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ORIGINAL RESEARCH

Analysis on the effect of lumbar musculoskeletal injuries and core strength training in male weightlifters

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Abstract

To study the effect of core strength training on male weightlifters with lumbar musculoskeletal injuries. Thirty male weightlifters were recruited for this study, and we examined the characteristics of sports injuries and analyzed their causes. Subsequently, the athletes underwent systematic core strength training, and we evaluated their physical motor function using the Functional Movement Screen (FMS) test and the Y-Balance Test (YBT) and assessed injury rehabilitation based on the Japanese Orthopaedic Association (JOA) low back pain score post core strength training. The results revealed that 23 out of 30 male weightlifters, constituting 76.67% of the sample, exhibited various degrees of lumbar injury. Chronic lumbar musculoskeletal injuries were predominant, accounting for 56.52%, with the lumbar region being the primary site, comprising 47.83% of injuries. The most common causes of injury were physical fatigue (65.22%) and inadequate preparation activities (56.52%). Analysis of baseline data indicated no significant differences in the incidence of lumbar musculoskeletal injuries among male weightlifters of different ages, sports grades, years of professional training, or best performance ($p > 0.05$). After core strength training, male weightlifters with lumbar musculoskeletal injuries demonstrated significant improvements in the deep squat, trunk stability push-up, hurdle steps, rotary stability and total scores of the FMS test ($p < 0.05$). Similarly, their Anterior, Medial and Lateral scores in the Y-Balance Test increased significantly post-training ($p < 0.05$). The Japanese Orthopaedic Association (JOA) improvement index was (3.31 ± 0.76), corresponding to a 59.64% improvement rate. The incidence of lumbar musculoskeletal injuries remains elevated in male weightlifters, with lumbar vertebrae and muscles being the most commonly affected areas, notably characterized by chronic lumbar injuries. Core strength training could be considered an effective strategy for improving the functional motor abilities of male weightlifters suffering from lumbar musculoskeletal injuries as it can reduce the severity of low back pain.

Keywords

Male; Weightlifters; Lumbar musculoskeletal injuries; Core strength training; Effect analysis

1. Introduction

Competitive weightlifting remains a sport associated with exceptionally high risk, where athletes face a significant likelihood of injury during both training and competition. Among these injuries, those affecting the waist are particularly prevalent, given the substantial demands placed on this region in weightlifting sports [1–3]. Lumbar musculoskeletal injuries not only jeopardize athletes' health but also disrupt their regular training and competition schedules. In severe cases, such injuries can stop athletes' sporting careers. Moreover, it has been observed that weightlifters often exhibit low item scores on push-ups in the Functional Movement Screen (FMS) test, indicating a potential association between weak core strength and sports injuries among this population [4–6]. However, limited research has investigated the efficacy of core strength training interventions in enhancing the athletic performance of male weightlifters with lumbar musculoskeletal injuries and alleviating their waist pain. Thus, the present study aims to analyze the impact of core strength training interventions on male weightlifters. The aim is to provide reference for relieving lumbar musculoskeletal injuries of male weightlifters and improving the training and competition effect of athletes.

2. Subjects and methods

2.1 Study subjects

Thirty male weightlifters who had not undergone systematic rehabilitation physical training before were recruited for the study. The age range of participants varied from 18 to 30 years old, with the youngest being 18 and the oldest 30 years old. Table 1 presents the distribution of their age, sports level, years of sports experience, and other data.

Sample size calculation: The primary outcome measures of this study entailed FMS, YBT and JOA scores. The above indicators were employed to calculate the sample size respectively. The calculation formula of paired *t* test was used:

$$N = [\frac{(Z_{\alpha/2} + Z_{\beta})\delta}{\partial}]^2$$

$\alpha = 0.05$, $\beta = 0.10$. The maximum sample size calculated by each indicator was 20. The sample size was increased to 23 considering the loss to follow-up and the actual situation.

2.2 Study methods

2.2.1 Literature method

The study conducted comprehensive searches across databases, including China national knowledge infrastructure (CNKI) and electronic libraries, employing keywords such as "weightlifting", "lumbar musculoskeletal injuries", "rehabilitation physical training" and "core strength training". This exhaustive process aimed to gather relevant data systematically. The collected information facilitated a thorough understanding of the current status of the topic, thereby establishing a robust theoretical foundation for the study's progression.

2.2.2 Outcome measures

2.2.2.1 Functional Movement Screening (FMS) [7]

FMS tests were conducted on male weightlifters twice: once before initiating core strength training and again after 4 months of training, with the same panel member overseeing both sessions. The FMS was used to evaluate athletes' movement patterns and obtain their total score from a total of 21 points, where scores above 14 points suggest a lower risk of injury. The test comprises seven movement assessments: deep squat, hurdle steps, inline lunge, shoulder mobility, active straight-leg raising, trunk stability push-up, and rotary stability. Additionally, three screening movements for shoulder impingement, spinal flexion and spinal extension are included. If any pain occurs during testing, the assessment is immediately discontinued.

2.2.2.2 Y-Balance Test (YBT) [8]

The YBT test was administered by the same team member before and after 4 months of core strength training for male weightlifters. During the test, participants were required to remove their shoes. Initially, the length of their lower limbs was measured, with subjects positioned naturally in a supine posture. They were then instructed to utilize specific detection instruments to perform the test in three directions. Each directional test was repeated three times, and the furthest distance reached was recorded as the final measurement. If participants failed more than 4 tests, they were deemed unqualified. The YBT was used to assess motor performance and is segmented

TABLE 1. Baseline data of the investigated male weightlifters.

Factors	Range	Case (%)
Age		
	18–20 yr	4 (17.39)
	21–23 yr	12 (52.17)
	24–27 yr	4 (17.39)
	28–30 yr	3 (13.04)
Sports level		
	Master sportsman	3 (13.04)
	National-level of athletes	7 (30.43)
	Level II national athlete	13 (56.52)
Professional training years		
	3–5 yr	6 (26.09)
	6–8 yr	7 (30.43)
	≥9 yr	10 (43.48)
Best grades		
	Country level	6 (26.09)
	Province level	17 (73.91)

Note: Description of nature of injury: Acute musculoskeletal injuries refers to the injury caused by direct or indirect violence suffered by athletes during training. Subacute musculoskeletal injuries refer to chronic musculoskeletal injuries transformed from acute musculoskeletal injuries without complete recovery. Chronic musculoskeletal injuries are caused by the long-term excess complex of local lumbar spine in athletes and subtle injury.

into lower limb and upper limb tests. Lower limb testing helps identify instability in chronic ankle and anterior cruciate ligament conditions of the knee, as well as predicting the risk of lower limb injuries in athletes. Conversely, upper limb testing aims to evaluate the motion and stability of the upper limbs to the fullest extent.

2.2.2.3 Japanese orthopaedic association (JOA) low back pain rating scale [9]

The JOA low back pain rating scale was performed on the male weightlifters before initiating core strength training and after 4 months of training, with the same panelist overseeing both assessments. The scale comprises four components: subjective symptoms (low back pain, leg pain/tingling, gait), clinical signs (straight leg raising test, sensory disturbance, dyskinesia), limited daily activities, and bladder function. The scores for the JOA low back pain rating scale range from 0 to 29 points, with lower scores indicating more pronounced waist dysfunction in the participants. Scores below 10 were classified as poor, while scores ranging from 10 to 15 were considered moderate, scores from 16 to 24 were deemed good, and scores from 25 to 29 were classified as excellent. The improvement index was calculated as the difference between the score after treatment and the score before treatment, while the improvement rate was determined as follows: Improvement index = score after treatment − score before treatment, Improvement rate = [improvement index/(29 − score before treatment)] × 100%.

2.2.2.4 Test instructions

All tests were performed by the same subject group members after receiving regular training. FMS test was conducted followed by YBT test. Finally, JOA low back pain rating scale was utilized. FMS test and JOA scale were scored within 10 min, and YBT test was performed within 20 min. To ensure the stability of the test, another experienced exercise rehabilitation physician was invited to perform the Cohen's kappa test for agreement, suggesting good agreement with the test.

2.3 Core strength training

Core strength training regimen includes various exercises targeting specific muscle groups such as the multifidus muscle, active straight-knee leg raising, supine wall pushing for core stability, rotational stability exercises in the supine position, core control exercises involving ball clamping, single-hand single-leg extension in the kneeling position, balance training in semi-kneeling position, and neck exercises in semi-kneeling position.

The frequency and duration of core strength training sessions were tailored to the athlete's condition and specific training requirements. Typically, core strength training was conducted 3 to 4 times per week, comprising 4 to 12 exercises per session. Each exercise set was repeated 5 to 7 times, with the entire training session lasting no more than 1.5 hours to prevent excessive fatigue. The training time ranged from November to March next year, that is, winter training, with a total length of 4 months.

Of note, the athlete's physical condition was primarily assessed based on their own perception and exertion level. Exercise intensity was calculated using the formula: exercise heart rate/(220 − age) × 100%. Training intensity typically ranged from 60% to 89% of the maximum heart rate. If the athlete feels well, the amount of exercise can be increased, otherwise it can be reduced.

2.4 Statistical methods

Data analysis was conducted using the SPSS v22.0 software (BMI, Inc., Chicago, IL, USA). Kolmogorov-Smirnov normality test and Levene variance homogeneity test were used. The measurement data conforming to normal distribution were expressed as (±s). Paired t-tests were used to compare mean values before and after the intervention. Enumeration data are reported as frequencies. The χ^2 test was utilized to compare between the two groups. A significance level of $p < 0.05$ was considered statistically significant.

3. Results

3.1 Statistics on the status of lumbar musculoskeletal injuries in male weightlifters

Of the 30 male weightlifters, 23 individuals, constituting 76.67% of the sample, exhibited various degrees of lumbar musculoskeletal injuries. Chronic lumbar musculoskeletal injuries comprised the largest proportion at 56.52%. The lumbar region was the primary site of injury, accounting for 47.83%, and the leading causes of injury comprised physical fatigue (65.22%) and inadequate preparation activities (56.52%) (Table 2).

When diagnosing lumbar musculoskeletal injuries, the sports medicine physicians conducted comprehensive evaluations, considering athletes' reported pain locations, accompanying symptoms, physical examinations and diagnostic imaging findings. These injuries were categorized into three types: acute, resulting from direct or indirect trauma during training; subacute, indicating incomplete recovery from an acute injury leading to chronic issues; and chronic, caused by prolonged and excessive loading on the waist region, accumulating minor injuries over time. Athletes' complaints and diagnostic records from hospital assessments provided the data for analysis.

3.2 Demographic characteristics of male weightlifters with waist injury

Analysis of baseline data from male athletes who experienced lumbar musculoskeletal injuries revealed no significant difference in the incidence of such injuries among male weightlifters of varying ages, sports grades, years of professional training, and best performance ($p > 0.05$), as illustrated in Table 3.

3.3 Analysis of FMS test results of male weightlifters with lumbar musculoskeletal injuries before and after core strength training

After undergoing core strength training, male weightlifters with lumbar musculoskeletal injuries (23 cases) demonstrated

TABLE 2. Nature, distribution and causative factors of injuries among male weightlifters.

Injury investigation	Group	Case (n (%))
Injury nature		
	Acute lumbar musculoskeletal injuries	7 (30.43)
	Chronic lumbar musculoskeletal injuries	13 (56.52)
	Subacute lumbar musculoskeletal injuries	3 (13.04)
Injury distribution		
	Lumbar spine injury	11 (47.83)
	Lumbar muscle injury	7 (30.43)
	Ligament injury	5 (21.74)
Injury cause		
	Physical fatigue	15 (65.22)
	Inadequate prep activities	13 (56.52)
	Overloaded exercise	9 (39.13)
	Unreasonable technical action	9 (39.13)
	Inattention	6 (26.09)

TABLE 3. Baseline data of male weightlifters with lumbar musculoskeletal injuries.

Item	Range	Case	Lumbar injury (n (%))	χ^2	p
Age					
	18–20 yr	7	6 (85.71)	1.800	0.615
	21–23 yr	16	11 (68.75)		
	24–27 yr	4	3 (75.00)		
	28–30 yr	3	3 (100.00)		
Sports level					
	Master sportsman	3	3 (100.00)	3.955	0.138
	National-level of athletes	11	10 (90.91)		
	Level II national athlete	16	10 (62.50)		
Professional training years					
	3–5 yr	6	5 (83.33)	0.186	0.911
	6–8 yr	12	9 (75.00)		
	≥9 yr	12	9 (75.00)		
Best grades					
	Country level	5	5 (100.00)	1.826	0.177
	Province level	25	18 (72.00)		

significant improvements in the scores of the deep squat, trunk stability push-up, hurdle steps, rotary stability, and total score of the FMS test compared to their pre-training scores. These improvements were statistically significant ($p < 0.05$) (Table 4).

3.4 Analysis of YBT results of male weightlifters with lumbar musculoskeletal injuries before and after core strength training

After completing core strength training, male weightlifters with lumbar musculoskeletal injuries experienced statistically significant increases in their Anterior, Medial and Lateral scores on the YBT compared to their scores before training, as evidenced by Table 5.

3.5 Analysis of JOA low back pain rating scale score of male weightlifters with lumbar musculoskeletal injuries before and after core strength training

After completing core strength training, male weightlifters with lumbar musculoskeletal injuries demonstrated statistically significant reductions in their scores on the JOA low back pain rating scale compared to their pre-training scores,

TABLE 4. Analysis of FMS test results among male weightlifters with low back injury before and after core strength training.

Item	Pre-training (n = 23)	Post-training (n = 23)	*t*	*p*
Deep squat	1.04 ± 0.23	1.93 ± 0.43	−12.934	<0.001
Trunk stability push-up	1.08 ± 0.24	1.83 ± 0.35	−12.193	<0.001
Hurdle steps	1.36 ± 0.36	1.85 ± 0.39	−6.267	<0.001
Inline lunge	1.42 ± 0.33	1.46 ± 0.48	−0.474	0.786
Shoulder mobility	1.72 ± 0.37	1.86 ± 0.32	−1.946	0.435
Active straight-leg raising	2.36 ± 0.45	2.37 ± 0.63	−0.089	0.973
Rotary stability	1.28 ± 0.29	1.77 ± 0.33	−7.581	<0.001
Total score	10.26 ± 1.03	13.11 ± 1.46	−10.978	<0.001

TABLE 5. Analysis of YBT test results among male weightlifters with lumbar musculoskeletal injuries before and after core strength training.

Item	Pre-training (n = 23)	Post-training (n = 23)	*t*	*p*
Left				
Anterior	54.56 ± 13.15	61.15 ± 12.35	−2.479	0.037
Medial	94.46 ± 14.49	107.43 ± 13.87	−4.387	<0.001
Lateral	93.32 ± 15.37	105.76 ± 16.37	−3.759	<0.001
Right				
Anterior	53.68 ± 9.45	58.79 ± 7.69	−2860	<0.001
Medial	93.43 ± 15.09	105.43 ± 14.73	−3.806	<0.001
Lateral	92.49 ± 14.39	103.47 ± 15.05	−3.577	<0.001

as indicated in Table 6. The JOA improvement index was calculated to be (3.31 ± 0.76), with an improvement rate of 59.64%.

TABLE 6. Analysis of JOA low back pain rating scale score in male weightlifters with low back injury before and after core strength training.

Time	n	Total JOA score
Pre-training	23	23.45 ± 3.79
Post-training	23	26.76 ± 4.23
t		−3.959
p		<0.001

JOA: Japanese Orthopaedic Association.

4. Discussion

Low back injuries are common in weightlifters. The analysis attributes this prevalence to the essential role of the waist as the motor center within the human trunk, responsible for supporting weight, bearing loads and managing pressure exerted by the upper and lower limbs. Particularly noteworthy is the significance of waist strength during weightlifting exercises, which serve as the primary power source and are especially important when lifting the barbell from the ground [10]. The analysis of lumbar musculoskeletal injuries among male weightlifters revealed a predominant prevalence of chronic injuries (56.52%), followed by acute injuries (30.43%) and subacute injuries (13.04%). Chronic injuries primarily arise from prolonged overload of the lumbar spine, while acute injuries typically arise from explosive force or indirect trauma, commonly occurring during competitive events or high-intensity training sessions. Subacute injuries often progress into chronic conditions if acute injuries are not allowed sufficient time for full recovery. It is recommended that male weightlifters prioritize intervention strategies aimed at addressing chronic, subtle lumbar musculoskeletal injuries to impede further injury progression. Notably, lumbar musculoskeletal injuries predominantly manifest in the lumbar region and muscles, with ligament injuries exhibiting a comparatively lower incidence rate. Examination of injury causation reveals that physical fatigue, inadequate warm-up activities, excessive exercise loads, and improper technique are the primary contributors to injuries. To reduce the risk of injury, male weightlifters are advised to refrain from lifting when experiencing physical fatigue and diligently engage in stretching and warm-up routines before lifting [11, 12]. Furthermore, this study observed a consistent incidence of lumbar musculoskeletal injuries among male weightlifters across various baseline characteristics, including different ages, sports grades and training durations.

Core strength plays an important role in maintaining overall body movement stability, pelvis and spine stabilization, enhancing body balance, refining nerve-muscle control and enhancing body control and balance strength. Moreover, when coordinated with surrounding muscle groups, core strength can optimize exercise efficiency by reducing energy expenditure [13]. Core strength training, encompassing both static and dynamic exercises, contributes significantly to enhancing movement posture, lumbar stability and abdominal muscle tension. Static exercises enhance physical stability and coordination, promoting optimal posture and reducing the risk of lumbar injuries during exercise. Conversely, dynamic exercises enhance motor regulation capabilities, enabling the body to adapt posture to varying environmental conditions, thereby maintaining physical stability and minimizing injury risks [14, 15].

As demonstrated in the study of Szafraniec R *et al*. [16], short-term core stability training can effectively improve trunk muscle endurance of weightlifters' dynamic balance. The addition of core stability training to exercise training programs can enhance their technical action effects such as weightlifting snatching and clean and jerk. However, few studies have investigated the role of core strength training in improving lumbar musculoskeletal injuries in weightlifters. This study observed notable improvements following core strength training intervention. Post-training, male weightlifters had better scores in various functional movement assessments, including deep squat, trunk stability push-up, hurdle steps, rotary stability and total FMS scores compared to pre-intervention levels. Additionally, scores in the Anterior, Medial and Lateral components of the YBT also increased post-intervention. Furthermore, there was an observed increase in the JOA low back pain score post-training compared to pre-intervention levels, which underscore the efficacy of core strength training in augmenting the functional exercise capacity of male weightlifters and mitigating low back pain severity. However, the sample size of the studies included in this paper is small, and there is bias in the reported data. We can subsequently increase the sample size of the studies, and further analyze the effect before and after core strength training in patients with various types of lumbar musculoskeletal injuries. It can provide a reference for core strength training and rehabilitation in male weightlifters with lumbar musculoskeletal injuries.

5. Conclusions

In summary, core strength training can efficiently improve the functional motor ability of male weightlifters with lumbar musculoskeletal injuries and reduce the low back pain.

AVAILABILITY OF DATA AND MATERIALS

The authors declare that all data supporting the findings of this study are available within the paper and any raw data can be obtained from the corresponding author upon request.

AUTHOR CONTRIBUTIONS

WHZ—designed the study and carried them out; prepared the manuscript for publication and reviewed the draft of the manuscript. WHZ, HYD and HJC—supervised the data collection. WHZ and HYD—analyzed the data; interpreted the data. All authors have read and approved the manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Ethical approval was obtained from the Ethics Committee of Changzhi University (Approval no. DW2021543). Written informed consent was obtained from a legally authorized representative for anonymized patient information to be published in this article.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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