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Altered Start Position Reduces Horizontal Displacement during the Snatch and Clean

John Petrizzo[1], Fred J. DiMenna[1,2], Ryan Page[1], Grant Smith[1], Kimberly Martins[1], Jonathan Lester[1], Susan Kang[1], Lauren Chandler[1], John W. Wygand[1], Robert M. Otto[1]

[1]Department of Exercise Science, Health Studies, Physical Education, and Sport Management, Adelphi University, New York, USA, [2]Teachers College, Department of Biobehavioral Sciences, Columbia University, New York, USA

ABSTRACT

Petrizzo J, DiMenna FJ, Page R, Smith G, Martins K, Lester J, Kang S, Chandler L, Wygand JW, Otto RM. Altered Start Position Reduces Horizontal Displacement during the Snatch and Clean. **JEPonline** 2016;19(3):24-34. The purpose of this study was to determine which of two Olympic Weightlifting start positions would yield the more efficient movement pattern. We compared the traditional Olympic lifting starting position with an experimental alignment that has been proposed to reduce horizontal displacement of the barbell. It was hypothesized that the experimental alignment would produce a barbell path more closely approaching linear movement. Ten subjects completed a series of cleans and snatches under both alignment conditions. The experimental alignment resulted in significant reductions in horizontal displacement (~40.3 mm and ~31.9 mm for snatch and clean, respectively; P<0.05). The experimental alignment did not result in a significant difference in peak power (snatch, ~2.2%; clean, ~2.6%). The findings indicate that experimental alignment proposed in this study reduced barbell horizontal displacement during the snatch and clean. Further research is needed to determine if there is an influence of the starting position on power output during these lifts.

Key Words: Biomechanics, Coaching, Efficiency, Performance

INTRODUCTION

With respect to motion of a body or implement, efficiency is maximized when movement approaches a straight line (8,14,27). For more than four decades, researchers have sought to determine the most efficient movement pattern during Olympic lifting by studying barbell trajectory in the sagittal plane to characterize its displacement in both vertical and horizontal directions (20). It is intuitive that the lifter's starting position relative to the barbell plays a critical role in this regard. However, heretofore, the influence of starting position on barbell trajectory during the Olympic lifts has not been investigated.

In 1978, Vorobyev analyzed the various barbell trajectories in Olympic lifting and defined three distinct types (26). The type 1 trajectory displayed the least net horizontal displacement (HD) and was, therefore, considered the most energy-efficient pulling pattern (20,26). In contrast, the type 2 trajectory was characterized by an increase in net HD towards the lifter while the type 3 trajectory involved an initial displacement to the rear followed by forward displacement in advance of the original starting position to a finish at a point behind the original starting position (14). However, despite the theoretical superiority of the type I trajectory due to its reduced HD, studies reporting on the frequency and distribution of these trajectory types in the practical setting suggest no consensus as to which is preferred and each has produced world-record performances (14). One factor responsible for this ambiguity is the lasting influence exerted by the original rules that governed the sport (14).

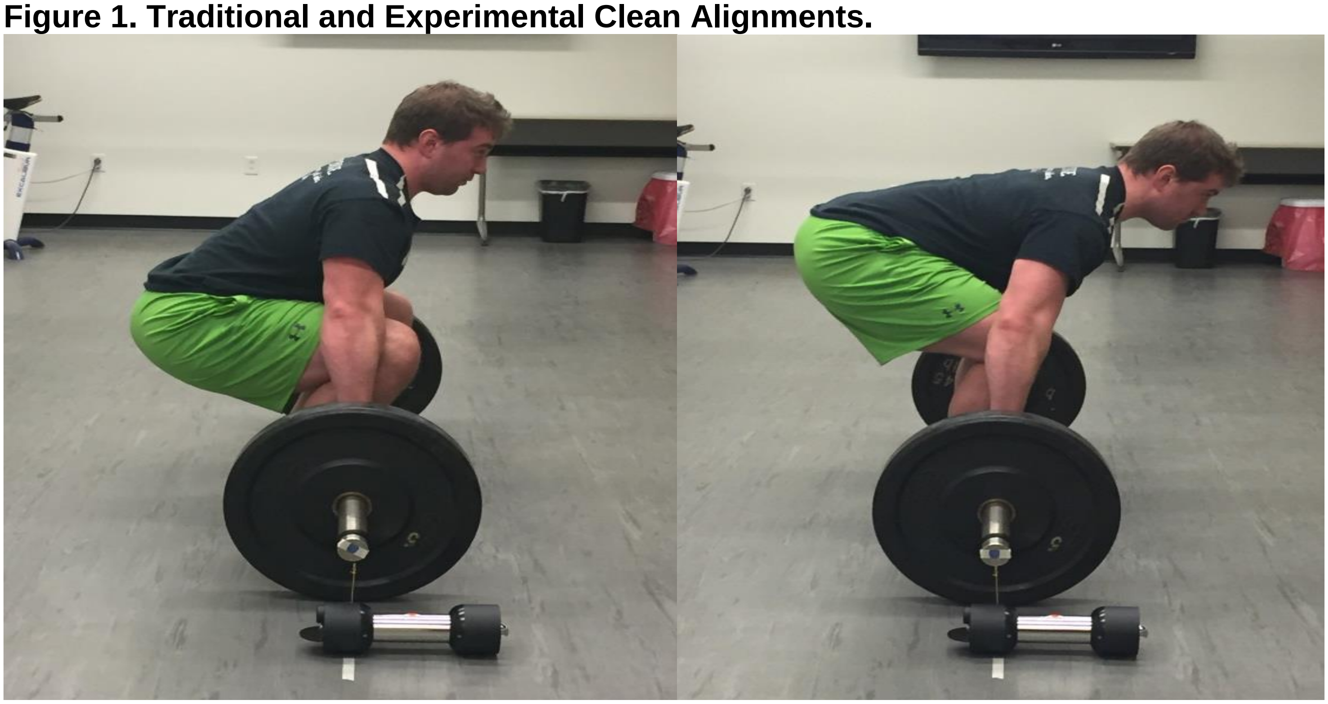
During the first half of the 20th Century, it was illegal for the barbell to contact any part of the body other than the lifter's hands during the pull phase of the snatch and clean. Consequently, lifters often assumed a position with either their phalanges or metatarsophalangeal joints of the feet (MTP) directly under the barbell to maximize the horizontal distance the barbell would have to travel before contacting the body. However, by the middle of the 1960s, rule changes made it legal for the barbell to contact the shins and thighs. This meant that the barbell could be kept close to the lifter's body, which led to the development of the double-knee bend technique that changed the way most lifters performed the snatch and clean. However, despite this alteration in movement pattern, many lifters did not adjust their starting position (barbell over MTP) and, to this day, some top coaches continue to teach this alignment. For example, Drechsler (4) recommends that the lifter's initial alignment should place the barbell "roughly over the juncture of the metatarsal/phalangeal joints" and that the shoulders should be positioned directly over or slightly forward of the bar. Similarly, Everett (6) describes an initial alignment that has the barbell resting over the balls of the feet with the athlete's arms oriented vertically when viewed from the side. Finally, even coaches who recommend a more horizontal back angle (similar to the one that is assumed during the experimental alignment assessed in the present study) often recommend an initial set-up that places the "toes below the barbell" (28). The end result is that for many lifters, the bar is displaced horizontally towards the body during the first pull of the snatch and clean.

Virtually all published accounts of the pulling motion during the snatch and clean have focused on the trajectory of the barbell without consideration of the anatomical alignment and relationship of lifter to barbell in the starting position (14). Over the course of the previous four decades, there have been many examinations of elite male and female weightlifters across multiple weight classes and age groups during submaximal and maximal loading in order to derive kinematic and kinetic analyses of barbell trajectories (1-3,10,11,13,15,16,21). There has even been a study that compared bilateral barbell kinematics and kinetics during weightlifting competition (23). However, none of these investigations have revealed conclusive support for the barbell trajectories commonly employed. Moreover, to date, only one study has considered the relationship between individual anthropometry and barbell trajectory during Olympic lifts (20). Yet, in that study, Musser et al. (20) did not examine anatomic alignment in relation to the barbell for the starting position.

In “Starting Strength,” Rippetoe (22) proposed an association between foot, bar, and scapula during any pulling motion that occurs from the floor (22). Rippetoe’s objective was to improve efficiency and performance in both the deadlift and power clean by minimizing barbell HD (22). The theory posits placing the barbell directly over the mid-foot and under the scapular spine, an alignment proposed to reduce extraneous muscular work that does not contribute directly to the lift (14). It had previously been hypothesized that even a small amount of HD while lifting could significantly increase the total energy expenditure required for successful completion, although data ultimately did not support this contention (7).

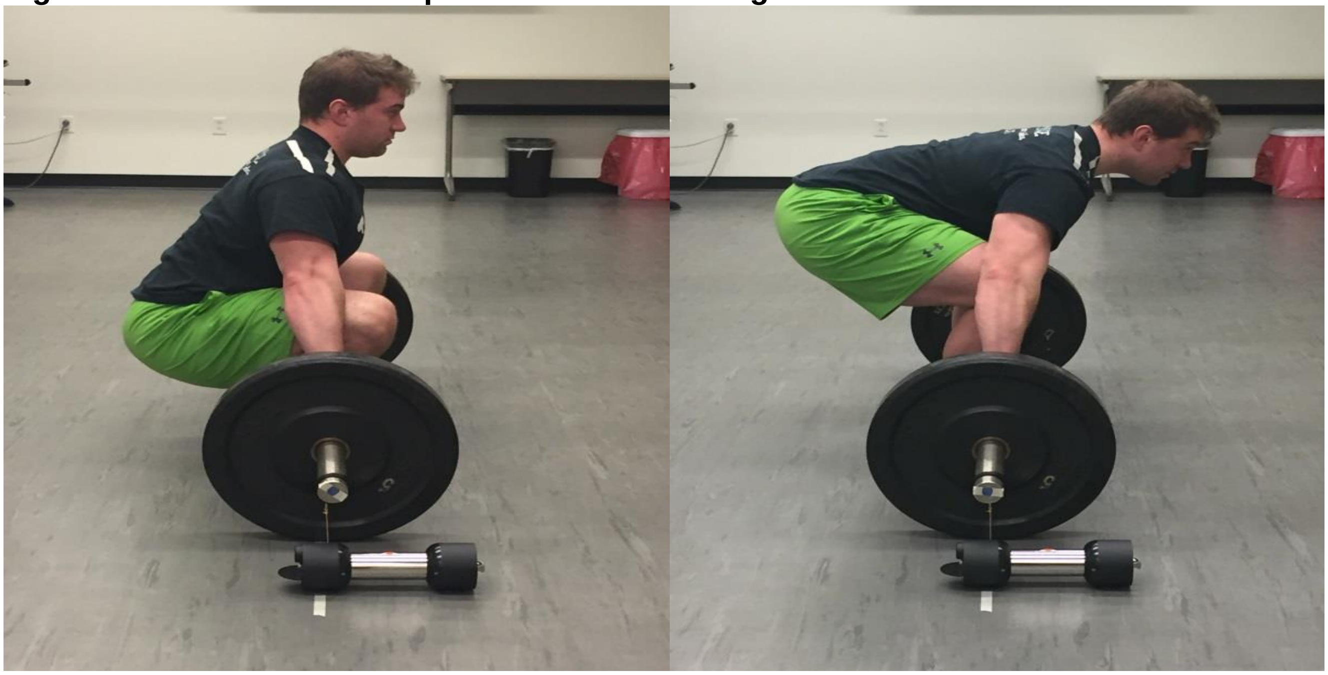
The purpose of the present study was to determine whether a modified anatomical alignment relative to the barbell at the initiation of the snatch and clean alters movement efficiency and impacts power output. Specifically, the traditionally-used starting position (TRAD), which places the bar over MTP and under the acromioclavicular joints of the shoulders (AC) (Figures 1 and 2) was compared to an experimental alignment (EXP) that places the bar over the navicular bones of the feet (N) and under the inferior and medial aspect of the scapular spine (SS) (Figures 1 and 2). It was hypothesized that EXP would produce less HD (and, therefore, a more efficient movement pattern) thereby allowing for greater power output compared to TRAD.

Figure 1. Traditional and Experimental Clean Alignments.



The traditional and experimental alignments of the clean with the barbell placed directly over the metatarsophalangeal joints and under the acromioclavicular joints on the left and the barbell placed directly over the navicular and under the inferior and medial aspects of the scapular spine on the right.

Figure 2. Traditional and Experimental Snatch Alignments.



The traditional and experimental alignments of the snatch with the barbell placed directly over the metatarsophalangeal joints and under the acromioclavicular joints on the left and the barbell placed directly over the navicular and under the inferior and medial aspects of the scapular spine on the right.

METHODS

Subjects

Ten subjects (age, 24.5 ± 4.1 yr; height, 1.5 ± 0.4 m; body mass, 75.1 ± 22.0 kg; Snatch 1RM, 74.9 ± 30.0 kg; Clean 1RM, 98.8 ± 37.3 kg; 7 male) with at least 2 yrs of Olympic Weightlifting experience participated in this study. Three of the participants had competed at the national level. The research was approved by Adelphi University's Institutional Review Board and all of the involved investigators received training in the treatment of human subjects through the NIH Office of Extramural Research. All subjects volunteered to participate and were briefed as to potential risks and benefits involved in their participation. Written informed consent was obtained from all subjects prior to participation.

Procedures

Each subject visited the laboratory on one occasion and, in a randomized, crossover design, performed a series of snatch and clean using TRAD, which placed the barbell directly over MTP and directly under AC, and EXP, which placed the barbell directly over N and directly under SS. The barbell HD during the first pull was analyzed using Dartfish software. Measurements of peak power outputs were recorded with a TENDO Power and Speed Analyzer.

Prior to testing, a standard 20-kg men's or 15-kg women's Olympic barbell was placed on a lifting platform. Athletic tape was used to mark the platform directly beneath the barbell and the tape line ran parallel to the barbell's orientation across the platform's length. This line was used as a reference to elicit precise anatomical alignment of the subject's feet relative to the barbell. The center of the barbell's endcap was also marked for video analysis. A Panasonic

PV-GS150 2.3MP 3CCD Mini DV Camcorder (Panasonic Corporation of North America) was placed 3 m from the end of the barbell with the lens at a height of 1 m. The camera was oriented perpendicular to the barbell so that the lifter and barbell could be viewed in the sagittal plane. This orientation, which has been used in previous kinematic analysis of the deadlift and Olympic lifts, allows for detection of barbell HD throughout lift execution (5,8,14,17,19,20,24).

A TENDO Power and Speed Analyzer 310 (Sorinex Exercise Equipment, Lexington, SC), which consists of two functional components (a velocity sensor unit and a microcomputer) was attached to the distal end of the barbell's sleeve adjacent to the end-cap. As per the manufacturer's "User Manual," the system measures upward vertical average and peak velocity of the barbell during lifting. Prior to execution of every snatch and clean, the barbell's mass in kilograms was input into the microcomputer. Using this known mass, the system calculated average power and power at peak velocity during the concentric phase of each lift.

To ensure that foot placement was identical across subjects, participants wore weightlifting shoes with a non-compressible sole and elevated heel (effective heel height, ¾-inch). Prior to the subject's shoes being laced, N and MTP were palpated and their positions were marked on the lifter's shoes with athletic tape. AC and SS were palpated and marked in a similar manner. Following this preparation, a familiarization trial was performed to ensure that the lifter understood the different starting positions for the snatch and clean. Following this trial, subjects were randomly assigned to a cross-over design of traditional snatch (TRAD-Snatch), experimental snatch (EXP-Snatch), traditional clean (TRAD-Clean) and experimental clean (EXP-Clean). Prior to data collection, subjects performed four progressively heavier sets of both snatch and clean as a "warm up" (14). The four sets comprised five, three, three, and one repetition at 30, 50, 65, and 80% 1RM, respectively. Subjects performed warm-up sets for both TRAD and EXP.

Following the warm-up, the bar was loaded to 90% of a subject's self-reported 1RM. Prior to data collection, the two anatomical alignments were randomly ordered between subjects. In order to begin in the correct alignment, subjects were instructed to place the appropriate shoe-marking tape (N or MTP) directly over the tape marks on the platform. Subjects were allowed to use their normal stance width during all trials. Following alignment of the feet relative to the barbell, subjects grasped the barbell with their normal grip width and assumed their normal starting position. Subjects were then coached into the correct shoulder-alignment position through the use of verbal and tactile cues. All alignments were confirmed by the primary investigator and a co-investigator prior to initiation of every trial. TENDO Unit recordings of peak power were documented following the completion of every successful lift. Upon completion of two trials in the first assigned alignment, the subject proceeded to the second alignment. A 3-min break was allowed between trials to standardize testing conditions across subjects.

Following successful completion of all trials, subjects' video recordings were transferred to a computer using a Dazzle DVD Recorder HD (Corel Corporation, Ottawa, Ontario Canada). Once the video images were transferred, Dartfish 7 (Dartfish USA, Inc., Alpharetta, GA) software was used to determine barbell HD during each trial. In order to accurately measure HD, the original start position of the barbell on the platform was used as the reference point of the vertical axis from which displacements were measured (14). Similarly, the system was calibrated by using the diameter of the standard-dimension Olympic plates, which were loaded onto the barbell. Once the vertical reference marker was created and the system was calibrated, the marked center point of the barbell end cap was manually traced frame by frame from the starting position on the floor to the finish position either overhead (Snatch) or on the shoulders (Clean). The position of greatest horizontal excursion from the original vertical axis during the "first pull of the lift" (i.e., from initial liftoff until the first maximal knee extension; Gourgoulis et al., 2009) was measured in millimeters. Data were entered into a Microsoft Excel (Microsoft, Seattle, WA) spreadsheet and stored for statistical analysis.

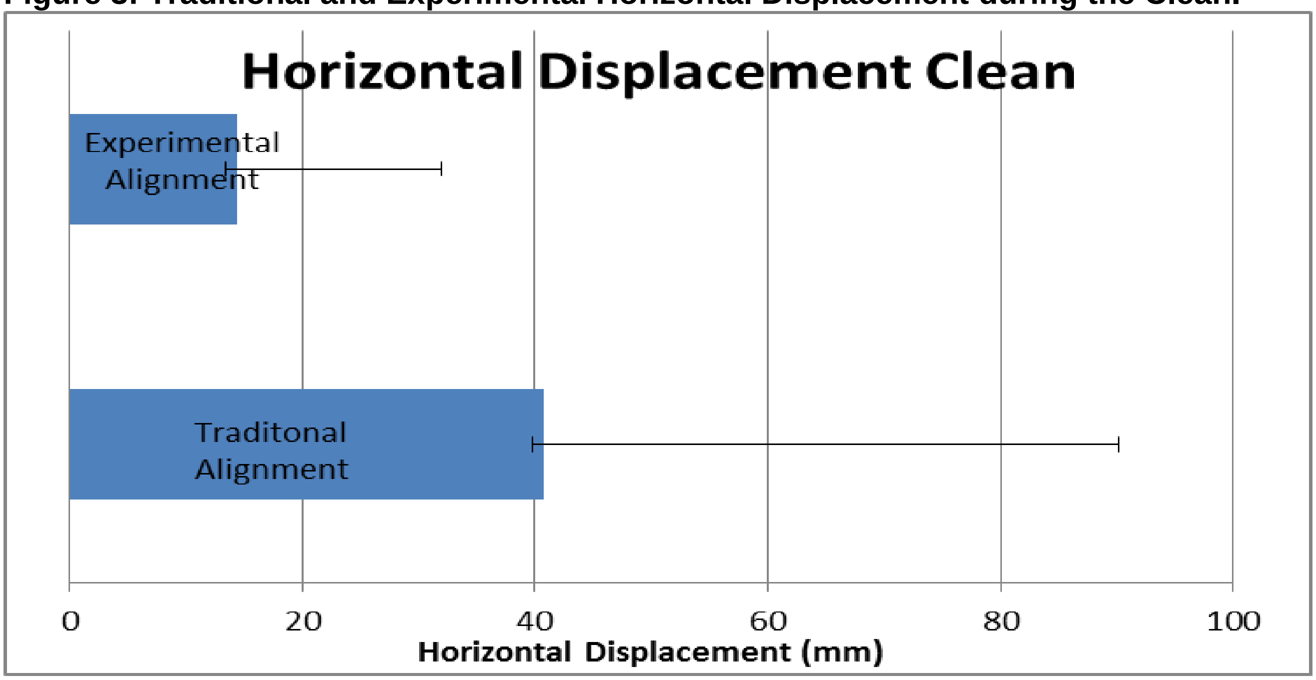
Statistical Analyses

T-tests were used to evaluate the probability that any differences in HD as well as peak power outputs between TRAD and EXP for snatch and clean did not occur by chance. The level of statistical significance was set at P≤0.05.

RESULTS

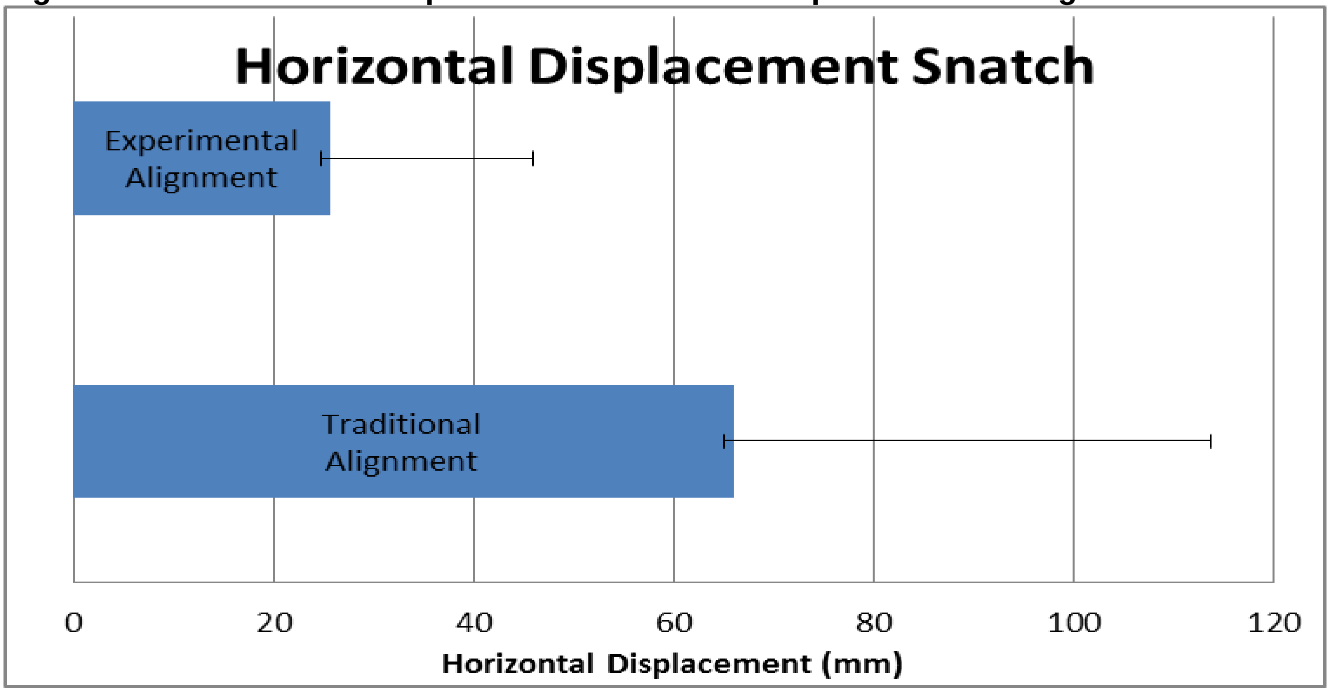
Both TRAD and EXP consistently displayed posterior displacement of the barbell during the first pull for both snatch and clean; however, EXP resulted in a significant reduction in barbell HD compared to TRAD. During the first pull, HD was reduced by 40.3 mm and 31.9 mm for snatch and clean, respectively (Figures 3 and 4). Similarly, EXP-Snatch and Clean resulted in mean peak power outputs of 715.8 ± 362.2 and 926.3 ± 440.8 W while TRAD-Snatch and Clean resulted in mean peak power outputs of 700.3 ± 362.3 and 902.7 ± 381.7 W, respectively. Compared to TRAD, EXP alignment did not result in a significant difference in peak power (snatch, ~2.2%; clean, ~2.6%).

Figure 3: Traditional and Experimental Horizontal Displacement during the Clean.



Average horizontal barbell displacement during the first pull of the clean by group. EXP-C resulted in mean HD of 17.5 ± 14.4 mm while the TRAD-C resulted in mean HD of 49.4 ± 40.7 mm, respectively.

Figure 4: Traditional and Experimental Horizontal Displacement during the Snatch.



Average horizontal barbell displacement during the first pull of the snatch by group. EXP-S resulted in mean HD of 25.7 ± 20.2 mm while the TRAD-S resulted in mean HD of 66.0 ± 47.6 mm, respectively.

DISCUSSION

The main finding of this investigation was that an experimental anatomic alignment, which placed the barbell above the navicular bones of the feet and below the scapular spine of the shoulder girdle at the initiation of the Olympic-style lifts produced a more linear and, mechanically efficient, barbell trajectory compared to the traditionally used alignment with the barbell directly above the MTP joints of the feet and below the AC joints of the shoulders. In fact, mean maximal HD during EXP was reduced by ~61.0% and ~64.6% for the S and C lifts, respectively. However, EXP did not result in significantly greater peak power output during the snatch or clean despite its more efficient mechanical nature.

In support of our experimental hypothesis, EXP resulted in a decrease in barbell HD during the first pull of the snatch (~40.3 mm) and the clean (~31.9 mm), which suggests a more efficient movement pattern. These results are similar to previous reports for the deadlift during which EXP reduced HD by 29.2 mm (Hancock et al., 2012). Additionally, when comparing HD data for TRAD to previous investigations of barbell trajectory during Olympic-style lifts using the traditional starting position, results were similar (8,9). For example, Garhammer (8) reported a range of HD between 30.0 and 90.0 mm to the posterior in competitive Olympic weightlifters while Gourgoulis and colleagues (9) found a mean posterior displacement of 62.0 ± 22.3 mm in their investigation of elite Greek Olympic weightlifters. Compared to previous findings, the mean HDs for TRAD (66.0 ± 47.6 mm and 49.4 ± 40.7 mm for the snatch and the clean, respectively) suggest that the testing condition and data-analysis procedures used in the present study created a valid reference condition to which EXP could be compared.

The importance of limiting barbell HD in Olympic lifts was recognized by Gourgoulis et al., (10) who found that the difference between successful and unsuccessful snatch performance resided in the direction of the force vector during the pull from the floor. This is consistent with the observation that male and female weightlifters of higher skill display a smaller amount of HD compared to those that are less skilled (18,25). However, these previous investigations did not consider how the initial anatomic alignment of the lifter impacted HD.

To our knowledge, the present study is the first to directly examine the performance effects of variations in anatomic positioning at the initiation of the Olympic lifts and in that regard, our finding of reduced HD with EXP provides an objective rationale for using this specific starting alignment rather than the more subjective approach that has been used historically (14). However, contrary to what might be expected, we also found that peak power output did not increase significantly with this modification. The reason for this lack of detectable effect is unclear, but might involve a type 2 error and/or a lack of sufficient familiarization for subjects to the EXP technique for which they were less accustomed. Consequently, future studies utilizing a larger sample size and more prolonged familiarization period are warranted.

CONCLUSIONS

While researchers have been assessing performance during the Olympic lifts for four decades, a consensus as to what constitutes a technique that optimizes efficiency is still lacking. The present investigation is the first to not only consider how the lifter's starting position impacts barbell trajectory, but also how that trajectory ultimately impacts peak and average power output during the snatch and clean lifts. Our findings support the contention that compared to the traditional starting position in which the MTP joints of the foot, barbell and AC joints of the shoulder girdle are vertically aligned, an alignment that places the mid-foot, barbell and spine of scapulae in vertical alignment minimizes barbell HD during the first pull of the lift. We hope that these findings will spur further research into the impact of anatomical alignment on barbell trajectory and performance during the Olympic lifts. Indeed, if our findings are extended by future research, coaches and athletes who either participate in the sport of Olympic Weightlifting or utilize the Olympic lifts in their training for other sports will benefit by having a more objective, data-based means of coaching, performing, and analyzing these lifts.

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Address for correspondence: John Petrizzo, DPT, Department of Exercise Science, Health Studies, Physical Education, and Sport Management, Adelphi University, Garden City, NY, USA, 11530-0701, Email: jpetrizzo@adelphi.edu

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