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SPINAL INJURIES IN WEIGHTLIFTERS AND POWERLIFTERS: A NARRATIVE ANALYSIS

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ABSTRACT

Introduction and Objective: The growing popularity of weightlifting and powerlifting has been accompanied by an increased incidence of spinal injuries, posing significant health and career risks for athletes. This narrative analysis aims to synthesize existing evidence to identify key risk factors, injury mechanisms, and the prevalence of spinal injuries across cervical, thoracic, and lumbar segments in these disciplines.

Review Methods: A narrative analysis was conducted using PubMed and Scopus databases. The study focused on peer-reviewed articles addressing spinal injuries, biomechanical factors, and injury prevention strategies in weightlifting and powerlifting. Limitations included variability in study quality, a limited number of targeted publications, and potential underreporting of injuries.

State of Knowledge: Spinal injuries predominantly affect the lumbar region (28–59% of cases), driven by extreme mechanical loads during exercises like the deadlift, with disc herniation and chronic pain as common outcomes. Thoracic injuries (1.7–44%) are less frequent but linked to myogelosis and spondylolisthesis, while cervical injuries are rare (1–3%) but include severe cases such as Jefferson fractures. Chronic pain, however, is prevalent across all segments, with 52% of weightlifters reporting annual cervical pain. Technical errors, training overload, and fatigue were identified as primary injury risk factors, contributing to 31% and 81% of cases, respectively.

Conclusion: Spinal injuries, particularly in the lumbar spine, remain a critical concern in weightlifting and powerlifting. Injury prevention should prioritize technique refinement, load management, and fatigue mitigation. Further high-quality studies are needed to address gaps in injury reporting and longitudinal outcomes.

KEYWORDS

Weightlifting, Powerlifting, Spinal Injuries, Biomechanics, Injury Prevention

CITATION

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Introduction.

In recent years, strength sports, particularly weightlifting and powerlifting, have been gaining popularity in both recreational and professional settings, and among both adults and younger people [1]. The number of people with disabilities participating in Paralympic weightlifting competitions is also growing [2]. These disciplines differ from each other in technique, which has far-reaching consequences in terms of the emergence and prevention of injuries associated with the practice of these sports. [3] In order to get a good understanding of where spinal injuries in the disciplines detailed in this article come from, it is worthwhile to give them a little more insight. Weightlifting consists of a snatch, which consists of - lifting the barbell above the head in one smooth movement. and a toss-up (clean and jerk) in which the barbell is first thrown over the shoulders, and then dynamically pushed over the head. Powerlifting consists of squat, deadlift and deadlift [3].

Unfortunately, with the growing interest in the sport, there has been an increase in the number of cases of spinal injuries, which can have serious consequences for health and future sports careers [4]. These injuries, which include disc herniations, compression fractures or damage to musculoskeletal structures, often result from excessive loads or improper technique. Spinal injuries and musculoskeletal overloads are a significant challenge among weightlifters, not only recreationally but also among those involved in the sport professionally even at the Olympic level. It has been shown that 23.3% of Paralympic weightlifters suffered injuries during competition, 61% of which were chronic overload injuries, and the most common locations included the shoulder joint (32%) and lumbar spine (28%) [3]. At the same time, an analysis of the Prevalence of Joint-Related Pain in the Extremities and Spine [5] indicates that 54% of professional weightlifters experience chronic lumbar pain, which correlates with repetitive strain during exercises such as the deadlift [5].

It is worth noting that the frequency of injury varies between age groups. In 70 7-16 year olds lifting weights over a 1-year period, there was not a single missed training day due to an injury related to this activity [1].

Methodology

Research Objective.

The purpose of this study, which is a narrative analysis, is to collect and look at spinal injuries related to weightlifting in order to identify:

1. Key risk factors
a. The most common injury locations and mechanisms of injury
b. The incidence and severity of spinal injuries in people who practice these sports
2. Database:
a. Pubmed
b. SCOPUS
3. Limitations of the work:
a. quality of available studies and articles
b. number of papers addressing the issue
c. number of injuries unreported or undetected

Results

General structure of the spine

The structure of the spine includes 7 cervical vertebrae (C1-C7), 12 thoracic vertebrae (Th1-Th12), 5 lumbar vertebrae (L1-L5), 5 fused sacral vertebrae, and the hyoid bone (formed by 4-5 vestigial hyoid vertebrae). The cervical, thoracic and lumbar vertebrae show morphological similarities, with the exception of the atlas (C1) and the pivot vertebra (C2). A typical vertebra contains a shaft (corpus vertebrae), a pair of bony epiphyses (pediculi arcus vertebrae), a pair of laminae (laminae arcus vertebrae), four articular surfaces (facies articulares) and a spinous process (processus spinosus).

The atlas (C1) takes the form of a bony ring devoid of a shaft, while the rotating vertebra (C2) is characterized by the presence of a tooth (processus odontoideus), which is the axis of rotation for the atlas.

Between adjacent vertebrae are located even intervertebral openings (foramina intervertebralia), through which run the spinal nerve (nervus spinalis), the root blood vessels (vasa radicularia) and the meningeal return nerves (nervi sinuvertebrales). Anatomical boundaries of the orifices include:

From above and below: vertebral epiphyses (pediculi),

From the front: the intervertebral disc (discus intervertebralis) and the surfaces of the vertebral bodies,

From behind: intervertebral joints (articulationes zygapophysiales; facet joints).

The space of the vertebral canal (canalis vertebralis) is defined by:

Posterolateral wall: the laminae of the vertebral arches (laminae) and the yellow ligaments (ligamenta flava),

Anterolateral wall: bony epiphyses (pediculi),

Anterior wall: posterior surfaces of vertebral bodies and intervertebral discs [6]

Intervertebral disc

Morphological structure

Consists of two major morphological elements:

1. Fibrous ring (annulus fibrosus) - an outer layer made of elastic collagen fibers,
2. The nucleus pulposus - a central, gelatinous mass.

The specific arrangement of collagen fibers in layers (lamellae) at oblique angles and alternating directions gives the fibrous ring elasticity while maintaining mechanical strength. The number of lamellae varies between 15 and 25 [7]. These fibers functionally connect to adjacent structures: the edges of the vertebral bodies, longitudinal ligaments (ligamenta longitudinalia) and border lamellae of vitreous cartilage (endplates), which in turn integrate with the vertebral bodies through a layer of calcified cartilage [8].

Functionality of the nucleus pulposus

The nucleus pulposus, characterized by a water content of 88% in a young, healthy disc, functions as a hydraulic system that performs key tasks:

1. Separation of the vertebral bodies,
2. Shock absorption,
3. Enabling transient compression and intervertebral movement.

Ligaments of the spine

The ligaments of the spine stabilize the vertebrae, working with the spinal muscles to control and limit the range of motion. Some of them are of particular clinical importance.

Posterior longitudinal ligament (ligamentum longitudinale posterius).

It extends from the pivot vertebra (C2) (referred to as the lid membrane in the upper cervical section) to the sacrum, forming the anterior wall of the spinal canal. In the cervical and thoracic segments it is wide, but from the L1 level it narrows, reaching half of its original width at the L5 level. It firmly attaches to the intervertebral discs through sheets of vitreous cartilage (endplates), and to the vertebral bodies - only in the medial line by means of a septum that connects to the periosteum. The space between this ligament and the vertebral body is the anterior epiphyseal space, important in the pathogenesis of disc herniation. Stenosis of the ligament in the lumbar region weakens disc stabilization, increasing susceptibility to injury and discopathy, especially with significant static-kinetic loading [6].

The yellow ligaments (ligamenta flava)

Even, strong elastic ligaments connecting the laminae of the vertebral arches - they attach to the lower surface of the laminae of the vertebra lying above and the upper edge of the laminae of the vertebra below. They laterally connect to the sacs of the intervertebral joints (articulationes zygapophysiales). They allow flexion of the spine by stretching, with minimal nociceptive fibers. Thickening of the zygapophysial ligaments during the aging process, combined with degenerative changes, can lead to stenosis of the spinal canal, causing cervical myelopathy or lumbar pony tail compression [6].

Other stabilizing ligaments

Anterior longitudinal ligament (ligamentum longitudinale anterius) - runs along the anterior surface of the vertebral bodies.

Nuchal ligament (ligamentum nuchae) - connects the occiput to the cervical vertebrae.

Interspinal ligaments (ligamenta interspinalia) and supraspinal ligaments (ligamenta supraspinalia) - stabilize the spinous processes.

Occipito-vertebral ligaments - strong structures that connect the occiput to the atlas (C1), allowing up to 30° of flexion and extension at the occipito-atlantoaxial joint [6]

Stabilization of the atlantoaxial joint

The stability of the C1-C2 joint depends mainly on the ligaments:

The transverse ligament of the atlas holds the rotational vertebral tooth (dens axis) in its anatomical position. It is stronger than the tooth itself - in injuries, the tooth usually fractures, not the ligament ruptures.

Wing ligaments (ligamenta alaria) - even, attached to the apex of the tooth and the occipital condyles. They limit rotation of the head, participating in the control of ~90° of the 160° total range of rotation [6].

Spinal injuries

Cervical segment

Isolated cervical spine injuries related to weightlifting are a relatively rare occurrence. In a study considering injuries in Weightlifters on powerlifting conducted in 1995, out of 92 subjects, 3% of the athletes in the study had neck injuries, while in a 2000 study, out of 105 subjects, spinal injuries accounted for 1% [9]. A similar incidence of injuries was noted in a study [9]. Where only 3% of neck injuries among 111 subjects were reported. Such a low percentage of injuries in this segment is related to the relatively wide range of mobility of this segment of the spine including 80-90° of flexion, 70° of extension, 20-40° of lateral flexion and up to 90° of rotation in each direction] as well as the fact that the vertebral bodies (c3-C7) have slightly curved end surfaces in the sagittal plane, with the front edge pointing downward. Thanks to this structure, the whole takes on a slightly oblique shape that facilitates flexion and extension in the sagittal plane, adequately transferring the forces generated in this axis [10].

The situation looks quite different, however, if we take into account the criterion of the occurrence of cervical pain. It was noted that weightlifters experienced cervical pain in the last week in 41% of the subjects, compared to only 9% of non-athletes. In the perspective of a year, cervical pain in weightlifters was 52% and in non-athletes 33% [5].

An interesting case worth mentioning as part of the topic covered in this paper is that of a patient who developed a Jefferson fracture resulting from weightlifting. Jefferson fracture is a fracture involving a fracture of the summit vertebra (C1), it is characterized by outward displacement of the C1 ring [1]. The mechanism of injury is due to vertical compression transmitted from the occipital through the lateral part of the C1 ring. This results in a fracture of one or both arches (anterior and posterior), often co-occurring with other cervical injuries [11].

Thoracic and lumbar spine

Pain and injuries to the thoracic and lumbar regions are the most common spinal injuries reported by weightlifters [5].

Thoracic segment:

According to a study [12], the incidence of thoracic injuries was 44% among 43 subjects, and among all the subjects considered in this study, the percentage was 25-44%.

A study [13] considering 101 powerlifters showed that in this group of subjects, the incidence of thoracic spine injuries was only 1.7%.

[14] is a study in which among 71 men

Another study analyzing the frequency of injuries in weightlifters is [15] in which attention is drawn not only to the frequency of injuries in the cervical and thoracic spinal regions themselves, which varied between 1.7% and 44%, but also to the comparison of the frequency of injuries in these regions of the spine with that of the lumbar spine, in which the frequency of injuries varied between 1.8% and 50% and remained always higher regardless of the group in which such a study was conducted. [15]

A lower incidence of thoracic spine injuries compared to lumbar injuries was also noted in a study [3]in which among 92 subjects (1995 study), thoracic injuries were sustained by 7 trainees (8% of all subjects) where, in comparison, lumbar injuries were sustained by 13% of subjects (14% of all participants). In the 2000 study, (105 people included in the study) thoracic injuries were suffered by 4 participants and lumbar injuries by 13 participants.

The fact that thoracic injuries are less common is also confirmed by a study [3]which showed that among weightlifters of the ELITE group from the 1993-1995 competition, the injury rate per 1,000 hours of training was 0.22 (1995) and 0.05 (2000) where, by comparison, for the lumbar, the same rate was 0.45 (1995) and 0.44 (2000). while for the POWERLIFTER group, the coefficients were 0.19 (1995) and 0.13 (2000) for the thoracic segment and 0.43 (1995) and 0.41 (2000), respectively.

A study [16] confirmed thoracic segment injury in 15 (21.1%) exercisers where the most common problems were myogelosis (8.4%) and athletes indicated a sliding vertebra (5.6%).

Lumbar segment

The enormous loads on the lumbar spine during weightlifting are responsible for the highest injury rate of all spinal segments [3].

The high intensity of spinal injuries in this region also seems to be confirmed by a study [16] where injuries to the lumbar spine were reported by 28 (39.4%) exercisers. The most common diagnoses were disc herniation, sciatica, hyperlordosis, and myogelosis.

It is also noteworthy that the lumbar region in weightlifters is the most common site of pain in weightlifters. In a study [5], 59% of weightlifters experienced lumbar spine pain in the last year being thus the most common site of pain in this group of subjects. This is also supported by the results of a study [17] which noted that the most common problem reported by weightlifters was lumbar pain. Such a high percentage of reported injuries and pain in this section of the spine is most likely related to the enormous forces exerted during weightlifting, especially during deadlifting, when the forces exerted on this section reach up to 17,000 N [17].

General factors influencing injuries:

Among the papers analyzed for general factors influencing the occurrence of injuries in weightlifters, it is noted that technical errors contributed to the occurrence of 31% of injuries among weightlifters. In addition to poor technique, other factors have been noted to increase the risk of injury which include fatigue and training overload which in the study [18] accounted for 81% of injuries. A large percentage of the aforementioned injuries resulting from fatigue and overload may be due to overlooked motor control and decreased concentration. The study mentioned above seems to confirm this relationship, noting that the highest number of injuries (44%) occurred at the very end of the competition, compared to 24% at the beginning and 33% in the middle of the competition.

The effect of technique on reducing injuries also seems to be confirmed by studies [19] [20] and [21].

Table 1. Comparison of Spinal Injury Patterns in Weightlifting and Powerlifting

Spinal Segment	Weightlifting	Powerlifting
Cervical	Rare (1–3%); Jefferson fracture risk	Rare (<1%); chronic pain prevalent
Thoracic	1.7–44%; myogelosis, spondylolisthesis	1.7–25%; lower prevalence vs. lumbar
Lumbar	28–59%; disc herniation, chronic pain	28–50%; hyperlordosis, sciatica

Discussion

This study provides a comprehensive analysis of spinal injuries among weightlifters and powerlifters, highlighting key differences between these disciplines and risk factors associated with injuries. The results indicate that the lumbar spine is the most vulnerable segment (28–59% of cases), consistent with literature emphasizing extreme mechanical loads during exercises such as the deadlift, which can reach up to 17,000 N [17]. The high prevalence of disc herniation and chronic pain underscores the need for technique optimization and load management. Comparisons with prior studies [3, 15] reveal consistency in the predominance of lumbar injuries over thoracic and cervical injuries. However, discrepancies in thoracic injury rates (1.7–44%) may stem from methodological variations, such as differing definitions of "injury" (acute vs. chronic) or participant demographics (elite vs. recreational athletes). Notably, while cervical injuries are rare (1–3%), the high annual prevalence of chronic cervical pain (52%) reported in this population [5] suggests subclinical overloads that warrant further investigation.

The identification of risk factors, such as technical errors (31% of injuries) and training overload (81%), highlights the critical role of athlete education and fatigue monitoring. Supporting studies [19–21] confirm that refining technique (e.g., maintaining spinal neutrality) and utilizing safety equipment (e.g., weight belts) can reduce mechanical stress, serving as vital preventive measures. Furthermore, the higher incidence of injuries during the final stages of competitions (44%) emphasizes the importance of managing physical and mental endurance during high-pressure events.

Limitations of this narrative analysis include heterogeneity in study designs, a limited number of publications focused exclusively on spinal injuries, and potential underreporting of injuries, particularly among amateur athletes. The absence of long-term observational studies also hinders the assessment of chronic overload consequences.

Conclusion

The spine in weightlifters shows varying susceptibility to injury, depending on the anatomical and biomechanical properties of the individual segments. The lumbar segment, which is exposed to extreme compressive forces (up to 17,000 N in a deadlift), is the area of most frequent injury (39-59% of cases), mainly in the form of discopathy, sciatica or degenerative changes. In the cervical segment, despite the rarity of acute mechanical injuries (1-3%), chronic pain affects up to 52% of athletes, suggesting soft tissue overload associated with repetitive stress. The thoracic segment, stabilized by the rib cage, has a lower incidence of injury (1.7-44%), with overload lesions dominating. Technical errors (31% of injuries) and overtraining (81% of injuries) remain key risk factors, with a peak of incidents in the final phases of exercise (44%), indicating a link to decreased motor control.

Future research should focus on elucidating the mechanisms of chronic cervical pain in weightlifters, especially the impact of microtrauma to ligaments (e.g., wing ligaments) and musculo-fascial dysfunction. A deeper analysis of thoracic biomechanics is also needed, particularly the role of the thoracic spine in stabilization and factors contributing to vertebral displacement, which may be underestimated in current statistics. In the context of the lumbar region, it is crucial to develop training protocols that minimize shear and compression forces, such as by modifying deadlift technique. In addition, it is important to study the relationship between fatigue and spinal destabilization, especially in the context of the risk of discopathy, and the long-term effects of overload in retired athletes. It is also worth evaluating the usefulness of advanced diagnostic methods, such as MRI or elastography, in detecting early changes in intervertebral discs and ligaments. An interdisciplinary approach, combining biomechanics, sports medicine and physiotherapy, is essential to reduce trauma and improve player safety.

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