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Metabolic and Functional Profile of Premenopausal Women With Metabolic Syndrome After Training With Elastics as Compared to Free Weights

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Abstract

The aim of this study was to compare the effects of a strength training program (STP) using free weights (FW) versus elastic tubing (ET) in 62 premenopausal, sedentary women diagnosed with metabolic syndrome (MS). Participants were randomly assigned to the FW or ET experimental group (EG) or a control group whose members remained sedentary. Members of each EG followed their assigned STP for 12 weeks, and biomarkers (BMs) related to MS and motor function (MF) parameters were evaluated. Both EGs showed a significant reduction in C-reactive protein level and a positive trend in the other BMs. Almost all MF parameters increased significantly in both EGs. No positive changes were found in the CG. These results indicate that the implementation of an STP, with either FW or ET, improves both metabolic health and MF and should be considered part of the basic approach to health care in women.

Keywords

strength, elastic tubing, free weights, cardiovascular risk

Women between 45 and 55 years old are close to the end of their reproductive lives. The hormonal changes associated with menopause contribute to the development of metabolic risk factors such as dyslipidemia, insulin resistance, and increased abdominal fat (Orsatti, Nahas, Maesta, Nahas-Neto, & Burini, 2008), which are all possible triggers for various cardiovascular risk factors (Huebschmann et al., 2015). Conclusive scientific evidence demonstrates a relationship between physical inactivity and the presence of risk factors associated with metabolic syndrome (MS) and obesity (J. W. Kim & Kim, 2012). Moreover, regular exercise may reduce the loss of strength that is common among women in this age-group (Lauretani et al., 2003), in turn enhancing their physical performance (Clark & Manini, 2008) and metabolic health (Gudmundsdottir, Flanders, & Augestad, 2013).

Several studies have shown the effectiveness of resistance training in reducing cardiovascular risk and dynapenia in women of different ages, including the menopausal age-group (Colado, Garcia-Masso, Rogers, et al., 2012; Colado & Triplett, 2008; Martins et al., 2015). However, we could not find any previous experimental intervention programs comparing the effects of traditional devices (such as free weights [FWs] or machines) with novel devices (e.g., multifunctional training with elastic tubes) during muscular strength training. Therefore, the possible metabolic and functional adaptive effects of these novel types of strength training programs (STPs) in sedentary women aged 40–50 years with MS remain unknown.

Recent studies have confirmed that STPs using elastic tubes can create the same levels of muscle activation in both the trunk and the extremities as machines or FWs (Aboodarda, Hamid, Muhamed, Ibrahim, & Thompson, 2013; Jakobsen, Sundstrup, Andersen, Aagaard, & Andersen, 2013). In addition, STPs using elastic tubes may provoke higher intrinsic motivation among health practitioners advocating strength exercises

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Table 1. Baseline Descriptive Statistics of the Anthropometric and Cardiovascular Risk Variables.

Variable	*M*	*SD*
Body weight (kg)	77.01	14.14
Height (cm)	154.14	6.31
Body mass index (kg/m^2)	32.58	5.05
Percentage of fat mass	32.31	5.35
Waist circumference (cm)	95.35	9.21
Waist/hip ratio	0.87	0.05
Triglycerides (mg/dl)	150.05	76.32
Fasting glucose (mg/dl)	110.10	49.58

Note. N = 62.

(Polyte, Belando, Huéscar, & Moreno-Murcia, 2015). More specifically, José and Dal Corso (2016) recently suggested that training with elastic materials is ideal in health-care settings because they are as effective as traditional weights but much easier to transport and storage (in settings that often have very limited space) and significantly less expensive. Additionally, patients can easily acquire and use these low-cost, user-friendly materials in their own homes.

Several studies that incorporated the use of elastic tubes have demonstrated the efficacy of strength training in reducing cardiovascular risk and dynapenia in both young and menopausal women (Colado, Garcia-Masso, Rogers, et al., 2012; Colado & Triplett, 2008; Colado, Triplett, Tella, Saucedo, & Abellán, 2009). These studies aimed to control the participants' perception of effort by setting the range of target repetitions. Importantly, nursing units can easily incorporate training in these types of programs in both primary and secondary health care. However, relatively little is known about the effects of STPs with elastic materials at the premenopausal stage.

Against this backdrop, the objective of this study was to analyze the effects that STPs with different resistance equipment have on various metabolic and functional parameters in premenopausal women in a randomized clinical trial. Our subjects were participating in a program aimed at preventing complications associated with menopause that had been developed by a multidisciplinary group of midwives, nurses, and professionals specializing in physical education and sports. We hypothesized that implementation of an STP using a multifunctional training station that included elastic tubing (ET) would reduce cardiovascular risk and improve lipid profiles and functional fitness to the same degree as a FW STP in a cohort of sedentary premenopausal women.

Materials and Method

Participants

Participants comprised 62 women aged 40−50 years (46.47 ± 3.71 years; Table 1). All of them met the criteria to be categorized as premenopausal (Burger, Hale, Robertson, & Dennerstein, 2007), were sedentary, did not work outside the home, had MS (Marquezine, Oliveira, Pereira, Krieger, & Mill, 2008), and attended the Municipal Family Health Center in Valdivia (Chile). We randomly divided participants into three groups: (1) the experimental group (EG) using elastic tubes (ETG) comprising 22 participants, (2) the EG using FWs (bars and discs; FWG) with 20 participants, and (3) the control group (CG) comprising 20 participants who did not follow any STP and received no interventions. The exclusion criteria were (a) the presence of cardiovascular disease contraindicating exercise; (b) receipt of treatment to control any cardiovascular, metabolic, or musculoskeletal risk factors; (c) failure to attend the sessions scheduled in the study. As in previous studies (Colado, Garcia-Masso, Rogers, et al., 2012; Colado et al., 2009), we instructed all participants to refrain from modifying their behavior or diet and doing any other type of physical exercise for the duration of the study. To ensure strict compliance with participation instructions, we monitored these aspects of the study weekly by asking the women to complete a daily diary of activities and diet. The ethics committee at the Chilean Ministry of Health approved the research project, and the interdisciplinary council in Valdivia (Chile) granted permission. Participants signed an informed consent form and participated on a voluntary basis.

Variables and Procedures

Anthropometry. We performed anthropometric tests to describe the sample prior to administering the functional aptitude tests (Guillén del Castillo & Linares, 2002). We used an eight-polar bioelectrical impedance system (BC-418, Tanita Corp., Tokyo, Japan) to determine fat mass percentage and body weight (Colado & Triplett, 2008; Colado et al., 2009). We measured height and waist circumference according to International Society for the Advancement in Kinanthropometry recommendations (Stewart & Sutton, 2012).

Metabolic parameters. A certified clinical laboratory assayed the metabolic health variables using standard techniques with 12-hr fasting blood samples. Qualified nurses withdrew the blood samples according to the procedures established by health authorities. They performed venipuncture using 32-gauge disposable hypodermic needles attached to disposable 10-ml plastic syringes and then secured sterile gauze soaked in 96-degree ethyl alcohol to the venipuncture site with compression tape.

An automated system (Roche, Cobas C-311 analyzer) was used to analyze the chemical blood parameters. The lipid profile (total cholesterol, low-density lipoprotein cholesterol [LDL-c], and triglycerides) was analyzed using an enzymatic colorimetric test with a Shimadzu UV-160 dual beam model spectrophotometer. An immunoturbidimetry test was used to determine levels of C-reactive protein, glucose, and glycosylated hemoglobin (HbA1c) biomarkers (BMs) using the automatic biochemistry and immunoturbidimetric BT 3500 analyzer. Enzyme Type 1 reagents were used in all of these

Table 2. Exercises Used in Each of the Sessions.

Upper Limb training	Lower Limb Training
Horizontal chest press on fitball	Front lunge
Biceps curl	Lateral lunge
Horizontal French press on fitball	Half squat
Military press sitting on fitball	—
Vertical rowing	—
Inclined rowing	—
Reverse fly	—

tests, and all the parameters were evaluated and analyzed before and after the intervention.

Functional fitness parameters. Although gold standard laboratory-based measurements are most desirable for assessing fitness parameters, some field tests have established reliability and validity for use in particular types of subjects and age-groups to assess physical performance variables (Cancela, Ayán, Gutiérrez-Santiago, Prieto, & Varela, 2012; Rikli & Jones, 1999). In the present study, we used field tests that had been previously validated.

We measured flexibility in centimeters using the sit-and-reach test as described by Lemmink, Kemper, Greef, Rispens, and Stevens (2003). For balance, we recorded the number of supports and falls for the unipedal dominant-leg balance test described by Lopez (2002). To assess general coordination, we measured gait and balance in seconds using the 3-min timed up-and-go test (Bischoff et al., 2003). We used the half-squat test with a load cell to measure maximal voluntary isometric strength of the lower limbs (Dugan, La Doyle, Humphries, Hasson, & Newton, 2004). We used a similar protocol to evaluate the maximal voluntary isometric strength of the upper limbs with the upright row test (Smith & Loschner, 2002). We recorded strength endurance of the front and back of the trunk musculature in seconds using the prone bridge test and side bridge test (Bliss & Teeple, 2005). For evaluation of aerobic capacity in meters, we used the 6-min walk test (Casanova et al., 2011). We evaluated and analyzed all parameters before and after the intervention.

Experimental Design and Training Protocol

We designed a standard STP and applied it equally to the ETG and FWG across the 12-week intervention (which involved 3–4 sessions per week, with 3–4 sets of 10–15 repetitions per exercise). The first 2 months of the program focused on developing local muscular endurance resistance, and the last month focused on developing muscle hypertrophy. Sessions were organized in a circuit of 10 specific exercises for upper limbs, lower limbs, and lumbo-pelvic stability (Table 2). We conducted three familiarization sessions prior to starting the program to ensure proper and safe execution with optimal adaptation to the intensity of each workout. We also designed a warm-up (lasting a maximum of 10 min) that included a light trot, joint mobility exercises, and stretching. We controlled the intensity for the elastic-tubing exercises from the beginning to the end of the program using a Resistance Perceived Effort Scale (Colado, Garcia-Masso, Triplett, et al., 2012) with an incremental range of 7–9. We allowed 30 s of active between exercises (jogging in place and soft tissue joint mobility for upper limbs) and 60 s recovery between sets (completion of the whole circuit). Nurses and technicians with extensive experience with physical activity supervised the exercises at all times.

Exercise Equipment

The ETG used a multifunction training station (111.8 cm long, 61 cm wide, and 5.1 cm high) with different types of elastic tubes anchored to it in several positions (TheraBand Exercise Station, Hygienic Corporation, Akron, OH). This training station also had anchor points for affixing elastic tubes with up to three different levels of viscoelastic hardness (30.5 cm of length) that could be attached to either individual handles or a bar. We developed the prescribed exercises by modifying the types of anchor and material and by adding a fitball. The FWG used bars, discs, and standard dumbbells, and as with the ETG STP, we used a fitball for assistance in certain exercises. The intensity was modified while the participant did the exercise by changing the equipment according to the procedure followed in previous studies (Colado et al., 2009, 2010; Colado & Triplett, 2008).

Statistical Analysis

We analyzed the data using the Statistical Program for the Social Sciences (SPSS, version 20.0; SPSS Inc., Chicago, IL). All the variables met the assumption of normality (Kolmogorov–Smirnov test) and homoscedasticity (Levene test). We used standard statistical methods to calculate the mean and standard deviation as a measurement of the central tendency and dispersion, respectively. To establish the effects of the training program on the dependent variables, we applied an analysis of variance of repeated one-way measurements. When we found differences, we applied post hoc Bonferroni analysis. A 95% confidence level (significance of $p < .05$) was accepted for all the analyses.

Results

There were no significant differences in the blood BMs or functional parameters before the start of the intervention.

Effects of the Intervention on Blood BMs

C-reactive protein level decreased significantly from baseline to after the intervention in both the ETG and FWG ($p < .05$) and also compared with the control group ($p < .05$; Table 3). HbA1c was significantly reduced in both EGs and significantly augmented in the CG, although we did not find significant between-group differences. We found a similar trend for the CG for the other metabolic parameters (not statistically

Table 3. Pre and Postintervention Metabolic Parameter Results by Study Group.

	ETG ($n = 22$)			FWG ($n = 20$)			CG ($n = 20$)		
Variable	Pretest *M* (*SD*)	Posttest *M* (*SD*)	Δ%	Pretest *M* (*SD*)	Posttest *M* (*SD*)	Δ%	Pretest *M* (*SD*)	Posttest *M* (*SD*)	Δ%
C-reactive protein, mg/L	0.43 (0.34)	$0.28^{\dagger}$ (0.24)	−33.96*	0.37 (0.21)	$0.28^{\dagger}$ (0.41)	−22.98*	0.42 (0.38)	047 (0.48)	+9.41
Glycosylated hemoglobin, mg/L	5.80 (1.05)	5.41 (0.79)	−6.74*	5.38 (0.32)	5.21 (0.30)	−3.03*	6.09 (1.66)	6.22 (1.59)	+3.49*
LDL-c, mg/dl	142.36 (31.53)	128.27 (24.21)	−9.9*	137.35 (40.06)	135.85 (33.44)	−1.09	145.65 (48.80)	147.05 (48.73)	+0.96
Total cholesterol, mg/dl	217.91 (39.69)	207.23 (25.88)	−4.61	223.10 (35.32)	217.55 (35.16)	−2.49	229.60 (59.59)	231.40 (52.43)	+0.78

Note. Δ% = percentage difference between pre- and posttest; CG = control group; ETG = elastic-tube training group; FWG = free-weight training group; LDL-c = low-density lipoprotein cholesterol; *M* = median; *SD* = standard deviation.
*$p < .05$, statistically significant intragroup difference from pre- to posttest. $^{\dagger}p < .05$, statistically significant difference relative to the control group.

significant) at the end of the intervention period. For the ETG, we also found a significant reduction in LDL-c ($p < .05$) from baseline to postintervention as well as a trend toward reduction in all of the metabolic parameters (not statistically significant). There were no statistically significant within- or between-group differences in total cholesterol after the training program intervention. There were no significant differences between the two EGs in blood BMs.

Effects of the Intervention on the Functional Parameters

All of the functional variables analyzed (Table 4) showed improved intragroup values in both the ETG and FWG ($p < .05$). An increase in physical performance ability with respect to the CG was also noted in each of the EGs, and there was no significant difference between the ETG and FWG. In other words, there was a significant increase in general coordination, maximal voluntary isometric strength of the upper and lower limbs, the local muscular endurance of the lateral and ventral trunk area, and aerobic capacity ($p < .05$) in the EGs relative to the control group. None of these functional skills significantly changed in the CG.

Discussion

In the present study, we evaluated the effects of a physical exercise STP with an innovative device, specifically the elastic-tube multifunction training station, compared to those of an STP with traditional FW devices. We found improvements in blood BMs and functional aptitude parameters in premenopausal women with MS in both exercise groups after the intervention, thus confirming our initial hypothesis. Our results provide evidence that training with elastic materials produces improvements in both metabolic parameters and functional fitness (Paditsaeree, Intiraporn, & Lawsirirat, 2014) equal to those achieved using other traditional devices such as FWs (Colado et al., 2009, 2010).

Previous studies have shown that moderate- to high-intensity exercise produces improvements in insulin sensitivity, fat oxidation, and triglyceride and LDL-c concentrations in sedentary overweight or obese adults (Gondim et al., 2015; Whyte, Ferguson, Wilson, Scott, & Gill, 2013). Of note, there was a significant decrease in HbA1c in both EGs in the present study. While LDL-c level decreased significantly by 9.9% in the ETG and nonsignificantly by 1.09% in the FWG from pre- to postintervention, it increased nonsignificantly by 0.96% in the CG. This finding contrasts with that of Behall, Howe, Martel, Scott, and Dooly (2003) who did not find any differences in LDL-c levels after groups of overweight and sedentary pre- or postmenopausal women performed exercise for 3 months (aerobic or strength). Similarly, Rodríguez et al. (2005) found no changes in lipid profiles after an STP in sedentary adults with high cholesterol. However, our results agree with other work that indicated that STP improved the lipid profile of premenopausal women, reducing both total cholesterol and LDL-c and increasing high-density lipoprotein cholesterol (HDL-c; Prabhakaran, Dowling, Branch, Swain, & Leutholtz, 1999). In a study analogous to our own, Park et al. (2015) recently examined how STP with elastic bands affected glucose, body composition, and physical fitness (isometric strength of upper and lower limbs measured as biceps and squat curls) in adult women with type 2 diabetes. After 12 weeks of intervention, all variables were significantly improved. Likewise, postmenopausal women who participated in an exercise program similar to the program in the present study achieved significant improvements in total cholesterol/HDL-c ratio and a reduction in triglyceride and LDL-c levels (Colado et al., 2009).

In addition, both groups participating in the STP in the present study had significantly reduced C-reactive protein levels by an average of 28.47% compared to the CG. This finding is noteworthy because C-reactive protein is one of the BMs that help to define cardiovascular risk and systemic inflammation (Fischer, Berntsen, Perstrup, Eskildsen, & Pedersen, 2007). Previous researchers have reported comparable findings for

Table 4. Pre- and Postintervention Functional Parameter Results by Study Group.

	ETG ($n = 22$)			FWG ($n = 20$)			CG ($n = 20$)		
Variable	Pretest *M* (*SD*)	Posttest *M* (*SD*)	Δ%	Pretest *M* (*SD*)	Posttest *M* (*SD*)	Δ%	Pretest *M* (*SD*)	Posttest *M* (*SD*)	Δ%
Flexibility (cm)	23.18 (8.52)	29.27 (8.69)	+26.27*	26.65 (7.42)	33.05 (7.87)	+24.01*	27.20 (8.80)	27.95 (8.56)	+2.75
Balance (no. of supports and falls)	2.23 (2.04)	0.68 (1.43)	−69.51*	1.30 (1.92)	0.45† (1.19)	−65.39*	2.65 (6.38)	3.05 (5.53)	+15.09
General coordination (s)	5.21 (0.51)	4.43† (0.44)	−9.26*	5.32 (0.80)	4.52† (0.41)	−15.13*	5.80 (0.57)	5.73 (0.86)	−1.19
MVISUE (Newtons)	244.13 (113.98)	339.25† (148.68)	+38.96*	257.20 (122.15)	328.05† (100.25)	+31.42*	222.15 (80.99)	221.50 (64.70)	−0.29
MVISLE (Newtons)	479.16 (263,55)	724,26† (167,28)	+51.15*	622.37 (223.15)	714.74† (140.76)	+14.77*	524.51 (155.96)	497.07 (144.25)	−5.23
Prone bridge (s)	56.47 (23.18)	98.53† (60.13)	+74.47*	51.91 (21.14)	114.54† (100.29)	+120.64*	47.21 (25.52)	44.90 (20.37)	−4.9
Side bridge (s)	66.88 (38.74)	107.35† (73.96)	+60.49*	66.19 (31.43)	135.83† (88.01)	+105.20*	62.488 (38.42)	58.94 (30.59)	−5.66
Aerobic capacity (m)	571.68 (36.76)	616.14† (46.87)	+7.77*	595.70 (68.52)	634.95† (44.85)	+6.59*	564.9 (67.44)	561,80 (71.29)	−.055

Note. Δ% = percentage difference between pre- and posttest; CG = control group; ETG = elastic-tube training group; FWG = free-weight training group; *M* = median; MVISUE and MVISLE = maximum voluntary isometric strength of the upper and lower extremities, respectively; *SD* = standard deviation.

*$p < .05$, intragroup statistically significant difference at pre- and posttest. $^{\dagger}p < .05$, statistically significant difference compared to the control group.

similar programs in different age-groups (Donges, Duffield, & Drinkwater, 2010; Phillips et al., 2012). However, very few scientific studies have specifically measured the changes that occur in C-reactive protein level after implementing an STP specifically with elastic materials, and the few that have mostly found no positive effects (K. Kim, Lee, Jeon, Jeong, & Kye Soon, 2010; So et al., 2013). This absence of response may be because there were no precise controls on the intensity of the elastic tube or band training (Martins et al., 2015). Nevertheless, the present study provides evidence that the use of appropriate training methodology, with either elastic tubes or traditional materials such as FWs, can reduce cardiovascular risk and systemic inflammation.

Both types of training devices were also effective in producing positive functional adaptations; however, there were some differences between them. The anchored elastic tube device resulted in 36.4% greater strength adaptations of the lower extremities, while FW resulted in greater local muscular endurance of the trunk. These differences were not significant; however, they are in line with recent findings about stability and body positioning when handling the resistance during strength exercises (Behm & Colado, 2012). These findings suggest that variation in training devices during exercise programs might help to maximize physical adaptations (Colado et al., 2011).

This study did have some limitations that future researchers should consider and address in subsequent studies. For one thing, a longer intervention might have allowed for the detection of significant differences between the EGs in both the functional and metabolic values. It would also be interesting to compare anthropometric parameters at the start and end of the program. Similarly, causative factors of MS, continence, and bone mineral density could also be analyzed. Longitudinal studies are needed to analyze additional biomedical parameters and physical and psychosocial variables related to the performance of STPs using alternative materials; these should focus on improving the quality of life and well-being of premenopausal women.

Conclusion

In the present study, we demonstrated that a 12-week STP using a multifunctional training station with elastic tubes improved the metabolic health and functional aptitude of premenopausal women with moderate cardiovascular risk (i.e., with MS) to a similar degree as did an STP using traditional FW equipment. Importantly, these nontraditional devises based on ET are highly practical in that they are low cost, accessible, effective, and motivating. Qualified health personnel could readily use these materials to develop programs to improve patient strength and health risk factors and easily supervise such programs (Colado & Triplett, 2008). Our findings thus provide scientific evidence, supporting the use of practical tools that health professionals could use to help prevent and treat cardiovascular and metabolic diseases in sedentary premenopausal women. In addition, the study demonstrates collaborative strategies that can be used between different health and nonhealth professionals to help prevent disease and improve patients' quality of life. Nurses, in particular, can play a key role in coordinating physical exercise interventions.

Authors' Contribution

Jorge Flandez contributed to conception, design, and acquisition; drafted the manuscript; critically revised the manuscript for important intellectual content; gave final approval; and agrees to be accountable for all aspects of work ensuring integrity and accuracy. Noelia Belando contributed to conception and design; drafted the manuscript; gave final approval; and agrees to be accountable for all aspects of work ensuring integrity and accuracy. Pedro Gargallo contributed to conception and design; drafted the manuscript; gave final approval; and agrees to be accountable for all aspects of work ensuring integrity and accuracy. Julio Fernández-Garrido contributed to conception and design; critically revised the manuscript for important intellectual content; gave final approval; and agrees to be accountable for all aspects of work ensuring integrity and accuracy. Ronald A. Vargas-Foitzick contributed to conception and design; critically revised the manuscript for important intellectual content; gave final approval; and agrees to be accountable for all aspects of work ensuring integrity and accuracy. Jose Devis-Devis contributed to conception and design; critically revised the manuscript for important intellectual content; gave final approval; and agrees to be accountable for all aspects of work ensuring integrity and accuracy. Juan C. Colado contributed to conception, design, analysis, and interpretation of data; drafted the manuscript; critically revised the manuscript for important intellectual content; gave final approval; and agrees to be accountable for all aspects of work ensuring integrity and accuracy.

Declaration of Conflicting Interests

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