Snatch Technique of United States National Level Weightlifters

Paul N. Whitehead,[1] Brian K. Schilling,[1] Michael H. Stone,[2] J. Lon Kilgore,[3] and Loren Z. F. Chiu[4]

[1]Department of Health and Sport Sciences, The University of Memphis, Memphis, Tennessee; [2]East Tennessee State University, Johnson City, Tennessee; [3]University of the West of Scotland, Paisley, Scotland; and [4]University of Alberta, Edmonton, Alberta, Canada

Abstract

Whitehead, PN, Schilling, BK, Stone, MH, Kilgore, JL, and Chiu, LZF. Snatch technique of United States national level weightlifters. *J Strength Cond Res* 28(3): 587–591, 2014—This study analyzed the top 3 successful snatch attempts by individual lifters in each weight class at a U.S. National Championship weightlifting meet. Two-dimensional (2-D) body position and characteristics of the lifts were compared via 2D video analysis in groups of lifters who displaced forward, showed no displacement, or displaced backward to receive the bar. No significant group differences ($p > 0.05$) were noted for body mass, bar mass, or hip angle. The rearward displacement group had a significantly greater horizontal distance between the shoulder and heel at the end of the pull (determined as the point where the bar ceases to accelerate vertically). Hip angles for the no displacement group had a small-to-moderate effect size (0.50) in comparison to the forward displacement group, but they only showed a small effect size (0.17) when compared with the rearward displacement group. The forward displacement group showed a small-to-moderate effect size compared with both the no displacement group (0.51) and the rearward displacement group (0.55) concerning the horizontal distance from the shoulder to the heel. These data seem to suggest that rearward displacement in the drop-under phase in the snatch is not detrimental to performance and actually seems to be a preferred technique in U.S. national level lifters. In addition to evidence that rearward displacement is exhibited in elite lifters and is coached globally, it seems this is the preferred technique in international competitions. This technique may be considered a viable variation of the snatch by coaches and athletes of all levels.

Key Words weightlifting, rearward displacement of COM, hipping

Address correspondence to Brian K. Schilling, bschllng@memphis.edu.

28(3)/587–591

Journal of Strength and Conditioning Research

Introduction

The snatch is 1 of 2 lifts contested in the sport of weightlifting. The bar is lifted from the floor to overhead in 1 motion with 6 phases: the start position before liftoff, the first pull, transition, second pull, the catch, and the finish (recovery to a standing position) (10). The motions of the body during the snatch affect both the path the bar takes during the lift and the subsequent displacement of the feet as the lifter drops under the bar after the second pull (drop-under phase) and transitions into the catch position (13).

Three main types of barbell trajectories (Figure 1) were proposed by Vorobyev (15), of which a type B trajectory represented a lift where the bar does not intersect the vertical reference line after liftoff. Type B lifts likely result in rearward displacement of the lifter in the drop-under phase to catch the bar (3,5,14). However, this trajectory has been shown to account for over 42% of the snatch attempts in World and Olympic Champion weightlifters during international competition (8). Horizontal displacement of the barbell during the snatch is highly correlated with the horizontal displacement of the lifter's center of mass (LCOM) (13). Although the cause of rearward foot displacement may be multifactorial, it has been called "inefficient" by some coaches and sport scientists attributing the trajectory to a premature movement of the shoulders behind the bar (15). Some have even considered this type of lift trajectory to be "dangerous" for the success of the snatch (1). The presumption by these coaches and scientists is that the shoulders are thrown backward via a hip-hinging action resulting in excessive hip extension, rather than using the hip and knee extensors and ankle plantar-flexors optimally. This is also known as "hipping" the bar, and it is believed to increase the likelihood of a missed attempt. Although there are likely several variations of each trajectory, it is unlikely that "hipping" is the only way to have the bar remain behind the vertical reference line. Thus, type B trajectories are also regarded as a positive technique by others in that they elicit a greater portion of the force production during the pull in a vertically directed manner (14).

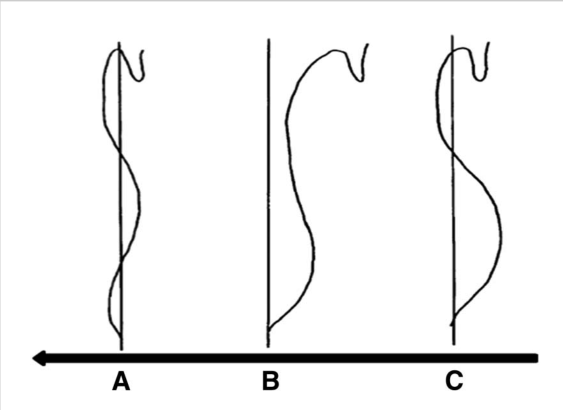

Figure 1. Proposed variations in bar trajectory, adapted from Vorobyev (15). The type B trajectory represents a lift where the bar does not intersect the vertical reference line after liftoff. Adaptations are themselves works protected by copyright. So in order to publish this adaptation, authorization must be obtained both from the owner of the copyright in the original work and from the owner of copyright in the translation or adaptation.

The path of the bar in weightlifting is dictated by the body motions during the pull. With the LCOM moving rearward during the first pull, it is common for the barbell to move toward the lifter (5). If the LCOM is maintained in the rearward direction during the second pull, a backward lean to the body can be expected, resulting in a type B or similar trajectory (14). This dictates where the bar and the body are during the conversion to the catch position and is often observed in international level weightlifters (10). Trajectories closely resembling type B appear to require the lifter to move their feet backward to move the LCOM under the barbell before the catch (3,5,14). Type B trajectories and the related rearward displacement of the lifters' feet have been demonstrated by many successful weightlifters whether short or tall (2), including 3 of the 10 champions in the snatch at the 1996 Olympics (11). These 3 won gold medals in the 3 lightest weight classes, and Hiskia et al. (8) reported type B trajectories in multiple other medalists at the same Olympic competition.

Stone et al. (14) also described the second pull as critical to successful lifts in the snatch, as it is considered the highest power phase of both lifts (12). It is during the second pull when the trajectory of the bar either remains behind the vertical line to maintain a type B path or whether it crosses the vertical line away from the lifter, eliciting a type A or type C bar trajectory. Gourgoulis et al. (7) reported evidence that this point in the lift and the subsequent trajectory are associated with the caliber of weightlifter. In analyzing the snatch technique of elite male and female lifters from the beginning of liftoff to the point at which the lifter dropped under the barbell and caught it overhead, Gourgoulis et al. (7) indicated that women (who were of lower ability than men) had a significantly lower relative vertical velocity at the end of the first pull. This could be because of the fact that the same women analyzed crossed the vertical reference line during their snatch. Ultimately, following a nontype B trajectory for these women increased the horizontal displacement of the bar, which in turn increased the additional horizontal mechanical work that needed to be produced (5,7).

There are many questions left unanswered concerning snatch technique because of the many variables that affect barbell and body kinematics and kinetics (13). Some have labeled weightlifting success as a multifactorial phenomenon, suggesting that there is no single variable that can completely explain success or failure in the snatch (14). The purpose of this study was to examine body position in U.S. national level weightlifters and to determine the prevalence of rearward displacement. We hypothesized that rearward displacement of the body would be the most common technique, and that large hip angles would not be present in the rearward displacement group.

Methods

Experimental Approach to the Problem

This study uses a cross-sectional analysis of the top 3 successful snatch attempts by individual lifters in each weight class at a U.S. national championship weightlifting meet. Two-dimensional (2-D) body position and characteristics of the lifts were compared in groups of lifters who displaced forward, showed no displacement, or displaced backward to receive the bar. We chose to examine both the hip angle and the horizontal distance from the shoulder to

Table 1. Descriptive statistics for analyzed lifters.*

Mean ± *SD*	*n*	Body mass (kg)	COM displacement (m)	Average vertical velocity ($m \cdot s^{-1}$)	Bar displacement (m)
Forward displacement	5	84.9 ± 26.5	0.10 ± 0.1	−1.04 ± 0.2	0.02 ± 0.05
No displacement	6	90.6 ± 24.9	0.0 ± 0.0	−0.93 ± 0.1	−0.05 ± 0.05
Rearward displacement	13	79.1 ± 19.1	−0.10 ± 0.1	−0.94 ± 0.1	−0.19 ± 0.08

*COM = center of mass.

Table 2. Descriptive statistics for the analyzed lifters, divided into groups based on displacement of feet.*

Mean ± *SD*	*n*	Hip angle (in degrees)	S-H distance (m)	Peak pull velocity ($m \cdot s^{-1}$)	Drop delay (s)
Forward displacement	5	195.9 ± 4.8	0.01 ± 0.04	1.9 ± 0.1	0.04 ± 0.03
No displacement	6	187.9 ± 8.4	0.10 ± 0.1	1.9 ± 0.1	0.0 ± 0.0
Rearward displacement	13	185.8 ± 10.2	0.11 ± 0.1†	1.9 ± 0.1	0.03 ± 0.03

*S-H distance = shoulder-heel distance; peak pull velocity = maximum velocity of bar during lift.
†Significant difference rearward greater than forward displacement group.

the heel at the top of the pull, based on suggestions of "hipping" the bar causing rearward displacement.

Subjects

Subjects included 24 male weightlifters, 3 each from the 56, 62, 69, 77, 85, 94, 105, and 105+ kg weight classes competing at the national level in the 1999 USA Weightlifting Senior Nationals. All subjects were over 18 years of age. All participants gave informed consent for use of their video image as approved by the university Institutional Review Board, and they were all required to lift a qualifying total for their weight class. Subject body mass was (X ± *SD*) 83.2 ± 21.7 kg. All trials were recorded on April 23–25, 1999.

Procedures

All snatch lifts during the competition were recorded with a Panasonic model AG-450 S-VHS camera (Panasonic, Secaucus, NJ, USA), 45° to the sagittal plane. Two-dimensional affine scaling calibration modification was used where a square scale object is digitized for the plane of interest. The advantage of this type of scaling is that it does not require the camera to be level and perpendicular as in traditional 2-D scaling. Lens height was 0.92 m above the lifting surface, and the camera was 7.4 m from the center of the platform. Video was recorded at 30 frames per second and deinterlaced to yield 60 fields per second, and shutter speed was set at 1/250 seconds with the camera manually focused by visual means. The heaviest successful attempts of the top 3 finishers in the snatch in each weight class were analyzed using the Peak Motus 2000 video analysis system (Peak Performance Technologies, Englewood, CO, USA). A 19-point 2-D spatial model was used, and data were conditioned using a low pass, Butterworth digital filter with a cutoff frequency of 5 Hz. A 2-m square frame was used as the reference scale, and video frames were determined visually by the investigators.

Hip angle and horizontal distance from the shoulder to heel (S-H) were taken when the barbell reached its apex (vertical acceleration = 0). Drop delay is the time from the barbell reaching its apex to when the LCOM begins to descend. The horizontal bar and body displacement were the horizontal distance between these points at liftoff and after receiving the barbell in the squat position. The first place snatch in the 105+ kg class was unsuitable for analysis, so the fourth place snatch was used in its place to ensure an even number of participants per weight class. Average downward velocity of the COM (Table 1) and peak pull velocity (Table 2) and were also analyzed.

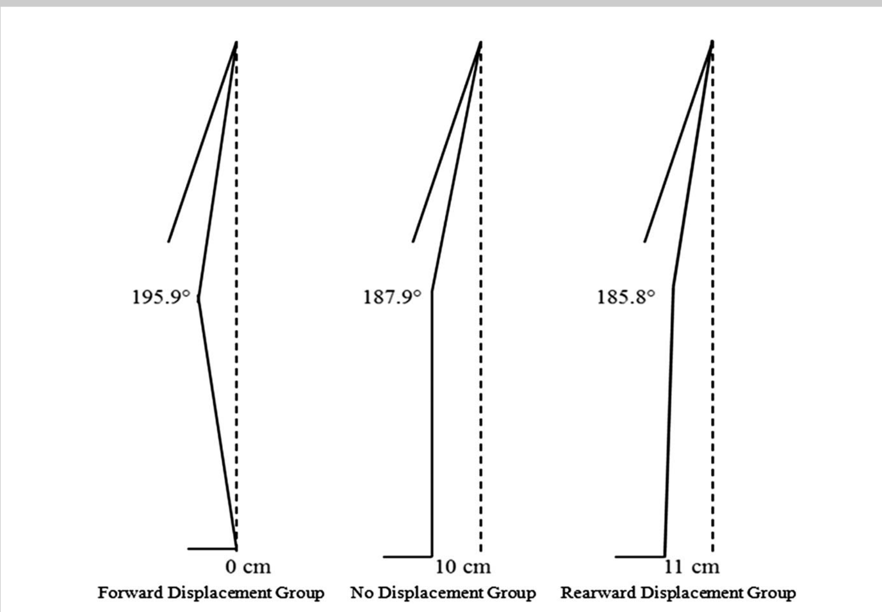

Figure 2. Average hip angles and shoulder-heel distance for the 3 groups at the point where the bar ceases to vertically accelerate. The nonexistent shoulder-heel distance in the forward displacement group indicates that "hipping" the bar may be related to forward displacement, not rearward displacement of the bar/body.

Statistical Analyses

In analyzing the video, all lifts were classified into 3 groups on the basis of average displacement of the athlete's feet: forward displacement

(>2.5 cm) of the feet during the drop-under phase, no horizontal displacement (±2.5 cm), and rearward displacement (>2.5 cm) during the period of time when the lifter moves under the bar. A 1-way analysis of variance ($\alpha \leq 0.05$) was used to examine differences between groups taking in all lifts and also the heaviest successful lift for the following variables: body mass, bar mass, hip angle at the end of the pull, and horizontal distance from the shoulder to the heel at the end of the pull. Tukey's post hoc was used to examine significant differences between groups. Effect size was calculated to compare hip angles, displacement, and mass across groups.

Results

Results are shown in Table 1, where the 24 lifters were categorized into a forward displacement group, a no displacement group, or a rearward displacement group. No significant group differences were noted for body mass, bar mass, or hip angle. The rearward displacement group had a significantly greater horizontal distance between the shoulder and heel (S-H distance) at the end of the pull. Effect sizes were calculated to compare hip angles (Figure 2) between groups. The strongest effect size existed between the forward displacement and rearward displacement groups (0.82), which amounts to a moderate to large difference in means (9). Hip angles for the no displacement group had a small-to-moderate difference in means (0.50) in comparison to the forward displacement group, but they only showed a small effect size (0.17) when compared with the rearward displacement group. A similar analysis was conducted to test the effect size of comparison for the S-H distance across groups. The forward displacement group showed a small-to-moderate difference in means to both the no displacement group (0.51) and the rearward displacement group (0.55). The rearward displacement group had only a trivial difference in means (0.05) to the no displacement group, in terms of S-H distance.

Discussion

Average hip angles differed by nearly 10° between the rearward displacement group (185.8 ± 10.2) and the forward displacement group (195.9 ± 4.8); however, there was no statistical significance to indicate that the rearward displacement group possessed more hip extension than either of the other groups. Regardless, substantive meaning in the data is believed to exist because of the presence of a large effect size between the 2 groups (0.82), and the fact that statistical power is limited because of the nature of our subject pool. This suggests the rearward displacement group executed the snatch similar to that described by Stone et al. (14). By shifting the center of pressure of the foot back during the first pull and remaining on the heels as long as possible, it became necessary to move backward during the drop-under to catch the bar. This is the contrary to the opinion that "hipping" the bar causes rearward displacement. The significant difference noted in the horizontal distance between the shoulder and hip between the rearward and forward displacement groups suggests that the rearward displacement is actually caused by leaning back as described by Stone et al. (14).

The results show that rearward displacement accounted for 54% of the snatch attempts sampled. If the rearward displacement indicates type B or similar trajectory, this is more than previous studies (8). Some of these may actually be type C, where the bar intersects the vertical reference line early in the lift. Although the lifters in this sample were U.S. national medal winners, the mean Sinclair scores for these lifters are an average of 25% less than the top 3 finishers at the 1999 World Championships.

Most of the literature only analyzed weightlifting kinematics in 2-D, concentrating on the sagittal plane (5,6,10). Future considerations to further analyze the snatch technique and its relation to LCOM and feet displacement should consider using, at a minimum, a 2-camera system to perform a 3-dimensional (3-D) analysis of the movement (3,7). In using only 1 camera, movement can only be monitored from the side of the athlete. As a result, view of knee positioning behind the weights during a majority of the lift can be obstructed. Estimations of body angles, which are intended to be 3-D projections of the athlete, could potentially be overestimations of true values because the joint angles are based on images collected only from the sagittal plane (7). Three-dimensional analysis of bar trajectory would help explain differences in foot displacement and provide more clarification on the trajectory itself by reducing error caused by the transverse rotation of the bar (13).

For the current study, no significant differences were seen in body mass, with the greatest difference in means being only a small-to-moderate effect size (0.58) between the no displacement group and the rearward displacement group. The forward displacement group had small effect sizes when compared with the no displacement group (0.30) and the rearward displacement group (0.28). Lighter body mass could result in a need to stay on the heels longer to prevent lifters from being pulled forward by the bar weight and, in turn, keeping the barbell closer to the base of support. This shifts the LCOM backward to act as a "counterweight," ultimately resulting in rearward displacement of the feet. There were no differences in peak pull velocity or the delay in the downward movement of the LCOM after the bar stops accelerating. Previous results (13) have indicated that heavier lifters could elicit more rearward displacement when compared with lighter lifters. This could be a function of the athlete's ability rather than body mass; however, some additional data on training experience and competition level would be needed to elucidate this comparison. Further analysis of body kinematics and kinetics in higher-caliber lifters is required as the lifters in the current investigation only lifted an average of 71.9% of the world record (4).

Practical Applications

These data seem to suggest that rearward displacement in the drop-under phase in the snatch is not detrimental to performance and actually seems to be a preferred technique in U.S. national level lifters. In addition to the fact that rearward displacement is exhibited in elite lifters and is coached globally, it seems this is the preferred technique to succeed in international competitions (10). Although some use type B trajectories naturally, it is also taught as the proper technique by many coaches. Because of the prevalence in international level lifters, as well as in national level lifters as indicated in this study, this technique may be considered to be a viable variation of the snatch by coaches and athletes of all levels, including those who use the snatch as an exercise to improve athletic performance.

References

1. Barton, J. Are there general rules in snatch kinematics? In: *Proceedings of the Weightlifting Symposium.* A. Lukacsfalvi and F. Takacs, eds. Budapest, Hungary: IWF, 1997. pp. 119–128.
2. Bartonietz, K. Biomechanics of the snatch: Toward a higher training efficiency. *Strength Cond J* 3: 24–31, 1996.
3. Baumann, W, Gross, V, Quae, K, GalBierz, P, and Schwirtz, A. The snatch technique of world class weightlifters at the 1985 world championships. *Int J Sport Biomech* 4: 68–89, 1988.
4. Chiu, LZ. A proposed method for world weightlifting championships team selection. *J Strength Cond Res* 23: 1627–1631, 2009.
5. Garhammer, J. Biomechanical characteristics of the 1978 world weightlifting champions. In: *Biomechanics VII-B.* A. Morecki, K. Fidelus, K. Kedzior, and A. Wit, eds. Baltimore, MD: University Park Press, 1980. pp. 300–304.
6. Garhammer, J. Biomechanical profiles of Olympic weightlifters. *Int J Sport Biomech* 1: 122–130, 1985.
7. Gourgoulis, V, Aggeloussis, N, Antoniou, P, Christoforidis, C, Mavromatis, G, and Garas, A. Comparative 3-dimensional kinematic analysis of the snatch technique in elite male and female greek weightlifters. *J Strength Cond Res* 16: 359–366, 2002.
8. Hiskia, G. Biomechanical analysis of world and Olympic champion weightlifters. In: *Proceedings of the Weightlifting Symposium.* A. Lukacsfalvi and F. Takacs, eds. Budapest, Hungary: IWF, 1997. pp. 137–158.
9. Hopkins, WG. A new view of statistics. Available at: http://sportsci.org/resource/stats/index. html. Accessed April 3, 2012.
10. Isaka, T, Okada, J, and Funato, K. Kinematic analysis of the barbell during the snatch movement in elite Asian weightlifters. *J Appl Biomech* 12: 508–516, 1996.
11. *Olympic Weightlifting 1990–1996 Highlights (Disc 1) [CD-ROM].* International Weightlifting Multimedia Database [Producer and Distributor], 1997.
12. Safrushahar, Y, Norhaslinda, H, and Wilson, B. Biomechanical analysis of the snatch during weightlifting competition. In: *Proceedings of International Symposium on Biomechanics in Sport. Anonymous,* 2002. pp. 226–229.
13. Schilling, BK, Stone, MH, O'Bryant, HS, Fry, AC, Coglianese, RH, and Pierce, KC. Snatch technique of collegiate national level weightlifters. *J Strength Cond Res* 16: 551–555, 2002.
14. Stone, MH, O'Bryant, HS, Williams, FE, Johnson, RL, and Pierce, KC. Analysis of bar paths during the snatch in elite male weightlifters. *Strength Cond J* 20: 30–38, 1998.
15. Vorobyev, A. *A Textbook on Weightlifting. W.J. Brice (Trans.).* Budapest, Hungary: International Weightlifting Federation, 1978.