

Static Analysis of Lumbar Spine Compression Load Imposed by Olympic-Style Weightlifting in Female College Athletes

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BACKGROUND AND PURPOSE

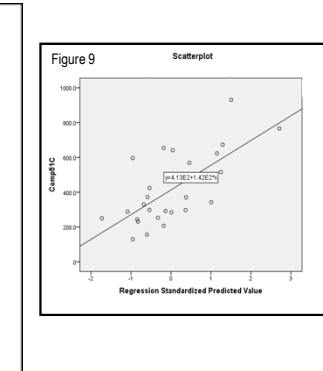
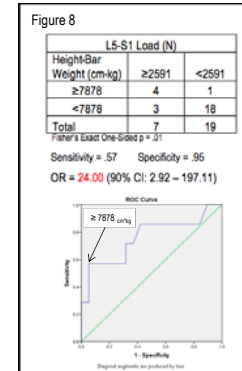
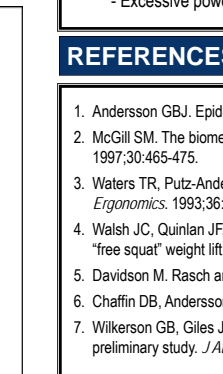
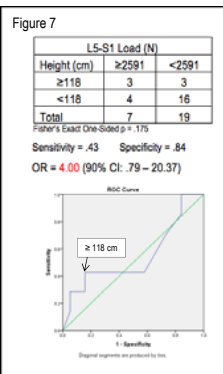
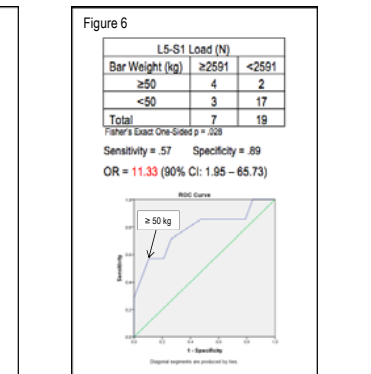
- The prevalence of low back pain (LBP) that limits activity is estimated to be 70-85% in the general population¹
 - LBP is more common in the female population; 70.3 per 1000 for females versus 57.3 per 1000 for males
- Improper lifting can produce micro-structural damage, which may lead to LBP and disc degeneration²
 - The National Institute of Occupational Safety and Health (NIOSH) has established safe lifting load limits
- L5-S1 loading imposed by Olympic-style weightlifting may exceed NIOSH standards for prevention of back injury³
 - LBP among female athletes could be caused by excessive loading of the L5-S1 motion segment
 - Weightlifting technique may be an important factor influencing the magnitude of imposed compressive load⁴
- The purposes of this study were to quantify loads imposed on L5-S1 by power clean and back squat lifts and to assess a possible association with self-reported lumbar spine dysfunction among female college athletes

PARTICIPANTS AND PROCEDURES

- 28 NCAA Division-I female athletes (20.0 ± 1.1 years of age; 170.6 ± 8.8 cm; 69.8 ± 14.5 kg)
- Survey for quantification of low back disability (0-100 score) administered: Oswestry Disability Index (ODI)⁵
- Video recording obtained during performance of "power cleans" and "back squats" during strength training session
 - Still images extracted from each recording at specific points during lift performance (Figures 1 - 3)
 - Initial "ascent" during performance of the back squat
 - Initial "pull" (bar at knee level) and "catch" (termination of downward bar motion) of power clean
- 3D Static Strength Prediction Program™ (3DSSPP; Center for Ergonomics, University of Michigan, Ann Arbor, MI)⁶
 - 73 still images (back squat ascent: 21; power clean: 26 pull, 26 catch) uploaded (Figure 4)
 - Compressive forces on L4-L5 and L5-S1 motion segments estimated
- NIOSH back compression limits for injury avoidance based on general working population
 - Lower Limit for maximum safety = 3400 N (770 lbs); Maximum Permissible Limit = 6400 N (1430 lbs)
- ODI score used to categorize athletes as free from low back dysfunction (0) or having low back dysfunction (≥ 2)
 - Receiver operating characteristic (ROC) analyses identified thresholds for low back dysfunction risk

RESULTS

- Analysis of back squat ascent failed to identify any meaningful associations between loads and low back dysfunction
 - None of 21 participants exceeded NIOSH L5-S1 3400 N Lower Limit during ascent
- 88% (23/26) of participants exceeded NIOSH L5-S1 3400 N Lower Limit during the power clean pull stage
 - None of 26 participants exceeded NIOSH L5-S1 6400 N Maximum Permissible Limit
- 8% (2/26) of participants exceeded NIOSH L5-S1 Lower Limit during the power clean catch phase
 - None of 26 participants exceeded NIOSH L5-S1 Maximum Permissible Limit
- Analysis of power clean "pull" failed to identify any meaningful associations between loads and low back dysfunction
- Analysis of power clean "catch" identified possible thresholds associated with elevated risk for low back dysfunction
 - ≥ 2591 N (583 lbs) L5-S1 load identified as threshold associated with ODI score ≥ 2 (Figure 4)
 - ≥ 50 kg (110 lbs) bar weight identified as threshold for avoidance of low back dysfunction (Figure 5)
 - ≥ 118 cm (70 in) height identified as threshold at which L5-S1 compression load may increase risk (Figure 6)
- Combination of height and bar weight identified as "catch" threshold for ≥ 2591 N (583 lbs) L5-S1 load (Figure 8)
 - ≥ 7878 cm-kg associated with 24 X increase in odds for L5-S1 load corresponding to low back dysfunction
 - Regression equation calculated to estimate bar weight for a given height to minimize risk (Figure 9, Table 1)



Height cm (in)	Bar Weight kg (lbs)
188 (74)	48 (106)
185 (73)	49 (108)
183 (72)	49 (109)
180 (71)	50 (111)
178 (70)	51 (113)
175 (69)	52 (114)
173 (68)	53 (116)
170 (67)	54 (118)
168 (66)	54 (119)
165 (65)	55 (121)
163 (64)	56 (123)
160 (63)	57 (125)
157 (62)	58 (127)
155 (61)	59 (129)
152 (60)	59 (131)



CLINICAL RELEVANCE

- A strong association appears to exist between intervertebral compression level and low back dysfunction
 - Both height and bar weight appear to be important determinants of the potential for degenerative changes
- For a given height, the recommended maximum bar weight may reduce risk for gradual or sudden injury
 - A high core strength level and proper lifting technique may allow for safe use of greater bar weight
- Intra-abdominal peak pressure during an explosive lift has been shown to be 20% greater than a sustained effort⁶
 - 3DSSPP provides static estimates that may substantially underestimate dynamic loads
- An association between a low level of low back dysfunction and lower extremity injuries has been established⁷
 - Excessive power clean loads could induce degenerative changes that increase sport-related injury risk

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