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Changes in Peak Acceleration in the Snatch Across Multiple - Attempts in Training: A Case Study

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CHANGES IN PEAK ACCELERATION IN THE SNATCH ACROSS MULTIPLE ATTEMPTS IN TRAINING: A CASE STUDY

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Accelerometers are devices that have been recently used to assess the performance of weightlifters in training. This case study used vertical acceleration data to assess multiple snatch attempts in a single lifter during a training session. The lifter exhibited variability in a number of measures, including peak acceleration and peak velocity. The measures calculated from the acceleration-time data did not show consistent trends between made and missed lifts. More work is needed identify variables of interest for snatch performance.

KEYWORDS: accelerometer, weightlifting, peak acceleration, peak velocity

INTRODUCTION:

Monitoring weightlifting training has evolved in many forms. Everything from the coaches' trained-eyes to various types of instrumentation have been involved. Unfortunately, the "eyeball" method of evaluation of a lift is highly subjective, often difficult to quantify, and very difficult to obtain a coaching consensus. Thus, in order to compare the characteristics of a lift between repetitions, loads, training sessions over time, or between lifters, some type of objective quantification is necessary.

There are numerous instruments for measuring weightlifting performance, including video analysis, potentiometers/encoders, 2D/3D motion capture, the V-Scope^{TM}, and others. Unfortunately, there can be many drawbacks these devices, including extensive scientific and/or engineering expertise, cost, or often, a significant delay of time between collection and return of the data to the athlete.

Recently, accelerometry was added to the gamut of devices available for measurement of weightlifting performance (Sato, Fleschler, & Sands, 2009a; Sato, Sands, & Stone, 2012; Sato, Smith, & Sands, 2009b). Accelerometry addresses some of the drawbacks of other devices, such as cost, engineering expertise, and time delay between data collection and return to coach and athlete. The listed studies have established concurrent validity of accelerometers for acceleration-time data with high speed video (Sato, et al., 2009b) and between-session reliability of peak acceleration (Sato, et al., 2012). Studies have noted decreasing peak acceleration with increasing loads from 80-90% 1-RM in the snatch in resident weightlifters at the US Olympic Training Center at Colorado Springs (Sato, et al., 2009a; Sato, et al., 2012). The following case study examines the usefulness of accelerometry with a collegiate weightlifter.

METHODS:

One collegiate female weightlifter participated in this case study (national/international level, 75+kg weight class, best snatch 104 kg). As part of her training, the lifter performed 8 single repetitions with 83% of her best competition snatch, with approximately 1-3 minutes of rest between each repetition. The lifter had been in a high volume phase of her training at the time. During each repetition, acceleration of the bar in the vertical direction was measured using an accelerometer (PS-2119, Pasco Scientific, Roseville, CA, USA). Acceleration data were collected using proprietary software (Capstone 1.1.1, PASCO Scientific, Roseville, CA, US). Peak velocity, positive area under the curve, and negative area under the curve were calculated by integrating the acceleration-time signal using the trapezoid rule. A ratio of negative area under the curve to positive area under the curve (NAPA ratio) was calculated evaluate the negative acceleration in the transition phase relative to positive acceleration in the other phases.

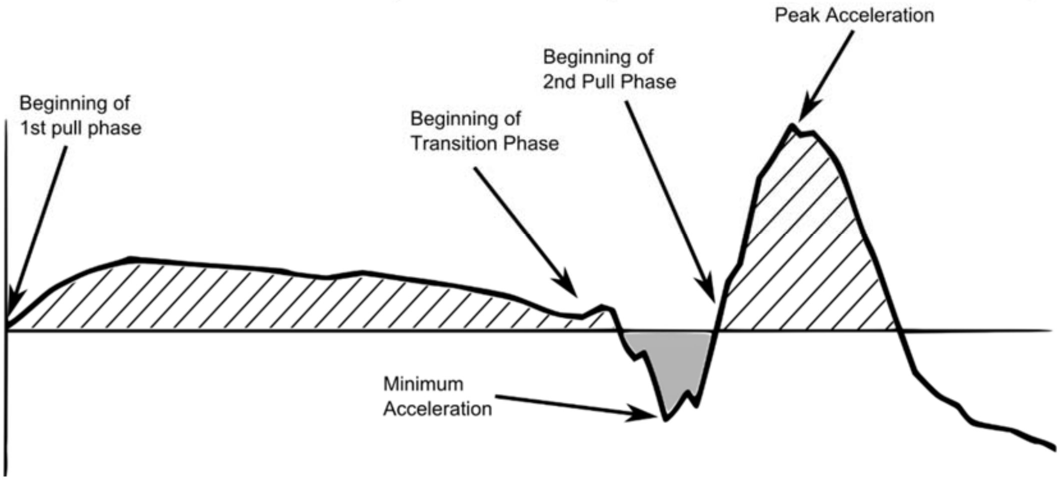

Figure 1: Example acceleration-time trace. Lined area represents positive area under the curve. Gray area represents negative area under the curve. Phase labels are approximations based on observation.

RESULTS:

Kinematic data for each repetition can be found in Table 1. Of the 8 attempts, three were missed attempts, and five were made attempts. Little or no patterns of makes and misses were clear. Figure 2 represents the acceleration time-traces for each attempt.

Table 1: Measurements of Interest

Repetition Number	1	2	3	4	5	6	7	8
Make/Miss	Miss	Make	Miss	Make	Make	Miss	Make	Make
Peak Acceleration (m/s^2)	9.71	9.20	7.60	8.27	7.89	7.54	8.56	8.11
Min Acceleration (m/s^2)	-4.28	-3.55	-3.51	-2.14	-4.57	-3.67	-3.71	-3.35
Peak Velocity (m/s)	2.13	2.55	2.05	1.75	1.66	1.64	1.75	2.06
Positive Area Under Curve	2.34	2.70	2.14	1.76	1.66	1.64	1.76	2.07
Negative Area Under Curve	-0.21	-0.15	-0.09	-0.01	0.00	0.00	-0.01	-0.01
NAPA ratio	9.0%	5.5%	4.2%	0.8%	0.0%	0.0%	0.8%	0.6%

DISCUSSION:

While an interesting topic for discussion, it does not appear that any patterns were evident to explain why each lift was a make or a miss. The athlete's coaches indicated that the location the bar brushes this athlete's thighs during the transition and second pull varies from lift to lift. This may be a cause of variability in the pattern of the trace in the transition phase. Some lifts appear to have a large negative acceleration and large negative area under the curve, while others do not (e.g. repetition 1 versus repetition 4). Some authors have suggested that slowing the bar down during the transition phase may be undesirable because the bar must be "reaccelerated" in the second pull (Ho, Lorenzen, Wilson, Saunders, & Williams, 2014). Neither the total negative area under the curve nor the NAPA ratio were indicative of a complete lift. In missed lifts, one would expect that there would be a larger (due to a smaller actual velocity compared to positive area under the curve), although this concept was not clearly shown (e.g lift 2).

There is also variation in the “smoothness” of the transition phases (e.g. repetition 2 and 4 compared to repetition 5). However, there is no apparent pattern in made and missed lifts associated with these factors. It is possible that horizontal movements of the bar may have played a role in the success of each of the attempts, but this is difficult to tell using vertical component of acceleratoin. Work by Gourgoulis et al. (2009) has suggested that the acceleration vector of the bar is important in the success of a lift, but in this study, only vertical acceleration was measured, thus the vector of the present lifter could not be evaluated.

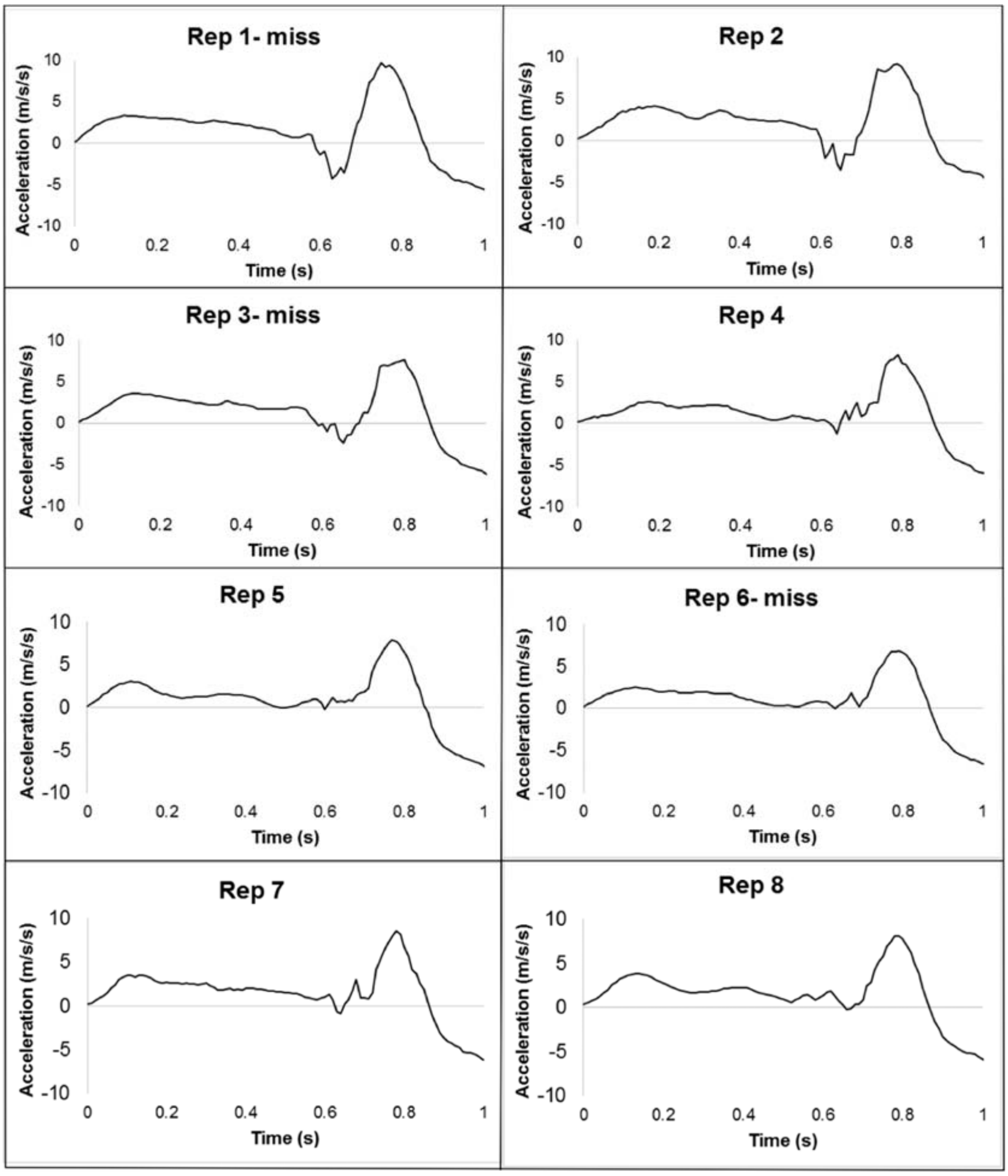

Figure 2: Acceleration-time trace for each attempt

One possible explanation of the variability in the lifts is fatigue from the preceding high volume period of training. Previous work has suggested that technique often suffers in high volume phases of training (Stone & Fry, 1998) so it is plausible that fatigue was responsible. However, repeated measurement of the athlete's normal variability is necessary to scrutinize the idea of fatigue as a cause.

Another question is the consistency of peak acceleration values measured from the acceleration time trace in a single lifter in the snatch. A previous study found high between-session reliability in peak acceleration in the snatch (Sato, et al., 2012), but the within-session or within-athlete variability has not been tested. It is not clear if the calculated coefficient of variation of 9% for peak acceleration is a normal level of variability in the athlete or exercise, although it is possible that the variability observed is reflective of a submaximal load in the snatch. The minimum bar velocity necessary for success in a submaximal snatch is well below the lifter's maximum velocity (lifters are frequently seen catching the bar in a power position with submaximal weights). Thus, a variety of peak velocities (and accelerations) are adequate for success with submaximal weights, and a high coefficient of variation might be expected with submaximal loads because a maximal effort is not necessary to catch a snatch in the low position. The coefficient of variation of peak velocity in this lifter was 15.9%, which supports this idea. Lift consistency has been noted to be a hallmark of better lifters (Ho, et al., 2014), but an acceptable or ideal level of variability is unknown.

Interestingly, the peak accelerations measured in each lift are well below those found in the literature. One previous study, using accelerometers (although measuring resultant, rather than vertical acceleration) reported a mean of 15.98 ± 2.73 m/s^2 in male and female national and international level weightlifters (Sato, et al., 2012). The low values found could reflect fatigue from the high-volume training phase (Stone & Fry, 1998),or that the Sato et al. (2012) study included male lifters. A number of attempts had somewhat low peak velocities, given that they were at 85% of 1-RM, compared to the peak velocities of 100% 1-RM attempts reported elsewhere in the literature (1.68 ± 0.14 m/s; Akkus, 2012), although this also could be related to fatigue.

CONCLUSION:

There is a limited amount of literature using barbell acceleration to evaluate the abilities of weightlifters, and there remains much to learn of this aspect of barbell movement. From this study, it is clear that vertical acceleration is not adequate to evaluate weightlifting performance, at least in this particular lifter. The addition of an antero-posterior acceleration direction is warranted to glean more information about movement of the bar in the sagittal plane, especially with regard to success or failure of the lift. Finally, some of the patterns seen in the acceleration-time trace still need to be evaluated, especially compared with video to understand their properties

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