Title: Auto-regulated exercise selection training regimen produces small increases in lean body mass and maximal strength adaptations in strength-trained individuals

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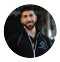

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AUTO-REGULATED EXERCISE SELECTION TRAINING REGIMEN PRODUCES SMALL INCREASES IN LEAN BODY MASS AND MAXIMAL STRENGTH ADAPTATIONS IN STRENGTH-TRAINED INDIVIDUALS

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ABSTRACT

Rauch, JT, Ugrinowitsch, C, Barakat, CI, Alvarez, MR, Brummert, DL, Aube, DW, Barsuhn, AS, Hayes, D, Tricoli, V, and De Souza, EO. Auto-regulated exercise selection training regimen produces small increases in lean body mass and maximal strength adaptations in highly trained individuals. *J Strength Cond Res* 34(4): 1133–1140, 2020—The purpose of this investigation was to compare the effects of auto-regulatory exercise selection (AES) vs. fixed exercise selection (FES) on muscular adaptations in strength-trained individuals. Seventeen men (mean ± *SD*; age = 24 ± 5.45 years; height = 180.3 ± 7.54 cm, lean body mass [LBM] = 66.44 ± 6.59 kg; squat and bench press 1 repetition maximum (1RM): body mass ratio 1.87, 1.38, respectively) were randomly assigned into either AES or FES. Both groups trained 3 times a week for 9 weeks. Auto-regulatory exercise selection self-selected the exercises for each session, whereas FES was required to perform exercises in a fixed order. Lean body mass was assessed via dual-energy X-ray absorptiometry and maximum strength via 1RM testing, pre-, and post-training intervention. Total volume load was significantly higher for AES than for FES (AES: 573,288 ± 67,505 kg; FES: 464,600 ± 95,595 kg, $p = 0.0240$). For LBM, there was a significant main time effect ($p = 0.009$). However, confidence interval analysis (95% CI_{diff}) suggested that only AES significantly increased LBM (AES: 2.47%, effect size [ES]: 0.35, 95% CI_{diff} [0.030–3.197 kg]; FES: 1.37%, ES: 0.21, 95% CI_{diff} [−0.500 to 2.475 kg]). There was a significant main time effect for maximum strength ($p \leq 0.0001$). However, 95% CI_{diff} suggested that only AES significantly improved bench press 1RM (AES: 6.48%, ES: 0.50, 95% CI_{diff} [0.312–11.42 kg]; FES: 5.14%, ES: 0.43, 95% CI_{diff} [−0.311 to 11.42 kg]). However for back squat 1RM, similar responses were observed between groups (AES: 9.55%, ES: 0.76, 95% CI_{diff} [0.04–28.37 kg]; FES: 11.54%, ES: 0.80, 95% CI_{diff} [1.8–28.5 kg]). Our findings suggest that AES may provide a small advantage in LBM and upper body maximal strength in strength-trained individuals.

KEY WORDS periodization, muscular hypertrophy, readiness, volume load

INTRODUCTION

It has been suggested that taking into account an individual's response to exercise may optimize the adaptive process in a given training cycle (2,3,9,10,19). This concept has been referred to as auto-regulatory periodization, which is a form of periodization that adjusts the training load to the athlete's readiness for exercise on a day-to-day or week-to-week basis (9). Previous research on auto-regulatory schemes has suggested superior strength-induced adaptations compared with traditional models in which training loads are predefined (9,10). For instance, Mann et al. (9) demonstrated greater maximal strength and strength endurance adaptations in Division I college football players following 6 weeks of auto-regulatory progressive resistance exercise compared with traditional linear periodization. Furthermore, McNamara and Stearne (10) compared the effects of flexible nonlinear periodization (NLP) and NLP on maximal strength in untrained individuals and revealed that although there were no differences between groups on the bench press or standing long jump assessments, the flexible group demonstrated greater strength improvements on the leg press exercise.

It is important to note that most of the research available on the effects of autoregulation has addressed primarily quantitative resistance training variables (e.g., volume, intensity, and rest interval) and the subsequent effects on muscular strength. However, practitioners vary not only

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Table 1. Periodization schemes for the fixed exercise selection (FES) group on the 3 weekly training sessions.*

Muscle group	Day 1 (6–8RM)	Day 2 (12–14RM)	Day 3 (18–20RM)
FES			
Legs	Squat	Leg press	Leg extension
Chest	Barbell bench press	Dumbbell incline press	Cable fly
Back	Bent barbell row	Pull-up	Straight arm lat pull-down
Shoulders	Dumbbell military press	Dumbbell lateral raises	Cable face pulls
Biceps	Dumbbell bicep curls	E-Z bar preacher curls	Dumbbell incline curls
Triceps	Cable press down	Dumbbell incline skull crusher	Cable overhead triceps extension

*1RM = 1 repetition maximum.

quantitative training variables, but also qualitative variables such as exercise selection throughout training programs. To the best of our knowledge, there is a paucity of data comparing lean body mass (LBM) and strength gains when using an auto-regulatory approach to exercise selection vs. predetermined exercise selection.

Furthermore, varying exercise selection may affect total volume load. In fact, it has been demonstrated that greater volume loads may result in greater increases in muscular hypertrophy and strength (11,13,16). However, it has yet to be determined how auto-regulating exercise selection will affect this volume load and subsequent training adaptations. Therefore, the purpose of our study was to investigate the effects of auto-regulatory exercise selection (AES) compared with fixed exercise selection (FES) on total LBM and maximal strength in strength-trained individuals. We hypothesized that several years of strength training experience will allow individuals to select exercises they feel most prepared to perform, which may optimize lean mass accretion and strength-induced adaptations.

Methods

Experimental Approach to the Problem

This was a parallel group repeated measures design, which investigated the effects of AES and FES on total LBM and strength adaptations in strength-trained males. Both groups trained 3 times a week for 9 weeks. Training intensity (load) and number of sets performed were equated between groups. Auto-regulated exercise selection subjects were allowed to select which exercises they wanted to perform on a daily basis, whereas FES was given predetermined exercises. To increase ecological validity, volume load (i.e., sets × repetitions × kilogram) was monitored, but not balanced between groups, to determine whether training-induced adaptations (i.e., muscle mass and strength) would result in different volume loads. To ensure proper nutrition throughout the experimental period, subjects received preworkout supplementation and postworkout whey protein powder (25 g). One serving of whey protein powder (25 g) was also provided on nontraining days, in an attempt to optimize muscle protein synthesis throughout the entire experimental period. Subjects were trained to track their dietary intakes during weeks 1, 2, 5, and 9. Total calories and macronutrients were calculated for these time points. Perceptual measures of recovery (i.e., perceived recovery scale–PRS) and exertion (i.e., rate of perceived exertion–RPE) were obtained before and after each training session, respectively, to monitor possible differences in internal load between groups. Total LBM and maximal strength 1 repetition maximum (1RM) were assessed at weeks 0 and 10 on the back squat and bench press exercises.

Subjects

Thirty-two strength-trained men volunteered for this study. Inclusion criteria consisted of being able to squat and bench 1.75 and 1.3 times their body mass, respectively. After pretesting, 14 subjects withdrew because of either not meeting the predetermined strength requirements ($n = 6$) or personal reasons ($n = 8$). Therefore, 17 strength-trained men (mean ± *SD*; age = 24 ± 5.45 years; height = 180.3 ± 7.54 cm; total body mass = 83.08 ± 8.70 kg; LBM = 66.44 ± 6.59 kg; squat and bench press 1RM: body mass ratio 1.87 and 1.38, respectively) completed the experimental protocol. Subjects were excluded from participation if they were currently taking any medications, anti-inflammatory drugs, or performance enhancers. No medical disorders, diseases, or musculoskeletal injuries were reported among subjects. Last, subjects were required to have continuously trained for at least 3 years before the commencement of the experimental protocol (mean 5.6 ± 3.29 years). Subjects were classified into quartiles according to total LBM. Then subjects from each quartile were randomly assigned to either AES or FES. All subjects read and signed an informed consent approved by the University of Tampa.

Procedures

Familiarization. All subjects completed 2 familiarization sessions interspersed by a minimum of 48 hours before the commencement of the study. During the familiarization

Table 2. Total caloric intake and macronutrient distribution throughout the 9-week period for the auto-regulatory exercise selection (AES) and fixed exercise selection (FES) groups.*

Weeks	Total calories (kcal)	Fat·g^{-1}·kg^{-1} (g)	CHO·g^{-1}·kg^{-1} (g)	PRO·g^{-1}·kg^{-1} (g)
AES				
Week-1	2,430.8 ± 373.3	1.04 ± 0.22	3.00 ± 0.77	1.86 ± 0.49
Week-2	2,352.8 ± 381.3	0.92 ± 0.18	2.95 ± 0.91	1.98 ± 0.47
Week-5	2,446.8 ± 426.4	1.00 ± 0.27	2.85 ± 0.76	2.06 ± 0.39
Week-9	2,610.7 ± 791.8	1.10 ± 0.43	3.23 ± 1.26	1.99 ± 0.30
FES				
Week-1	2,345.1 ± 295.3	1.04 ± 0.13	2.83 ± 0.67	1.74 ± 0.35
Week-2	2,300.2 ± 346.6	1.05 ± 0.13	2.68 ± 0.74	1.72 ± 0.35
Week-5	2,258.1 ± 526.8	0.99 ± 0.21	2.58 ± 0.99	1.75 ± 0.36
Week-9	2,331.5 ± 469.5	1.01 ± 0.18	2.65 ± 0.94	1.81 ± 0.37

*CHO = carbohydrate; PRO = protein.

sessions, subjects performed a general warm-up consisting of 5 minutes of walking at 5.5 km·h^{-1} on a treadmill (Tuff Tread; White Phoenix, LLC., Willis, TX, USA). After warming-up, subjects were given a thorough explanation of the squat and bench press 1RM testing protocols as described elsewhere (17). In brief, for the squat exercise, body and foot placement were determined with measuring tape fixed on the bar and floor. In addition, an adjustable seat was placed behind the subject to keep the bar displacement and knee flexion angle (~100°) constant on each repetition. Subjects' positioning was recorded during the familiarization sessions and replicated on testing sessions. For the bench press exercise, subjects were required to maintain 5 points of contact (head, shoulder blades, lower back, left foot, and right foot) at all times while lowering the bar with control touching the sternum and fully extending the arms for a rep to be considered successful. Individuals were considered familiarized with the 1RM tests, when the coefficient of variation (CV) between familiarization sessions was <5% on both strength tests (17).

Supplementation. Each participant was provided with 1 serving of preworkout 30 minutes before exercise (Dymatize M.Pact; Dymatize Nutrition, Dallas, TX, USA), and protein supplementation containing 25 g protein (2.77 g) and 4 g carbohydrates (Elite Whey Protein; Dymatize Nutrition) immediately after each training session. To continuously optimize protein synthesis and recovery after training days, subjects were also provided with 1 serving of whey protein for every nontraining day. To ensure compliance with protein intake on nontraining days, subjects were required to bring back the empty protein bags on the next training day.

Nutrition Monitoring (Dietary Intake). Dietary intake was assessed through a self-reported food diary (MyFitnessPal–http://www.myfitnesspal.com). Subjects tracked dietary intake during weeks 1, 2, 5, and 9. Subjects' body mass was reassessed at weeks 5 and 9 to accurately quantify their nutritional intake relative to body mass. Subjects were instructed to maintain their normal dietary habits and advised on how to properly record all food and their corresponding portion sizes throughout the duration of the study. If any subject's protein intake fell below 1.5 g·kg^{-1}, they were given additional nutritional guidance from a certified sports nutritionist.

Perceptual Measures. Perceived recovery scale was assessed before beginning the general warm-up. Subjects were required to sit down and determine their perceived recovery (i.e., 0–10 scale) on that given day. Zero and 10 indicate very poorly recovered/extremely tired, and very well recovered/highly energetic, respectively (7). Rate of perceived exertion assessments were performed 5 minutes after each training session. Subjects were again required to sit down and point to a number on a 1–10 scale that best indicated their perceived level of effort for that given workout. All assessments were performed in isolation from other subjects to ensure accuracy (14). Perceptual measures of the 3 weekly sessions were averaged for further analysis.

Body Composition Assessments. A Lunar Prodigy dual-energy X-ray absorptiometry apparatus (Hologic, Bedford, MA, USA) was used to measure body composition. Total LBM and fat mass (FM) were determined with the subject lying in a supine position with knees extended and instructed not to move for the entire duration of the scan. Subjects were required to fast for 10 hours before the examination and refrain from exercising for 48 hours before the assessment. Body composition measures were acquired at weeks 0 and 9. The CV was determined before the study using 5 different subjects with similar characteristics to the current participants. Dual-energy X-ray absorptiometry scans were

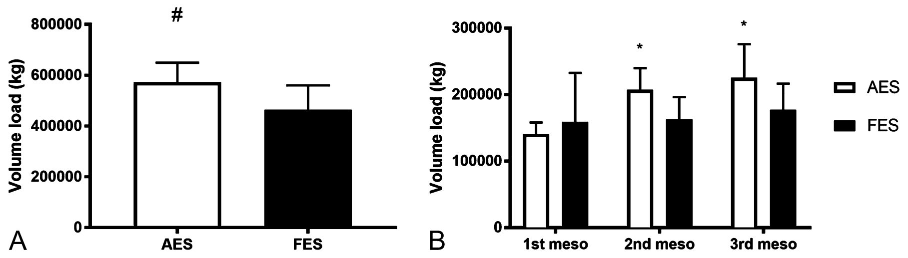

Figure 1. #$p \leq 0.05$ for between-group comparisons, *$p \leq 0.05$ for within-group comparisons. AES = auto-regulatory exercise selection; FES = fixed exercise selection.

performed on 3 different days interspersed by 48 hours at the same time of the day. The CV for body composition was 1.5%.

Muscular Strength Assessments. Maximal strength was assessed on the 1RM back squat and 1RM bench press exercises. The same researcher conducted all the tests. Strength testing loads were progressively increased until failure was reached. In brief, participants performed a general warm-up and a specific warm-up consisting of 2 sets. During the first set, participants performed 10 repetitions with 50% of the predicted 1RM. In the second set, they performed 5 repetitions with 75% of the predicted 1RM. After the second warm-up set, participants rested for 3 minutes. Then, each participant had up to 5 attempts to achieve the 1RM load. A rest period of 3–5 minutes was allotted between 1RM attempts. Strong verbal encouragement was given throughout the 1RM test. In order for subjects' 1RM test to be considered for further analysis, the CV between assessments had to have been less than 5%. If a subject demonstrated a CV >5%, a third testing session was provided. Maximal strength was assessed at weeks 0 and 48 hours after the last training session.

Strength Training Regimen. Subjects underwent a 9-week (3 $d \cdot wk^{-1}$) hypertrophy-oriented full-body training regimen. Each workout consisted of 6 different exercises. A 90–120 second rest interval was allowed between sets, whereas 2 minutes were respected between exercises. A daily undulating periodization model was implemented for both groups as follows: day 1: 6–8RM, day 2: 12–14RM, and day 3: 18–20RM. The training regimen was divided into 3 mesocycles, the number of sets progressed in each mesocycle; mesocycle 1: 4 sets per exercise, mesocycle 2: 5 sets per exercise, and mesocycle 3: 6 sets per compound exercise and 5 sets per accessory exercise. The only difference between conditions was the exercises performed. The FES group was handed a workout sheet with 7 predetermined exercises, whereas the AES group was handed a workout sheet in which they had to select 1 exercise per muscle group. Four certified strength and conditioning specialists were present for every training session, providing verbal encouragement and ensuring the proper amount of sets and repetitions were being performed.

Exercise options for the lower body included barbell back squat, plate loaded leg press, and knee extensions. Exercise options for the upper body included barbell bench press, incline dumbbell chest press, cable pec fly, bodyweight

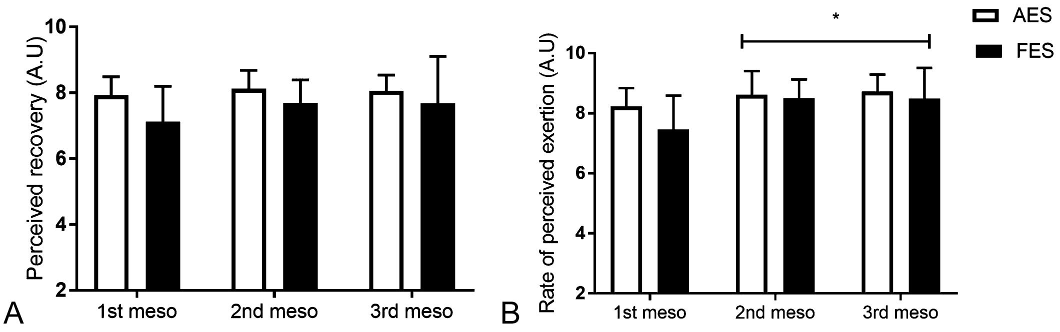

Figure 2. *$p \leq 0.05$ for main effect of time. AES = auto-regulatory exercise selection; FES = fixed exercise selection.

Table 3. Individual LBM values.*

	AES				FES		
Participant	LBM (kg) pre	LBM (kg) post	Δ (kg)	Participant	LBM (kg) pre	LBM (kg) post	Δ (kg)
1	65.19	66.22	1.03	9	77.18	80.34	3.16
2	70.65	72.24	1.59	10	77.37	81.39	4.02
3	66.25	67.98	1.73	11	76.61	75.11	−1.5
4	69.04	69.30	0.26	12	67.49	67.10	−0.39
5	67.45	67.36	−0.09	13	61.89	61.57	−0.32
6	63.67	67.59	3.92	14	73.35	75.73	2.38
7	62.59	62.74	0.15	15	59.24	58.54	−0.70
8	63.41	67.69	4.28	16	56.80	57.88	1.08
	–	–	–	17	53.64	54.80	1.16
Mean	66.03	67.64	1.60		67.06	68.05	0.98
SD	2.67	2.50	1.56		8.9	9.71	1.78

*AES = auto-regulatory exercise selection; FES = fixed exercise selection; LBM = lean body mass.

pull-ups, bent over barbell row, and straight-arm cable pull down. Exercise options for the accessory muscles included military press, dumbbell lateral raises, cable face-pulls, dumbbell bicep curls, preacher curls, cable bicep curls, triceps cable press down, dumbbell skull crushers, and overhead dumbbell triceps extensions. In the AES condition, there was no limit on how many times a subject could select a given exercise per week. In the FES condition, each subject completed each exercise once per week (Table 1).

Statistical Analyses

After normality (i.e., Shapiro-Wilk) and variance assurance (i.e., Levene), a 2-sample *t*-test was used to detect differences between groups at pretraining. The overall volume load between groups was also compared using a 2-sample *t*-test. Volume load of each mesocycle for the AES and FES groups was compared using a mixed model with the group (AES and FES) and mesocycle (first meso, second meso, and third meso) as fixed factors, and subjects as a random factor. In addition, a mixed model was performed for the remaining dependent variables, assuming group (AES and FES) and time (pre and post) as fixed factors, and subjects as a random factor (SAS 9.4; SAS Institute, Inc., Cary, NC, USA). Whenever a significant F value was obtained, a post hoc test with a Tukey's adjustment was performed for multiple comparison purposes (18). In regard to exercise selection, the number of times each exercise was chosen was analyzed through an unpaired T-test (i.e., when data passed to normality test) or through nonparametric test (e.g., Mann-Whitney) when normality was rejected. In addition, we presented the mean difference (Mean$_{\text{diff}}$), upper and lower limit values of 95% confidence intervals of within-group

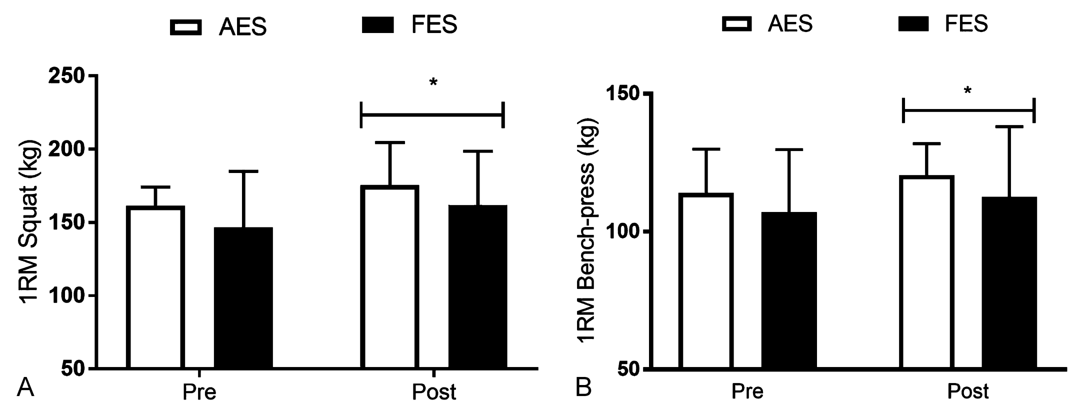

Figure 3. *$p \leq 0.05$ for main effect of time. 1RM = 1 repetition maximum; AES = auto-regulatory exercise selection; FES = fixed exercise selection.

comparisons (CI_{diff}). Confidence intervals that did not cross zero were considered as significant. Finally, within-group effect sizes (ES) were calculated as follows: mean post-test minus mean pre-test postminus mean predivided by the pooled *SD* of pretest values. The significance level was previously set at $p \leq 0.05$. Results are expressed as mean ± *SD*.

RESULTS

Macronutrients and Caloric Intake

There were no significant differences in macronutrients and caloric intake within and between groups throughout the training period ($p > 0.05$) (Table 2).

Exercise Selection

Fixed exercise selection performed each exercise 9 times throughout the duration of the study. Auto-regulatory exercise selection selected various exercises in a similar fashion compared with FES; these include squat (8.44 ± 1.21 vs. 9.0 ± 0.0, $p = 0.65$), DB incline press (7.11 ± 1.23 vs. 9.0 ± 0.0, $p = 0.14$), cable fly (8.55 ± 1.29 vs. 9.0 ± 0.0, $p = 0.73$), bent over BB row (8.11 ± 3.56 vs. 9.0 ± 0.0, $p = 0.66$), DB military press (11.78 ± 7.07 vs. 9.0 ± 0.0, $p = 0.37$), DB lateral raise (10.25 ± 3.10 vs. 9.0 ± 0.0, $p = 0.24$), DB skull crusher (7.55 ± 3.67 vs. 9.0 ± 0.0, $p = 0.25$), DB incline curl (9.55 ± 2.24 vs. 9.0 ± 0.0, $p = 0.07$), E-Z bar preacher curl (7.66 ± 5.31 vs. 9.0 ± 0.0, $p = 0.46$), and DB biceps curl (8.66 ± 1.78 vs. 9.0 ± 0.0, $p = 0.85$). There was a trend toward significance in which the AES group selected a greater frequency for the BB bench press (11.63 ± 1.32 vs. 9.0 ± 0.0, $p = 0.06$). In addition, there were significant differences in the number of times in which several exercises were selected. For example, AES chose the leg press (14.11 ± 1.90 vs. 9.0 ± 0.0, $p = 0.01$), straight arm lat pull-down (12.44 ± 5.50 vs. 9.0 ± 0.0, $p = 0.002$) and cable press down (17.33 ± 5.5 vs. 9.0 ± 0.0, $p = 0.0003$) more frequently when compared with FES. On the other hand, AES chose the following exercises on fewer occasions when compared with FES; leg extension (4.33 ± 1.21 vs. 9.0 ± 0.0, $p = 0.001$), pull-up (6.5 ± 1.30 vs. 9.0 ± 0.0, $p = 0.0002$), cable face pull (6.42 ± 2.22 vs. 9.0 ± 0.0, $p = 0.0035$), and overhead cable triceps extension (1.88 ± 2.47 vs. 9.0 ± 0.0, $p = 0.0001$).

Volume Load

Overall volume load was significantly higher ($p = 0.0240$) for AES than for FES (AES: 573,288 ± 67,505 kg, FES: 464,600 ± 95,595 kg) (Figure 1A). In addition, when volume load was analyzed per mesocycle, there was a trend toward a group by time interaction ($p = 0.075$) indicating that the 2 groups responded differently over time. Auto-regulatory exercise selection second vs. first $\text{Mean}_{\text{diff}}$ 66,915 kg, CI_{diff} (15,377–118,453 kg), 47.6%, ES: 4.01, $p = 0.009$; FES: $\text{Mean}_{\text{diff}}$ 3.722 kg, CI_{diff} (−54,717 to 62,160 kg), 2.33%, ES: 1.40, $p = 0.98$. AES- third vs. first $\text{Mean}_{\text{diff}}$ 84,772 kg, CI_{diff} (33,234–136,310 kg), 60.3%, ES: 5.08, $p = 0.001$; FES: $\text{Mean}_{\text{diff}}$ 18,093 kg, CI_{diff} (40,346–76,532 kg), 11.3%, ES: 0.26, $p = 0.72$ (Figure 1B).

Perceptual Measures

No significant between-group differences were detected at pretesting for PRS and RPE ($p \geq 0.05$). For PRS, there was a trend toward a main time effect ($p = 0.051$) (AES: $\text{Mean}_{\text{diff}}$ 0.131 AU, CI_{diff} [−0.450 to 0.713 AU], 1.65%, ES: 0.24, $p = 0.84$; FES: $\text{Mean}_{\text{diff}}$ 0.56 AU, CI_{diff} [−0.01 to 1.150 AU], 7.99%, ES: 0.07, $p = 0.056$) (Figure 2A). For RPE, there was a significant main time effect ($p = 0.0004$) (AES: $\text{Mean}_{\text{diff}}$ 0.110 AU, CI_{diff} [−0.543 to 0.765 AU], 6.0%, ES: 0.86, $p = 0.16$; FES: $\text{Mean}_{\text{diff}}$ 1.040 AU, CI_{diff} [0.384–1.694 AU], 13.9%, ES: 0.98 $p \leq 0.001$) (Figure 2B).

Body Composition

No significant differences between groups were detected at pretesting for FM and LBM ($p \geq 0.05$). For FM, there was a significant group effect ($p = 0.04$) in which FES group was leaner than AES group. For LBM, there was a significant main effect for time ($p = 0.009$). However, confidence interval analysis suggested that only AES significantly increased LBM (AES: $\text{Mean}_{\text{diff}}$ 1.609 kg, CI_{diff} [0.030–3.197 kg], 2.47%, ES: 0.35, $p = 0.045$; FES: $\text{Mean}_{\text{diff}}$ 0.988 kg, CI_{diff} [−0.500 to 2.475 kg], 1.37%, ES: 0.21, $p = 0.238$). The individual values for total LBM are presented in Table 3.

Maximal Strength

For back squat 1RM, there was a significant main effect for time ($p \leq 0.0001$) (AES: $\text{Mean}_{\text{diff}}$ 14.2 kg, CI_{diff} [0.04–28.37 kg], 9.55%, ES: 0.75, $p = 0.04$; FES: $\text{Mean}_{\text{diff}}$ 15.15 kg, CI_{diff} [1.8–28.5 kg], 11.54%, ES: 0.80, $p = 0.02$) (Figure 3A). For, bench press 1RM, there was a significant main effect for time ($p \leq 0.003$). Confidence interval analysis suggested that only AES demonstrated a significant improvement in bench press 1RM (AES: $\text{Mean}_{\text{diff}}$ 6.53 kg, CI_{diff} [0.312–12.76 kg], 6.48%, ES: 0.50, $p = 0.03$; FES: 5.55 kg, 95% CI_{diff} [−0.311 to 11.42 kg], 5.14%, ES: 0.43, $p = 0.06$) (Figure 3B).

DISCUSSION

The purpose of this study was to examine the effects of AES compared with FES on total LBM and strength adaptations in strength-trained individuals. We hypothesized that trained individuals would auto-regulate exercise selection based off of their recovery and readiness for exercise further optimizing strength training-induced adaptations. We partially confirmed our initial hypothesis as our findings suggest that AES regimen produced a small advantage in total LBM and upper body maximum strength adaptations compared with FES.

Research has shown that there is a dose-response relationship between volume load and increases in muscle mass and strength (6,15). In this study, volume load was monitored but not equated. After 9 weeks of training, AES trained with significantly greater volume loads compared with FES (AES: 573,288 ± 67,505 kg, FES: 464,600 ± 95,595 kg). This may be further explained by the fact that the AES group selected compound exercises more frequently than the FES group. For example, AES selected the leg-press exercise

14.1 times compared with the set 9.0 in FES throughout the experimental period. Furthermore, the AES group selected the bench press exercise 11.6 times compared with the set 9.0 in the FES group. Therefore, our data suggest that strength-trained individuals self-selected compound exercises more frequently compared with isolation or accessory exercises, which may have allowed them to more effectively increase volume load. In addition, a dose-response relationship between volume loads and perceptual measures of internal load has previously been identified (RPE) (8). Lodo et al. (8) demonstrated that increases in training volume load resulted in an increase in session RPE. In our investigation, both groups responded similarly in measures of internal load, despite AES training with 20% more volume load (i.e., ~100.00 kg). Thereby, through allowing trained individuals to select exercises in which they feel the most comfortable and prepared to perform this may enhance their ability to tolerate greater volume loads.

Furthermore, there was a significant time effect in which both groups increased LBM (i.e., 1.28 kg). Our results confirm previous findings that demonstrated LBM gains following resistance training protocols in combination with protein supplementation to be 0.98 kg in trained individuals (1). Although some subjects lost LBM in the FES group (Table 1), this was not sufficient to reach a significant group by time interaction. However, the $\text{Mean}_{\text{diff}}$ and CI_{diff} analyses suggested that only AES significantly increased LBM (e.g., AES: 2.47%-$\text{Mean}_{\text{diff}}$ 1.609 kg, CI_{diff} [0.030–3.197 kg], ES: 0.35; FES: 1.37%-$\text{Mean}_{\text{diff}}$ 0.988 kg, CI_{diff} [−0.500 to 2.475 kg], 1.37%, ES: 0.21). In addition, research has demonstrated a continuum of trainable adaptations that is directly associated with the training status of the individual (5,12), indicating that untrained individuals may be more responsive to training, whereas trained individuals may need to add more variation or progression to see further adaptations. In this regard, the small changes in lean tissue reported in our study may be considered important for trained individuals. Moreover, as there are limited data on LBM regimens in strength-trained populations, our data may suggest that for this population to see small additional gains in LBM, significant increases in volume load may be necessary (>10,000 kg additional volume load) to prompt adaptations. In fact, Schoenfeld et al. (15) mentioned in a recent meta-analysis that while 10 sets per muscle group is superior for muscle growth when compared with 1–5 and 5–9 sets per week, there are limited data that have analyzed the effects of greater volume loads (i.e., >12 sets per week). In our investigation, our subjects progressed from 12 to 16 weekly sets per muscle group. On average between the groups, this amount of volume resulted in increases of LBM by roughly ~1.92%.

As the training protocol in the current study was designed to maximize muscle mass and not muscular strength, significant maximal strength increases were not expected. However, our maximal strength assessments revealed that both groups increased back squat and bench press 1RM values similarly. In addition, CI_{diff} suggested that AES produced a small benefit in strength gains on the bench press exercise over FES (AES: 0.312–12.76 kg and FES: −0.311 to 11.42 kg, respectively). It has been demonstrated that strength gains are specific to the movement that is practiced most frequently (4). Thus, the increased frequency of the bench press exercise in the AES group may have led to improved bench press adaptations. However, as both groups performed the back squat exercises in a similar frequency (8.44 vs. 9.0 sessions), similar responses to strength gains on the back squat were observed.

The previous literature addressing auto-regulatory schemes has primarily investigated different methods of auto-regulating intensity; whereas the magnitude of strength response between autoregulating intensity on trained individuals is in agreement with our current study (i.e., 6.5 and 15.6 kg on the bench press and back squat exercise, respectively) (2). Comparisons between these studies should be taken with a degree of caution as different methods of auto-regulation were applied.

In conclusion, our findings suggest that AES may provide a small advantage in lean mass accretion and upper body strength in strength-trained men. Our results also support the use of compound exercises in a resistance training protocol in trained individuals, as they aid in increasing overall training volume. Furthermore, allowing strength-trained individuals to select the exercises they feel most prepared to perform on a given day may allow them to tolerate greater volume loads without additional increases in measures of internal load. Although the previous auto-regulatory studies have each manipulated different training variables, those studies demonstrate that providing individuals some degree of freedom to decide either intensity, repetition range, or now exercise selection may allow them to optimize the adaptive process to strength training. Although the exact mechanisms are not completely understood, it is likely that this is due to increased adherence and effort to a give training regimen as well as providing them with an optimal load on each given day based off of their recovery and readiness for exercise (2).

This study has several inherent limitations. First, as volume load was not equated between groups, both training regimens demonstrated varying training stimulus, which may have affected the response to training. Second, the study duration (9 weeks) limits our ability to determine the long-term effects of AES on LBM and strength adaptations. Future research should investigate this topic over a longer duration of time. Third, strength endurance assessments were not conducted, which may have been a more specific measurement as training intensity did not near 1RM loads throughout the intervention. In addition, future investigations on the topic may wish to provide more than 3 exercise options per muscle group as this may have limited the true self-regulation of exercise selection. Last and perhaps the most important, the absence of muscle hypertrophic assessment (i.e., muscle cross-sectional area) limits our understanding of how an auto-regulatory protocol varying exercise selection can modulate muscle hypertrophy compared with a predetermined exercise selection routine.

PRACTICAL APPLICATIONS

Strength and conditioning professionals may wish to implement auto-regulating exercise selection into their training protocols, as this may improve one's ability to tolerate greater training loads. When dealing with trained populations, small improvements in performance are important, what may not appear, as statistically significant may still be practically relevant. As each individual responds differently to training and there are various factors that affect one's readiness for exercise on a daily basis, any training model that affects an individual's response to exercise may improve fatigue management and maximize training adaptations.

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