Static Analysis of Load on the Lumbar Spine During an Olympic-Style Lift Performed by College Football Players

Lauren J. Miller, MS, ATC; Tara M. Milburn, MS, ATC; Marisa A. Colston, PhD, ATC; Gary B. Wilkerson, EdD, ATC

THE UNIVERSITY of TENNESSEE CHATTANOOGA

BACKGROUND AND PURPOSE

- The prevalence of low back pain (LBP) that limits activity is estimated to be 70-80% in the general population[1]
- Lifting imposes repetitive compressive loads that produce LBP and can lead to disc degeneration[2]
  - The National Institute of Occupational Safety and Health (NIOSH) has established safe load limits
- L5-S1 loading imposed by Olympic-style weightlifting exercises may exceed NIOSH standards
  - LBP among football players could relate to excessive loading of the L5-S1 motion segment
  - Lifting technique may be an important factor that influences LBP severity and risk for disc degeneration
- The inter-related purposes of this study were to quantify loads imposed on the L5-S1 motion segment by power cleans and to assess a possible association with self-reported symptoms of lumbar spine dysfunction

PARTICIPANTS AND PROCEDURES

- 31 NCAA Division I-FCS football players (20.0 ±1.3 years of age; 182.5 ±6.7 cm; 102.5 ±18.2 kg)
- Surveys designed to quantify low back function and disability were administered
  - Micheli Functional Scale (MFS)[3] and Modified Oswestry Disability Index (ODI)[4]
- Video recording obtained during performance of "power cleans" during off-season strength training session
  - Still images extracted from each recording at 2 specific points during lift performance (Figures 1 & 2)
    - Initial "pull" stage (bar at knee level) and "catch" stage (point at which downward bar motion terminated)
- 3D Static Strength Prediction Program™ (3DSSPP)
  - Each of the 62 still images (31 pull and 31 catch) uploaded independently (Figure 3)
  - Compressive forces on L4-L5 and L5-S1 motion segments calculated
- Pearson r correlation used to assess relationship between MFS and ODI
- NIOSH back compression limits for injury avoidance based on general working population adjusted for athletes
  - Lower Limit (LL) for maximum safety = 3400 N (770 lbs); Maximum Permissible Limit (MPL) = 6400 N (1430 lbs)
    - MPL – LL difference added to MPL to establish Adjusted Upper Limit (Adj UL) = 9400 N (2090 lbs)
- ROC analyses performed to categorize participant characteristics

Figure 1

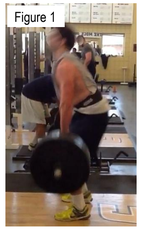


Figure 2

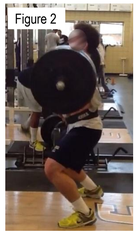
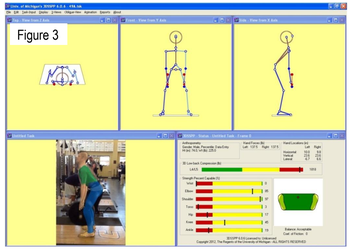


Figure 3



RESULTS

- A high degree of agreement was evident between MFS and ODI for self-reported low back dysfunction (Figure 4)
  - Bivariate correlation between MFS and ODI: r=.81; p<.001
- 52% (16/31) of participants exceeded L5-S1 LL during catch stage
  - 10% (3/31) exceeded MPL
  - None of the 31 participants exceeded Adj MPL
- 100% of 31 participants exceeded L5-S1 LL during pull stage
  - 77% (24/31) exceeded MPL
  - 29% (9/31) exceeded Adj MPL (Figures 5-7)
    - 67% (6/9) who exceeded Adj MPL had an ODI ≥ 6
    - 78% (7/9) who exceeded Adj MPL had height ≥ 188 cm (74 in)
    - 67% (6/9) who exceeded Adj MPL were lifting a load ≥ 1.1 times body weight (BW)
  - 67% (4/6) of participants with height ≥ 188 cm and Load/BW ≥ 1.1 exceeded Adj MPL (Figure 8)
    - Participants with both factors positive were 8X more likely to report low back dysfunction
  - 83% (5/6) of participants with height ≥ 188 cm and Load/BW ≥ 1.1 had ODI ≥ 6 (Figure 9)
    - Participants with both factors were 10X more likely to exhibit excessive intervertebral compression

Figure 4

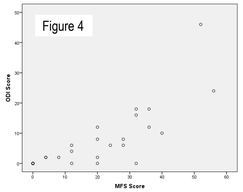


Figure 5

L5-S1 Compression		
ODI	≥ Adj MPL	< Adj MPL
≥ 6	6	7
< 6	3	15
Total	9	22

Fisher's Exact One-Sided p = .084

Sensitivity = .67 Specificity = .68

OR = **4.29** (90% CI: 1.07 – 17.13)

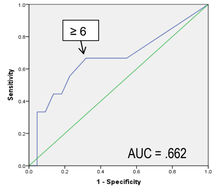


Figure 6

L5-S1 Compression		
Height	≥ Adj MPL	< Adj MPL
≥ 74	7	9
< 74	2	13
Total	9	22

Fisher's Exact One-Sided p = .070

Sensitivity = .78 Specificity = .59

OR = **5.06** (90% CI: 1.13 – 22.64)

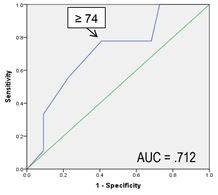


Figure 7

L5-S1 Compression		
Load/BW	≥ Adj MPL	< Adj MPL
≥ 1.10	6	8
< 1.10	3	14
Total	9	22

Fisher's Exact One-Sided p = .084

Sensitivity = .67 Specificity = .64

OR = **3.50** (90% CI: .89 – 13.81)

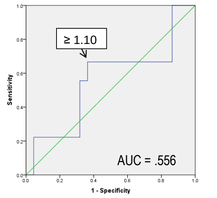


Figure 8

L5-S1 Compression		
Factors +	≥ Adj MPL	< Adj MPL
Both +	4	2
0 or 1 +	5	20
Total	9	22

Fisher's Exact One-Sided p = .043

Sensitivity = .44 Specificity = .91

OR = **8.00** (90% CI: 1.54 – 41.44)

L5-S1 Compression		
Factors +	≥ Adj MPL	Percent +
0	0/7	0%
1	5/18	28%
2	4/6	67%

Figure 9

Low Back Dysfunction		
Factors +	ODI ≥ 6	ODI < 6
Both +	5	1
0 or 1 +	8	17
Total	13	18

Fisher's Exact One-Sided p = .034

Sensitivity = .39 Specificity = .94

OR = **10.63** (90% CI: 1.54 – 73.56)

Low Back Dysfunction		
Factors +	ODI ≥ 6	Percent +
0	2/7	29%
1	6/18	33%
2	5/6	83%

CONCLUSIONS

- A strong association appears to exist between intervertebral compression level and low back dysfunction
  - Both height and load level appear to be important determinants of the potential for degenerative changes
- Intra-abdominal peak pressure during an explosive lift has been shown to be 20% greater than a sustained effort[5]
  - 3DSSPP provides static estimates that may substantially underestimate dynamic loads
- Cartilage endplate microfractures are likely to occur at ≥ Adj MPL, which may weaken the annulus fibrosus
  - Lack of pain receptors may result in cumulative damage without symptoms, other than minor discomfort
- An association between a low level of low back dysfunction and lower extremity injuries has been established[6]
  - Excessive power clean loads may induce degenerative changes that increase sport-related injury risk

REFERENCES

1. Andersson GBJ. Epidemiological features of chronic low-back pain. *Lancet*. 1999;354:581-585.
2. Waters TR, Putz-Anderson V, Garg A, Fine LJ. Revised NIOSH equation for the design and evaluation of manual lifting tasks. *Ergonomics*. 1993;36:749-776.
3. Allou d'Hemecourt P, Zurakowski D, Allou d'Hemecourt, C, et al. Validation of a new instrument for evaluating low back pain in the young athlete. *Clin J Sport Med*. 2012;22:244–248.
4. Davidson M. Rasch analysis of three versions of the Oswestry Disability Questionnaire. *Man Ther*. 2008;13:222–231.
5. Chaffin DB, Andersson GB, Martin BJ. Occupation Biomechanics. New York, NY: John Wiley & Sons, Inc.; 1999:224-228.
6. Wilkerson GB, Giles JL, Seibel DK. Prediction of core and lower extremity strains and sprains in collegiate football players: a preliminary study. *J Athl Train*. 2012;47:264-272.