IDENTIFYING A SURROGATE MEASURE OF WEIGHTLIFTING PERFORMANCE

[1]S. Kyle Travis, [1]Jacob Goodin, [1]Dylan Suarez, [1]Caleb Bazyler

[1]Department of Sport, Exercise, Recreation, and Kinesiology, Center of Excellence for Sport Science and Coach Education, East Tennessee State University, Johnson City, TN, USA, 37614

INTRODUCTION: Weightlifting is an anaerobic sport where two separate lifts are contested by lifting a loaded barbell from the ground to standing with the bar extended overhead. In competition, these lifts are executed in the order of snatch which is a one-part lift, and clean and jerk which is a two-part lift. An athlete is given three attempts for each of the two lifts. The heaviest successful attempt made for the snatch and clean and jerk are summed to determine an athlete's absolute weightlifting total. Each athlete's official pre-competition body mass is factored into Sinclair formula to determine the best overall lifter across all weight classes (Sinclair coefficient, 2017). The number that is derived from the Sinclair formula is theoretically what the lifter would total if they were in the heaviest weight class with the same performance capability in relation to their actual total. The calculated Sinclair total is perhaps the most important variable to consider when determining each athlete's overall placing in a given weight class or event, especially at the national or international level. The winner of the heaviest weight class will have lifted the most overall weight during the competition, but by using the Sinclair total the lighter lifters may have lifted more weight relative to their body mass indicating that they are indeed the better lifter kilogram-per-kilogram. However, Sinclair total can only be measured in a competition environment, which highlights the need for a surrogate measure for competition performance that coaches can implement as a monitoring and training feedback tool.

Vertical jumps are widely used to evaluate general athletic ability (Ostojić, et al., 2010) and are biomechanically similar to weightlifting movements (Canavan et al., 1996; Garhammer et al.,1992). Accordingly, Carlock et al. (2004) observed strong relationships between countermovement jump and squat jump height (CMJH, SJH) with snatch and clean jerk performance scaled to body mass (r=0.72 to 0.76) in national level male and female weightlifters. Similar results were observed by Vizcaya et al. (2009) who reported strong correlations between SJH (r=0.66) and CMJH (r=0.75) and Sinclair total in international level weightlifters. However, a limitation of these studies was the use of contact mats, which have been shown to misestimate jump height (Buckthorpe et al., 2012). Therefore, an analysis with more robust instrumentation is needed.

The isometric mid-thigh pull is a viable monitoring test for weightlifters as it measures maximal strength and rate of force development (RFD), which are strongly related to weightlifting performance and sensitive to changes in training volume-load (Haff et al., 2005, Haff et al., 2008 and Beckham et al., 2013). Beckham et al. (2013) found strong relationships between isometric mid-thigh pull peak force (IPF) and allometrically scaled (IPFa) with snatch (r=0.83;0.622), clean and jerk (r=0.838; r=0.597), and total performance (r=0.838; r=0.794). Sinclair total and allometric scaling of competition results also showed a very strong relationship to IPF and IPFa which indicates that maximum strength is an important factor even when body mass is accounted for (Stone et al., 2005). Similar relationships between IPF and weightlifting performance (r=0.64 to 0.93) were reported by Haff et al., 2005 in a group of elite female weightlifters. While appreciating the competition level of weightlifters in these studies, the generalizability of their findings are limited due to small sample sizes (n≤12). Considering the potential value of vertical jumps and isometric mid-thigh pulls as monitoring tools for weightlifters, further research is needed examining their relationship to weightlifting performance with a larger sample size. Therefore, the purpose of this study was to compare vertical jumps to isometric mid-thigh pulls as surrogate measures of weightlifting performance in male weightlifters.

METHODS

Experimental Approach to the Problem: The current study evaluated the relationships between competition performance of weightlifters with vertical jumps and isometric mid-thigh pull variables obtained from a testing session within a 30-day period of the competition. Athletes were tested during a week of reduced training that occurred before or after a training block ending with a competition.

Subjects: Participants of this study were males (n=34) who were intermediate to advanced level weightlifters (24.3±4.6y, 91.6±17.3kg, 174.7±8.3 cm). All athletes were familiar with testing protocols, and all data were collected and analyzed as part of the East Tennessee State University (ETSU) Olympic Training Site athlete monitoring program. The universities Institutional Review Board approved this retrospective study.

Testing Procedures: A standardized dynamic warm-up protocol was performed by each athlete before beginning vertical jump and isometric mid-thigh pulls. Unloaded (near weightless plastic pipe <1kg) SJ (90° knee angle) and CMJ (self-selected depth) were performed on force plates sampling at 1,000 Hz to determine jump height from flight time. Athletes were instructed to give a 50% and 75% warm-up jump before at least 2 SJs at 100% effort. The CMJ warm-up only consisted of a 75% attempt before performing 2 jumps at 100% effort. Isometric mid-thigh pulls were performed in an isometric rack with force plates sampling at 1,000 Hz to determine IPF, IPFa, and RFD from 0-200ms (RFD200). Athletes were placed inside the isometric rack standing on force plates sampling at 1,000 Hz. Athletes were secured to the bar using athletic tape and positioned at a hip and knee angle of 125° and 135°, respectively. Athletes were instructed to give one warm-up attempt at 50% and 75% before performing 2-3 maximal effort isometric pulls with 2-3 minutes' rest between. All vertical jumps and isometric mid-thigh pulls were analyzed using a custom analysis program operating software (LabView 2010, National Instruments Co., Austin, TX, USA). Test-retest intraclass correlation coefficients(1.0; 0.96; 0.98) and coefficients of variation (0.53%; 16.3%; 2.31%) for each variable (IPF; RFD200; JH) have been previously established in our laboratory (Bazyler et al., 2017a; Bazyler et al., 2017b; Beckham et al., 2013; Carroll et al., 2017). Competition results for snatch, clean and jerk, total, and Sinclair total were obtained for comparison of absolute and relative competition and testing performance. The Sinclair formula is expressed as 10^{AX^2} where x=$\log 10\left(\frac{x}{b}\right)$. If $x < b$ where x is the weightlifter's body mass, b is the current world record holder's body mass in the heaviest category (i.e., heaviest male in 105+ kg category weighs 175.508kg) and A is the coefficient during the current Olympic cycle (Sinclair, 1985). If a lifter's body mass (x) is greater than the aforementioned cutoff (b), then the ST is the same as the non-adjusted total and the coefficient is equal to 1.0. For the current Olympic cycle, A=0.751945030 and b=175.508 (Sinclair coefficient, 2017).

Statistics: A Shapiro-Wilks normality test was used to determine outliers for each variable 3SD above or below the mean and removed prior to further analyses. Pearson's product moment zero-order correlations were used to assess the relationships between variables of the three testing methods. Fisher's r to z transformation was subsequently used to compare correlation coefficients. To assess the relative strength of the correlations, calculated r-values were evaluated using the following scale: 0.0-0.1 trivial, 0.1-0.3 weak, 0.3-0.5 moderate, 0.5-0.7

strong, 0.7-0.9 very strong, 0.9-1 nearly perfect (Beckham et al, 2013). For all tests, criteria for statistical significance were set at $p \leq 0.05$. SPSS software version 23 (IBM Co., New York, NY, USA) and Microsoft Excel (Microsoft Corporation, Redmond, WA, USA) were used to perform all statistical analyses.

RESULTS: Results showed a very strong relationship between SJH and Sinclair total (Figure 1), and strong relationships between CMJH, IPFa and Sinclair total (Table 1). Weak and trivial relationships were observed between IPF, RFD200 and Sinclair total, respectively. The relationship between SJH and competition total was statistically greater than the relationship between IPF and competition total (z=2.23, p=0.02). However, the relationship between SJH and Sinclair total was not statistically greater than the relationship between IPFa and Sinclair total (z=1.14, p=0.13).

Figure 1. Relationships between Sinclair total and (A) static jump height (SJH), and (B) allometrically-scaled isometric peak force (IPFa)

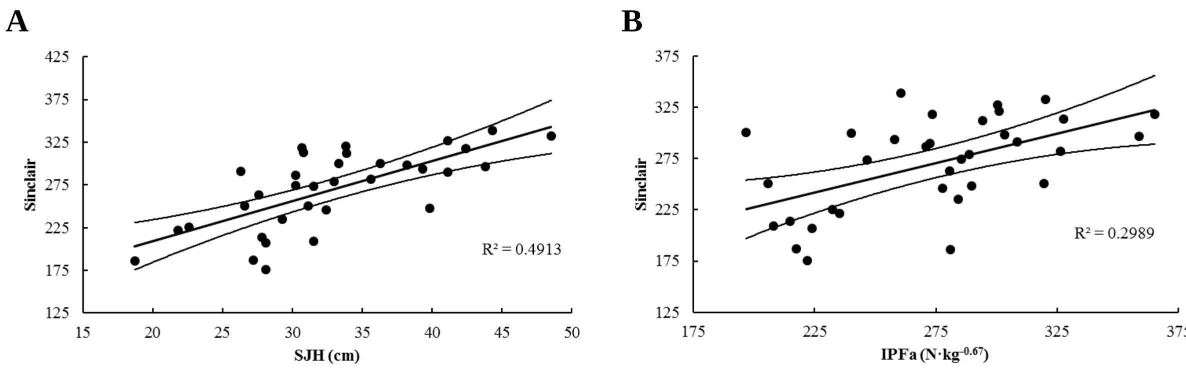

Table 1. Bivariate Correlations

	IPF	IPFa	RFD200	SJH	CMJH	Total
IPFa	0.761*					
RFD200	0.525*	0.504*				
SJH	0.059	0.411*	-0.033			
CMJH	0.195	0.525*	0.096	0.834*		
Competition Total	0.456*	0.565*	0.146	0.604*	0.545*	
Competition Sinclair Total	0.198	0.547*	0.08	0.701*	0.64*	0.907*

*Statistically significant at $p \leq 0.05$. isometric peak force (IPF), allometrically-scaled isometric peak force (IPFa), rate of force development from 0-200ms (RFD200), static jump height (SJH), counter-movement jump height (CMJH).

DISCUSSION: The purpose of this study was to compare vertical jumps to isometric mid-thigh pulls as surrogate measures of weightlifting performance. The current investigation shows that SJH had the strongest correlation to Sinclair total; however, IPFa should also be considered a useful indicator of weightlifting performance. Although weakly related to Sinclair total, IPF was still strongly related to competition total suggesting that absolute maximum strength is an important component of weightlifting performance as noted previously (Beckham 2013, Stone

2005). The weak relationships observed between RFD200 and weightlifting performance disagree with previous findings of Beckham et al. (2013) of (r=0.57 to 0.65), which may be due to differences in sample size and the time between competition and testing. Furthermore, the isometric mid-thigh pull is performed so that no countermovement is allowed, thus minimizing or eliminating the contribution of the stretch-shortening cycle that the competition lifts require. The non-significant, slightly larger relationship between SJH and Sinclair compared to CMJH may be due to standardization of squat depth during the SJ, which has been shown to have an influence on jumping height (Mandic et al., 2016). The findings from this investigation suggest that SJH is the strongest correlate of Sinclair total and is thus the preferred surrogate measure of weightlifting performance in male weightlifters.

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