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# *Common Risk Factors for Lower Back Pain in High School Students and Sports Rehabilitation Strategies*

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***Abstract.*** Low back pain (LBP) has become one of the most common musculoskeletal health problems among adolescents worldwide. It not only affects daily activities, athletic performance and sleep quality, but also tends to become chronic in adulthood. This article, from the perspective of evidence-based medicine, focuses on the high school student group and systematically sorts out the common risk factors and mechanisms of action of lower back pain. It is classified into two major categories based on modifiability: non-modifable factors (genetic susceptibility, gender) and interventionable factors (prolonged sitting, poor posture, excessive use of electronic devices, academic pressure and psychological factors, improper carrying of schoolbags, insufficient physical activity, sleep disorders), and the mechanisms by which it causes disease through pathways such as biomechanical imbalance, neuroendocrine disorders, and central sensitization are clarified. On this basis, the focus is on discussing strategies such as core stability training, hamstring and hip flexibility training, as people as phased rehabilitation and comprehensive school intervention. The analgesic and functional improvement effects are evaluated by combining randomized controlled trials and meta-analysis quantitative evidence. Existing evidence indicates that scientific exercise rehabilitation can significantly reduce pain scores, improve lumbar function, and is safe, economical, and easy to promote in schools. It can provide a reference for the early identification and precise prevention of lower back pain among high school students.

***Keywords:*** Lower back pain, high school students, sports rehabilitation strategies

## 1. Introduction

Low back pain (LBP) refers to the pain or stiffness in the area from the lower edge of the ribs to the gluteal fold. It can be classified into specific (with clear pathology, about 10%) and non-specific (without clear organic lesion, about 90%). In recent years, the prevalence rate among teenagers has continued to rise. GBD 2021 shows that the disease burden among the 10-19 age group remains relatively high [1]. Large-scale surveys show that the lifetime prevalence rate of non-specific lower back pain is 48.98%, and the disabling rate accounts for 13.89% [2]. The incidence rate among domestic high school students is approximately 32.8%, with higher rates among girls and senior three students [3, 4]. Longitudinal studies have shown that lower back pain in adolescence is an important predictor of chronic lower back pain in adulthood, with approximately one-third of patients experiencing recurrent episodes in adulthood [2]. Therefore, identifying risks and

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conducting early intervention during the high school stage are of great significance in blocking the chronic progression process. Based on evidence-based evidence, this article systematically sorts out the common risk factors and mechanisms of lower back pain among high school students.

## 2. Common risk factors for lower back pain in high school students

Lower back pain in high school students is the result of the multi-dimensional interaction of genetic susceptibility, individual biological characteristics, lifestyle and psychosocial factors. According to modifiability, it can be divided into two major categories: Non-modifiable factors include genetic susceptibility and gender, which determine an individual's basic susceptibility; Intervenable factors include sedentary behavior, poor posture, excessive use of electronic devices, academic pressure and psychological factors, improper way of carrying schoolbags, insufficient physical activity and sleep disorders, which are the main targets for prevention and intervention.

### 2.1. Genetic factors

Genetic factors are the basis of susceptibility to lower back pain. A systematic review that included 7 twin studies (n= 35,547) found that the heritability of low back pain was 21% to 67%, with a higher genetic component for chronic and disabling low back pain. The biological basis includes: the heritability of lumbar intervertebral disc degeneration is as high as 74%, and family aggregation explains 61% of the degeneration scores of the upper lumbar vertebrae and 34% of the lower lumbar vertebrae [2]. And genetic differences in the pain regulation system. Clinically, adolescents with a first-degree relative history of lower back pain have a significantly increased risk [2]. The relative risk of lumbar intervertebral disc protrusion before the age of 21 in those with a positive family history is approximately five times that of those without a family history. It should be emphasized that genetics determines susceptibility rather than inevitability, and a healthy lifestyle can significantly reduce the actual incidence rate. Females sex are consistent independent risk factors, with the risk for females being approximately 2.4 to 2.6 times that of males. A Lebanese study found that women were highly significant independent predictors (aOR=2.55, $p<0.001$), and the results of a Brazilian study were similar (OR=2.36). The mechanisms include: weak core muscle strength in women and insufficient protection of the spine; The changes in estrogen during adolescence affect the relaxation of ligaments. Higher sensitivity to pain perception and a greater tendency to report pain; When facing academic pressure, the psychological burden is greater, and negative emotions intensify the perception of pain through the neuroendocrine system.

### 2.2. Poor posture

Sitting for long periods is one of the most important modifiable risk factors. High school students can sit for more than 10 hours a day on average. Binary logistic regression of 2,000 adolescents showed that for every additional hour of inactivity and prolonged sitting each day, the risk of lower back pain increased by 80% (95%CI: 20% - 170%). A meta-analysis in the British Journal of Sports Medicine (44 studies, n> 92,617) confirmed that prolonged sitting was significantly positively correlated with spinal pain, with an adjusted OR of 1.25 [5]. Sitting for more than six hours a day is still a high-risk factor for lumbar intervertebral disc protrusion in teenagers. The mechanism lies in the fact that the internal pressure of the lumbar intervertebral disc in a sitting position is approximately 1.5 times that in a standing position, and can reach 1.8 times in a relaxed sitting position. The continuous static contraction of the lumbar and back muscles compresses blood

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vessels, leading to the accumulation of metabolic products and stimulating the injury receptors. At the same time, prolonged sitting reduces changes in body position, decreases the exchange of nutrients between intervertebral discs, and accelerates their degeneration. Poor posture is a risk factor independent of the duration of prolonged sitting. Prolonged sitting emphasizes the "quantity of time", while poor posture emphasizes the "quality of posture". Cross-sectional and longitudinal combined analysis showed that poor sitting posture was significantly associated with back pain (OR=2.029, $p<0.001$), that is, the risk was approximately twice that of those with good sitting posture, and poor sitting posture played a mediating role between single-shoulder backpack and back pain [6]. Common poor postures among high school students include slouching and leaning over the desk, sitting askew and bearing weight on one side, crossing one's leg, and practicing shoulders forward. The pain-causing pathways include: when bending over and hunching, the lordosis of the lumbar vertebrae disappears, and the pressure at the posterior edge of the intervertebral disc increases sharply; Sitting crookedly and crossing one's legs can cause the pelvis to tilt, scoliosis, and uneven force distribution on both sides. The forward extension of the head conducts downward along the mechanical chain, causing the entire spinal force line to become disordered. Long-term abnormal postures cause the adaptive shortening of soft tissues (tension in the hamstrings and iliopsoas muscles) and weakness (suppression of the core muscle groups), forming a vicious cycle. The way a schoolbag is carried has a significant impact on spinal health. Studies have shown that carrying a schoolbag on one shoulder is significantly associated with back pain (OR=1.402, $p=0.002$), meaning the risk is 40% higher than that of those who carry a backpack on both shoulders [6]. The mechanism lies in the compensatory imbalance of the spine: to prevent the schoolbag from slipping, the body tilts compensatorily to the opposite side, resulting in pelvic tilt, scoliosis, and uneven force distribution on the muscles and ligaments on both sides. Over time, this leads to functional scoliosis and muscle strain. At the same time, single-shoulder backpacks indirectly increase the risk by inducing poor sitting postures (leaning), and poor sitting postures play a mediating role. If the schoolbag is too heavy, it will increase the compressive load on the lumbar vertebrae, prompting students to lean forward to maintain balance and increasing the pressure on the posterior edge of the intervertebral disc. It is recommended that the weight of the schoolbag does not exceed 10% to 15% of the body weight, and it is preferred to use a backpack.

### 2.3. Excessive use of electronic devices

The use of electronic devices has become an emerging risk factor. Studies show that the use of PCS, mobile phones and tablets is significantly associated with lower back pain [3]. Playing video games for at least 2 hours a day is an independent risk factor (AOR=1.83, $p<0.001$), meaning the risk is 83% higher than that of those who play for less than 2 hours. The mechanism is the dual effect of posture and behavior: The "head forward extension" posture when using a mobile phone with the head down, chest in and shoulders rounded causes additional force on the cervical vertebrae, which is then transmitted downward along the spine, leading to the disorder of the mechanical chain. When using a laptop, the screen and keyboard are integrated, which leads to looking down at the screen and having the wrist suspended in the air, causing abnormal combined postures of the neck, shoulders and waist. In addition, using screens is often accompanied by prolonged sitting and forgetting to change postures, which prolongs the static contraction time.

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## 2.4. Psychological factors

Psychosocial factors play an important role in the occurrence and persistence of lower back pain. Domestic research shows that all four types of chronic pain among high school students are significantly associated with study pressure, and the prevalence rate among senior three students is even higher [3, 4]. The Chinese Adolescent study quantified using the SCL-90 scale found that clinically unhealthy psychological state (score >3) was significantly associated with chronic lower back pain. After adjusting for each dimension, the odds ratio (OR) was: Depression OR=7.21 (risk increased by 621%), anxiety OR=6.59 (risk increased by 559%), paranoia OR=4.47, interpersonal sensitivity OR=4.28, obsessive-compulsive OR=3.96 (all $p<0.01$) [7]. A meta-analysis involving 7 studies (n= 15,778) confirmed that depression and psychological distress significantly predicted persistent lower back pain and disability ($\beta=0.28$, $p=0.02$) [8].

Its mechanism is realized through neuroendocrine and neurobiological pathways: Long-term stress activates the HPA axis, causing a continuous increase in cortisol. On the one hand, it increases skeletal muscle tension, keeping the lumbar and back muscles constantly tense. On the other hand, it leads to an increase in the excitability of nociceptive neurons in the spinal dorsal horn (central sensitization), and at the same time inhibits the function of the descending analgesic system in the brainstem, amplifying and persisting pain signals in the central nervous system - this is why, with the same degree of muscle fatigue, In students who are under great pressure, anxious or depressed, it will be perceived as more intense and longer-lasting pain. In addition, anxiety and depression also indirectly aggravate pain by affecting sleep.

## 2.5. Insufficient physical activity

Regular physical activity is a protective factor for spinal health, while insufficient physical activity is a clear risk factor for lower back pain. Research has found that low-level physical activity is significantly associated with lower back pain in adolescents and the physical activity dimension scores of students with lower back pain are significantly lower than those of students without pain [3]. The core mechanism lies in the disuse atrophy of the core muscle group and the decline in spinal stability: Long-term lack of exercise leads to the atrophy and delayed activation of deep stabilizing muscles such as the transverse abdominis and multifidus, resulting in a decline in the neuromuscular control ability of the lumbar vertebrae segments and greater abnormal shear force on the spine. At the same time, the endurance of the waist and back muscles declines, making one more prone to fatigue when maintaining a sitting posture in class. After fatigue, the ability to control posture decreases, further inducing bad postures. In addition, regular exercise exerts analgesic and anti-inflammatory effects by promoting the secretion of endorphins, while a lack of exercise loses these protective effects. It should be noted that more exercise is not necessarily better. Excessive or inappropriate exercise may also increase the risk.

## 2.6. Sleep disorder

Sleep disorders and lower back pain are mutually causal and form a vicious cycle. Research has found that sleeping less than 5 hours per night is a significant associated factor for lower back pain, and both sleeping less than 5 hours or more than 9 hours are significantly associated with disabling lower back pain ($p<0.001$), presenting a "U-shaped" relationship [9]. A Saudi study quantified the effect of sleep quality: for every 1-unit increase in the global sleep quality score (better sleep), the incidence of lower back pain decreased by 42% (95%CI: 35% - 48%) [9]. The mechanism lies in the

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fact that sleep is a crucial period for tissue repair and pain regulation: during slow-wave sleep, the secretion of growth hormone reaches its peak, promoting the repair of muscles, ligaments and intervertebral discs. The secretion of endogenous analgesic substances such as endorphins also increases during sleep. Insufficient sleep leads to delayed soft tissue repair, slowed clearance of inflammatory factors, and reduced endogenous analgesic substances, ultimately resulting in a lower pain threshold and increased pain sensitivity. In addition, insufficient sleep affects emotional regulation, reduces pain tolerance, and further amplifies the pain experience. Conversely, the nighttime pain caused by lower back pain interferes with sleep, creating a vicious cycle.

## 3. Sports rehabilitation strategy

Exercise therapy is the preferred treatment for non-specific lower back pain recommended by international guidelines. The following elaborates on specific strategies from two aspects in combination with quantitative evidence.

### 3.1. Core strength training

Exercise therapy is the preferred intervention method for non-specific lower back pain recommended by the international clinical guidelines for lower back pain. Core stability training, as the core program of exercise rehabilitation, aims to activate deep lumbar stabilizing muscle groups such as the transverse abdominis and multifidus, improve the control ability of lumbar segments, reduce the pain risk caused by repeated minor spinal injuries, and meet the rehabilitation needs of high school students.

A randomized controlled trial (RCT) enrolled 60 young subjects with chronic nonspecific lower back pain and randomly divided them into a core stability training group and a conventional stretching control group. The intervention period was 8 weeks. The core stability training program includes movements such as the double bridge, single bridge, and plank, and is trained three times a week. The test results showed that after 8 weeks of intervention, the VAS pain score of the core training group decreased from 3.74 points at baseline to 1.11 points, with a pain reduction of 70.3% ($p<0.001$). The score of pain-related symptoms decreased by 72.2%, and the ODI lumbar dysfunction index was significantly improved. In this study, 93.3% of the subjects in the core training group achieved the minimum clinically important difference, which was 30 percentage points higher than 63.3% in the traditional training group ($p<0.001$), demonstrating that the clinical benefits of core stability training for lower back pain in adolescents are significantly better than those of conventional training [10].

Another cohort study was conducted on adolescents with lower back pain induced by prolonged sitting. It adopted a combined intervention program of 8-week core stability training and hamstring stretching, with 2 to 3 training sessions per week. The results confirmed that this program could significantly alleviate the symptoms of lower back pain related to prolonged sitting. The mechanism was continuous activation of the deep core muscle group can share the pressure on the lumbar vertebrae. Meanwhile, the enhanced extensibility of the hamstrings can improve the compensation for posterior pelvic tilt and reduce passive traction injuries to the lumbar vertebrae.

A meta-analysis in 2026 integrated data from 33 randomized controlled trials involving a total of 1,757 adolescent participants. The combined effect size showed that the standardized mean difference (SMD) for pain relief through core stability training was -0.95, which was a large effect size. The SMD for improving lumbar function is -1.09, which is also a large effect size. This has

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been confirmed from an evidence-based perspective that this training program has a stable intervention effect on non-specific lower back pain in adolescents [11].

The basic training exercises suitable for high school students include plank, Dead bug Pose, bird-dog pose and hip bridge. Given that high school students generally lack a foundation in professional strength training, the training should follow the principle of prioritizing deep stabilizing muscles, starting with low load, and gradually advancing step by step. Abdominal breathing should be prioritized to activate the transverse abdominis muscles, and blind pursuit of movement duration and weight should be avoided to prevent the surface muscles from compensating and increasing the burden on the lumbar vertebrae. During the training process, it is necessary to avoid incorrect postures such as sagging waist and pelvic torsion to prevent secondary injuries.

### 3.2. Hamstring and hip flexibility training

Hamstring tension and limited hip joint range of motion change the normal mechanical curve of the lumbar spine through the pelvis-lumbar linkage mechanism, which is an important cause of non-specific lower back pain related to prolonged sitting, especially suitable for the problem of posterior chain shortening caused by long-term sitting in the classroom among high school students. The goal of hamstring and hip flexibility training is to restore the normal length of hip muscle groups such as the hamstrings, iliopsoas, and piriformis, correct abnormal pelvic position, reduce compensatory load on the lumbar vertebrae, and at the same time improve the range of motion of the hip joint and reduce passive traction injuries to the lumbar vertebrae during daily activities.

A randomized controlled trial (RCT) included 52 sedentary young people aged 18 to 25, who were randomly divided into an experimental group and a control group. The intervention period was 8 weeks, with training sessions conducted 5 times a week for 20 minutes each time. The experimental group received active hamstring stretching combined with core stability training and neutral lumbar posture education, while the control group only received health education. The experimental results showed that after 8 weeks of intervention, the VAS pain score of the experimental group decreased from the baseline 5.8 points to 5.3 points, with a pain reduction of 8.6% ($p=0.0458$), while the VAS score of the control group that only received health education increased by 7.5% instead (from 5.3 points to 5.7 points). There was a significant difference in VAS changes between the two groups ($p=0.0367$). In addition, the ODI lumbar dysfunction index ($p=0.0479$) and lower back discomfort score ($p=0.0137$) in the experimental group were significantly improved. The angle of the straight leg elevation test(SLR) was significantly increased (right leg + 7.5°, left leg + 6.8°, $p<0.0001$), and 61.5% of the subjects in the experimental group self-confirmed the improvement of symptoms. It has been confirmed that hamstring stretching combined with core control training has a clear clinical benefit for sedentary lower back pain [12].

A systematic review and meta-analysis included 12 randomized controlled trials with a total of 432 subjects suffering from back pain. The pain intensity was evaluated using the VAS and Digital Pain Scale (NPRS), and the combined effect size showed: Hamstring stretching can significantly reduce the pain score of lower back pain compared with conventional treatment. The standardized mean difference (SMD) is -0.72 (95% CI: -1.35 to -0.09, $I^2=89\%$, $p=0.03$), which belongs to a moderate to large effect size. This has been confirmed from the evidence-based level that hamstring stretching has a stable intervention effect on the pain relief of lower back pain. It should be noted that the heterogeneity among the meta-analysis studies is relatively high ($I^2=89\%$), which may be related to the differences in included populations, stretching protocols, and control Settings among the studies [13].

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Another single-blind randomized controlled trial (RCT) included 75 patients with non-specific lower back pain (ultimately 66 were included in the analysis, 34 men and 32 women, aged 30 to 65 years), and they were randomly divided into three groups. The intervention period was 6 weeks, with training three times a week for a total of 18 times, each time for 45 minutes. All three groups received 30 minutes of core stability training. The additional 15 minutes of intervention were as follows: The stretching group (n=24) received maximum range of motion stretching training for the peri-hip muscles (including hamstrings, iliopsoas, piriformis, and tensor fascia latae stretching, each holding for 30 seconds and repeated 3 times); The reinforcement group (n=22) received maximum isometric contraction reinforcement training of the perihip muscles (held for 30 seconds each time, repeated 3 times). The sham treatment group (n=20) received sham treatment with gentle palpation of the lumbosacral skin. The test results showed that after 18 training sessions over 6 weeks, the pain intensity in the stretching group decreased by 3.58 points, in the strengthening group by 3.75 points, and in the sham treatment group with only core stability training by 2.93 points. This suggests that the analgesic effect of combined hip periarticular training is 22% - 28% higher than that of core training alone. In addition, the stretching group was superior to the sham treatment group in terms of improvement in lower back instability (7.5° vs 3.3°), ODI function (28.42 points), and balance ability (4.78 seconds), confirming that hip flexibility training combined with core stability training has a synergistic effect on improving lumbar stability and function [14].

The mechanism of action lies in the biomechanical regulation of the interaction between the pelvis and the lumbar vertebrae: Prolonged sitting keeps the hamstring and iliopsoas muscles in a shortened state. The tension of the hamstring pulls the pelvis backward, flattening the physiological lordosis of the lumbar vertebrae, altering the normal mechanical curve of the lumbar vertebrae, and increasing the tension of the annulus fibrosus at the back of the intervertebral disc. When the iliopsoas muscle is tense, it pulls the pelvis forward, increasing the lumbar lordosis and the pressure on the intervertebral discs. Restoring the normal length of the hamstrings and hip flexors through stretching can correct abnormal pelvic position and reduce compensatory load on the lumbar vertebrae. At the same time, strengthening the hip muscle groups such as the gluteus medius and gluteus maximus can improve the stability of the hip joint and further reduce the compensatory demand of the lumbar vertebrae. In addition, the improvement of hip flexibility can also increase the range of motion of the lumbar vertebrae and reduce passive traction injuries to the lumbar vertebrae during daily activities.

The basic training exercises suitable for high school students include sit and reach, supine straight leg raise stretch, lunge stretch, clamshell exercise and closing, and hip bridge. Given that high school students generally suffer from posterior chain tension and lack professional stretching guidance, training should follow the principles of gradual progress, painless stretching, and breathing coordination. Each movement should be held for 20 to 30 seconds, with three sets on each side, to avoid muscle strains caused by ballistic stretching. During the stretching process, it is necessary to maintain normal breathing and not hold breath. The intensity of the stretching should be such that people feel a slight stretch in the muscles and should not reach a painful level.

## 4. Conclusion

Nonspecific lower back pain in adolescents has become a highly prevalent musculoskeletal health issue among high school students. Its occurrence is the result of the combined effect of unmodifiable congenital factors and modifiable environmental, behavioral and psychological factors. Genetic traits lay the innate foundation for an individual's lumbar spine structure and pain sensitivity. However, sedentary behavior, poor posture, weak hip and core muscle function, sleep disorders,

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anxiety and depression induced by academic pressure, and excessive schoolbag load are the key triggers that promote the occurrence of pain, aggravate symptoms, and increase the risk of chronic pain. There is a synergistic and superimposed effect among various risk factors: Prolonged sitting can induce posterior chain muscle tension and pelvic compensation, while psychological stress can amplify pain perception through central sensitization, ultimately forming a vicious cycle of "pain - reduced activity - decreased muscle strength - intensified pain".

Exercise rehabilitation is the first-line intervention method recommended by evidence-based practice for non-specific lower back pain in adolescents. Among them, core stability training focuses on activating the deep stabilizing muscle groups of the lumbar vertebrae and rebuilding the ability to control spinal segments. Hamstring and hip flexibility training regulates pelvic-lumbar biomechanics and improves the soft tissue of the posterior chain that has shortened due to prolonged sitting. Both types of training have reliable quantitative clinical effects. The analgesic and functional improvement effects of the combined intervention are superior to those of the single training program.

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