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ORIGINAL ARTICLE

Effects of an elastomeric technology garment on different external and internal load variables: A pilot study

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ABSTRACT

Resistance training is one key method for improving physical conditioning. With this purpose, Menatechpro System® has designed an avant-garde garment that includes elastomeric technology that may stimulate the neuromuscular system in a better way, but a deeper knowledge of its effects is needed. Objective: To explore the effects of a new garment with elastomeric technology on upper-limb performance, and neuromuscular, perceptual, and cardiovascular responses in two upper-extremities exercises. Methodology: Fit young men trained in resistance exercises performed a seated shoulder press (80% of one-repetition maximum) and push up (bodyweight) until muscle failure with the garment that incorporates the elastomeric technology versus a placebo garment without it. The number of repetitions, mean propulsive velocity, mean and peak muscle activation, rate of perceived effort and perceived velocity, and heart rate were analysed. Possible differences were obtained with a two-way mixed ANOVA of repeated measures with post-hoc analysis. Results: Compared with a placebo garment, the use of this new garment with elastomeric technology improved positively the physical performance and muscular activation during the exercises analysed ($p \leq .05$). Conclusion: Menatechpro System®'s elastomeric technology integrated into the garment could provide an optimal neuromuscular stimulus for the development of the performance during the upper extremity training.

Keywords: Performance analysis of sport, Physical conditioning, Number of repetitions, Mean propulsive velocity, Rate of perceived effort, Velocity perception of execution, Heart rate, Muscle activation.

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INTRODUCTION

Human physical conditioning is determined by a wide range of athletic abilities which include strength and cardiovascular status (Joyner & Dominelli, 2021; Suchomel et al., 2016). From these items, central and peripheral pathways involved in performance and fatigue are explained (Taylor et al., 2016). Accordingly, as exercise training leads to morphological, biochemical, and functional adaptations, training variables may be cautiously selected for maximizing the desired effects (Gene-Morales, Flandez, et al., 2020; Gene-Morales, Gené-Sampedro, et al., 2020; Halson, 2014).

Exercise stimulus is produced through skeletal muscle contraction. In this sense, the inputs and outputs involved in muscle contraction are driven by the nervous system (Alix-Fages et al., 2022). Thus, motor control and force production of each muscle fibre is determined by supraspinal structures, spinal cord, and peripheral skeletal muscle activity (Alix-Fages et al., 2022). Nervous system peripheral function can be measured through the electrical responses of the neuromuscular system with non-invasive tools such as surface electromyography (EMG) (Hermens et al., 2000). Besides, although EMG may provide valuable information concerning the specific mechanisms of muscle contraction, mechanical performance (e.g., kilograms used, repetitions, velocity) may be measured for ensuring a direct relevant outcome on performance. In this regard, previous research has identified a wide variety of outcomes for assessing resistance training such as the mean propulsive velocity (MPV) and velocity loss of a linear movement or the direct force produced against a surface (González-Badillo et al., 2017; Hinshaw et al., 2018).

On the other hand, metabolic factors of performance can be evaluated through the cardiovascular system and the peripheral responses of blood vessels and organelles as mitochondrion (Lee & Zhang, 2021). In this sense, heart rate has been proposed as a predictor of training intensity (Mikus et al., 2009). Moreover, heart rate behaves in a different way in acute and chronic exercise exposures (Reimers et al., 2018). During exercise, athletes suffer a rise in heart rate as a consequence of the need for higher levels of blood perfusion, however, chronic adaptations to endurance training lead to lower basal values, which are correlated with increased lifespan (Reimers et al., 2018).

Of note, these different physiological outcomes can be improved through a wide range of physical exercise modalities and methods (Carlson et al., 2016; Gene-Morales et al., 2022). In recent years elastic materials have been proposed as a plausible tool for enhancing physical abilities due to their inexpensive acquisition, easy portability, and verified results (Gene-Morales, Gené-Sampedro, et al., 2020; Hammami et al., 2022; Saez-Berlanga et al., 2022). Consequently, new devices based on elastomeric technology have been recently created for improving multicomponent elastic training.

Therefore, this study aimed to explore the effects of a new elastomeric garment on upper-limb performance and neuromuscular, perceptual, and cardiovascular responses in the seated shoulder press and push up exercises. It was hypothesized that this new garment may exert a positive impact on all the different analysed variables.

MATERIALS AND METHODS

Participants

Five healthy, trained men (see Table 1) were recruited for this study. Exclusion criteria included any metabolic, cardiovascular, neurological, and/or muscular disorder. The participants signed the informed consent after being informed about the study's aims and procedures. The participants were asked not to consume stimulants (i.e., caffeine) or other ergogenic substances before the experimental session and not to engage in strenuous physical activity 24 hours prior to the session. Additionally, they were encouraged to sleep at least 8 hours the night before data collection.

Table 1. Characterizing values of the participants (n = 5).

Variable	Mean (SD)
Age (years)	24 (2.45)
Height (cm)	183 (0.89)
Body weight (kg)	80.56 (7.27)
Body fat percentage	11.02 (3.46)
Handgrip strength (kg)	52.82 (8.20)
Strength training experience (years)	5.20 (2.17)
Number of training sessions per week	4.00 (0.71)

Procedures

All the procedures were conducted during the morning (i.e., between 9 AM and 2 PM) to avoid diurnal variations in participants' performance (Sundstrup et al., 2012). All measurements were recorded by the same trained researchers. The present study was approved by the Local Research Ethics Committee (H20190325095509) and was in accordance with the tenets of the Declaration of Helsinki.

Each participant participated in a single session that comprised: (i) familiarization and anthropometric measurements; (ii) specific warm-up; (iii) determination of maximum voluntary isometric contraction (MVIC) to normalize EMG values; (iv) determination of 80% of one-repetition maximum (1RM) for the shoulder press; (v) military press at 80% 1RM and push-ups until muscle failure. Both exercises were performed with the elastomeric technology garment (Proadvance, Menatechpro System®, Madrid, Spain) and with the placebo equivalent (same garment without elastomers). Therefore, a total of four conditions were performed by each participant. The order of the conditions was: (i) shoulder press at 80% 1RM with the elastomeric garment; (ii) push-ups to muscle failure with the elastomeric garment; (iii) military press at 80% 1RM with placebo garment; (iv) push-ups to muscle failure with placebo garment. The variables analysed were the number of repetitions, mean propulsive velocity (MPV) of the first and last repetition, rate of perceived exertion (RPE), perceived velocity (RPV) of the first and last repetition, EMG, and heart rate.

At the beginning of the session, weight, body fat percentage (Tanita® model BF-350; Tanita Corpo., Tokyo, Japan; accuracy 0.01 kg), height (Seca T214; Seca Gmbh & Co., Hamburg, Germany; accuracy 0.01 cm), resting heart rate, and maximum handgrip isometric force in the dominant hand (SCACAM-EH10117; Camry Scale, South El Monte, CA, USA) were measured. For the handgrip test, the participants were standing with the back against a wall, elbow extended, and the grip placed at the level of the second phalange. The best of two attempts of 5 seconds was recorded for further analysis. At this point, participants performed a standardized warmup consisting of 5 minutes of joint mobility of the shoulder, elbow, and wrist, as well as two repetitions of abdominal plank for 20 seconds each.

After the warmup, two 5-second MVIC assessments of the shoulder press were performed against an immovably fixed resistance (i.e., Smith machine). Three minutes of rest were allowed between attempts. Verbal feedback was homogeneously given to all the participants. The position for the MVIC test was chosen according to standardized procedures (i.e., approximately 90º of shoulder and elbow flexion; Calatayud et al., 2014). To ensure reliability between participants and measurements, EMG data were normalized as the average of the central second in the best of the two attempts performed (Hermens et al., 2000).

Thereafter, two attempts to estimate the load of 80% 1RM for the shoulder press were carried out based on the mean propulsive velocity (MPV) (see García-Ramos et al., [2021] for further information). A velocity of 0.52 m/s determines the load of 80% 1RM in this exercise (García-Ramos et al., 2021). Both attempts were separated by 5 minutes of rest. Two researchers stood at the sides of the Smith machine during the test to assist the participant to return the bar to the support (Calatayud et al., 2014).

After the aforementioned tests, both exercises (i.e., seated shoulder press and push up) were performed with 5 minutes of rest in between. A 10-minute rest was allowed between conditions. To homogenize the speed of movement, an execution tempo of a maximum-speed concentric phase and a 3-second eccentric phase was established for both exercises. The tempo was controlled with a metronome (Ableton Live 6; Ableton AG, Berlin, Germany). The participants received verbal and visual feedback to maintain hand and foot distance and range of motion. The following technique cues were adopted in the shoulder press: (i) an upright seated position with back support, (ii) bent knees, (iii) feet equidistant on the floor, (iv) elbow and shoulder flexed 90º, and (v) standardized biacromial grip width. For the push-ups, according to previous research (Calatayud et al., 2015), each participant (i) started the exercise in an outstretched arms position, (ii) fingers extended, (iii) feet distance fixed according to hips width, and (iv) spine and hips were kept neutral throughout the entire set. The dependent variables (the number of repetitions, MPV, RPE, RPV, EMG, and heart rate) were collected immediately after finishing the set. Additionally, MPV, RPE, and RPV were also collected immediately after performing the first repetition.

Electromyography

To ensure consistency in electrode placement, each participant was shaved and cleaned with a cotton swab moistened with alcohol (Calatayud et al., 2015). Surface electrodes were placed over the clavicular portion of the pectoralis major (PEC); the long head of the triceps brachii (TRI); the anterior deltoid (ADELT); and the upper rectus abdominis (REC) of the dominant side of the body. Surface Electromyography for the Non-Invasive Assessment of Muscles criteria (SENIAM; Hermens et al., 2000) and previous studies in this field (Calatayud et al., 2016, 2017) were followed. Chlorinated silver pre-gelled bipolar surface electrodes (KendallTM Medi-Trace; Coividien, Barcelona, Spain) were placed with an inter-electrode distance of 10 mm. The reference electrode was placed approximately 5 cm from the electrode pair, according to the manufacturer's specifications.

The participants then performed one repetition of the seated shoulder press and a push up to check signal saturation. Two synchronized two-channel handheld devices coupled to a Shimmer branch inertial sensor (Realtime Technologies Ltd; Dublin, Ireland) with 16-bit analog-to-digital (A/D) conversion were employed. The sampling rate was planned at 1024 Hz. One device collected EMG data from the anterior deltoid and long head of the triceps brachii muscles, while the other collected data from the upper rectus abdominis and clavicular bundles of the pectoralis major muscles. The EMG signal was monitored using the validated (Hermens et al., 2000) mDurance software (MDurance Solutions S.L.; Granada, Spain) for Android. All EMG signals were stored on a hard disk for subsequent evaluation. The mDurance software digitally filtered the raw signals automatically using a fourth-order "*Butterworth*" bandpass filter between 20 and 450 Hz. A high-pass cut-off frequency of 20 Hz was employed to reduce any "*artifacts*" that might occur throughout the movement to have a negligible impact on the total power recorded by the EMG (Ferri-Caruana et al., 2022).

Mean propulsive velocity

A linear position transducer (ADR Encoder; ADR, Toledo, Spain) was used to collect the mean propulsive velocity (m/s) of the first and last repetition of each set in the shoulder press at 80% 1RM. The transducer was attached to the bar, allowing the exercise to be performed smoothly and to move vertically (Naclerio et al., 2011). The execution velocity in the push-ups was assessed with a dynamometric platform (Force Decks; Vald Performance, NSW, Australia).

Rate of perceived exertion and velocity

The participants reported global perceived exertion (RPE) and perceived speed values on the first repetition and the last repetition. The OMNI scale of perceived exertion for continuous loads (Robertson et al., 2003) and the speed perception scale ("*Velscale*"; Bautista et al., 2014) were used.

Heart rate

Pre- and post-test heart rate was monitored via a Polar H7 heart rate monitor (Polar Electro Ltd.; Kempele, Finland) linked via Bluetooth to the PolarTeam app version 1.8.5.

Elastomeric garment

To perform the exercises, the participants wore a garment with the Menatechpro System®'s elastomeric technology and a placebo garment without it. Menatechpro System®'s elastomeric technology is sophisticated sportswear that includes the patented system of Menatechpro System® which generates elastic resistance in most planes of motion. The garment with the Menatechpro System®'s elastomeric technology is composed of more than 20 different pieces. Concretely, we used for this study the model "*Pro-advance*" with a final resistance of 8 kilograms. This garment is intended for users and athletes with previous experience in training who want to enhance both their physical performance and the intensity of their resistance training.

Statistical analysis

Statistical analyses were performed using commercial software (SPSS, version 28.0; IBM corp., Armonk, NY, USA). The assumption of normality of the dependent variables was verified with the Shapiro-Wilk test. The level of statistical significance was set at $p < .05$. Results were reported as mean and standard deviation (SD).

A two-way mixed analysis of variance (ANOVA) of repeated measures was used to assess the influence of using or not the technical garment (placebo versus elastomeric technology from Menatechpro System®) and the type of exercise (with external resistance versus body weight) on the number of repetitions performed, mean propulsive velocity, rate of perceived effort of the first and last repetition, rate of perceived velocity of the first and last repetition, heart rate, and mean and peak muscle activation in the anterior deltoid fibres, clavicular fibres of the pectoralis major, and long head of triceps brachii. All the cases complied with Mauchly's sphericity assumption. For the effect size analysis, partial eta squared (n_p^2) was obtained derived from the ANOVA and was interpreted as low (< 0.04), moderate (0.04 – 0.13), and large (> 0.13). Planned pairwise comparisons were conducted using the Least Significant Difference (LSD) correction to evaluate differences.

Aiming at verifying the correlation between variables, Pearson's test was conducted and interpreted as neglectable (≤ 0.19), low (0.20 – 0.39), moderate (0.40 – 0.59), good (0.60 – 0.79), and excellent (≥ 0.80) (Cohen, 2013).

The reliability of the different types of variables was assessed through the intraclass correlation coefficient (ICC). As previously suggested, ICC values were interpreted as poor (< 0.50), moderate (0.50 – 0.75), good (0.75 – 0.90), and excellent (> 0.90) reliability, based on the lower bound 95% confidence interval (Fleiss, 1986).

RESULTS

The ANOVA testing showed that independently of the exercise performed, the use of the elastomeric garment showed significant differences or tendencies compared with the placebo garment in the number of repetitions ($F(1,4) = 3.61$, $p \le .05$, $n_p^2 = 0.99$), RPE of the first repetition ($F(1,4) = 45.00$, $p \le .05$, $n_p^2 = 0.92$), mean activation of the ADELT ($F(1,4) = 5.32$, $p = .08$, $n_p^2 = 0.57$) and PEC ($F(1,4) = 8.60$, $p \le .05$, $n_p^2 = 0.68$), and maximum activation of ADELT ($F(1,4) = 7.83$, $p \le .05$, $n_p^2 = 0.66$) and TRI ($F(1,4) = 4.69$, $p = .09$, $n_p^2 = 0.54$).

Considering the effects of the type of exercise, it is worth highlighting that the use of the garment showed a tendency of significant differences in the mean activation of the TRI ($F(1,4) = 4.70$, $p = .1$, $n_p^2 = 0.54$).

Finally, the interaction use of the garment * type of exercise showed significant differences or tendencies in the number of repetitions ($F(1,4) = 13.88$, $p \le .05$, $n_p^2 = 0.78$), mean activation of ADELT ($F(1,4) = 5.74$, $p \le .05$, $n_p^2 = 0.59$) and PEC ($F(1,4) = 3.20$, $p = .12$, $n_p^2 = 0.44$).

Table 2 presents the results and differences in the external load (number of repetitions and MPV) between using the garment or the placebo to perform both exercises (seated shoulder press and push-ups). On the other hand, Table 3 shows the results and differences in the external load (RPE, RPV, and heart rate). Finally, Table 4 contains the results and differences in the mean and maximum muscle activation of the studied muscles.

Table 2. Comparison of the use of the garment that incorporates the Menatechpro System®'s elastomeric technology versus the placebo garment differentiated by the type of exercise in terms of external load variables.

		Nº reps	%	MPV-1	%	MPV-F	%
Shoulder press	MPS®	5.6 (1.95)	--	0.41 (0.015)	--	0.17 (0.05)	-10.53
	Placebo	5.6 (1.52)		0.41 (0.10)		0.19 (0.06)	
Push-ups	MPS®	23.2 (5.26) *	+19.60	0.58 (0.04)	--	0.17 (0.03)	+13.33
	Placebo	19.4 (4.28)		0.58 (0.03)		0.15 (0.05)	

*Note. The table shows the mean values and in parentheses the standard deviation (n = 5). * Statistically significant difference (p ≤ .05) between the placebo garment and the garment that incorporates the Menatechpro System®'s elastomeric technology. MPS®: Menatechpro System®´s elastomeric technology; Nº reps: Repetitions' number; %: percentage of variation between conditions (elastomeric minus placebo); MPV-1: Mean propulsive velocity of the first repetition; MPV-F: Mean propulsive velocity of the last repetition.*

Table 3. Comparison of the use of the garment that incorporates the Menatechpro System®'s elastomeric technology versus the placebo garment differentiated by the type of exercise in terms of the internal load variables (rate of perceived effort, velocity perception, and heart rate).

		RPE-1	RPE-F	RPV-1	RPV-F	HR-pre	HR-post
Shoulder press	MPS®	6.0 (1.00) *	9.8 (0.45)	2.8 (0.45)	5.0 (0.00)	57.2 (5.80)	167.0 (13.13)
	Placebo	5.4 (1.52)	9.8 (0.45)	3.0 (0.71)	5.0 (0.00)	57.2 (5.80)	163.0 (8.70)
Push-ups	MPS®	2.8 (1.64) *	9.8 (0.45)	1.6 (0.89)	5.0 (0.00)	56.8 (5.89)	155.6 (13.52)
	Placebo	2.6 (1.67)	9.8 (0.45)	1.6 (0.55)	5.0 (0.00)	56.8 (5.89)	155.2 (10.57)

*Note. The table shows the mean values and, in parentheses, the standard deviation (n = 5). * Statistically significant difference (p ≤ .05) between the placebo garment and the garment that incorporates the Menatechpro System®'s elastomeric technology. MPS®: Menatechpro System®´s elastomeric technology; RPE-1: Rate of perceived effort for active muscles in the first repetition (0-10); RPE-F: Rate of perceived effort for active muscles in the last repetition (0-10); RPV-1: Rate of perceived velocity in the first repetition (1: very fast; 2: fast; 3: moderate; 4: slow; 5: very slow); HR-pre: peak heart rate just before the first repetition; HR-post: peak heart rate after the last repetition.*

Table 4. Comparison of the use of the garment that incorporates the Menatechpro System®'s elastomeric technology versus the placebo garment differentiated by the type of exercise in terms of the internal load corresponding to muscle activation.

		Mean muscle activation (μV)					
		Deltoid	*%*	*Pectoral*	*%*	*Triceps*	*%*
Military Press	MPS®	1036.73 * (381.90)	+25.15	631.01 * (328.15)	+33.52	1248.88 * (657.78)	+25.01
	Placebo	828.40 (333.47)		472.61 (192.85)		999.04 (504.05)	
Push-ups	MPS®	679.27 (479.95)	+9.1	344.88 (117.00)	+3.35	644.05 (280.91)	-1.88
	Placebo	622.79 (307.23)		333.70 (76.35)		656.38 (214.92)	

		Peak muscle activation (μV)					
		Deltoid	*%*	*Pectoral*	*%*	*Triceps*	*%*
Military Press	MPS®	126.25 * (32.61)	+18.12	138.27 (15.88)	+11.63	181.72 * (116.51)	+28.86
	Placebo	106.88 (23.16)		123.86 (16.29)		141.02 (97.84)	
Push-ups	MPS®	134.66 (69.83)	+12.20	130.89 (57.99)	+8.90	198.73 (194.16)	+12.88
	Placebo	120.02 (53.65)		120.19 (90.07)		176.05 (165.53)	

*Note. The table shows the mean values and in parentheses the standard deviation (n = 5). * Statistically significant difference (p ≤ .05) between the placebo garment and the garment that incorporates the Menatechpro System®'s elastomeric technology. MPS®: Menatechpro System®´s elastomeric technology; %: percentage difference between conditions.*

Bivariate correlation analyses showed that the participants with higher levels of ADELT mean activation in the shoulder press performed with the Menatechpro System®'s elastomeric garment, also obtained higher levels of mean activation with the placebo garment (r = 0.99, $p \leq .05$). The same correlation regarding the mean activation of the ADELT was observed in the push-ups (r = 0.97, $p \leq .05$). Similarly, the participants with higher activation levels at the shoulder press with the elastomeric garment also obtained greater activation levels in the push-ups with the elastomeric garment (r = 0.93, $p \leq .05$). Additionally, the participants with higher levels of ADELT maximum activation in the shoulder press performed with the Menatechpro System®'s elastomeric garment also obtained higher levels of maximum activation with the placebo garment (r = 0.88, $p \leq .05$). The same correlation regarding the maximum activation of the ADELT was observed in the push-ups (r = 0.99, $p \leq .05$).

The reliability analyses showed good to excellent values in some of the most relevant study variables (number of repetitions: ICC = 0.95, $p \leq .05$; mean activation PEC: ICC = 0.96, $p = .12$; maximum activation PEC: ICC = 0.85, $p = .12$; RPE of the first repetition: ICC = 0.89, $p = .10$; heart rate: ICC = 0.97, $p \leq .05$).

DISCUSSION

The main aim of this study was to explore the effects of a new elastomeric garment on upper-limb performance and neuromuscular, perceptual, and cardiovascular responses in the seated shoulder press and push up exercises. The main finding was that the garment with the Menatechpro System®'s elastomeric technology significantly increased several physical performance parameters compared with the placebo garment. This finding is in line with previous research focused on the effects of training with variable resistance such as elastic bands (Colado et al., 2020; de Oliveira et al., 2017; Suchomel et al., 2018). Hereunder, the effects of using the elastomeric garment on each of the dependent variables are going to be discussed.

First, the number of repetitions and MPV in the seated shoulder press were the same in both conditions (elastomeric garment vs placebo garment). Considering that the Menatechpro System®'s elastomeric technology adds a resistance of approximately 8 kilograms at the end of the range of motion, it is worth highlighting that the participants used a greater resistance without losing volume (number of repetitions) or intensity (in terms of movement speed). In this regard, the greater resistance employed by the participants is reflected in the higher mean and maximum muscular activation obtained when using the garment with the Menatechpro System®'s elastomeric technology compared with the placebo garment. Potential reasons for the differences (and non-differences) in the external load between using the elastomeric garment or the placebo may be that, due to the elongation coefficient (Andersen et al., 2016; Saeterbakken et al., 2016), the extra resistance of the elastomers is progressively being added at the last degrees of the range of motion and not in the "*sticking point*" (see Kompf & Arandjelović [2016] for further information). Therefore, the participants are utilizing a greater resistance during the more biomechanically advantageous phase of the range of motion (Aboodarda et al., 2013). Taken together, the use of the Menatechpro System®'s elastomeric technology could be helping to overcome the biomechanical disadvantages of the locomotor system by adding more resistance in the phases of the range of movement in which the athlete is "*stronger*". Considering this, this elastomeric garment may optimize the neuromuscular response to resistance exercises (Kompf & Arandjelović, 2016). Additionally, and although we have not measured this, systematically repeating this training stimulus may induce greater performance levels compared to traditional resistance training with constant resistance (Soria-Gila et al., 2015).

Regarding the push-ups, the use of the garment with the Menatechpro System®'s elastomeric technology allowed the participants to perform a greater number of repetitions to failure without significant differences in the MPV and EMG values (Aboodarda et al., 2016; Calatayud et al., 2015). These results may be probably caused by the elastomeric properties of the garment (Andersen et al., 2019), which may assist certain movements such as push-ups. Therefore, the elastomeric garment would be enhancing the performance through a greater time under tension and longer efforts (i.e., a greater number of repetitions).

Apart from the positive results obtained with the use of the garment with the Menatechpro System®'s elastomeric technology in terms of the external load (i.e., greater or similar number of repetitions and muscular activation, without modifying the MPV), the RPV and heart rate were also similar between both conditions. Only a significantly higher RPE was reported by the participants in the first repetition of both exercises. As happened in previous research comparing perceived and actual velocity (Babiloni-Lopez et al., 2022), the elastomeric properties of the garment allow the participants to equate the perceived and actual velocity of the first repetition. The nonsignificant differences between conditions in the RPE and RPV of the last repetition and the heart rate may be due to the maximum character of effort achieved in all the sets. Previous research has shown similar cardiovascular responses in front of similar characters of efforts at different intensities (Babiloni-Lopez et al., 2022; Colado et al., 2018). On the other hand, the higher RPE of the first repetition could be probably due to the greater resistance added by the Menatechpro System®'s elastomeric technology. This result is in line with previous research (Bergquist et al., 2018).

Finally, it is worth mentioning that the findings of the present study are limited to the studied variables and the sample size employed. Therefore, future studies with a bigger sample size and comparing athletes with different experience levels, physical fitness, including both sexes, and different exercises are warranted. Additionally, it would be interesting to analyse the potential effects of using other garments that include the Menatechpro System®'s elastomeric technology (i.e., models Progressive or Pro-sport, which provide 6 and 10 kilograms, respectively).

CONCLUSIONS

The findings of the present study are in line with previous research analysing elastic bands (Iversen et al., 2017). The use of the garment with the Menatechpro System®'s elastomeric technology could be providing an optimum neuromuscular stimulus in the training of the upper limb. Menatechpro System®'s elastomeric technology could be adding greater resistance after the sticking point without diminishing the MPV. This would represent a "*better*" stimulus at the end of the concentric phase and the beginning of the eccentric phase (Aboodarda et al., 2013). Additionally, depending on the movement pattern, Menatechpro System®'s elastomeric technology could be assisting during the first part of the concentric phase, increasing the performance until exhaustion (Andersen et al., 2019).

AUTHOR CONTRIBUTIONS

All authors have contributed positively to the research design, data collection, paper writing, and paper revision.

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DISCLOSURE STATEMENT

Dr. Juan C. Colado is a scientific and technical advisor of Menatechpro System® and so are the rest of the authors of the article.

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REFERENCES

Aboodarda, S. J., Hamid, M. S. A., Muhamed, A. M. C., Ibrahim, F., & Thompson, M. (2013). Resultant muscle torque and electromyographic activity during high intensity elastic resistance and free weight exercises. European Journal of Sport Science, 13(2), 155-163. https://doi.org/10.1080/17461391.2011.586438

Aboodarda, S. J., Page, P. A., & Behm, D. G. (2016). Muscle activation comparisons between elastic and isoinertial resistance: A meta-analysis. Clinical Biomechanics, 39, 52-61. https://doi.org/10.1016/j.clinbiomech.2016.09.008

Alix-Fages, C., Del Vecchio, A., Baz-Valle, E., Santos-Concejero, J., & Balsalobre-Fernández, C. (2022). The role of the neural stimulus in regulating skeletal muscle hypertrophy. European Journal of Applied Physiology, 122(5), 1111-1128. https://doi.org/10.1007/s00421-022-04906-6

Andersen, V., Fimland, M. S., Kolnes, M. K., Jensen, S., Laume, M., & Saeterbakken, A. H. (2016). Electromyographic comparison of squats using constant or variable resistance. Journal of Strength and Conditioning Research, 30(12), 3456-3463. https://doi.org/10.1519/JSC.0000000000001451

Andersen, V., Fimland, M. S., Mo, D.-A., Iversen, V. M., Larsen, T. M., Solheim, F., & Saeterbakken, A. H. (2019). Electromyographic comparison of the barbell deadlift using constant versus variable resistance in healthy, trained men. PloS One, 14(1), e0211021. https://doi.org/10.1371/journal.pone.0211021

Babiloni-Lopez, C., Gene-Morales, J., Saez-Berlanga, A., Ramirez-Campillo, R., Moreno-Murcia, J. A., & Colado, J. C. (2022). The use of elastic bands in velocity-based training allows greater acute external training stimulus and lower perceived effort compared to weight plates. International Journal of Environmental Research and Public Health, 19(24), Article 24. https://doi.org/10.3390/ijerph192416616

Bautista, I. J., Chirosa, I. J., Chirosa, L. J., Martín, I., González, A., & Robertson, R. J. (2014). Development and validity of a scale of perception of velocity in resistance exercise. Journal of Sports Science & Medicine, 13(3), 542-549.

Bergquist, R., Iversen, V. M., Mork, P. J., & Fimland, M. S. (2018). Muscle activity in upper-body single-joint resistance exercises with elastic resistance bands vs. Free weights. Journal of Human Kinetics, 61, 5-13. https://doi.org/10.1515/hukin-2017-0137

Calatayud, J., Borreani, S., Colado, J. C., Martin, F., & Rogers, M. E. (2014). Muscle activity levels in upper-body push exercises with different loads and stability conditions. The Physician and Sportsmedicine, 42(4), 106-119. https://doi.org/10.3810/psm.2014.11.2097

Calatayud, J., Borreani, S., Colado, J. C., Martin, F., Tella, V., & Andersen, L. L. (2015). Bench press and push-up at comparable levels of muscle activity results in similar strength gains. Journal of Strength and Conditioning Research, 29(1), 246-253. https://doi.org/10.1519/JSC.0000000000000589

Calatayud, J., Casaña, J., Martín, F., Jakobsen, M. D., Colado, J. C., Gargallo, P., Juesas, Á., Muñoz, V., & Andersen, L. L. (2017). Trunk muscle activity during different variations of the supine plank exercise. Musculoskeletal Science & Practice, 28, 54-58. https://doi.org/10.1016/j.msksp.2017.01.011

Calatayud, J., Vinstrup, J., Jakobsen, M. D., Sundstrup, E., Brandt, M., Jay, K., Colado, J. C., & Andersen, L. L. (2016). Importance of mind-muscle connection during progressive resistance training. European Journal of Applied Physiology, 116(3), 527-533. https://doi.org/10.1007/s00421-015-3305-7

Carlson, D. J., Inder, J., Palanisamy, S. K. A., McFarlane, J. R., Dieberg, G., & Smart, N. A. (2016). The efficacy of isometric resistance training utilizing handgrip exercise for blood pressure management: A randomized trial. Medicine, 95(52), e5791. https://doi.org/10.1097/MD.0000000000005791

Cohen, J. (2013). Statistical Power Analysis for the Behavioral Sciences. Academic Press. https://doi.org/10.4324/9780203771587

Colado, J. C., Mena, R., Calatayud, J., Flández, J., & Page, P. (2020). Effects of strength training with variable elastic resistance across the lifespan: A systematic review. Cultura, Ciencia y Deporte, 15(44), 147-164. https://doi.org/10.12800/ccd.v15i44.1458

Colado, J. C., Pedrosa, F. M., Juesas, A., Gargallo, P., Carrasco, J. J., Flandez, J., Chupel, M. U., Teixeira, A. M., & Naclerio, F. (2018). Concurrent validation of the OMNI-Resistance Exercise Scale of perceived exertion with elastic bands in the elderly. Experimental Gerontology, 103, 11-16. https://doi.org/10.1016/j.exger.2017.12.009

de Oliveira, P. A., Blasczyk, J. C., Souza Junior, G., Lagoa, K. F., Soares, M., de Oliveira, R. J., Filho, P. J. B. G., Carregaro, R. L., & Martins, W. R. (2017). Effects of elastic resistance exercise on muscle strength and functional performance in healthy adults: A systematic review and meta-analysis. Journal of Physical Activity & Health, 14(4), 317-327. https://doi.org/10.1123/jpah.2016-0415

Ferri-Caruana, A., Mollà-Casanova, S., Baquedano-Moreno, M., & Serra-Añó, P. (2022). Electromyographic activity of posterior kinetic chain muscles during hamstring strengthening exercises. Physical Therapy in Sport, 55, 205-210. https://doi.org/10.1016/j.ptsp.2022.04.008

Fleiss, J. L. (1986). The design and analysis of clinical experiments (John Wiley Sons).

García-Ramos, A., Suzovic, D., & Pérez-Castilla, A. (2021). The load-velocity profiles of three upper-body pushing exercises in men and women. Sports Biomechanics, 20(6), 693-705. https://doi.org/10.1080/14763141.2019.1597155

Gene-Morales, J., Flandez, J., Juesas, A., Gargallo, P., Miñana, I., & Colado, J. C. (2020). A systematic review on the muscular activation on the lower limbs with five different variations of the squat exercise. Journal of Human Sport and Exercise, 15(Proc4), 1277-1299. https://doi.org/10.14198/jhse.2020.15.Proc4.28

Gene-Morales, J., Gené-Sampedro, A., Salvador, R., & Colado, J. C. (2020). Adding the load just above the sticking point using elastic bands optimizes squat performance, perceived effort rate, and cardiovascular responses. Journal of Sports Science & Medicine, 19(4), 735-744.

Gene-Morales, J., Gené-Sampedro, A., Salvador-Palmer, R., & C. Colado, J. (2022). Effects of squatting with elastic bands or conventional resistance-Training equipment at different effort levels in post-exercise intraocular pressure of healthy men. Biology of Sport, 39(4), 895-903. https://doi.org/10.5114/biolsport.2022.109955

González-Badillo, J. J., Yañez-García, J. M., Mora-Custodio, R., & Rodríguez-Rosell, D. (2017). Velocity loss as a variable for monitoring resistance exercise. International Journal of Sports Medicine, 38(3), 217-225. https://doi.org/10.1055/s-0042-120324

Halson, S. L. (2014). Monitoring training load to understand fatigue in athletes. Sports Medicine, 44(S2), 139-147. https://doi.org/10.1007/s40279-014-0253-z

Hammami, R., Gene-Morales, J., Abed, F., Selmi, M. A., Moran, J., Colado, J. C., & Rebai, H. H. (2022). An eight-weeks resistance training programme with elastic band increases some performance-related parameters in pubertal male volleyball players. Biology of Sport, 39(1), 219-226. https://doi.org/10.5114/biolsport.2021.101601

Hermens, H. J., Freriks, B., Disselhorst-Klug, C., & Rau, G. (2000). Development of recommendations for SEMG sensors and sensor placement procedures. Journal of Electromyography and Kinesiology, 10(5), 361-374. https://doi.org/10.1016/S1050-6411(00)00027-4

Hinshaw, T. J., Stephenson, M. L., Sha, Z., & Dai, B. (2018). Effect of external loading on force and power production during plyometric push-ups. Journal of Strength and Conditioning Research, 32(4), 1099-1108. https://doi.org/10.1519/jsc.0000000000001953

Iversen, V. M., Mork, P. J., Vasseljen, O., Bergquist, R., & Fimland, M. S. (2017). Multiple-joint exercises using elastic resistance bands vs. conventional resistance-training equipment: A cross-over study. European Journal of Sport Science, 17(8), 973-982. https://doi.org/10.1080/17461391.2017.1337229

Joyner, M. J., & Dominelli, P. B. (2021). Central cardiovascular system limits to aerobic capacity. Experimental Physiology, 106(12), 2299-2303. https://doi.org/10.1113/EP088187

Kompf, J., & Arandjelović, O. (2016). Understanding and overcoming the sticking point in resistance exercise. Sports Medicine, 46, 751-762. https://doi.org/10.1007/s40279-015-0460-2

Lee, J., & Zhang, X. L. (2021). Physiological determinants of VO2max and the methods to evaluate it: A critical review. Science and Sports, 36(4), 259-271. https://doi.org/10.1016/j.scispo.2020.11.006

Mikus, C. R., Earnest, C. P., Blair, S. N., & Church, T. S. (2009). Heart rate and exercise intensity during training: Observations from the DREW Study. British Journal of Sports Medicine, 43(10), 750-755. https://doi.org/10.1136/bjsm.2008.046342

Naclerio, F., Rodríguez-Romo, G., Barriopedro-Moro, M. I., Jiménez, A., Alvar, B. A., & Triplett, N. T. (2011). Control of resistance training intensity by the OMNI perceived exertion scale. Journal of Strength and Conditioning Research, 25(7), 1879-1888. https://doi.org/10.1519/JSC.0b013e3181e501e9

Reimers, A. K., Knapp, G., & Reimers, C. D. (2018). Effects of exercise on the resting heart rate: A systematic review and meta-analysis of interventional studies. Journal of Clinical Medicine, 7(12). https://doi.org/10.3390/jcm7120503

Robertson, R. J., Goss, F. L., Rutkowski, J., Lenz, B., Dixon, C., Timmer, J., Frazee, K., Dube, J., & Andreacci, J. (2003). Concurrent validation of the OMNI Perceived Exertion Scale for resistance exercise. Medicine & Science in Sports & Exercise, 35(2), 333-341. https://doi.org/10.1249/01.MSS.0000048831.15016.2A

Saeterbakken, A. H., Andersen, V., & van den Tillaar, R. (2016). Comparison of kinematics and muscle activation in free- weight back squat with and without elastic bands. Journal of Strength and Conditioning Research, 30(4), 945-952. https://doi.org/10.1519/JSC.0000000000001178

Saez-Berlanga, A., Gargallo, P., Gene-Morales, J., Babiloni, C., Colado, J. C., & Juesas, A. (2022). Multicomponent elastic training improves short-term body composition and balance in older women. Scientific Journal of Sport and Performance, 1(1), 4-13. https://doi.org/10.55860/neqh2786

Soria-Gila, M. A., Chirosa, I. J., Bautista, I. J., Baena, S., & Chirosa, L. J. (2015). Effects of variable resistance training on maximal strength: A meta- analysis. Journal of Strength and Conditioning Research, 29(11), 3260-3270. https://doi.org/10.1519/JSC.0000000000000971

Suchomel, T. J., Nimphius, S., Bellon, C. R., & Stone, M. H. (2018). The importance of muscular strength: Training considerations. Sports Medicine (Auckland, N.Z.), 48(4), 765-785. https://doi.org/10.1007/s40279-018-0862-z

Suchomel, T. J., Nimphius, S., & Stone, M. H. (2016). The Importance of Muscular Strength in Athletic Performance. Sports Medicine, 46(10), 1419-1449. https://doi.org/10.1007/s40279-016-0486-0

Sundstrup, E., Jakobsen, M. D., Andersen, C. H., Zebis, M. K., Mortensen, O. S., & Andersen, L. L. (2012). Muscle activation strategies during strength training with heavy loading vs repetitions to failure. Journal of Strength and Conditioning Research, 26(7), 1897-1903. https://doi.org/10.1519/JSC.0b013e318239c38e

Taylor, J. L., Amann, M., Duchateau, J., Meeusen, R., & Rice, C. L. (2016). Neural Contributions to Muscle Fatigue. Medicine & Science in Sports & Exercise, 48(11), 2294-2306. https://doi.org/10.1249/mss.0000000000000923

