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Using Echo Intensity as a Monitoring Tool to Determine Training Adaptations and Recoverability In High-Level Weightlifters

USING ECHO INTENSITY AS A MONITORING TOOL TO DETERMINE TRAINING ADAPTATIONS AND RECOVERABILITY IN HIGH-LEVEL WEIGHTLIFTERS

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INTRODUCTION: Sport scientists and coaches should incorporate an athlete monitoring program that does not interfere or threaten an athlete's ability to train or perform. Therefore, integrating time efficient noninvasive monitoring modalities such as ultrasonography is warranted. Ultrasonography has recently become a popularized athlete monitoring tool providing feedback regarding approximate muscle size and quality. Throughout the training process, evident changes in muscle cross-sectional area (CSA) occur relative to the specific training emphasis that can be quantifiably useful for monitoring training adaptations and recoverability (Bazyler et al., 2016, 2018; Travis, 2018). Unfortunately, studies using ultrasonography to observe muscle CSA have many instrument limitations that cannot account for all physiological changes within the musculature such as muscular hydration, glycogen content, triglyceride accrual, edema or inflammatory responses. However, it may be possible to assess intramuscular and intermuscular environments using echo intensity (EI) (Arts, Pillen, Schelhaas, Overeem, & Zwarts, 2010). Echo intensity has been shown to be indicative of muscle quality directly corresponding with an athlete's ability to produce power and force (Hirsch, Smith-Ryan, Trexler, & Roelofs, 2016). Concurrently, changes in muscle CSA have also been shown to alter power and force fitness characteristics relative to body mass (BM) (i.e., strength per unit of mass) (Kawakami, Abe, Kuno, & Fukunaga, 1995; Scanlon et al., 2014). Thus, this study served to 1) examine the relationships between muscle CSA, EI, and BM and 2) to determine the efficacy of using EI as an athlete monitoring tool for strength-power athletes.

METHODS: Three high-level weightlifters (1 female and 2 males: 24.7±1.2y, 78.0±21.7kg, 137.9±42.9cm) voluntarily agreed to participate in the study. The athletes trained for 28-weeks preparing for a national competition using block periodization (i.e., phase potentiation) which consisted of sequenced phases: accumulation, transmutation, and realization. Written informed consent was obtained by each athlete and the study was approved by the University's Institutional Review Board.

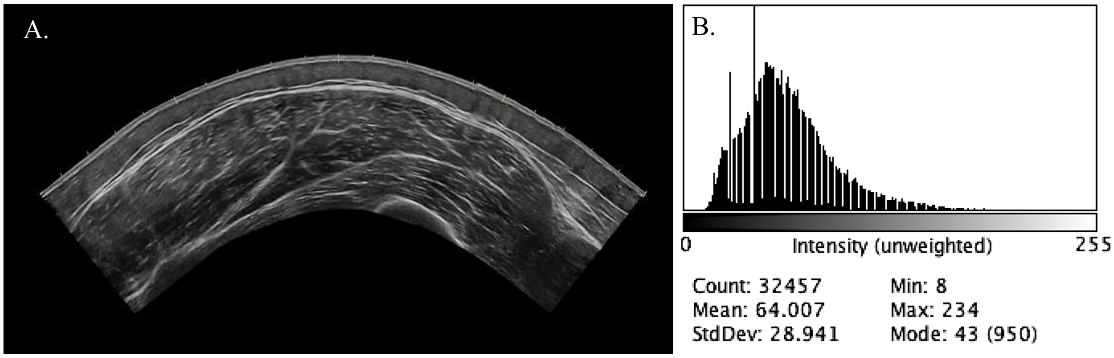

FIGURE 1. Ultrasonography vastus lateralis muscle cross-sectional area (A) with histogram output from Fiji software (B).

A stadiometer (Detecto, Webb City, MO) was used to measure each subject's height during the first testing session. Hydration status, BM, and ultrasonography measurements were assessed at the beginning and end of each training block over the 28-week period. The methods for collecting these variables have been previously described from our laboratory and were replicated during this study (Bazyler et al., 2016). After hydration status was confirmed, a cross sectional panoramic scan of the right vastus lateralis was collected using a 7.5 MHz ultrasound probe in B-mode (LOGIQ, P6, General Electric Healthcare, Wauwatosa, WI). The resulting images (refer to Figure 1left) were then exported where manual measurements of muscle CSA and EI were performed using Image-J software Fiji (version 2.0.0-rc-68/1.52g). Before performing measurements, each scan was individually calibrated by measuring the number of pixels in a known distance (1 cm). Vastus lateralis CSA was traced along the inter-muscular interface for each cross-sectional image. Echo intensity was determined in the standard histogram function using grayscale analysis of pixels ranging from 0 to 255 (refer to Figure 1 right). Ultrasound assessments of muscle characteristics can vary depending on operator technique, therefore, all scans were analyzed by the same technician. The sum of all reps for each training week was used to describe weekly training volume. Reliability for muscle CSA (ICC=0.98) and EI (ICC=0.97) was considered high. *Statistical Analysis:* Using Microsoft Excel 2016 (Microsoft Corporation, Redmond, WA, USA), percent change (%Δ) of each variable relative to the initial testing session was calculated. Pearson's correlations for CSA-EI %Δ, EI-BM %Δ, and BM-CSA %Δ were assessed to determine the relationships between each variable.

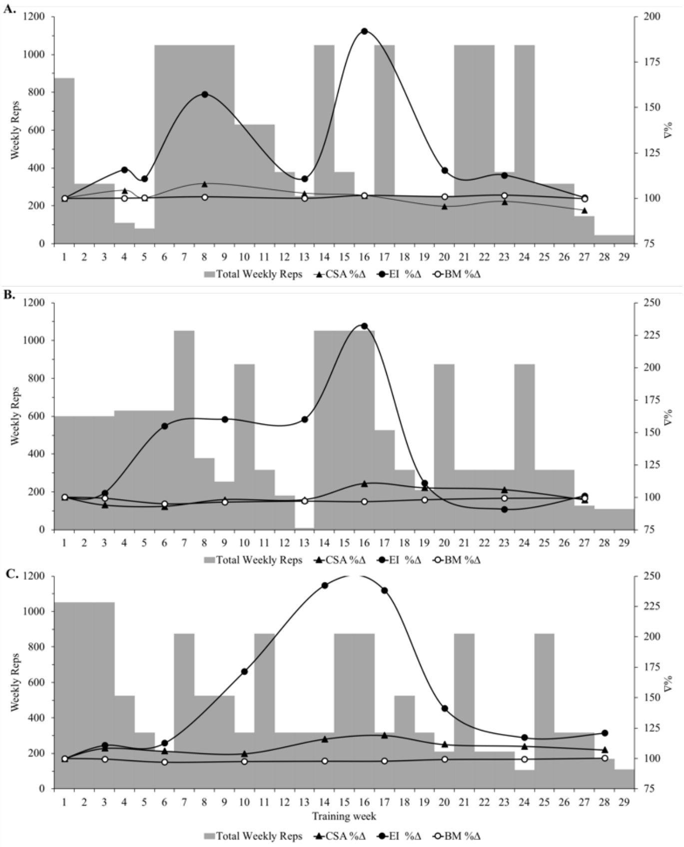

FIGURE 2. Longitudinal changes for muscle cross-sectional area, echo intensity, and body mass in relation to total weekly repetitions for female 1 (A), male 1 (B) and male 2 (C). *Notes: Percent change (%Δ) corresponds to observed changes relative to baseline measurement. CSA=muscle cross sectional area (cm^2); EI=echo intensity (au); BM=body mass (kg).*

RESULTS: Pearson's correlations revealed moderate to strong positive relationships between CSA-EI %Δ for the female (r= 0.480) and male 2 (r= 0.754), but weak positive relationships for male 1 (r = 0.284). Moderate positive relationships for BM-EI %Δ were observed for the female (r = 0.576) but moderate to strong negative relationships were observed for male 1 (r = -0.723) and male 2 (r = -0.491). Weak positive and negative relationships for BM-CSA %Δ was shown for the female, male 1, and male 2 (r = 0.045, r = 0.162, r = -0.106, respectively).

DISCUSSION: Although positive relationships were observed for CSA-EI and EI-BM, the relationship BM-CSA was unexpected. Weak relationships may be explained by athletes maintaining BM relative to their respective weight classes from block to block (i.e., 28±7 days) while muscle CSA seems more dependent on training volume. For instance, CSA typically increases during periods of higher volume training and decreases during periods of reduced volume training (refer to Figure 2). However, BM tends to only increase acutely with higher training periods and returns to baseline thereafter. Previously, it has been assumed that changes in muscle CSA are highly dependent on changes in BM (Brechue & Abe, 2002); however, in the current investigation, this trend was not observed. Thus, BM does not seem to directly influence fluctuations in CSA, and therefore EI, as previously perceived.

It is possible that although BM was maintained across the training regimen, body composition changes may have taken place during reduced training periods. However, CSA-EI seems to capture more physiological phenomena taking place such as triglyceride accrual, water hypo- or hyper-hydration, and glycogen saturation or depletion. The more hyperechoic EI values are the more likely a physiological disturbance is taking place relative to baseline values. Contrarily, hypoechoic EI values seem to be indicative of physiological recovery. If hyperechoic EI values are indeed capturing changes in triglyceride accrual, water and glycogen content, as well as edema and inflammatory responses, once the EI values become hypoechoic this may give implications for 1) supercompensation taking place along with 2) improved muscle quality and, in turn, 3) enhanced performance abilities.

After training periods that were typically indicative of high muscular stress (i.e., hypertrophy training emphasis, 1-2 week planned overreach, etc.) CSA-EI would increase. Other trends were noticed such as an inverse relationship existing between CSA-EI during moderate volume training blocks following high volume training periods where EI would continue to rise and CSA would begin to decrease. It is possible that EI continually increased due to residual training effects from the planned overreach weeks (Counsilman & Counsilman, 1991). However, if the athletes were given 1-2 weeks of reduced training thereafter, EI would drastically dissipate potentially leading to the above mentioned supercompensation.

In a squadron of track and field athletes ranging from throwers to distance runners, throwers had the lowest EI compared to athletes of other disciplines (Hirsch et al., 2016). Hirsch et al. (2016) suggest that low EI values are indicative of high muscle quality related to strength and power output. Although low EI values may suggest a higher quality muscle for strength and power characteristics, determining the efficacy of EI being indicative of performance has not been established. However, in the current study, all three athletes were considered to be peaked on the day of COMP corresponding with EI being decreased to or slightly below the initial baseline measurements. Thus, observing high EI values during normal training periods followed by a drastic decrease in EI values during the taper prior to a competition may indicate that muscle quality has been positively augmented allowing an athlete to express strength and power characteristics to the highest degree.

PRACTICAL APPLICATIONS: The relationship between EI coupled with muscle CSA appears to provide implications for physiological adaptation, recoverability, and preparedness across various training mesocycles in high-level weightlifters. Although the training emphasis regarding volume seems to directly influence muscle CSA, sport scientists and coaches wanting to assess fluctuations in EI longitudinally may be given further insights into 1) improving training adaptations, 2) preventing under-recovery, 3) assessing residual training effects, and 4) determining the effectiveness of tapering protocols to ensure their athletes are peaked. We advocate using EI as part of athlete monitoring evaluations to effectively assess how an athlete is responding to a current training program and if the athlete is making physiological strength and power adaptations accordingly.

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