CATCH IT IF YOU CAN: IS THE CATCH PHASE OVERLOOKED IN WEIGHTLIFTING?

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The purpose of this study was to present a new method of dividing the phases of weightlifting exercises and describe the accompanying barbell biomechanics. Ten competitive female weightlifters performed 4 sets at intensities ranging from 85 to 100% of their previous one repetition maximum (1RM) in snatch and clean. A motion capture system was used to record 3-D barbell trajectories for all attempts. Barbell kinematic and kinetic data were compared between the pull, turnover, and catch phases of the snatch and clean. During the catch phase, the average force exerted on the bar was greater than during the other two phases for both lifts even though it was applied over a shorter distance in comparison ($p<0.05$). The demands of the catch phase should be taken into account in future studies when analyzing the technical requirements of these exercises.

KEYWORDS: CLEAN, SNATCH, TURNOVER, CATCH, FORCE, WORK

INTRODUCTION: Bar mechanics have been one of the most important aspects of weightlifting biomechanics since it they are related to performance in competition (Baumann et al., 1988; Garhammer, 1985). To better understand the technical requirements of the snatch and clean, and to facilitate their biomechanical study, both lifts are usually divided into phases (Vorobyev, 1978). Different definitions of the phases have been provided based on ground reaction forces (Enoka, 1979; Garhammer & Gregor, 1992), moments (Baumann et al., 1988), joint kinematics (Häkkinen, 1984; Kauhanen, 1984), barbell kinematics (Böttcher & Deutscher, 1999; Garhammer, 1985), joint and barbell kinematics (Gourgoulis et al., 2000), or the use of knee and barbell kinematics as well as kinetics (Chavda et al., 2021).
Some of these phases of the lifts, however, have received considerably less attention, perhaps because of a lack of accurate definition. Most of the literature has focused on the analysis of the pull phase(s) (Baumann et al., 1988) because the primary goal in weightlifting is to displace the barbell and produce high levels of force or power (Garhammer, 1980, 1985). Nevertheless, the actual goal is to lift the most weight overhead (snatch) or upon the front of the shoulders (clean) (Vorobyev, 1978) and performance is not determined by the characteristics of the pull phase alone, but also by the lifter’s ability to quickly reposition themself under the barbell (turnover phase) and properly decelerate it (catch phase) (Böttcher & Deutscher, 1999).
Differences and unclear definitions of the catch phase in the literature make it difficult to conceptualize the phases and make comparisons between studies. For example, Garhammer referred to “move under the barbell” time as the time between maximum vertical barbell velocity until the elbow of the lifter rotated to a position below the barbell (Garhammer, 1985). Others defined the drop under the barbell phase from the maximum to minimum knee extension (Häkkinen, 1984; Kauhanen, 1984). Gourgoulis defined the catch phase from peak barbell height to the stabilization of the barbell overhead (Gourgoulis et al., 2000). Isaka used the term “catch position” without providing a clear definition of it (Isaka et al., 1996). The turnover phase has been defined using both joint and barbell kinematics e.g., from maximum knee extension to peak barbell height (Campos et al., 2006; Gourgoulis et al., 2000).
Therefore, the purpose of the study was to provide a meaningful definition of the phases and provide kinematic and kinetic data relative to those phases for the snatch and clean lifts in competitive female weightlifters.

METHODS: Ten elite female weightlifters, members of the USA National Weightlifting Team, voluntarily participated in this study: mean ± SD; mass: 84.1 ± 30.5 kg, maximum absolute load lifted during the test in snatch and clean: 96.4 ± 10.3 kg and 122.0 ± 12.1 kg, respectively. After individualized warm-ups, lifters performed four sets of one repetition at intensities ranging from 85 to 100% of their most recent one repetition maximum (1RM) in snatch and clean, with approximately three minutes of rest between sets. Three-dimensional barbell path was

acquired from a reflective marker, placed at the right end of a barbell, via four motion capture cameras (Bonita, Vicon, Los Angeles, CA, USA). Kinematic data were recorded at 200 Hz. Standard methods were used to calculate velocities, accelerations, forces, and work applied on the barbell (Chiu, 2018). Mean force and work values were used.
Determination of the phases: The present study focused on the snatch and clean exercises from the beginning of the barbell lift-off (vertical barbell position ≥ 0.25 m) to the instant at which the barbell achieved zero vertical velocity (i.e., its lowest point in the receiving position). The 3 phases (Figure 1) were denoted as follows: Pull = from take-off to maximum vertical barbell velocity; Turnover = from maximum vertical barbell velocity to minimum vertical barbell velocity; Catch = from minimum vertical barbell velocity to zero barbell velocity.

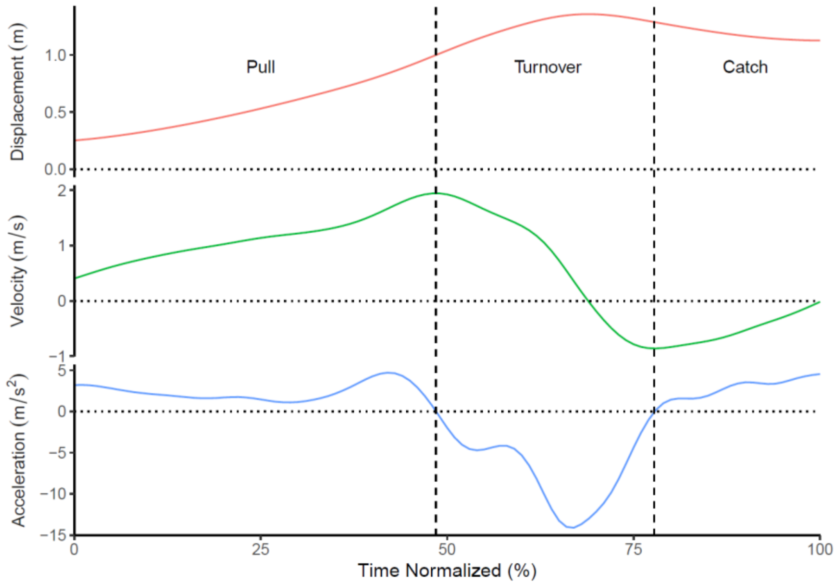

Figure 1: Barbell kinematics during the snatch, divided by phases.

Descriptive data are reported as mean ± SD. The analyses were conducted by averaging all the repetitions performed between 85-100% 1RM. Welch's or Kruskal-Wallis' one-way ANOVAs were performed using "Phase" as a factor with 3 levels ("Pull", "Turnover", "Catch") and Games-Howell or Dunn's post hoc test with Bonferroni and Holm corrections, depending if the data were heterogeneous and normal or heterogeneous and non-normal, respectively (Turner et al., 2021a). The criterion for statistical significance was set at an alpha level of 0.05. Between-group standardized means differences were calculated using Hedges g, together with their 95% confidence intervals (Turner et al., 2021b). All statistical analyses were performed in R (R Core Team, 2022).

RESULTS: Statistically significant differences between phases are found, together with "large" effect sizes (ES ≥ 0.8) (Cohen, 1988), for all lifts and phases, except for the work performed on the barbell between the turnover and catch phases (Table 1).

DISCUSSION: The definition of the phases based on barbell kinematic data, proposed in the present study, has several advantages. Mainly, it provides clear and easily quantifiable points based solely on barbell kinematics. In addition, each phase has a clear biomechanical purpose, which makes it easy to understand the task goals. For example, during the pull phase, the lifter pulls the barbell *to a specific height with a specific velocity*. After that, during the turnover phase, the lifter tries to actively *reposition themself under the barbell* until they are in an adequate position to apply an upward force and slow the barbell's downward velocity. The goal now is to completely *brake the downward movement of the barbell* and bring the barbell velocity to zero (Nagao et al., 2019).

Table 1. Kinetics and kinematics analysis of the snatch and clean exercises

		Phases			Effect Sizes Between Phases		
		Pull	TO	Catch	Pull vs. TO	Pull vs. Catch	TO vs. Catch
Force (N)	Snatch	1116 ± 138^{t,c}	260 ± 59^{p,c}	1254 ± 210^{p,t}	7.97 [6.64, 9.29]	-0.77 [-1.22, -0.31]	-6.36 [-7.45, -5.27]
	Clean	1335 ± 131^{t,c}	252 ± 31^{p,c}	1768 ± 274^{p,t}	11.23 [9.41, 13.05]	-1.99 [-2.53, -1.45]	-7.67 [-8.95, -6.39]
Disp. (m)	Snatch	0.71 ± 0.08^{t,c}	0.39 ± 0.03^{p,c}	0.10 ± 0.04^{p,t}	5.42 [4.46, 6.38]	9.89 [8.28, 11.51]	9.12 [7.62, 10.61]
	Clean	0.61 ± 0.07^{t,c}	0.35 ± 0.03^{p,c}	0.24 ± 0.06^{p,t}	4.86 [3.98, 5.74]	5.59 [4.61, 6.57]	2.32 [1.75, 2.88]
Work (J)	Snatch	838 ± 163^{t,c}	136 ± 15^{p}	117 ± 36^{t}	5.98 [4.94, 7.01]	6.02 [4.97, 7.06]	0.67 [0.22, 1.12]
	Clean	855 ± 144^{t,c}	151 ± 15^{p,c}	398 ± 67^{p,t}	6.79 [5.63, 7.94]	4.01 [3.24, 4.78]	-5.04 [-5.94, -4.14]

Superscripts indicate significant differences within a lift relative to the pull (^{p}), turnover (^{t}), or catch (^{c}) phase. TO = Turnover; Disp. = Displacement.

The present study provides detailed biomechanics data relative to the pull, turnover, and catch phases of the snatch and clean exercises. The results agree with those in the literature, although some of them needed to be combined when the pull phase was divided into first and second pulls, arithmetic operations were required when position instead of displacement was available, or work and displacement were provided but not force. Regarding the pull phase of the snatch exercise in elite female weightlifters, Akkuş found similar values of force: ≈ 1003 N; displacement: 0.70 ± 0.06 m; and mechanical work: 706 ± 94 J (Akkuş, 2012). Women competing in the 69-kg weight class in the 2010 World Weightlifting Championship also exhibited similar values during the pull phase in snatch: force: ≈ 1041 N; displacement: 0.67 ± 0.04 m; and mechanical work: 695 ± 61 J (Harbili, 2012). In comparison to studies with male samples, elite junior weightlifters showed similar displacements: 0.63 ± 0.07 m (Campos et al., 2006), while elite Greek weightlifters performed more work on the barbell: 1293 ± 213 J. The study from Harbili mentioned previously also provided values for men: force: ≈ 1395 N, displacement: 0.67 ± 0.04 m, and work: 932 ± 109 J (Harbili, 2012).

Although most research has focused on the pull phase, some studies have analyzed kinetic variables during the turnover and catch phases in weightlifting and pulling derivatives (Comfort et al., 2017; Suchomel et al., 2017). Even though our results are similar in magnitude for the catch phase regarding mean force data: present study (clean): 1768 ± 274 N; Comfort's (clean from the knee): 1830 ± 331 N; Suchomel's (hang power clean): 1488.1 ± 411.6 N, the different phases definition and exercise selection influencing the displacement measured yields greater differences in the mechanical work performed: present study (clean): 398 ± 67 J; Comfort's (clean from the knee): 665 ± 276 J; Suchomel's (hang power clean): 129.9 ± 93.7 J.

The work performed on the barbell during the turnover provides some insight into the relevance of this phase. The magnitudes of the mechanical work suggest that the lifter is continuing to apply an upward force while actively pulling themself under the barbell. The effect of this 'active pull under' would be a reduction in barbell deceleration and enable the barbell to reach a greater peak height (Böttcher & Deutscher, 1999). The work performed during the turnover phase would therefore also give a lifter more time to reposition themself and prepare for the catch phase (Böttcher & Deutscher, 1999). Barbell mechanics during the turnover phase would therefore appear very important for the success and efficiency of a lift (Böttcher & Deutscher, 1999), but alas have not received much attention in the literature.

CONCLUSION: The division of the phases based on vertical barbell velocity presented in this article, provides a precise definition of each phase and could improve the reproducibility of results and facilitate comparisons between future studies. The kinematic and kinetic analyses highlight the high force demands of the catch phase, which should be taken into account by coaches. Likewise, the non-trivial work performed during the turnover phase emphasizes the importance of actively continuing to pull the bar upwards while the lifter pulls themself downwards.

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