SCIENTIFIC
JOURNAL OF
SPORT AND
PERFORMANCE

ORIGINAL ARTICLE

Coupling an elastic resistance band to a selectorized resistance machine improves 1-RM bicep curl strength via accommodated resistance training

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ABSTRACT

The aim of this study was to determine the effects of using a selectorized resistance machine with and without the use of elastic resistance bands on bicep strength. Sixty-six participants (30 females) completed a four-week training program exercising thrice weekly. Participants were blinded and randomly allocated to either one of the two intervention groups using an elastic band of 30 lb (EB30) or 50 lb (EB50) coupled to the selectorized resistance machine or the control group using only the selectorized resistance machine (CONT). Standard anthropometric measures and one repetition maximum (1-RM) for the cable bicep curl were measured before and after completing the training program. Although all groups demonstrated significant increases in 1-RM bicep strength, both the EB30 and EB55 groups exhibited higher strength gains than CONT. Furthermore, the EB55 group showed an increase in strength approximately 10% higher than that of EB 30. These results suggest that using EB resistance in conjunction with a conventional selectorized machine can augment strength gains in the biceps.

Keywords: 1-RM, Muscular strength, Elastic resistance bands, Selectorized resistance machine, Conditioning.

Cite this article as:
Yamamoto, T., Goldman, F., Blatney, A. E., Sahni, T. K., Taylor, J., Shatagopam, V., Neufeld, E. V., Mologne, M. S., & Dolezal, B. A. (2025). Coupling an elastic resistance band to a selectorized resistance machine improves 1-RM bicep curl strength via accommodated resistance training. *Scientific Journal of Sport and Performance*, *4*(1), 1-11. https://doi.org/10.55860/DRMZ1217

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Submitted for publication August 11, 2024.
Accepted for publication September 19, 2024.
Published September 30, 2024.
Scientific Journal of Sport and Performance. ISSN 2794-0586.

doi: https://doi.org/10.55860/DRMZ1217

INTRODUCTION

Continuous efforts are being made to increase the efficacy of training programs, with new techniques being introduced at all levels of strength, conditioning, and rehabilitation. Over a century ago, tubular elastic cords and pulley systems were first patented in Switzerland as a "*gymnastic device*". However, flat elastic resistance bands have since been repurposed as a training modality and clinical tool by physical therapists and rehabilitation professionals (Simoneau et al., 2001).

Stretching an elastic band (EB) generates a resistance that can be harnessed when strength training. EB's induce accommodating resistance as they are stretched due to their elasticity (Page & Ellenbecker, 2003), eliciting increasing muscular demand throughout an exercise's range of motion (ROM). While the most common form of resistance training involves constant external loading, such as pulley systems and free weights, accommodating resistance via EB modifies the external resistance load during an exercise. This increase in load is particularly heightened at the end of the ROM, where resistance increases concurrently as the band lengthens (Iversen et al., 2017).

A systematic research review conducted by Lopes and colleagues demonstrated EB training alone is equally as effective for strength training compared to conventional methods across various therapeutic populations (Lopes et al., 2019). Furthermore, despite little data in ostensibly healthy cohorts, combining elastic bands with free-weights during resistance exercise has been shown to act synergistically, improving muscular strength to an even greater magnitude (Andersen et al., 2020). Consequently, an increasing number of EB resistance combinations with free-weights and machines have been used to combine the benefits of constant external loads with variable resistance.

Accommodated resistance training is proposed to produce maximal tension in skeletal muscle by reducing resistance in the weakest areas within the range-of-motion (Smith et al., 2019). Utilizing resistance from either free weights or machines, together with accommodated resistance, while considering joint angles across the whole ROM, can effectively tap into an ascending strength curve for optimal results (Berning et al., 2004).

Currently, there is a paucity of prospective research studies that have investigated the efficacy of this sort of accommodating resistance exercise as a training method for developing muscular strength. Thus, the aim of this 4-week, randomized controlled training study was to evaluate the effects of coupling an elastic resistance band to a selectorized resistance machine on strength measured by bicep curl one-repetition maximum (1-RM). To further identify the extent to which EB resistance affects strength, the experimental group was divided, with two groups training with EB's of varying resistance.

METHODS

Participants

A total of sixty-six healthy females and males (n = 30 and n = 36, respectively) from the Los Angeles area volunteered for this study. Inclusion criteria included individuals aged 18-29 years with a history of resistance training 1-3 workouts/monthly (i.e., untrained) within the past 12 months. Exclusion criteria included the presence of any significant medical diagnosis such as musculoskeletal, cardiovascular, metabolic, pulmonary, or other disorders that may limit the ability to exercise or increase the cardiovascular risk of exercising, and the use of any drug or supplement known to enhance anabolic responses. Participants provided written informed consent and ethical approval was obtained from UCLA, in accordance with principles documented in the Declaration of Helsinki and with the ethical standards of the International Journal of Exercise Science. Volunteers completed a preparticipation physical activity readiness questionnaire (PAR-Q) and an exercise history questionnaire. Sample size of n = 66 was calculated based on a priori power analysis using the 1-RM biceps curl reported from an unpublished study of similar design in our laboratory assuming a = 0.05 and b = 0.2.

Study design

The current investigation is a prospective, single-blinded, randomized control trial employing a parallel research design. Participants were randomly placed 1:1:1 into one of three groups that trained for four weeks, three training sessions per week. This included two intervention groups: one using an elastic resistance band of 30 lb (EB30) and one using a 55 lb band (EB55), both coupled to a selectorized resistance machine; and a control group using only a selectorized resistance machine (CONT). Randomization was conducted by an investigator independent of participant recruitment using an online-generated random number program, and allocation was concealed with the use of consecutively numbered envelopes.

To minimize confounding variables, participants were asked to refrain from additional resistance-type or high-intensity anaerobic training for the duration of the study. All assessments were performed by trained research personnel under the direction of the lab director from the UC Fit Digital Health – Exercise Physiology Research Laboratory at UCLA. While dietary intake and macronutrient portions were not controlled, participants were required not to start any new dietary supplements or weight loss/gain diets that might affect total and fat-free body mass.

Equipment and training intervention

The training was scheduled over a one-month period, between 15-20 minutes per session, thrice weekly, every-other-day for a total of 12 sessions. Only biceps curls exercises were performed using a cambered bar attached to a typical selectorized cable resistance machine (Prodigy HLP Selectorized Single Stack 2:1, Specialty Fitness Systems, PA, USA). The machine included a built-in weight stack attached to the frame (62L x 63W x 92H in) and utilized a system of pulleys with a pin to select the rectangular plates desired weight in 5-10 lb increments up to 200 lbs. (Figure 1).

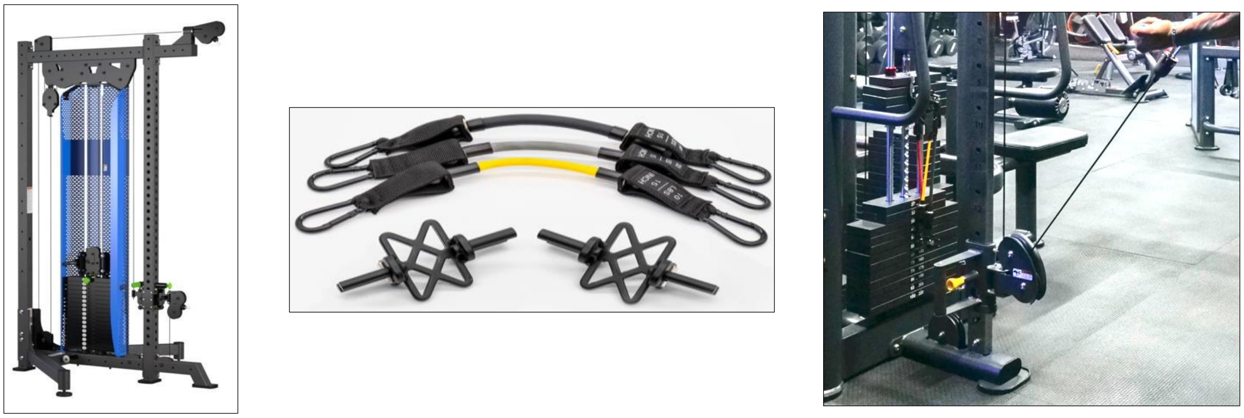


Figure 1. Selectorized resistance machine (left panel). Stack Bands ensemble (middle panel). They operate by using elastic cords pegged above and below the chosen selected weight on the machine. As a cable biceps curl is performed, the effective load on the stack (i.e., downward pull as a result of the tension in the elastic resistance bands) increases due to the tension in the elastic bands, which stretch and reach their maximum tension at the end of the concentric phase. When the arm is initially lowered (eccentric phase) the elastic cords are at their maximal resistance, providing an eccentric overload (right panel).

The intervention groups (EB30 and EB55) utilized an innovative elastic resistance band with a 15-inch tubular cord design that included carabiner clips on each end attached to dual pin connectors (Stack Bands, Stack Bands LLC, Huntington Beach, CA, USA) that were simply matched up to the weight stack pin holes. For the entire training, EB30 and EB55 groups utilized a single elastic resistance band rated at either 30 lb or 55 lb coupled to the machine, respectively. For standardization of EB resistance within and between groups, the distance the EB were pegged above (i.e., always 3 plate pin holes) and below (i.e., always 10 plate pin-holes) the selected pinned weight on the machine were constant (Figure 1).

A trained research associate supervised workout sessions and recorded workout data as well as training compliance. Cable biceps curl resistance was initially set to 70% of the participants' calculated 1RM during baseline. Each cable biceps curl training session consisted of a systematized warm-up followed by four sets to failure interspersed with a 3-minute rest period between sets. Completing sets to volitional fatigue helped to ensure that all participants received a comparable hypertrophic stimulus (Willardson, 2007). An intentional movement tempo of 2/0/1/0 was strictly adhered to for every set: that is, two-second eccentric phase, no intentional isometric pause during the transition phase, a one-second concentric phase, and no pause between the completion of the concentric phase and beginning of the next repetition. Incorporating the standard principles of progressive overload (Duchateau et al., 2021), after every week (i.e., 3 sessions) the weight was increased by 10 lbs. (Table 1).

Table 1. 4-week Cable Biceps Curl regimen.

Warm-Up:	**Details:**
● 3 mins light jog on treadmill. ● Personalized upper body stretching.	● Treadmill: 3 mph, 0% incline. ● Focus on upper arms and shoulder region.
Cable biceps curl:	**Details:**
● Wk #1, sessions 1-3: 4 sets x failure @ 70% 1RM. ● Wk #2-4, sessions 4-12: 4 sets x failure @ 70% 1RM plus 10 lb increase each week.	● Each set performed to volitional failure (i.e., where full-range-of-motion could no longer be maintained). ● Intentional movement tempo 2/0/1/0. ● Timed 3-min rest between sets. ● Cable biceps curl technique: Standing with slightly bent knees 1-2 ft away from pulley, using a double underhand grip and elbows tucked to the sides with wrists maintained straight throughout, slowly raise the weight by contracting the biceps until the lower and upper arms almost touch, then slowly lower the bar in a controlled motion all the way to the bottom.

Testing procedures

All participants were tested at baseline (anthropometric only) and 4-week time points with identical protocols followed before each testing session. To ensure accuracy, reliability, and consistency in test administration, all pre-and post-testing occurred at the same location and time of the day (*i.e.*, early evening to optimize the diurnal effect on performance) by the same investigator. All participants completed a familiarization session during which all testing protocols were practiced until participants were confident.

Anthropometric measures

Body mass and height

Body mass was measured on a calibrated medical scale (accuracy ± 0.1 kg), and height was determined using a precision stadiometer (Seca, Hanover, MD, United States; accuracy ± 0.01 m). Participants were instructed to remove unnecessary clothing and accessories prior to being weighed, as well as to remove their shoes prior to height measurements.

Performance measures

1-RM Cable Biceps Curl

Biceps isometric muscle strength was measured by determining the 1-repetition maximum (1-RM) of a standing cable biceps curl using a standardized procedure (Grgic et al., 2020). The 1-RM is defined as the greatest weight lifted through one’s full range of motion after reaching volitional or momentary failure (Reynolds et al., 2006). Briefly, participants performed a light warm-up including whole body exercise on a treadmill, followed by light stretching. Participants were allowed several practice trials of the cable biceps curl with minimum resistance to ensure proper form, full range of motion, adequate breathing technique, and the intentional 2/0/1/0 movement tempo (Wilk et al., 2020). The resistance was progressively increased by trained researchers following standard procedure, aiming for participants to complete 1–2 repetitions at a load estimated to be near their maximum. Participants subsequently rested for two minutes before attempting to achieve their 1-RM. For each 1-RM trial, participants attempted two repetitions. If participants successfully completed 2 repetitions, they were given a 2-minute rest, and the load was increased. If participants failed the 1-RM attempt, a 2-minute rest was provided, and the load was decreased to the midpoint between the last successful lift and the failed lift. This continued until a 1-RM was achieved.

Statistical analysis

Descriptive statistics are presented as mean and standard deviation (SD). Continuous data did not deviate significantly from normality per Shapiro-Wilk tests. Homogeneity of variances was present per Levene's tests. One-way between-subjects analyses of variance (ANOVA) with post hoc Tukey's tests were utilized. Effect sizes were measured by Cohen's d. Baseline comparisons between the only categorical data (sex) were performed via a chi-squared test. Statistical significance was determined by α = 0.05 and all tests were two-tailed. All data were exported to IBM SPSS Statistics for Windows, version 22 (IBM Corp., Armonk, N.Y., USA) for analysis.

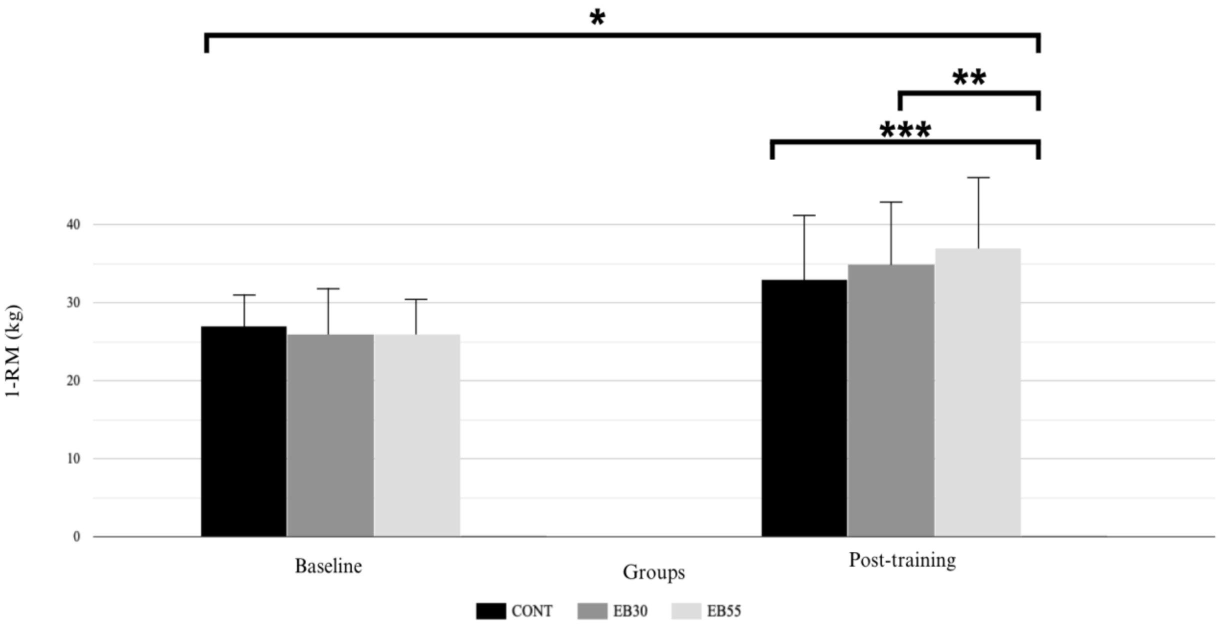
RESULTS

Demographics

All sixty-six participants (mean age = 23.0 ± 2.4 years old) successfully completed the study with no missed training sessions nor injuries reported. Mean height and weight collectively for all participants were 172 ± 11 cm and 70.5 ± 12.5 kg, respectively. No significant differences were detected between groups across sex, age, height, and body mass.

1-RM Bicep Curl

At baseline, there was no difference in 1-RM bicep curl performance between groups. While every group showed a subsequent post-training performance increase after four weeks ($p < .001$), these respective increases varied across groups. Both EB30 and EB55 groups showed significantly higher increases in 1-RM bicep curl weight compared to the CONT group (9.1 ± 2.3 kg and 11.6 ± 3.2 kg versus 6.4 ± 2.0, respectively; $p = .003$, 95% CI: (0.80, 4.56), d = 1.25; $p < .001$, 95% CI: (3.21, 6.97), d = 1.95). Furthermore, the EB55 group yielded an increase from baseline performance that was higher than that of the EB30 group (9.1 ± 2.3 kg versus 11.6 ± 3.2 kg, respectively; $p = .009$, 95% CI: (-4.29, -0.53), d = 0.90).



*Note. *, p < .001 baseline vs post-training; **, p < .009 EB30 vs EB55 at post-training; *** p = .003 and p < .001, respectively, CONT vs EB30 and EB55 at post training.*

Figure 2. Comparison of 1-RM bicep curl performance between baseline and post-training at 4 weeks.

DISCUSSION

To our knowledge, the present study is the first to assess accommodated elastic band (EB) resistance training in conjunction with a selectorized resistance machine. Notably, both the EB30 and EB55 groups exhibited significantly greater increases in 1-RM bicep curl performance post-training compared to the control group. Additionally, the EB55 group demonstrated an approximately 10% higher increase than that of EB30. These results suggest that utilizing EB resistance in conjunction with a conventional selectorized resistance machine can improve strength gains in the biceps beyond conventional means.

The findings of the present study align with previous research in several ways. A meta-analysis comparing the effects of traditional versus accommodated resistance training (interchangeably referred to as variable resistance training) identified significantly greater upper limb strength gains in 1-RM strength following accommodated resistance compared to traditional training (Soria-Gila et al., 2015). Similarly, superior strength gains were observed in accommodated resistance training across EB and chain modalities (Ghigiarelli et al., 2009), including improvements in lower limb strength as measured through the 1-RM back squat (Wallace et al., 2006) and squat jump performance (Masel & Maciejczyk, 2024). Additionally, accommodated resistance training was found to produce strength gains in training protocols of at least seven weeks long with a frequency of at least two sessions per week, which is similar to the training frequency implemented in the present study.

In contrast, several studies have shown inconsistent findings about the effectiveness of accommodating resistance, as assessed using the Rhea scale (Rhea, 2004). In participants with limited resistance training experience, no significant strength differences occurred after a 24-week training program incorporating both traditional and accommodated resistance training (Shoepe et al., 2011). Similarly, McCurdy et al. observed no detectable strength differences between a group undergoing an accommodated chain resistance training program and traditionally trained controls (McCurdy et al., 2009). These studies highlight two factors that can influence the efficacy of accommodated resistance training, the first of which being instability. Chain accommodated resistance is more unstable than free weight training (McCurdy et al., 2009), making it more challenging to load and thus observe statistically significant differences in strength. Second, training experience is critical. Given that lesser trained or untrained individuals would likely be subjected to greater instability, training experience could be an additional necessity. For individuals without extensive resistance training experience, strength enhancement is primarily driven through neuromuscular adaptation, which occurs most at loads below 80% of the 1-RM load (Lin et al., 2022). This serves as a viable explanation for the results of the present study, as the training protocol implemented started at 70% of a participants'1-RM and gradually increased through progressive overload. As a result, this may have allowed the untrained individuals in the study to acclimate to the accommodated resistance training and benefit from heightened neuromuscular adaptation.

When exercising with free weights, the maximal load one can lift is often dictated by a small portion within the range of motion (ROM) known as the "*sticking region*" (van den Tillaar & Ettema, 2009). The biomechanical disadvantage associated with the sticking region induces a disproportionate increase in the difficulty of the lift (Kompf & Arandjelović, 2016). This can lead to form degradation throughout the lift and subsequent injury (Elliott et al., 1989). Incorporating accommodating resistance, which refers to training techniques that alter the effective load throughout a repetition (Arandjelović, 2010), may serve as a potential solution to preventing the issues associated with sticking points. Ensuring movements are uniformly challenging throughout a lift helps prevent technique degradation. When a specific portion of a lift is disproportionately challenging, trainees might compromise their form to overcome that difficult part. By maintaining a consistent level of difficulty, lifters can focus on executing proper technique throughout the entire movement, which promotes better overall strength development and reduces the risk of injury.

Contemporary accommodated resistance techniques either fix EB's, such as those used in the present study, or chains to the lifted load (Kompf & Arandjelović, 2016). These methods will overload the top of the range of motion (ROM), increasing the rate of force development through the translation of stored elastic energy (Neelly et al., 2010; Palmer, 2011; Anderson et al., 2008; Baker & Newton, 2009; Rhea et al., 2009). As an EB lengthens throughout the process of lifting a load, the resistance experienced increases dramatically (Kuntz et al., 2014). In doing so, there is a curvilinear increase in tension that promotes an optimal length-tension relationship (McMaster et al., 2009). As a result, the greatest workload of EB-induced resistance occurs at the end of the ROM (Soria-Gila et al., 2015). These outlined mechanisms have profound implications for overcoming sticking regions in conventional training. With more controlled lifting velocity through accommodating resistance, the neuromechanical hindrance associated with the sticking region can be avoided at particularly inefficient ROM's (van den Tillaar & Saterbakken, 2012; Anderson et al., 2008; Elliott et al., 1989).

The use of EB accommodated resistance training offers several advantages. As previously noted, the conversion of stored elastic energy to kinetic energy can occur during the concentric phase of the lift (Cronin et al., 2003), resulting in a shorter muscle stretch-shortening cycle and improved synchronization of muscle motor units (Rhea et al., 2009). From a utility perspective, EB's offer notable low cost, convenience and portability (e.g., compared to chains) making them suitable for recreational and functional use by users, coaches, athletes and physical therapists. EB's can be utilized for exercises involving both the lower and upper extremities, and they can be used in tandem with free weights or machines, making them uniquely versatile compared to their counterparts. The innovative EB's used in the present study, in particular, offer the added benefits of efficient and safe setup through the use of their dual pin assembly onto a selectorized resistance machine. Moreover, since there are limitless exercises that can be performed on adjustable, dual-cabled selectorized machines, these EB's offer endless possibilities for accommodated resistance training across a wider range of exercises that are not compatible with typical bands.

Limitations

There are several limitations to the present study that should be considered before drawing practical implications. First, these findings are limited to a dynamic elbow flexion exercise and may not be applicable to other exercises or muscle groups. Future research should look at various single- and multi-joint exercises utilizing the selectorized resistance machine. Second, while performing sets to failure provided comparable stimuli to participants, it also impacts other factors, such as the number of repetitions performed. Moreover, the lack of standardization of training load performed was a confounder that could have explained the strength differences between groups. Third, since differences in muscle fibre composition can elicit varying degrees of fatigue (Scott et al., 2001), future research should examine the link between muscle fibre distribution and neuromuscular adaptation. Lastly, the present study's findings are specific to younger, healthy, untrained men and women and may not be generalized to other populations.

CONCLUSION

The findings of the present study suggest that coupling an elastic resistance band to a selectorized resistance machine may improve strength gains in the biceps through accommodated resistance training. Elastic resistance bands may mitigate the limitations of the sticking region within the range of motion, eliciting greater improvements in strength.

AUTHOR CONTRIBUTIONS

The study was conceived and designed by T.Y. and B.A.D., whereas A.E.B., T.K.S., J.T., and V.S. performed data collection. T.Y., P.G., E.V.N., M.S.M., and B.A.D. completed data analysis. T.Y., P.G., and B.A.D. interpreted data and composed the manuscript while A.E.B., T.K.S., J.T., V.S., E.V.N. and M.S.M. made crucial edits. All authors have read and agreed to the published version of the manuscript.

SUPPORTING AGENCIES

No funding agencies were reported by the authors.

DISCLOSURE STATEMENT

No potential conflict of interest was reported by the authors.

ETHICS COMMITTEE APPROVAL

This study was performed in accordance with the ethical standards of the Helsinki Declaration and was approved by the UCLA Institutional Review Board (#11-003190). All participants provided written informed consent.

ACKNOWLEDGEMENTS

We are grateful to the researchers from the UCFIT Digital Health-Exercise Physiology Research Laboratory for their dedication to the study, as well as the participants that gave their time, energy, and full effort.

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