EFFECTS OF THE BENCH SHIRT ON SAGITTAL BAR PATH

Ryan Williams, Tobin Silver[1], David Fortenbaugh[2], and Kathy Ludwig

Barry University, Miami Shores, FL, USA
[1]Purdue University, West Lafayette, IN, USA
[2]University of Miami, Coral Gables, FL, USA

Powerlifting, like many sports, uses performance-enhancing equipment. The purpose of this study was to explore whether wearing a bench shirt would alter the natural mechanics of the bench press. Participants (n=5) completed two bench press tests; the first was raw (no shirt), while the second utilized the bench shirt. Vertical bar path ranges were significantly smaller in the shirted condition compared to the raw condition. Significant differences were found between the optimal and observed values while benching during the raw condition, but no significant differences were found in the shirted condition. Assuming a straight line bar path is optimal, findings suggest the bench shirt may provide a more efficient bar path, improving load capability and decreasing the forces that act on the shoulder and thus the likelihood of injury.

KEY WORDS: bench shirt, bar path, powerlifting.

INTRODUCTION: Powerlifting is a sport involving maximum effort in each of three lifts: (a) the squat, which is a deep knee bend; (b) the deadlift, which involves lifting a weighted barbell from the floor straight up to a point above the knees (Raske & Norlin, 2002); and (c) the bench press, which is performed supine on a flat bench with a weighted barbell lowered from a position directly over the head down to the chest and promptly returned to the initial overhead position. These athletes use heavy loads so it is important to use proper technique to maximize performance and reduce the likelihood of injury (Raske & Norlin, 2002). As of early 2006, International Powerlifting Federation (IPF) records for the three lifts were 457.5 kg for the squat, 408.0 kg for the deadlift, and 350.5 kg for the bench press (Official Website of the International Powerlifting Federation, n.d.). Shoulder injuries are the most common injuries among powerlifters and have increased in recent years (Raske & Norlin, 2002). The bench press places considerable stress on the shoulders (Fees, Decker, Snyder-Mackler, & Axe, 1998; Haupt, 2001; Judge, 1998; Raske & Norlin, 2002), specifically the rotator cuff and the long head of the biceps brachii (Fees, Decker, Snyder-Mackler, & Axe, 1998). Further, increased loading can cause increased glenohumeral translation which may lead to arthrosis and possibly rotator cuff arthropathy (Hurschler, Wulker, & Mendila, 2000). The shoulder essentially becomes the weight bearing joint using the shoulder girdle for a base. During high joint loading and alternating contractions, there is an increased potential for harm (Hurschler, Wulker, & Mendila, 2000; Raske & Norlin, 2002). These injuries can be associated with maximum strength training. Intense one repetition maximums (1RM) can exacerbate these injuries. Consequently, it is recommended that 1RM testing be performed only two to three times a year (Fees, Decker, Snyder-Mackler, & Axe, 1998). One possible cause for the increased injury rate may be indirectly due to the use of the bench shirt by all competitive powerlifters. These performance-enhancing shirts are used at every level, from national and international competition to high school, to improve 1RM. Higher loads improve the chances of winning and enable the promulgation of one's accomplishments. However, by competing with these shirts, lifters may be elevating their risk of injury. The IPF has approved belts, shoes, shirts, suits, and wraps for each of the three lifts used in powerlifting competitions. During the bench press, lifters use an approved elastic shirt made from cotton and polyester that allows them to press higher loads. The shirts, as well as most of the other performance-enhancing equipment, are worn only for a limited time each year, usually prior to competitions. This is done to maximize raw strength and avoid dependency on the shirt in order to press large loads. Although from a purely mechanical standpoint the bar path of the bench press should be a straight line from the starting point (origin) to the chest and then returned directly to the origin (minimizing work), the lift has been taught so as to follow a four-phase "S" curve. The four phases are the acceleration phase, the sticking region, the maximum strength region, and the deceleration phase. It is recommended that both the eccentric (down) phase and the concentric (up) phase follow this pattern (Eliot, B.C., Wilson, G.J. & Kerr, G.K., 1998; Lander, J.E., Bates, B.T., Sawhill, J.A., & Hamill, J., 1985). While most lifters advocate the use of the shirt and are committed to the belief of its effectiveness, no known studies have analyzed the use of the bench shirt in an attempt to explain specifically how the shirt improves performance. Biomechanical studies, be them in kinematics, kinetics, or electromyography (EMG), may provide answers to this research question. Unfortunately, kinematics and kinetics are the only realistic research possibilities because the use of EMG, which would provide extremely beneficial information, is impractical for several reasons. Surface electrodes can neither be placed comfortably under the shirt nor effectively used if placed over the shirt. Needle measurements would be both uncomfortable for a lifter attempting maximal load lifting and would also necessitate the puncture and probable ruination of the shirt. Therefore, the purpose of this preliminary study was to determine whether wearing a bench shirt would significantly alter the natural path of the bench press. Since competitive lifters have relied heavily on the bench shirt to excel in competition, it was hypothesized that significant differences would exist in the observed variables when compared to the same participant performing the lift without the shirt.

METHOD:

Data Collection: Five healthy males (age: 18 to 30yrs; height: 174.41±7.30cm; and mass: 76.36±4.31kg) from Barry University were recruited to participate in this study. Participants were required to have a 1RM of at least 125% of their own body weight. Additionally, a minimum of one current year of experience with the bench press without lapse in training for a minimum of three months was required. Participants with illness or upper extremity injury were excluded from the current study. One marker was placed on the cap of the bar to track the bar's motion in the horizontal and vertical directions during lifting. The data was recorded in the sagittal plane using one 60 Hz camera placed at a distance of approximately 4 to 6m. Prior to each capture, the camera was calibrated using a standard meter stick. The Peak Motus 7.3.2 data analysis software (Centennial, CO) was later used to reduce the data. One of two available IPF-approved bench shirts was used according to body dimensions. A standard flat bench and weighted plates were also used. The bar path was defined as the path the bar followed from the starting point (origin), to the beginning of the eccentric (down) phase to the point of contact on the chest, through the full extension of the concentric (up) phase back to the origin. Participants completed the raw condition first. Lifters were asked to perform their 1RM, on the same day and prior to their normal bench training day. This helped to ensure that the participant were not fatigued prior to their effort in the laboratory. Each participant had as much time as they required for a proper stretching and warm up routine of their personal preference. Knowledgeable spotters were placed at either side of the bar for the duration of the lift for the safety of the lifter. With the lifter in the starting position and the bar in the rack the lifter counted to three. The spotter then lifted the bar off the rack and placed the weight above the lifter. When the lifter was comfortable and had full control of the bar, the spotter removed his hands and the lifter began the lift. Prior to the lift off, grip width was measured before each lift and adjusted to ensure consistency among lifts. The participants performed several warm-up attempts progressing towards the projected 1RM, and then were given as many attempts as necessary in order to ensure a true 1RM. Participants returned for the shirted trials after one week. After a warm up trial, the bench shirt was placed on the participant with the assistance of the spotters. It is necessary for others to assist in this process because of how tight the shirt fits. The participant was given an opportunity to complete a percentage (≤75%) of their 1RM to adjust to the fit and feel of the shirt. The first recorded attempt was 90-95% of the maximum load completed (1RM) in the raw, unshirted condition. The second attempt was 100% of the 1RM completed in the first trial. A successful attempt at this level was the trial used for comparison with the 1RM raw trial. More attempts in excess of 100%, not reported in this study, were used to assess the increase in load capability. If the bar traveled back toward the chest during the up phase of any attempt, the trial was discarded.

Data Analysis: The variables analyzed were the horizontal (x) and vertical (y) range covered between the shirt conditions, the line integrals of the bar path in the x, y, and total (r) directions between the shirt conditions, and the observed versus the mechanically optimal line integrals among each shirt condition. As mentioned earlier, the optimal value would occur when the bar traveled in a straight line from the origin to the point of contact on the chest and straight back to the origin. Repeated measures ANOVAs (α=.05) were calculated to compare raw and shirted conditions of the x and y ranges of the bar, and the line integrals of the bar path in the x, y, and r directions. Since lifters were unable to return precisely to the origin upon completion of the lift, the small additional distance that would have been required to return the bar to the origin was added to the observed path. One-tailed paired-samples t-tests were calculated comparing the observed values for x, y, and r versus the optimal values for x, y, and r. Since this optimal situation is highly unlikely, one-tailed tests were used based on the anticipated differences between optimal and observed values. To protect against family-wise error, α=.01 for all paired samples t-tests.

RESULTS: The means and standard deviations of the measured kinematic variables are reported below in Table 1. The repeated measures ANOVAs comparing the raw versus shirted conditions revealed a significantly smaller range in the y direction for the shirted condition ($F(1,4) = 7.55$, $p=.05$), but no significant differences in the x range or any of the observed line integrals. One-tailed paired-samples t-tests comparing the optimal path and observed path for the raw condition revealed a significant difference in the x direction ($t(4) = 4.27$, $p<.01$) and r direction ($t(4)=4.07$, $p<.01$). No significant differences were found between optimal and observed values in either the y direction or in any of the directions for the shirted condition, $p>.01$. One participant's raw and shirted trials are shown in Figures 1 and 2.

Table 1. Means and Standard Deviations.

Variable(cm)	Raw	Shirted
Range (x)	15.16 ± 5.71	17.79 ± 5.74
Range (y)	40.23 ± 6.98	35.67 ± 4.82
Observed linear integral (x)	35.12 ± 11.14	34.56 ± 9.31
Optimal linear integral (x)	22.67 ± 11.41	23.15 ± 9.09
Observed linear integral (y)	85.03 ± 17.26	73.22 ± 8.65
Optimal linear integral (y)	77.50 ± 14.11	67.46 ± 10.94
Observed linear integral (r)	96.65 ± 19.14	86.32 ± 10.51
Optimal linear integral (r)	81.38 ± 14.19	71.55 ± 12.67

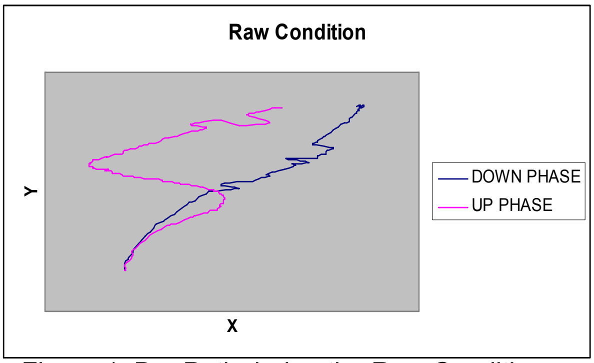

Figure 1 Bar Path during the Raw Condition.

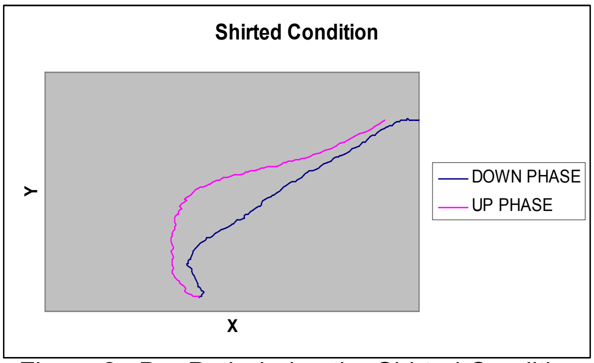

Figure 2. Bar Path during the Shirted Condition.

DISCUSSION AND CONCLUSION: The results of the observed raw condition showed significantly more distance traveled in the x and r directions compared to the optimal distance, implying that significantly more work was done in order to complete the lift. On the other hand, the non-significant results of the shirted condition suggest that the shirt reduces the workload to the point that it is not significantly more than the optimal condition. This is deduced from the general equation in which work is equal to force times distance. A shorter distance reduces the work done when the force is held constant. Integrating this information with the significantly smaller y range in the shirted condition, these data imply that the shirt stabilized the movement in the horizontal direction and reduced the vertical range, resulting in a more efficient path. This can be visualized by studying Figures 1 and 2. The shirted condition of Figure 2 clearly shows a more linear path than the raw condition seen in Figure 1. It is theorized that the shirt stabilizes the shoulder complex in the horizontal direction while pulling the shoulders back towards the bench, effectively lowering the origin and reducing the distance from the origin to the point of contact on the chest. Furthermore, the findings suggest that the shoulder stabilization provided by the shirt would decrease the chance of injury. With shoulder injuries being the most common injury among power lifters, (Raske & Norlin, 2002) improving the support by restricting the joint, eliminates less efficient, and potentially harmful motion. Less work done with the same load lessens the compression, tension, and shear forces acting on the shoulder complex. In conclusion, the bench shirt showed a trend towards improvement regarding the efficiency of the bar path. Limitations of the current study included: the use of non-elite powerlifters, the use of participants that may have been training for purposes other than improving their 1RM (the main purpose of training with a bench shirt), and a lack of bench shirts tailored to each lifter's body dimensions. Future studies should recruit participants that are elite lifters acclimated to training with the bench shirt. As well, a repeat of the current study with an increased sample size may show additional statistical significance. Lastly, a three-dimensional analysis of the bar as well as upper extremity and trunk kinematics would help to more accurately describe the mechanics of the bench press and the effects of the bench shirt.

REFERENCES:

Crawford, B. (2000). Bench press training tips. Retrieved October, 11, 2003, from http://www.geocites.com/bench700plus/bench.html

Elliot, B.C., Wilson, G.J. & Kerr, G.K. (1989). A biomechanical analysis of the sticking region in the bench press. *Medicine and Science in Sports and Exercise*, 21(4), 450-462.

Fees, M., Decker,T., Snyder-Mackler, L., & Axe, M.J. (1998). Upper extremity weight-training modifications for the injured athlete. *The American Journal of Sports Medicine*, 26(5), 732- 741.

Haupt, H.A. (2001). Upper extremity injuries associated with strength training. *Clinics in Sports Medicine*, 20(4), 481-489.

Hurschler, C., Walker, N, & Mendila, M. (2000). The effect of negative intraarticular pressure and rotator cuff force on glenohumeral translation during simulated active elevation. *Clinical Biomechanics*, 15(1), 306-314.

Judge, L.W. (1998). Proper techniques in the bench press for the track and field athlete. *Track and Field Coaches Review,* 72(1), 24-27.

Lander, J.E., Bates, B.T., Sawhill, J.A. & Hamill, J. (1985). A comparison between free-weight and isokinetic bench pressing. *Medicine and Science in Sports and Exercise*, 17(3), 344-353.

Official Website of the International Powerlifting Federation. (n.d.) Retrieved March 2nd, 2006, from http://www.powerlifting-ipf.com

Raske, A. & Norlin, R. (2002). Injury incidence and prevalence among elite weight and power lifters. *The American Journal of Sports Medicine*, 30(1), 248-256.