CHANGES IN TOTAL BODY WATER AND LEAN BODY MASS IN WEAK SUBJECTS AFTER A 3-WEEK STRENGTH ENDURANCE TRAINING BLOCK

Paul A. Moquin[1], Alexander B. Wetmore[1], and Michael H. Stone[1]

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

INTRODUCTION: Muscular hypertrophy is achieved through mechanical stress to the muscle fiber, metabolic alterations and damage sustained by the muscle fiber (Stone et al. 2007). It is widely theorized resistance training-induced hypertrophy is achieved due to increases in contractile protein. Haun et al. (2019) examined muscle fiber hypertrophy following 6-weeks of high-volume resistance training using weak subjects. In their paper, the authors reported contractile protein concentrations decreased over the 6-week study while fiber cross-sectional area increased over this same period indicating an increase in sarcoplasmic hypertrophy and not myofibrillar hypertrophy. A recent study by Damas et al. (2018) has shown early resistance training in untrained individuals can induce increases in muscle cross-sectional area. These increases in cross-sectional area were largely due to edema or swelling as a result of muscular damage from the early resistance training (Damas et al. 2018). Thus determining early resistance exercise-induced increases in muscle cross-sectional area cannot be assumed to be only myofibrillar hypertrophy. In a separate paper, Damas et al. also examined myofibrillar protein synthesis. The authors suggested increases in muscular hypertrophy as a result of myofibrillar protein synthesis coincides with a decrease in muscle damage (Damas et al. 2016). For untrained individuals, early bouts of resistance training induce increases in muscle damage markers along with increased myofibrillar protein synthesis (Damas et al. 2016). While elevated protein synthesis was noted in weeks 3 and 10, there was not a decrease in muscle damage markers until week 10. Therefore, changes in muscle cross-sectional area may not accurately reflect myofibrillar hypertrophy until levels of muscle damage attenuate (Damas et al. 2016). This examination is part of a larger research study. The purpose of this portion of the study was to examine the changes in lean body mass without water content from baseline through each training block of the 11 week periodized training study. This was an examination of the changes observed from baseline through the first 3-week high volume block of training.

METHODS: Ten subjects participated in the study (age = 23.90 ± 4.12y, body mass = 86.27 ± 18.11kg, BMI = 27.22 ± 4.66). The subjects were determined to be weak based on lower body strength (unable to squat ≥ 1.5x body weight) (Succhomel et al 2018). One month prior to the start of the study, subjects were familiarized with proper back squat and performance testing technique and protocol (unweighted and 20Kg static and countermovement jumps, isometric mid-thigh pull and 20m sprint) for four sessions over a two week period. All subjects read and signed an informed consent document prior to participating in the study, as approved by the university's Institutional Review Board. The subjects trained five days per week. Monday and Friday were push exercises (back squat, overhead press, bench press, dumbbell triceps extension). Wednesdays were pull exercises (mid-thigh pull, clean grip stiff leg deadlift, barbell bent over row, dumbbell bent lateral raise). Tuesday and Thursday consisted of 3x2 20m sprints. Each training session consisted of the same standardized warm-up as outlined by Carroll et al 2018. The training program is shown in Table 1. Prior to the study, each subject's total body water content was measured on four separate days at the same time. Hydration status was tested using a refractometer (Atago, Tokyo, Japan). The participants were deemed dehydrated if their urinary specific gravity (USG) was ≥1.02. Subjects with USG measured ≥ 1.02 hydrated until reaching USG <1.02. No physical activity was performed 48 hours prior to the baseline data collection. The subjects did not have to adhere to any dietary restrictions. BIA (Impedimed BSF-7) was used to measure the subjects' total body water content, lean body mass and the changes over the course of the training block. To calculate lean body mass corrected for change in total body water ($LBM_{\Delta TBW}$), total water content corrected for the water content of fat ($TBW_{adjusted}$) was subtracted from lean body mass $LBM_{\Delta TBW} = LBM - TBW_{adjusted}$ (Jensen 1992). Descriptive statistics and percent change for alterations in lean body mass corrected for change in total body water corrected for fat were assessed pre and post-test for all subjects using a paired samples t-test. Effects sizes were determined using Cohen's d. All data was assessed with Microsoft Excel (ver. 2016).

RESULTS: Body mass and percent fat is shown in Table 2. Body mass increased by 2.3% (pre 86.3Kg vs post 88.5Kg). Percent fat via BIA decreased 0.05% (pre 22.9% vs post 21.7%). Lean body mass as calculated via BIA pre and post is shown in Table 3. Lean body mass increased by 5.2% (pre 64.8Kg vs post 68.3Kg) via BIA measurement ($p < 0.01$). Total body water corrected for the water content of fat is shown in Table 3. Total body water increased by 5.5% (pre 45.3Kg vs post 48.0Kg) ($p < 0.01$). Pre and Post measurements of lean body mass corrected for change in total body water are shown in Table 3. Lean body mass corrected for change in total body water increased by 4.4% (pre 19.4Kg vs post 20.3Kg) ($p < 0.01$).

DISCUSSION: The results of this study indicate a small increase in LBM when corrected for TBW. The results of this study tend to coincide with the findings from both Damas et al (2016, 2016 and 2018) and Haun et al (2019) indicating that there may be a small increase in TBW in the early stages of resistance training which contributes to gains in LBM. The change in TBW demonstrates a potential increase in edema of the muscle or possibly sarcoplasmic hypertrophy and small gains in contractile elements (Damas et al 2016, 2016, 2018; Haun et al 2019). These findings are using the assumption that changes in LBM would occur based on changes from muscle, connective tissue and bone (to a lesser extent). Under this assumption, the equation used in this study is attempting to estimate total protein accretion trends non-invasively. As the study continues and the resistance volume and intensity is manipulated, it will be interesting to examine the physiological changes in the subjects. If BIA can successfully estimate changes in protein accretion for athletes, this test would be more cost effective, time effective and less invasive than muscle biopsies. While in the early stages of this overall research study, these results are encouraging.

CONCLUSIONS AND PRACTICAL APPLICATIONS: In conclusion, calculating lean body mass and total body water via BIA may provide insight into the early adaptations to resistance training in untrained subjects. Although subjects increased lean body mass, this change appears to be partially due to changes in TBW. Therefore, correcting for changes in TBW may be a more accurate and informative way to estimate adaptations to resistance training compared to measuring LBM alone. Incorporating BIA into a monitoring program may provide an effective and efficient means for coaches and sport scientists to regularly track adaptations to the training program.

Table 1. Sets, repetitions and relative intensity for each training session

Week	Sets x Reps	Day 1 and 2	Day 3
1	3 x 10	80%	70%
2	3 x 10	85%	75%
3	3 x 10	90%	80%

Table 2. Change in body mass and percent fat

Timeline	**Body Mass (Kg)**	**Net Change (Kg)**	**Percent Change**	**%Fat**	**%Fat Change**
Pre	86.3 ± 18.2			22.9 ± 8.1	
Post	88.5 ± 19.0	2.24	2.53	21.7 ± 8.4	-0.05

Table 3. Percent change, net change and effect size in lean body mass, total body water corrected for water in fat and lean body mass corrected for total body water

	LBM (Kg)	% Change	$TBW_{adjusted}$ (Kg)	% Change	$LBM_{\Delta TBW}$ (Kg)	% Change
Pre	64.8 ± 11.6		45.3 ± 8.0		19.4 ± 3.8	
Post	68.3 ± 12.1	5.2%	48.0 ± 8.4	5.5%	20.3 ± 3.8	4.4%
Net Change	3.55		2.65		0.90	
p-value	0.008		0.009		0.008	
Cohen's d	0.300		0.324		0.237	
95% CI UL	0.74		0.87		0.49	
95% CI LL	0.11		0.13		0.07	
Bonforoni adjusted p-value	0.033		0.033		0.033	

Note. LBM = lean body mass, $TBW_{adjusted}$ = total body water corrected for water in fat, $LBM_{adjusted}$ = lean body mass corrected total body water, St. Dev = standard deviation**,** CI UL = confidence interval upper limit, CI LL = confidence interval lower limit.

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