



Weight lifter lumbar health influence factor research based on sports medicine analysis

Kelei Guo

Department of Physical Education, Xianyang Normal University, Xianyang, China

ABSTRACT

Our country woman weight-lifting event has been kept ahead in the world for years, which indicates that our coaches and athletes have lots of successful experiences in weight-lifting training. However, it is little known that weight-lifting belongs to high-risk sports events, which has great damage to lumbar; some young excellent athletes tend to retire because of lumbar trauma that is regret for country's inputs and athlete's hard work. This paper analyzes weight lifters training and makes suggestions from medical perspective, with an aim to avoid lumbar injury and ensure lifters health. In this paper, firstly it makes investigation with 50 career women weight lifters, finds out that 82% lifters suffer lumbar diseases, the main causes are waist strain, excessive intensity and mistake motions such 3 factors. Then carries on structural mechanics analysis of weight lifters lumbar combining with human skeletal structure features from sports medicine perspective, gets two maximum lumbar force technical motions to research, and specifies the motions standard so as to reduce lumbar force as much as possible and make contributions to weight lifters lumbar health.

Key words: Sports medicine, weight lifter, lumbar strain, structural mechanics

INTRODUCTION

Weightlifting competition reveals human ultimate extraordinary power, is well-received by audiences. And our country women weightlifting is even the traditional dominant event, it has achieved good results of 14 gold 1 silver during recent 4 sessions of Olympic Games, which worth national pride and proud. However, it is little known that weightlifting has great damages to lumbar, lots of lifters suffer lumbar injuries, and the serious have to end sports life in advance which is regret to both country inputs and lifters' hard work. This paper analyzes lumbar force motions and makes suggestions from sports medicine perspective, with an aim to reduce injury to lifters' lumbar [1, 2].

For the research on weightlifting lumbar injury, lots of people have made efforts, from which Bao Chun-Yu(2009) Based on finite element method and through analysis of weight lifter snatch motions spine and lumbar force features, it points out that under weightlifting snatch entirely standing posture, Centrum main stress distributes in facet joint and vertebral pedicle, intervertebral disc contact pressure mainly concentrates on the middle and back part of fiber ring. If barbell weight is excessive heavy, lifter lacks of waist strength, waist and back muscle not sufficiently tighten, it will cause lumbar joint unstable, generate intervertebral disc excessive pinch so that let lumbar injured [1]; Shi He-Fu etc.(2003) Through investigation of the 27th Olympic Games woman weightlifting team sports injury, find that waist injury is uppermost in weightlifting injuries, its main causes are lacking of rigorous and scientific in training and insufficient sports medicine guarantee, which needs to strengthen medical monitoring and let team doctor to play their roles in lumbar diseases prevention and cure [2]; Hu Xian-Hao(2005) points out in his article of Chinese women weightlifting high level athletes waist injury research that training load should be well adjusted, rhythms should be noticed so as to prevent body partial excessive load that accumulate over a long period causing

lumbar injury[3-5].

This paper combines with previous results and suggestions, from medical perspective combining with human lumbar skeleton construction features to make force analysis of weightlifting key motions steps, gets lumbar shear force and pressure mechanics computational formula, specifies technical motions with mechanics formula with an aim to reduce weight lifters' lumbar shear force and pressure, and guarantee their lumbar health.

LUMBAR STRUCTURAL ANALYSIS BASED ON MEDICAL PERSPECTIVE

Lumbar (Figure 1) is one of the most important human parts; it can be regarded as human cross-beam. It bears weight of upper human body, when human naturally standing, lumbar bears human weight; when human bears load, lumbar endures the constriction of load, the bigger load is, the bigger constriction would be, and excessive loading and long time loading would cause waist muscle strain and generate diseases. Lumbar medial connects with each circuit of nerve and blood vessel; it plays an important role in human. If lumbar happened to be ill, it may constrict nerves, the slight lower limbs turn limb and occurs pain feeling, the serious lower limbs get paralyzed and bedridden. Lumbar structure is very complicated, once suffer illness, it is difficult to cure. Lumbar is the most important human structure, therefore people should take serious care of waist so as to avoid generating lumbar diseases [6, 7].

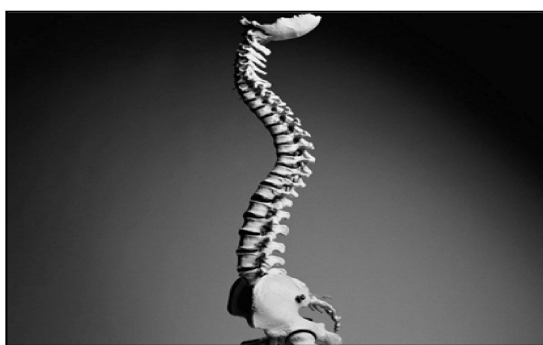


Figure 1: Lumbar

Lumbar diseases are complicated and diversity. Common lumbar diseases including lumbar disc herniation, waist muscle strain, lumbar hyperostosis, waist sprain, rheumatism or rheumatoid lumbago, cold-damp lumbago, blood stasis lumbago. Any diseases would bring great pain to people.

Common lumbar diseases symptoms are as following:

- 1) Lumbago: 90% sufferers have such symptoms. They are aware of waist continuously pains, it intensifies when standing and relieves when sleeping, normally it is tolerable; in case such symptom become serious, it is hard to endure and needs to lie in bed to take rest which seriously impacts on life and work.
- 2) Lower limbs radiation pain: 80% sufferers have such symptoms. It mainly shows that radiation stimulation and numbness feeling appear from waist to shank. The serious would show that electric shock sharp pains appear from waist to the bottom of foot while the slight can walk, lameness occurs, the serious cannot endure such pain and need to lie in bed to relieve pains.
- 3) Lower limbs numb: A minority of sufferers show that single lower limbs numb with own feeling of cold and chilly. Majority of sufferers get lower limbs numb accompany with pains.
- 4) Horsetail nerve symptoms: The sufferers appear numbness, pricking, urination and defecation function disturbance under waist, the serious would even appear out of control the urination and defecation as well as double lower limbs incomplete paralyzed.

Common induction causes:

- 1) Sudden weight-bearing: Waist load suddenly is increasing that produces larger impulse force to lumbar, is prone to generate herniation of the nucleus pulposus.
- 2) Waist trauma: Waist trauma may affect fiber ring, Chandra plate and other structure; make regressed nucleus pulposus get herniated.
- 3) Career factor: Every walk of life has different injury degrees on lumbar. Long-term in the same posture or long-time weight-bearing and other career features brings great damages to lumbar.

INVESTIGATION ON WEIGHT LIFTER LUMBAR INJURY CONDITIONS

Combine with above lumbar disease symptoms, make investigation on our country 50 career women weight lifters,

and find that 82% weight lifters have lumbar disease symptoms. It is known accordingly that to career weight lifters, lumbar diseases is quite universal, it need to take more rigorous care and cure. Find causes of 41 lifters suffering lumbar diseases can get Figure 2.

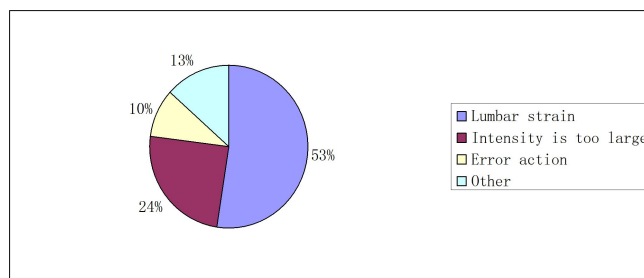


Figure 2: Lumbar injury main causes

From Figure 2, it is known that lumbar injury causes are mainly divided into waist strain, intensity too large, error action such 3 types, which cover 87% of numbers of lumbar injured people, while others only cover 13%. These 3 factors have closely relations with lumbar load bearing, waist strain is caused by long-term large intensity constriction that is hard to avoid and only can reduce injury through scientific training as much as possible. Intensity too large is because of weight lifters blindly pursuit of performance without considering themselves safety, therefore understanding of their own capacity in daily training should be strengthen, take a step-to-step training and avoid by all means blindly pursuit of performance. Error action is caused by weight lifers' unscientific and absent-minded; it needs to improve action scientificity in future daily training. Then this paper makes force analysis of weightlifting main motions and specifies its main technical motions from medical perspective, and reduces its injury to lumbar.

WEIGHTLIFTING TECHNICAL MOTION STEPS LUMBAR FORCE ANALYSIS AND SUGGESTIONS

Weightlifting mainly is divided into snatch and jerk such two types, the two types motion are of equal importance, usually add snatch and jerk performance together as competition performance in competition.

Analysis of jerk: Jerk motions including position at bar, clean and jerk such three stages.

Position at bar: Position at bar for two-hand jerk is that lifter walk to barbell, the first joint of his big toe lies right under the barbell, distance between two heels is 20 to 30 centimeters. Tiptoes slightly deviate outside, shank clings to bar, bent knee joint that make thigh and shank form into 90 degree. Hip joint bends to make thigh and upper lumbar form into 45 degree. Two arms relax freely extend and closely grip the bar, waist back straight up and shoulder slightly goes forward the bar, as Figure 3 shows.

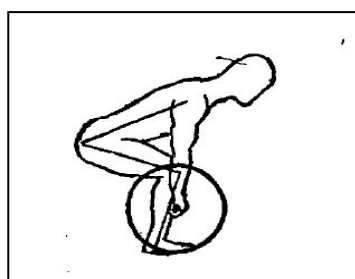


Figure 3: Jerk position at bar

Clean: Cleans can be divided into the split and the squat. Such two posts have their own features and both are widely used.

1) To split, first utilize leg strength, extend two legs to lift barbell, upper body remains original post without changing. In order to arrive at higher speed of barbell in the next stage, mighty strength should be used to lift barbell from the very beginning, enable it possesses relative higher onwads accelerated speed a . When barbell arrives at the height of knee joint(Figure 4-A), it should faster extend hip joint and make barbell accelerate and rise again. When barbell arrives at the middle height between knee joint and hip joint, two legs and upper body elevate onwads at the maximum speed, body strength entirely explodes, and barbell receives the highest onwads speed under such explosive force. After explosive force, due to barbell weight too large it would quickly fall, weight lifters then need

to make greatest efforts to hold back falling height so as to prevent lose their labor. Therefore, body must quickly squat under barbell, turn the barbell to the chest, and hold back barbell falling with the support of whole body, as Figure 4-B shows. Follow on two legs gradually draw close as Figure 4-C shows.

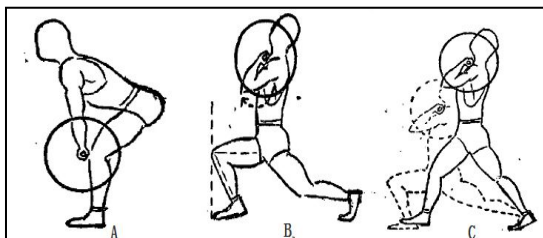


Figure 4: Split clean stage schematic figure

2) To squat, the difference between the squat and the split is body gravity center is lower in squat (Figure 5), therefore it is no need to lift barbell very high as the split. Therefore it is easier in the earlier stage of squat, higher barbell can be lifted in the earlier stage, but the difficulty in squat post is two feet lateral splitting cannot be too large, the larger two feet split, the more dispersal leg strength would be. But less splitting would also have great negative influences, which would affect stability in squat and prone to generate gravity center unstable and happened to dump, it is very dangerous.



Figure 5: Squat schematic figure

Jerk: After finish cleaning, body stands firmly can start jerking. For jerk, firstly should do squat beforehand as Figure 6-A shows, then quickly extend legs jerk and straighten the arm, and lift the barbell. During process from Figure 6-A to Figure 6-B, barbell mostly rises by inertia, arms strength cannot arrive at barbell weight, therefore the process is quite short, leg splitting, squat, arm extending, barbell supporting motions should be completed before barbell falling back, it will fail if done it later. Waist load suddenly increases in the process, produce greater impulse force to lumbar that is prone to injure lumbar.

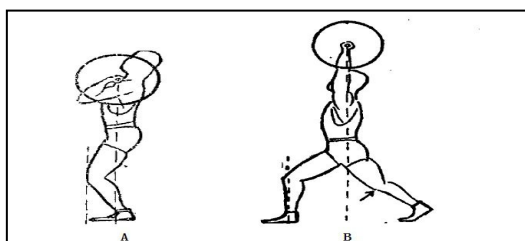


Figure 6: Jerk stage schematic figure

Analysis of snatch motions

Snatch motions has some differences from jerk motion steps, but from medical perspective ,they have no differences in lumbar major pressure and shear force bearing, therefore this paper would not make analysis of snatch motion steps one by one.

Two key steps lumbar force analysis and suggestions

Through above weightlifting steps analysis, it is known that majorly two steps bear the maximum lumbar force, and also danger would happen accordingly that lead to lumbar injury. First is the first half stage of cleaning that is process from Figure 3 to Figure 4-A, which is called step one for short in following text. Second is the process that body should quickly enter barbell and barbell instantly lifts that is the process from Figure 4-A to Figure 4-B, Figure 6-A to 6-B, though they are two steps, it can be known from analysis that the both the two steps are barbell instantly rising and then slightly falling, which can be concluded as one type on lumbar injury from medical perspective, is called step two for short in following text. This paper's analysis of such two steps is as following.

Key step one analysis and suggestions: From mechanics, it is known that waist bears great shear force, combining with lumbar structural features from medical perspective can know that lumbar is connected with one joint that not proper for bearing shear force. Detailed force analysis of the process is as Figure 7.

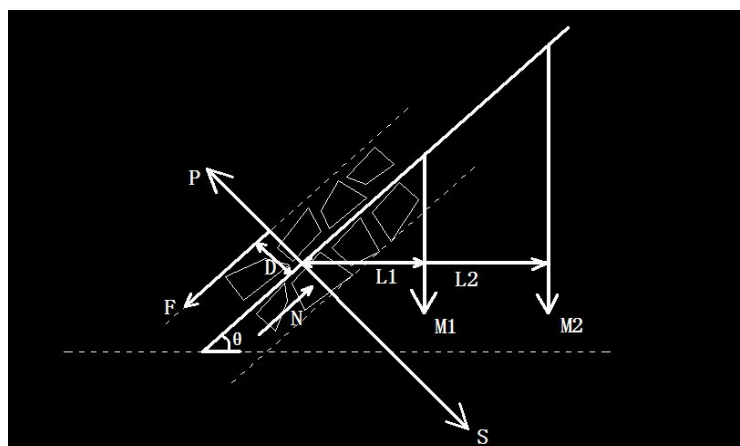


Figure 7: Lumbar force analysis

Sign convention in Figure 7 is as Table 1.

Table 1: Sign convention in Figure 7

Sign	Definition
$M1$	human trunk quality(unit)
$M2$	neck ,arm and barbell quality integration
θ	Angle forming by Spine forward flexion with ground
F	erector spin strength to maintain spine forward flexion
N	Extrusion force under spine
D	Distance between erector spine and spine
S	Spine shear force
P	Balance force counters S

Combine with Figure 7 and according to moment balance $\sum M = 0$ can get formula as following:

$$F \times D - M1 \times L1 - M2 \times L2 = 0 \quad (1)$$

Then get:

$$F = \frac{M1 \times L1 + M2 \times L2}{D} \quad (2)$$

Therefore total extrusion force is:

$$N = F + (M1 + M2) \times \sin \theta \quad (3)$$

Shear component force is:

$$S = (M1 + M2) \times \cos \theta \quad (4)$$

Combine with human body segment parameters in medicine; it is known that trunk covers around 43% of human quality, neck and arm cover 17% of human quality, therefore can get $M1$ and $M2$ only with human weight information. According lifters CT images, size of $L1$, $L2$ and D can be got. Every lifter has slightly difference in body parameters, therefore his $L1$, $L2$ and D also has slightly differences. When calculating, it can make CT test on every lifter, then bring into formula (2), (3), (4) so that can determine every lifter lumbar force condition. This paper makes body parameters test on a lumbar healthy weight lifter with height of 170cm and weight of 60kg, and assume that his trial barbell quality is 160kg, input into formula (2), (3), (4) to calculate (transitionally assign θ as 45°), find the maximum total extrusion force N to lumbar has arrived at 2174kg, shear force S has arrived at 137kg, which is far beyond the normal load. Combine with medicine can know that lumbar structure relies on Centrum connection, which is prone to appear stress concentration. In normal human activities, usually it would not bear shear force; however, in clean stage of weightlifting, around 137kg shear force should be bearing, so it brings huge damage to lumbar. Due to weightlifting career features that it is hard to avoid lumbar injury, therefore only can reduce lumbar injury through specifying technical motions, increasing scientific training, and combining exertion and rest. Through formula (3), (4) can know that angle θ should be increased so as to reduce shear force. However, θ increasing would lead to pressure F increasing, so it need to find a optimized angle θ , weigh and balance shear force and pressure injury conditions with medical knowledge, and according to formula (2), (3), (4) can work out that the optimized angle θ is 45° . Therefore, in future training it needs to ensure that $\theta = 45^\circ$ after ending position at bar when just starting clean to the chest.

Key step two analysis and suggestions: For the process that body should quickly squat under the barbell, from above lumbar diseases inducing causes can know that waist load suddenly increasing produces larger impulse force to lumbar so that tend to generate herniation of the nucleus pulposus. Therefore, during the process, it should try to let barbell produce smaller impulse force to lumbar. Make trajectory figure about key step 2 barbell gravity center rising process can get Figure 8.

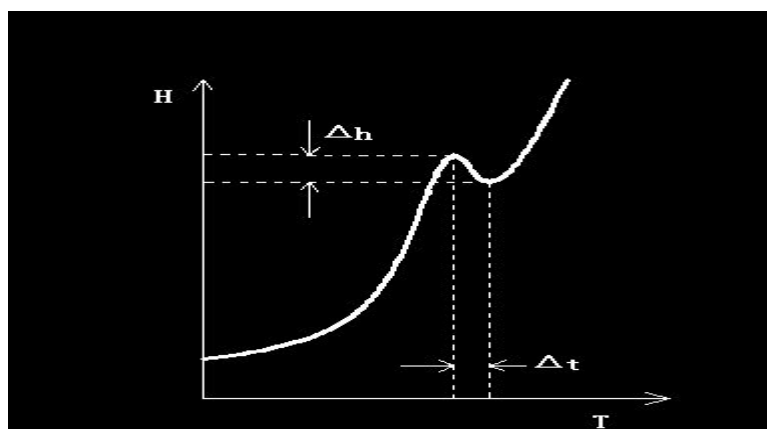


Figure 8: Barbell gravity center trajectory changes followed by time T

In Figure, Δt time phase is barbell falling process, which is also waist load suddenly increasing process. During the process, size of Δh is key to the size of lumbar force, combining with mechanics can know that when barbell rises to top point at speed zero, it is the best time for lifters entering beneath the barbell. In this moment, lifters transfer strength to barbell so as to stop it from falling, Δh is the buffer process that lifters stop barbell falling; If Δh is too small that buffer not working and causes lumbar instantly bear huge pressure; From medical perspective, the bigger Δh is, the longer buffer time is, and the instantly force to lumbar would be smaller that is helpful to protect lumbar. However, if Δh too big, it would lead to lifters lose their labor so that need them to work more in next step and affects lifters playing, therefore the size of Δh is of great importance. Combine with medicals

it should try to reduce falling height Δh on the condition that guarantee minimum lumbar injury.

CONCLUSION

This paper investigated on 50 lifters lumbar conditions and found that 82% of them have lumbar diseases symptoms, got by causes exploring that three main factors lead to lumbar injury are waist strain, intensity too large, error action; Made analysis of weightlifting key steps from medical perspective, obtained two key steps with maximum lumbar load, one is first half stage of clean that is the process from Figure 3 to Figure 4-A, two is body quickly enters beneath barbell and barbell instantly rises, such process is from Figure 4-A to Figure 4-B, Figure 6-A to 6-B; Made force analysis of key step one and then found key angle θ that influences lumbar shear force and pressure, according to mechanics formula determined $\theta = 45^\circ$ is the optimized angle, therefore in future training it should pay attention to arrive that $\theta = 45^\circ$; This paper considered from medical safety and health known that to weight lifting event, lumbar strain was hard to avoid due to long term heavier loading, only could reduce lumbar strain through scientific training and careful curing, step-to-step should be done in training and avoided by all means excessive intensity training. Once lumbar get injured, it is hard to cure and even affect lifter whole life. Therefore lifters no matter in training or in competition should take seriously protection of lumbar.

REFERENCES

- [1]BAO Chunyu, MENG Qinghua. *Journal of Tianjin Institute of Physical Education*, **2009**, 24(1), 42-44.
- [2]Shi He-Fu. *Chinese sports medicine*, **2011**.
- [3]REN Jing-ping, LIU Xue-zhen, WANG Xiang-dong. *Journal of Capital College of Physical Education*, **2006**, 18(3), 42-45.
- [4]Liu Xuezheng, Wang Xiangdong. *Journal of Beijing Sport University*, **1999**, (3).
- [5]GOU Bo, WANG Qi-rong. *Journal of Beijing Sport University*, **2000**, 23(3).
- [6]LIU Ping, ZHANG Gui-min, TONG Yong-dian, LIU Jian. *China Sport Science*, **2005**, 25(1), 46-49.
- [7] Bing Zhang, Sheng Zhang and Guang Lu. *Journal of Chemical and Pharmaceutical Research*, **2013**, 5(9), 256-262.