A Comparison of Elastic Tubing and Isotonic Resistance Exercises

Authors J. C. Colado[1], X. Garcia-Masso[1], M. Pellicer[1], Y. Alakhdar[2], J. Benavent[1], R. Cabeza-Ruiz[3]

Affiliations Affiliation addresses are listed at the end of the article

Key words
- physical performance
- strength training
- periodization

Abstract

The aim of this study was to assess effects of a short-term resistance program on strength in fit young women using weight machines/free weights or elastic tubing. 42 physically fit women (21.79±0.7 years) were randomly assigned to the following groups: (i) the Thera-Band® Exercise Station Group (TBG); (ii) the weight machines/free weights group (MFWG); or (iii) the control group (CG). Each experimental group performed the same periodised training program that lasted for 8 weeks, with 2–4 sessions per week and 3–4 sets of 8–15 submaximal reps. A load cell (Isocontrol; ATEmicro, Madrid, Spain) was used to test the evolution of the Maximum Isometric Voluntary Contraction (MIVC) in 3 different exercises: Vertical Rowing (VR), Squat (S) and Back Extension (BE). A mixed model MANOVA [group (CG, TBG, MFWG) x testing time (pre-test, post-test)] was applied to determine the effect of the different resistance training devices on strength. The only groups to improve their MIVC ($p<0.005$) were TBG and MFWG, respectively: VR 19.87% and 19.76%; S 14.07 and 28.88; BE 14.41% and 14.00%. These results indicate that resistance training using elastic tubing or weight machines/free weights have equivalent improvements in isometric force in short-term programs applied in fit young women.

Introduction

It is well known that muscle strength can be improved with a strength training program. Although free weights or a machine are usually used to provide resistance to the muscles working to improve strength, various devices currently exist for strength training [6,9]. Some of these try to improve ergonomics, to simplify design, and to making these training techniques more accessible to potential users of different ages and in different settings [7]. From this point of view, different studies have employed elastic bands or tubing in their intervention programs on older adults or elderly people and have shown positive improvements in muscular strength, muscular power, body composition, balance and functional mobility [5,7,14,15,18,21]. For example, Colado et al. [7] have suggested that elastic bands are an inexpensive alternative to weigh machines because they did not find significant short-term differences between these 2 training techniques in adaptations, body compositions, or improvements of physical fitness for middle-aged women. However, there are fewer studies on the effects of elastic band training in young, physically active and healthy populations; one such study is Kraemer et al. [14] To our knowledge, this was one of the first studies to propose a medium-high exercise intensity program for strength training using elastic bands on this kind of population. In an original proposal, it also was one of the first studies to use the concept of a targeted number of repetitions (Repetition Maximum [RM] zone of ±1 rep) using such elastic devices. Kraemer et al. [14] measured the increase in fat-free mass, strength and power production. However, no short- or long-term studies have compared this type of elastic device or similar methods with more traditional strength-training devices, such as weight machines and/or free weights.

It is also important to note that a new training device (Thera-Band® Exercise Station) that trains strength with elastic tubing has recently come onto market. Unlike traditional elastic devices, this new device allows easy exercise of both the upper and lower limbs, as well as the trunk. Once again it is surprising that no prior studies have checked the efficacy of this device in early adaptations in short-term exercise programs, nor have

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Correspondence
Juan C. Colado
University of Valencia
Physical Education
C/Gascó Oliag 3
46010 Valencia
Spain
Tel.: +34/96/386 43 74
Fax: +34/96/386 43 53
juan.colado@uv.es

Table 1 Subject characteristics.

	n	Age (years)	Weight (kg)	Height (cm)	Body Fat (%)
CG	13	22.23 (0.97)	57.43 (1.95)	165.02 (1.27)	20.06 (1.73)
TBG	12	21.41 (0.36)	61.17 (1.81)	168.00 (1.56)	21.82 (0.82)
MFWG	11	21.73 (0.78)	60.89 (1.95)	165.98 (1.60)	22.64 (1.97)

Values are Mean (SEM). TBG: Thera-Band® Exercise Station Group; MFWG: Weight machines/free weights; CG: Control group

they tested if its use makes any difference in the physical performance of young and physically well-trained people, compared to traditional devices that use gravity, such as weight machines and free weights.

Taking all the above into account, together with the need to develop studies examining new and popular forms of exercises used [14], this study assesses the short-term effects on physical performance of resistance training programs using weight machines/free weights or elastic tubing in young fit women. We hypothesised that subjects participating in either strength training program be no differences in short-term programs between the improvements obtained by the subjects using weight machines/free weights and those using elastic tubing.

Methods

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Study design

A randomised controlled design with 2 experimental groups was used in order to determine the effectiveness of a strength training program performed during 8 weeks and applied with 2 different exercise devices.

The implementation of this program differed only in the material used during the training sessions, as one group used weight machines and free weights and the other used elastic tubing. To ensure that the exercise program in the 2 experimental groups was similar, exercises with similar stabilisation requirements that involved the same main agonist muscle groups were chosen. To control and equate the intensity between the 2 groups, a method based on the combined use of the prescribed number of repetitions and the OMNI Resistance Scale for the active muscles was used. Previous studies have described the method used for controlling exercise intensity [5,7]. The control group did not follow any intervention program during this period. Before the start of the training program, all subjects underwent a strength assessment by performing 3 isometric exercises. They also participated in 2 familiarisation sessions where they learned the exercise techniques. In addition, they participated in 3 more sessions to determine the appropriate resistance for each subject and for each exercise, according to the subject specific level of perceived intensity and the number of target repetitions.

Subjects

42 women were recruited to participate in the study. All of them were physically active, but none of them performed strength training regularly. Exclusion criteria included neurological, cardiovascular, metabolic, inflammatory or musculoskeletal problems. The subjects were randomly divided into 3 groups: i) the Thera-Band® Exercise Station group (TBG); ii) the weight Machine and Free Weight Group (MFWG); and iii) the control group (CG). Initially, the sample size in each group was 14 subjects. ▶ **Table 1** shows the composition and characteristics of the groups. None of the subjects who left the program were injured during training; they left for personal reasons unrelated to the program.

The subjects signed an informed consent form before starting the protocol, in accordance with the Research Commission of the Department of Physical Education and Sports at the University of Valencia (Spain). All procedures meet the requirements listed in the 1975 Declaration of Helsinki (and its later amendment in 2008) and are in accordance with the ethical standards of the International Journal of Sports Medicine [13].

Procedures

The subjects underwent 2 assessment sessions, one before and the other after the intervention. All subjects completed the assessments in a controlled environment at a room temperature of 22 ± 0.1 C during the same week. For the pre-tests, the subjects attended a familiarisation session to learn the techniques for performing the tests 1 week before carrying out the first muscle function tests. Height, body mass, and body fat percentage (Tanita model BF-350) were obtained during the pre-test, according to previously published protocols [4,7]. All measurements for testing (pre- and post-training) were made using identical equipment, positioning, test technicians, and techniques for each subject. The examiners were appropriately trained and qualified. All tests resulted in good intra-class correlation coefficients (rowing = 0.82, squat = 0.75 and back extension = 0.78) for test-retest reliability.

Isometric measurements

A load cell (Isocontrol; ATEmicro, Madrid, Spain) was used to assess the maximal isometric voluntary contraction in 3 different conditions. The subjects performed a standard warm-up before the measurements were taken and had 10 min of rest between the tests. The subjects performed the test in the same order and at the same time of day before and after the intervention. Each subject performed 2 repetitions of each exercise in 5 s, with a 2-min rest period between repetitions. During each repetition the subjects gradually increased their force production in order to avoid sudden, potentially hazardous, jerks. All subjects were verbally encouraged throughout all physical tests. Each test was supervised by the same examiner, with one reference examiner who attended to monitor strict protocol compliance.

The load cell force signal was sampled at 200 Hz. The signals were analysed off-line by selecting the subject's best trial. All force signal analyses were carried out using Matlab 7.0 (Mathworks Inc., Natick, MA, USA). The central second of the force signal was selected and an average value was used as an indicator of the maximum isometric voluntary contraction (▶ **Fig. 1**).

Vertical rowing

The subjects began the exercise in a standing position, with the knees and hips extended (so that they avoided involving lower limb muscles). A bar was gripped with a width equal to the distance between the acromions of each subject. This bar was fixed to the floor by a chain. A load cell was placed between the end of the chain and the floor. The chain length allowed the subjects to place their arms parallel to the ground.

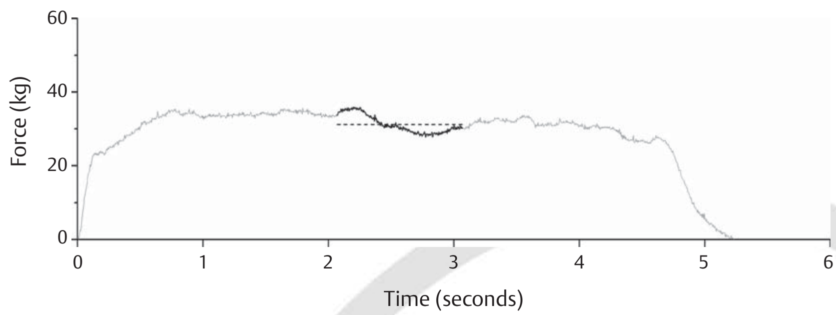

Fig. 1 Representative traces from a maximum isometric voluntary contraction trial. Force (kg) performed during vertical rowing maximum isometric contraction trial. The grey line represents the entire recorded signal of the trial, the rising part of the line coincides with the time that the subject increased the force to reach its maximum. The maximum force was maintained for about 5 s. The black line represents the central period which was averaged for the analysis (dotted line)

Squat

The subjects stood with 2 feet on the floor, with 90° of knee and hip flexion. The bar was placed behind the head, on the shoulders, and was attached to a chain at each end. The chain was connected to a load cell that was fixed to the ground. The chain length allowed the subjects to maintain 90° of knee flexion during the exercise. Knee flexion was monitored with a manual goniometer.

Back extension

Subjects lay prone on a stretcher with the iliac crest placed on its edge and the arms folded across the chest. A belt weight was placed around the dorsal area of the subject. The belt weight was attached to the load cell by a chain. The load cell was fixed to the floor. The chain length allowed the subjects to keep their back straight during the exercise.

Training protocol

The exercise techniques were taught to the subjects in 2 sessions prior to the start of the program, following the criteria of body position, range of movement and breathing [3,6,8]. In addition, movement velocity was standardised to a slow cadence (2 s concentric, 2 s eccentric) controlled by a metronome. The total number of exercises that the subjects performed during the program was 15. During the first familiarisation session they learned the techniques for 8 exercises, the others were learned in the second session. 3 more sessions were used to determine the resistance with which each subject should begin the training program, for each exercise. The subjects were familiarised with the intensity control method that was used to determine the appropriate resistance. This method consisted of a set number of repetitions and a perceived exertion criteria [19].

The TBG used the Thera-Band® Exercise Station whose dimensions are 111.8 cm long, 61 cm wide and 5.1 cm high. The training station has several anchorages where the elastic tubing, bars and handles for the elastic tubing can be attached, which allowed the subject to perform all of the prescribed exercises. In addition, it is possible to fit an exercise ball in the centre of the station (**Fig. 2, 3**). There were several 30.5 cm elastic tubings in 3 different intensities. The way to change the exercise intensity with elastic bands or tubing has been described previously [5,7,10]. The MFWG used machines and free weights with standard characteristics during the training sessions.

The periodised training program lasted 8 weeks, with 2–4 sessions per week. 3 different training sessions were designed depending on the selected exercises (**Table 2**). The first involved both the upper and lower limb muscles and the trunk muscles, the second involved only the upper limbs, and the third involved both the lower limb muscles and the trunk muscles. The exercises included in each session are shown in **Fig. 2, 3**. During the 8 weeks of training, at least 3 sets of each exercise were performed. The prescribed intensity for the first 4 weeks was 7 or “hard” on the OMNI-RES AM scale, with a rest period of 60 s between sets; during weeks 5–7 the intensity was 8–9 or “very hard – very very hard” on the OMNI-RES AM scale, with a rest period of 90 s between sets; and during the last week the intensity was 7 or “hard” on the OMNI-RES AM scale, with 90 s rest. The number of repetitions to perform varied throughout the program, starting with 15 repetitions during the weeks 1–2, 10 during weeks 3–4, 8 during weeks 5–7, and 15 during the last training week (**Fig. 4**). Each time the number of repetitions was changed, the resistance employed was anchored at the target number of repetitions and the perception of the effort determined previously. For example, if the number of repetitions decreased, resistance increased. Thus, resistance changed by adding more or less weight to the machines or free weights and adding tubing of a different intensity or more tubing for the elastic devices. The sessions were always monitored by the same qualified training instructor, in order to corroborate the methodology, performance, materials, room conditions, and program adherence. Warm-up and cool-down protocols were followed for both groups.

Statistical analysis

Statistical analysis was carried out using SPSS software version 17 (SPSS Inc., Chicago, IL, USA). All variables complied with the assumption of normality (K-S normality test), homoscedasticity (Levene’s test) and equality of co-variances matrices (Box test). Standard statistical methods were used to obtain the mean as a measurement of the central trend and the Standard Error of the Mean (SEM) as a measurement of dispersion. A mixed model MANOVA [group (CG,TBG, MFWG) x testing time (pre-test, post-test)] was applied to establish the effect of the different training methods over the strength variables. Multivariate contrasts were used to determine the existence of significant effects of the factors over the dependent variables. The follow-up to the MANOVA was performed using the univariate contrast. Furthermore, Bonferroni post hoc analyses were applied. The level of statistical significance was set at $p < 0.05$.

Results

As described above, 14 subjects were randomly assigned to each of the 3 groups. However, only 11 subjects in the MFWG and 12 in the TBG took part in the intervention with an attendance of

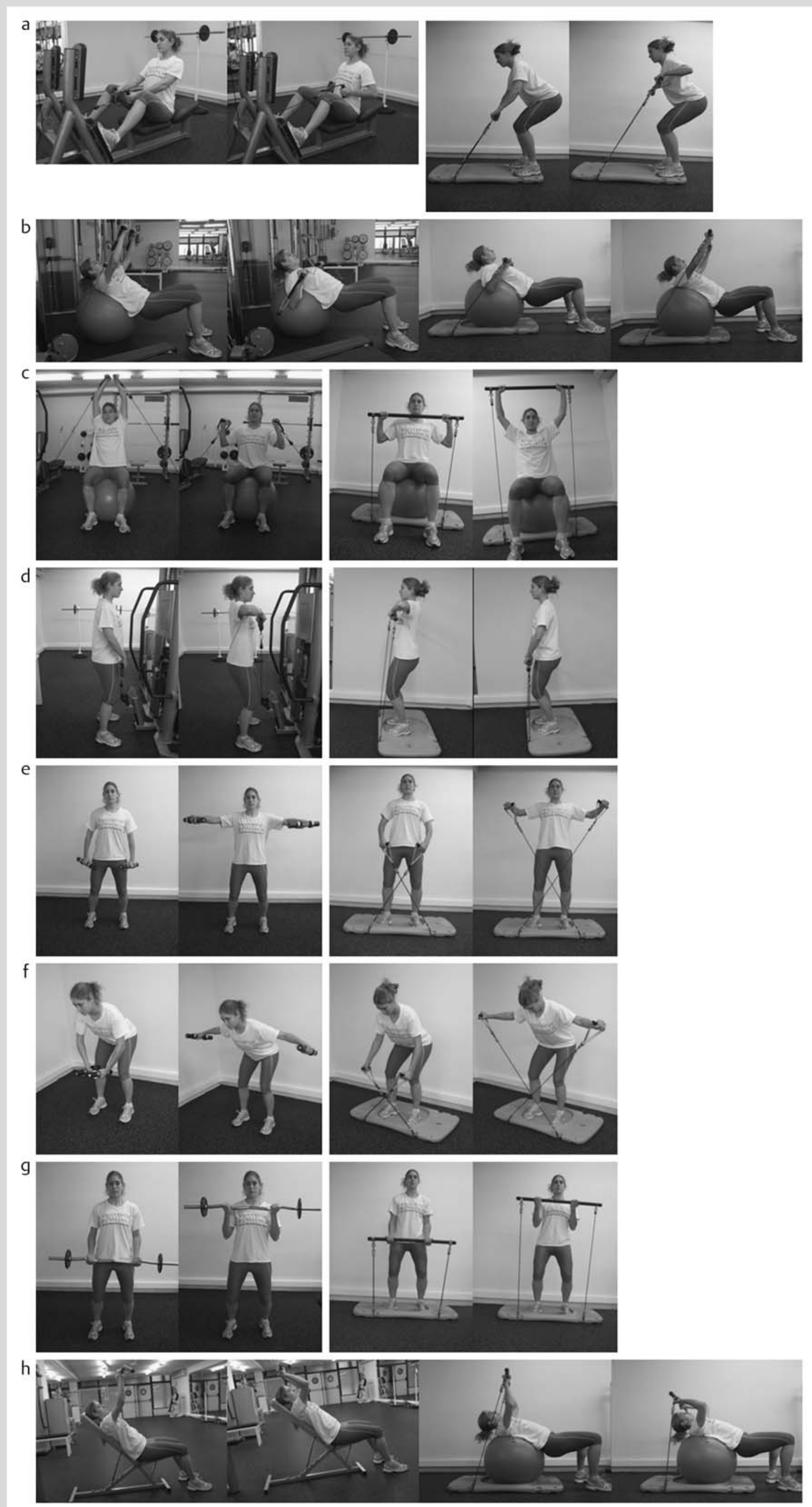

Fig. 2 Upper limb training exercises. Downwards: A, Inclined standing rowing; B, Horizontal bench press; C, Military press; D, Vertical rowing; E, Lateral raise; F, Horizontal abduction; G, Biceps curl; H, Horizontal French press.

the training sessions above 85%. From the initial MFWG, one subject did not take part in the training program due to an accident related to her daily life, one subject could not perform the post-test and 2 other subjects did not participate in the study for various personal reasons. One of the subjects in the initial TBG could not take part in the intervention because of an injury related to her daily life and 2 other subjects could not take part for personal reasons. Personal reasons were also the cause for dropping out in the CG. In total, 13 subjects in the CG, 12 in the TGB and 11 in the MFWG were evaluated in the post-test. All data were analysed on an intention-to-treat.

Multivariate contrasts showed that there was a significant main effect of the testing time over the dependent variables ($F_{3.31}$ = 8.88, $p < 0.001$). There was also a significant interaction effect

Fig. 3 Lower limb training exercises. *Downwards: A*, Squat*; B*, Frontal lunge*; C*, Lateral lunge*; D*, *Single*-joint deadlift*; E*, *Multi*-joint deadlift*; F*, Crunch*; G*, Standing frontal stabilisation.

between the testing time and the factor group ($F_{6.64}$=2.41, p=0.036).

The univariate contrasts revealed that the main effect of the testing time held for back extension ($F_{1.33}$=11.8, p=0.002), squat ($F_{1.33}$=8.47, p=0.006) and vertical rowing ($F_{1.33}$=13.22, p=0.001). Post-hoc analysis showed that there were higher values in the post-test than in the pre-test on these 3 variables.

On the other hand, the testing time x group interaction effect acted on the squat ($F_{2.33}$=4.24, p=0.023) and vertical rowing ($F_{2.33}$=4.74, p=0.016) exercises. Pairwise comparisons revealed that the values of the isometric squat strength were higher in the TBG (Mean=98.56, SEM=8.31) than in the CG (Mean=67.97, SEM=7.19) at the post-test. In addition, both the TBG and the MFWG improved their back extension, squat and rowing strength in the post-test related to the pre-test (**Table 3**).

There was not a main effect of the group over the dependent variables. In addition, pairwise comparisons determined that there were no differences between groups in the pre-test in any dependent variables.

Table 2 Exercises included in each session type.

Global training	Upper limb training	Lower limb training and trunk
inclined standing rowing	inclined standing rowing	squat
horizontal bench press	horizontal bench press	frontal lunge
military press	military press	lateral lunge
vertical rowing	vertical rowing	multi-joint deadlift
squat	lateral raise	single-joint deadlift
frontal lunge	horizontal abduction	crunch
multi-joint deadlift	biceps curl	standing frontal stabilisation
crunch	horizontal French press	–

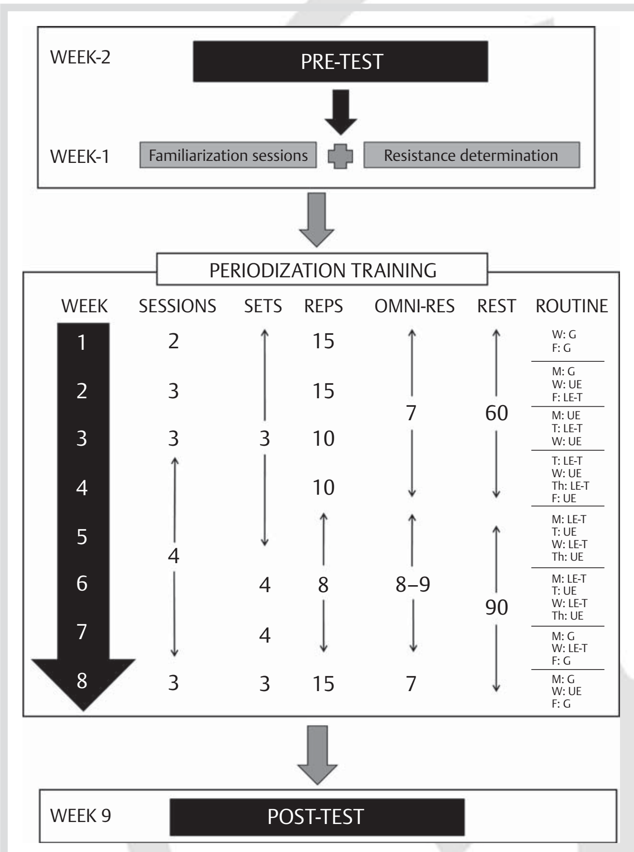

Fig. 4 Diagram of the training program and evaluation sessions. In the column "Routine" each line of each week represents "day: session type". M, Monday; T, Tuesday; W, Wednesday; Th, Thursday; F, Friday; G, Global session; UE; Upper Extremity; LE-T, Lower Extremity and Trunk.

Discussion

To our knowledge, this study is the first that compares the newly created elastic devices to the traditional weight machines and free weights. Furthermore, this research is the first of its kind that uses isometric tests for strength measurements; to date, only clinical tests have been used. In addition, the population used in our study differs from previously studied populations. The young and physically active women in our study represent a step forward when trying to confirm the efficacy of the elastic bands or tubings for strength training, as it may be easier to produce adaptations in women who are not physically active and/or aging population.

Prior studies have had difficulty controlling the elastic band exercise intensity [17,20]. This difficulty is due to different elongation coefficients and their modification during use [20]. In addition, it is difficult to evaluate the intensity of the elastic band exercise for comparison with traditional methods. We have solved these problems by using the OMNI-RES-AM scale that has been validated for free weight use [11,16,19] together with the number of target repetitions as a method for controlling the intensity [2,14]. This method of intensity control has been used in recent studies and has been considered to be effective [1,5,7].

The results obtained in our study confirmed that the use of elastic tubing in strength training in young and physically active women is effective and can yield results that are equivalent to those obtained with weight machines and free weights. Both the group that trained with elastic devices and the group that trained with machines and free weights obtained significant improvements in the 3 isometric tests performed. The control group did not show signs of improvement.

The TBG showed an increase of 14.41, 14.07 and 19.87% in back extension, squat and rowing, respectively. On the other hand, the MFWG had increases of 14.00, 28.88 and 19.76% in back extension, squat and rowing, respectively.

Our results support those found by other studies. Colado et al. [5] found improvements in body composition, physical capacity and blood chemistry with strength training programs of 24 weeks in which middle-aged women used elastic bands. In this work, improvements that they obtained were similar to those improvements reached with a strength training program in water, using devices that increase drag force. Increases in muscular strength and improvements in body composition in middle-aged women have been also identified for a training program lasting 10 weeks [7]. In this case, only minor differences in the variables related to body composition between the group that trained with elastic bands and the weight machine group were identified. Furthermore, Ribeiro et al. [18] obtained improvements in isometric strength in dorsi- and plantar flexion, in balance, and in functional mobility through an elastic band based training program in institutionalised elderly people. The improvements obtained were 50% in maximal isometric strength in dorsiflexion and 34.61% in plantar flexion. These values are higher than those obtained in our study, due to differences in the selected sample (elderly people vs. young females) and also because the implemented program was aimed to improve plantar and dorsi- flexion strength. Zion et al. [21] obtained increases in dynamic strength in elderly individuals with orthostatic hypotension. The improvements were 40% in bench press, 70.83% in leg extension and 55.88% in leg press. However, there were no significant improvements in upper or lower limb isometric grip strength (similar to a biceps curl and a leg press). Ghigiarelli et al. [12] applied strength training for 7 weeks in soccer players who were divided into 3 groups depending on the combination of materials they used during the program (weight; weight and elastic bands; weight and heavy chains). The result of this study confirmed the effectiveness of using a combination

Table 3 Effects of the intervention over the strength variables.

		TBG (n=12)	MFWG (n=11)	CG (n=13)
back extension	*pre-test*	45.31 (3.8)	43.34 (2.71)	38.33 (2.62)
	post-test	51.84 (4.03)*	49.41 (2.44)*	40.43 (3.26)
squat	*pre-test*	86.4 (7.35)	73.27 (6.92)	71.07 (6.18)
	post-test	98.56 (8.31)*‡	94.43 (8.7)†	67.97 (7.19)
rowing	*pre-test*	33.92 (2.54)	33.75 (2.01)	35.96 (1.90)
	post-test	40.66 (2.95)†	40.42 (3.17)†	35.24 (2.23)

Values are Mean and Standard Error of the Mean (SEM). TBG: Thera-Band® Exercise Station Group; MFWG: Weight machines/free weights; CG: Control group

* Significant differences between pre-test and post-test ($p<0.05$)

† Significant differences between pre-test and post-test ($p<0.005$)

‡ Significant differences related to control group ($p<0.05$)

of traditional weight exercises with the extra resistance of the elastic bands; all 3 groups improved their strength and their muscular power.

It is difficult to directly compare our results to those results published previously because we used different dependent variables. Moreover, this study is the first to show that the participation in a training program using elastic tubing is as effective as a training program using weight machines and free weights in improving maximal isometric strength in young women; the populations studied previously were elderly people and/or physically impaired people. One of the few studies that used a young healthy subject population was Kraemer et al. [14] This study also developed a training methodology using medium-high exercise intensity. However, this study did not compare the effects produced by elastic band training to other resistance materials. Our work confirmed the effectiveness of these elastic devices in improving the muscular performance in young and fit women.

It is possible that with a larger sample size and a long-term program, some other significant differences between the post-test groups could have been detected. Furthermore, future studies should compare the effectiveness of the 2 training methods in improving other parameters such as body composition or dynamic and/or explosive force. For example, in this study the rate of force development was not measured, as during each repetition the subjects gradually increased their force production.

The results of this study highlight possible practical applications of the elastic band technique and suggest the need for further study. When referring to practical applications, it continues to demonstrate the usefulness of elastic bands or tubing in strength training, expanding further the characteristics of the people who can benefit from its use. In this case, it has been shown that the elastic tubing use is as effective as the weight machines and free weight use when trying to obtain increases in strength in young and physically active women. Moreover, this study effectively used the OMNI-RES-AM scale, together with the number of target repetitions, to control the exercise intensity. We recommend that future studies compare the OMNI-RES-AM scale to other methods of intensity control. Finally, we suggest further research in this area to determine if other populations will benefit from elastic band or tubing training.

From the present study, we can conclude that the strength training using elastic tubing or weight machines and free weights lead to an equivalent increase of isometric strength in young and physically active women. The elastic devices, and more specifically the exercise station with elastic tubing, could be an inexpensive alternative for people who want to perform strength training but do not have access to more expensive or sophisticated equipment.

Affiliations
[1] University of Valencia, Laboratory of Physical Activity and Health, Department of Physical Education and Sports, Valencia, Spain
[2] University of Valencia, Department of Physiotherapy, Valencia, Spain
[3] University of Seville, Department of Physical Education and Sports, Seville, Spain

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