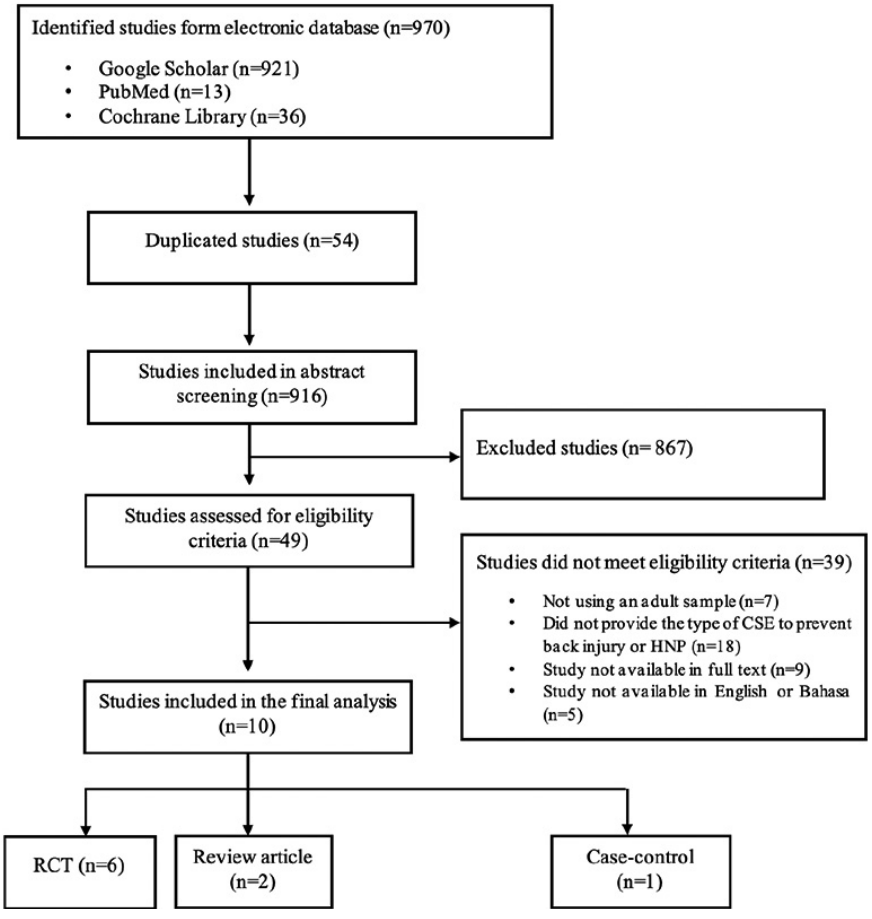

Figure 1. The PRISMA flowchart of our systematic review

Table 1. Characteristics of the study

Study	Study design	Sample characteristics	Exercise	Study result
Axel *et al.*, 2013, USA[15]	RCT	Nineteen junior elite surf athletes	Bench presses, squats, shuttle runs, back extensions, trunk flexion, and left and right bridges made up the 8-week core strength training program (CSTP).	In order to execute and perform good actions in the sport of surfing, it is crucial for the surfer athlete to have efficient core musculature. The total surfing performance of the surf athlete may be enhanced by a core strengthening program.
Cissik *et al.*, 2011, USA.[9]	Review article	N/A	Partial sit-ups with hold, varied abdominal exercises, strength training, back extensions, isometric holding exercises, and lumbar strengthening exercises.	The benefits of core stability training are still not conclusive in preventing injury-causing HNP in athletes.
Durall *et al.*, 2009, USA.[16]	Case-control	Fifteen female members of the gymnastics team.	Trunk muscle training twice weekly for 10 weeks (each session 15 minutes), side bridges, and abdominal exercise.	Significant improvement in all trunk endurance tests and side bridge tests was found in the training group. No new episode of LBP was found in the training group.
Fisher *et al.*, 2012, UK.[17]	RCT	36 male-trained subjects.	The ten-week progressive training program consists of a Romanian deadlift and an isolated lumbar extension exercise.	The isolated lumbar extension exercise is useful for preventing and treating back issues, whereas the Romanian deadlift does not appreciably strengthen the lumbar extensors.
Granacher *et al.*, 2012, Germany.[18]	RCT	Thirty-two older adults.	Frontal, dorsal, rotational, and lateral core movements make up progressive core instability training (CIT), which is carried out over nine weeks.	In comparison to the control group, CIT dramatically increased the intervention group's trunk muscle strength, spinal mobility, dynamic balance, and functional mobility.
Hides *et al.*, 2001, Australia.[19]	RCT	Thirty-nine patients with acute LBP.	Rehabilitation exercise of transversus abdominus muscle.	The group of patients that receive rehabilitation exercise experiences fewer recurrences of LBP.
Kumar *et al.*, 2009, India.[20]	RCT	Thirty hockey players.	Exercises for the trunk extensor muscles and spinal extension make up the lumbar stabilization exercise. Dynamic muscle stabilization techniques (DMST) were used on the opposing group for 35 days, with 40-minute sessions in between.	Both exercises effectively prevent back pain and injury, but DMST showed higher improvement.
Nadler *et al.*, 2001, USA.[21]	Cohort prospective	National collegiate athletes.	Strengthening compliance exercises consisted of deadlifts, hang cleans, squats, leg presses, crunches, pelvic tilts, and back extensions.	Core strengthening exercises provide better stability and control for an athletic activity that can prevent injury to the spine.
Szafraniec et *al.*, 2020, Poland.[22]	RCT	Thirty novices and five experienced weightlifters.	The 4-week core stability training program consisted of abdominal drawing-in maneuver, quadruped arm lifts, and stability ball exercises.	Short-term core stability training improved dynamic balance and trunk muscle endurance in novice weightlifters
Willardson *et al.*, 2007, USA.[10]	Review article	N/A	Swiss ball exercise, shoulder press, chest press, balance training.	Exercises for core stability aid physically unfit athletes by enhancing sports performance and enhancing force output in the upper and lower limbs.

Abbreviation: CIT=core instability training; CSE=core stability exercise; CSTP=core strength training program; DMST= dynamic muscle stabilization techniques; HNP=herniated nucleus pulposus; LBP=low back pain; RCT=randomized controlled trial; UK=United Kingdom; USA=United States of America.

Synthesis of the study

The narrative synthesis then incorporated all pertinent studies that were eligible to participate. This systematic review, which is qualitative research, gathers data on the influence of core stability training on the health effects of athletic activities, particularly weightlifting and deadlifting. From the studies included in the analysis, we extracted data in the form of the researcher's identity, study design, number of samples, CSE intervention, assessed outcomes, and study result (impact of CSE).

RESULTS

Study characteristics

Based on the search results on three electronic databases, we found 970 studies that matched the search keywords. After excluding 54 duplication studies, 916 were screened for abstracts to determine the suitability of the study with the research topic. A total of 867 studies were excluded from the abstract screening, so 49 studies were analyzed for the eligibility criteria. A total of 39 studies did not meet the eligibility criteria, as shown in **Figure 1**, so in the last phase, only 10 were included in the final analysis. Of the 10 studies, 6 studies were randomized controlled trials. Two studies were review articles; one was case-control, and one was a prospective cohort study. Studies from several countries such as Australia, Germany, India, Poland, the UK, USA and published from 2001-2020. Most studies used athletes as the study subject, such as weightlifter athletes, gymnastic teams, hockey players, surf athletes, and national collegiate athletes, as stated in **Table 1**. A checklist from the Joanna Briggs Institute was used to evaluate the quality of case-control, cohort prospective, review papers, and randomized controlled trials. All of the studies were rated as good studies with a point range of 7 to 11, according to the assessment of research quality.[11-14]

The core musculature

The abdominal muscle is referred to as the front of the core muscle, the paraspinal and gluteal muscles are the back, the diaphragm is the roof, and the pelvic floor and hip girdle muscles are the foundation or bottom. Transverse abdominis, internal oblique, external oblique, rectus abdominis, erector spine, quadratus lumbarum, latissimus dorsi muscle, and gluteal muscles are a few of the muscles referred to as the core muscle. All of those muscles support the spine and hips, enabling the best possible force generation, transmission, and control from the proximal to the distal parts of the body. Additionally, they enable the production of flexion, lateral flexion, and rotational motions, as well as the control of external forces that move the spine in extension, flexion, and rotation.[15] One of the main muscle groups that supports the spine and protects the nerves and spine is the spinal system. The passive musculoskeletal component of the spinal stabilizing system includes the intervertebral disc, facet joint, vertebrae, spinal ligaments, and joint capsules. In comparison, the muscles and tendons that produce force make up the active musculoskeletal subsystem. The final component is the brain and feedback subsystem, which, as depicted in **Figure 2**, receives data and directs the active subsystem to achieve stability. To develop core stability, the abdominal, hip, and spine muscles must work together with endurance, strength, and coordination. Exercises for core stability are therefore helpful for developing the core musculature.[10,15]

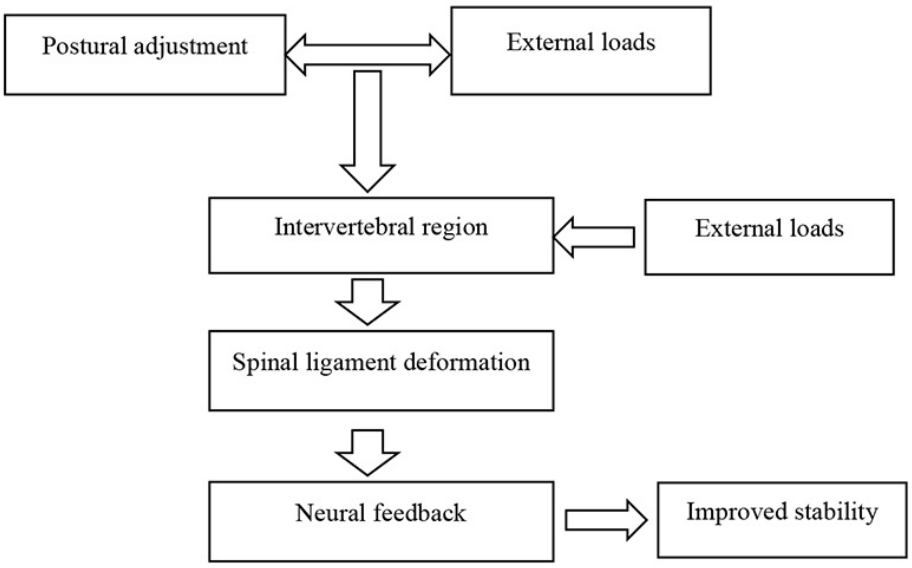

Figure 2. Model of core stability[10,15]

Type of core stability exercises

According to the notion, performing CSE as part of core training will enhance performance, reduce the risk of injury, and heal lower back ailments. Exercises for core stability (CSE) can be used to control the motion and position of the trunk in relation to the pelvis for the best possible mobility. The CSE is crucial in supplying localized strength and balance so that motions and activities can be carried out more effectively. Additionally, the CSE enhances postural balance, reducing or eliminating the chance of injury.[16-22] The research that we analyzed employed various types of CSE. A study by Cissik *et al.* compiled core stability exercises from several studies; they found exercises used for CSE are partial sit-ups with hold, varied abdominal exercises, strength training, back extensions, isometric holding exercises, and lumbar strengthening exercises. However, their review still did not find any conclusive results regarding the role of those exercises in preventing back pain or injury.[9] The other review by Willardson *et al.* found different results; they stated that core stability exercise consisting of Swiss ball exercise, shoulder press, chest press, and balance training is beneficial for unhealthy athletes by improving sports performance and resulting in greater force production in the upper and lower extremities.[10] A case-control study by Durall *et al.*

involved gymnastic female athletes who did core exercise by trunk muscle training consisting of side bridges training and abdominal exercise for about 15 minutes for each session twice a week for ten weeks with a total of 20 training sessions, as shown in **Figure 3**.[16]

A prospective cohort study by Nadler *et al.* involved national collegiate athletes who used strengthening compliance exercises consisting of a deadlift, hang cleans, squats and lunges, leg presses, pelvic tilts, and back extensions. In order to improve the proximal hip, quadriceps, and paraspinal musculature, squats and lunges were used to target numerous joint activations, including the ankle, knee, and hip. In addition to the gluteus maximus, the quadriceps, and hamstrings were also strengthened using the leg press. The other six randomized controlled trial studies used several kinds of core exercise.[21] An eight-week core strength training program (CSTP) that included the bench press, squat, shuttle run, back extension, trunk flexion, and left and right bridge was employed in an RCT study by Axel *et al.*[15] While a study by Fisher *et al.* only used two kinds of exercise; Romanian deadlift and isolated lumbar extension exercise.[17] **Figure 4** illustrates the frontal, dorsal, rotational, and lateral core movements included in the nine-week progressive core instability training (CIT) regimen used by Granacher *et al.* Each training session lasted 60 minutes, including a 10-minute warm-up exercise and a 5-minute stretching routine for the cool-down.[18]

A study by Hides *et al.* only did one exercise on the transverse abdominus muscle.[19] A study by Kumar *et al.* involved hockey players in India using spinal extension exercises, trunk extensor muscles exercises, and dynamic muscle stabilization techniques (DMST) for 35 days and 40 minutes each session.[20] The last study was conducted by Szafraniec *et al.* and involved 30 beginner and 5 experienced weightlifters. The participants employed a four-week core stability training program that included exercises including the abdominal drawing-in technique, quadruped arm lifts, and stability ball work.[22]

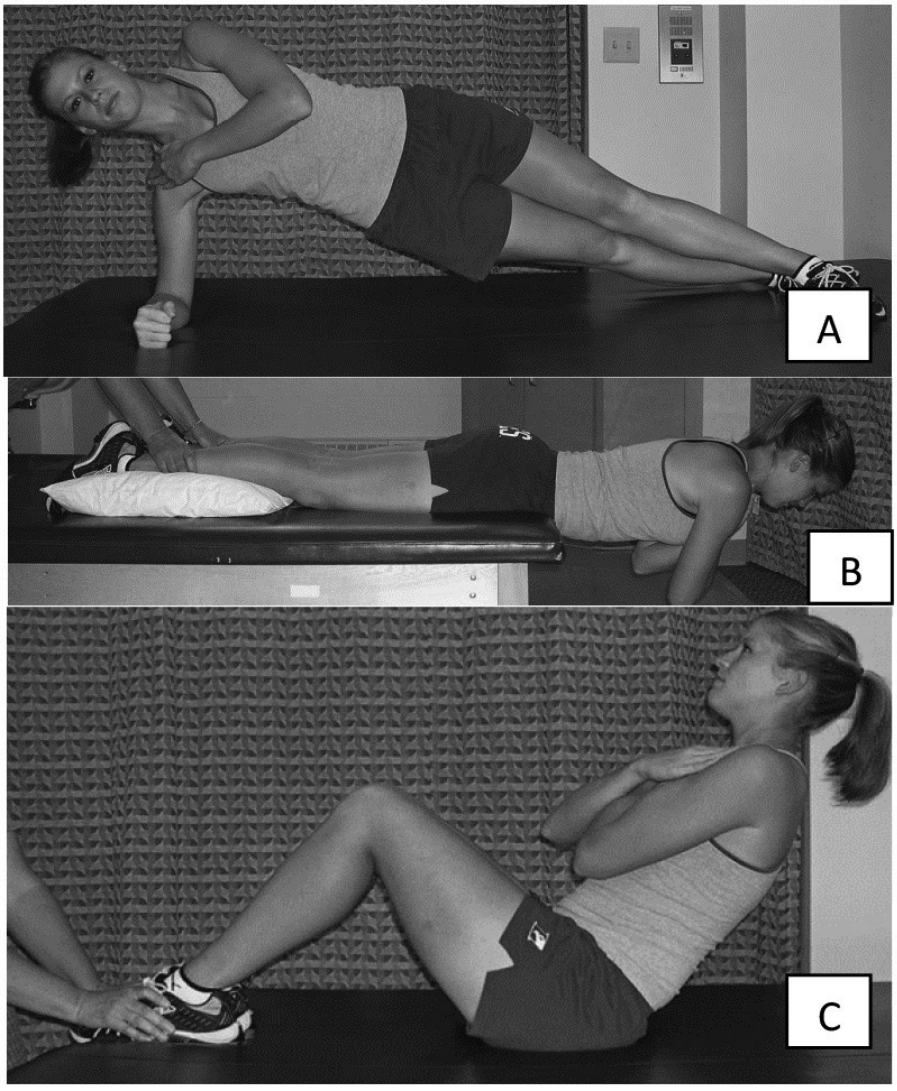

Figure 3. Core stability exercise consisted of (A) trunk side endurance exercise, (B) trunk extensor endurance exercise, and (C) trunk flexor endurance exercise.[16]

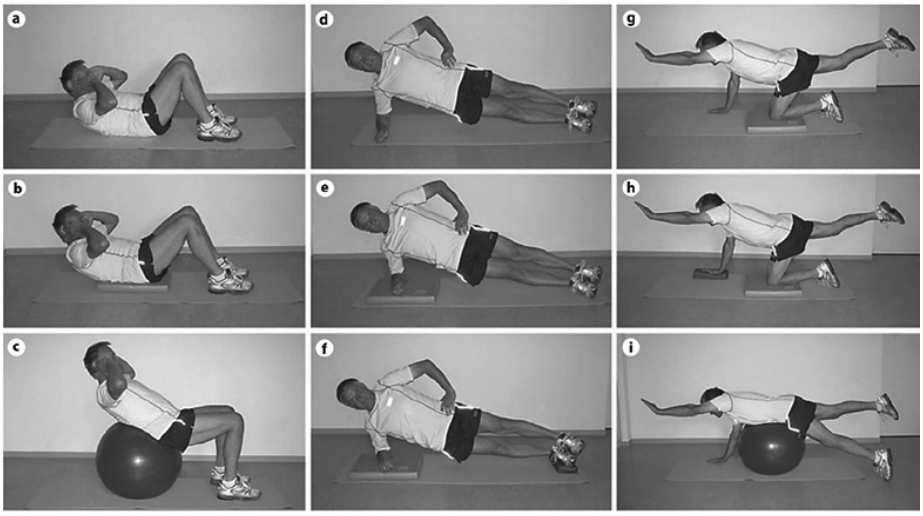

Figure 4. Core stability exercise consisted of (a-c) curled-up exercise, (d-f) side bridge exercise, and (g-i) quadruped exercise.[18]

Impact of core stability exercise

Based on our analysis, most of the studies in our systematic review showed that CSE effectively improves the endurance, strength, mobility, and dynamic balance of core muscles, especially spinal muscles, which can prevent injury. Only one study, a review by Cissik *et al.*, did not find any conclusive result regarding the role of CSE in preventing back injury.[9] In contrast, research by Durall *et al.* with gymnastic athletes discovered that ten weeks of trunk muscle training employing core stability exercises led to appreciable gains in the isometric power of the trunk's extensors, flexors, and lateral flexors. Additionally, they stated that they had no further instances of back pain following the training, which suggests that exercising your core stability can help with back discomfort.[16] Another study by Fisher *et al.* found that isolated lumbar extension exercise is effective in preventing back injury by strengthening the lumbar extensors, which can improve back stability. The study involved 36 trained male subjects and involved a ten-week progressive training program that included a Romanian deadlift and isolated lumbar extension exercise. It was discovered that the lumbar exercise was not considerably impacted by the Romanian deadlift exercise. In order to strengthen the lumbar muscle, they advised athletes to perform solo lumbar extension workouts in addition to the Romanian deadlift.[17] A review by Willardson *et al.* stated that core stability exercise resulted in greater core stability. Based on a sports performance perspective, greater core stability can provide greater force production and stability in the upper and lower extremities. At the same time, maintain stability to prevent back injury.[10] According to Granacher *et al.*, CSE can enhance spinal flexibility, dynamic balance, and functional mobility. The ability to move freely across the spine is crucial for carrying out daily tasks, and athletes may benefit from core strength training's constant and gradual stimulation of the trunk muscles.[18] While Nadler *et al.* stated that a supervised core-strengthening program for trunk muscle, spine, and extensors reduced back pain or back injury in male athletes.[21] Szafraniec *et al.* found that short-term CSE training can improve dynamic balance and trunk muscle endurance, which is beneficial for weightlifting athletes. This training can be incorporated into the athlete's training regimen to prepare for difficult exercises and prevent the incidence of back injury, especially HNP.[22]

DISCUSSION

This systematic review aims to evaluate the impact of core stability on preventing HNP or back injury in athletes, especially dead lifters and weight lifters. As we know, people who do athletic sports are at high risk of experiencing spinal trauma or injury that can cause HNP. Various factors have been reported to be related to back injury in athletes, such as poor muscle endurance, muscular imbalance, lack of flexibility of the lower extremities, and lack of muscle control.[3,7] As stated by Nadler *et al.*, in the development of back pain and injury, the hip musculature plays a significant role in the lower extremity toward spine transferring. The poor endurance and delayed firing of the gluteus maximus muscle (hip extensor) and gluteus medius (hip abductor) were observed in an individual with lower instability. Sports training has shown interest in core strengthening exercises as a way to help athletes avoid spinal and/or extremity injuries. The primary goal of CSE training is to strengthen the gluteal, paraspinal, and abdominal muscles for better stability and control during athletic action.[21]

Previous studies have shown the importance of lumbar extension strength exercises for pelvic stability. In weight-bearing athletes such as dead-lifters and weightlifters, due to the heavy burden, spinal torsion and compression could happen and cause back injuries such as HNP. Mechanical lesions can happen due to decreasing stability and increasing ROM that cause functional degeneration of the intervertebral disc. When the trunk rotates, the hip extensors, or gluteus maximus muscle, are crucial for maintaining the pelvis. By strengthening the back, legs, and abdomen muscles to increase muscular stabilization, back discomfort or injury can be lessened.[21] By posing a challenge to the spinal and trunk postural control stability, the CSE training stimulated particular motoric patterns in the trunk muscles. As a result, this workout is suggested for improving sports performance and avoiding injuries. Deep spinal muscles like the lumbar multifidus and abdominal muscles like the transversus, obliques, and rectus abdominis were trained as part of CSE. The most stable position for a weight lift will be provided by strong abdominal and lower back muscles, which also lowers the danger of damage. Dynamic balance, the most crucial motor skill that demonstrated the ability to maintain balance on an unstable surface with little additional motion, was also improved by CSE training. Therefore, strengthening dynamic balance will help an athlete perform better physically in sports like judo, gymnastics, or weightlifting.[16,20-22]

Although there is no guarantee that CSE will result in 100% no back pain or back injury, this exercise is feasible and beneficial enough to be incorporated into athletes' exercise regimens. All sports exercise programs should place a strong premium on strengthening the core, especially weight-bearing activities, because they carry a higher risk of back injuries. The prescription of CSE should vary based on the training phase and the athlete's health condition. Most of the study's results showed the beneficial effect of CSE training for preventing back injury in athletes; this can be adopted by the sports coach in programming the athlete's exercise.[10,21,22] The limitation of this study is due to the small amount of research that was relevant to the topic; we only found 10 papers, just one of which included weightlifting athletes as the study sample.

CONCLUSION

Our data leads us to the conclusion that practicing core stability is beneficial for athletes, particularly weightlifters and deadlifts. The primary goal of CSE training is to strengthen the gluteal, paraspinal, and abdominal muscles for better stability and control during athletic action. The CSE efficiently increases the spinal muscle's dynamic balance, mobility, strength, and endurance so that back injuries can be avoided. Exercises that focus on core stability should be introduced into training regimens for athletes to enhance

sports performance and lower the risk of back injuries, particularly HNP.

CONFLICT OF INTEREST

The authors declare that there is no competing interest regarding the manuscript.

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AUTHOR CONTRIBUTION

All authors contributed to the study from the conceptual framework, data gathering, and analysis until the study's results were interpreted upon publication.

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