RBCDH Brazilian Journal of KINANTHROPOMETRY and Human Performance

DOI: http://dx.doi.org/10.5007/1980-0037.2013v15n4p427

original article

Effects of a low intensity strength training program on overweight/obese and premenopausal/menopausal women

Efeitos do treinamento de força de baixa intensidade em mulheres com sobrepeso/obesidade e pré-menopausa/menopausa

Cristian Álvarez[1]
Rodrigo Ramírez Campillo[2]

Abstract – Obesity-related complications may be compounded by the detrimental consequences of menopause. Strength training programs may have an impact on this relationship. Our objective was to examine strength (1RM) and kinanthropometric alterations for overweight/obese pre- and menopausal women who participated in a strength program. Methods: 35 women were separated into: overweight premenopausal (n=8), obese premenopausal (n=9), overweight menopausal (n=8) and obese menopausal (n=10) categories. Participants attended a strength program for 8 weeks. Kinanthropometric characteristics and 1RM were determined at baseline, week 4 (except 1RM) and week 8. Results: All groups reduced ($p< 0.05$) body weight, body mass index (BMI), skinfolds and waist circumference. Furthermore, all groups achieved an increase ($p< 0.05$) in 1RM. When grouped per menopausal state or BMI, a more significant increase in strength was seen in menopausal and obese subjects. A significant correlation was observed for menopausal state, BMI and strength. The strength changes were significantly superior vs. kinanthropometric changes. Within kinanthropometric changes, skinfolds exhibit a more significant reduction vs. body weight, BMI and waist circumference. Conclusions: all groups showed changes in strength and kinanthropometric parameters. Strength adaptations were superior in menopausal and obese women. The strength adaptations exhibit a superior magnitude vs. kinanthropometric changes. In short term, a strength program may lead to important health and functional benefits, especially in menopausal or obese women.

Key words: Obesity; Menopause; Resistance training.

Resumo – *As complicações relacionadas à obesidade podem ser agravadas pelas consequências prejudiciais da menopausa. Programas de força podem ter um impacto sobre esta relação. O objetivo foi examinar alterações cineantropométricas e força em mulheres com excesso de peso/obesas e pré-menopausa/menopausa que participaram de um programa de força. Participaram do estudo 35 mulheres que foram separadas em grupos: excesso de peso pré-menopausa (n = 8), obesas pré-menopausa (n = 9), excesso de peso menopausa (n = 8) e obesas menopausa (n = 10). Os sujeitos foram treinados durante oito semanas. Características cineantropométricas e de força foram analisadas no início, na quarta e oitava semana (exceto força). Os grupos conseguiram uma redução no peso corporal, IMC, da gordura subcutânea e circunferência da cintura. Todos os grupos obtiveram um aumento ($p < 0,05$) na força máxima. Um aumento de força significativamente maior foi observado em mulheres obesas ou na menopausa. Uma correlação significativa foi observada para estado menopausal, IMC e força. As mudanças de força foram significativamente mais elevadas versus mudanças cineantropométricas. Dentro das mudanças cineantropométricas, a gordura subcutânea apresentou uma redução mais significativa versus o peso corporal, IMC e circunferência da cintura. Pode-se concluir que os grupos apresentaram alterações nos parâmetros cineantropométricos e de força. As adaptações de força foram superiores em mulheres na menopausa e obesas. As adaptações de força apresentaram uma magnitude superior versus alterações cineantropométricos. Em curto prazo, o programa de treinamento de força pode conduzir a importantes benefícios na saúde e funcionais, especialmente, em mulheres na menopausa ou com obesidade.*

Palavras-chave: *Menopausa; Obesidade; Treinamento de resistência.*

1 Centro de Salud Familiar de Los Lagos, Programa de Promoción de la Salud, Región de Los Ríos, Chile.

2 Universidad de Los Lagos. Departamento de Ciencias de la Actividad Física. Región de Los Lagos, Chile.

Received: 23 April 2012
Accepted: 14 January 2013

INTRODUCTION

The ENS survey, conducted in 2009-2010, has provided evidence that more than 64% of women in Chile, older than 17 years, are overweight or obese[1].

Obesity/overweight is a highly prevalent chronic disease associated with numerous co-morbidities including cardiovascular disease, diabetes, hypertension, some types of cancer[2,3], and functional/mobility impairment[4,5].

Moreover, obesity-related complications may be compounded by the detrimental consequences of menopause[4,6]. The confluence of aging and obesity may create an ideal environment for skeletal muscle catabolism and decline in physical function (strength). During menopause there is an altered hormonal status (less anabolic), that is aggravated by obesity, leading to decreased muscle mass and development of sarcopenic obesity, a condition that may be translated into a reduced ability to perform daily activities such as walking, chair rising, stair climbing, body transfer, among others[7].

The relationship between obesity, increased age and physical disability will increase from the year 2012[8] onwards. Treatment for obesity has proven difficult, with a high proportion of those who lose weight, subsequently regaining much of the weight loss[9]. The high prevalence of obesity, the increasing relationship between obesity-aging-physical disability and the lack of treatment success argue for the evaluation of strategies to prevent/treat overweight and obesity. There is widespread consensus that lifestyle changes, such as increased skeletal muscle activities, are the cornerstones in both prevention and treatment of obesity and the metabolic syndrome[10].

Strength training must be an integral part of adult fitness programs[11]. Unlike aerobic exercise, which results in significant increases in energy expenditure during, and for a short time following cessation of the activity, the energy expenditure during strength training is relatively low[12,13], but the increase in energy expenditure after cessation of the activity may be elevated[14]. A strength training session of minimum volume (11 min per session) demonstrated a significant effect on post exercise energy expenditure and fat oxidation[15]. Furthermore, strength training has demonstrated a beneficial effect on body composition in overweight/obese postmenopausal[16] and premenopausal women[17,18].

The objective of the present study was to determine the effects of a guided short duration low intensity (but metabolically strenuous) strength training program with kinanthropometric measurements and muscle strength in overweight/obese and premenopausal/menopausal women. In contrast to other studies published so far, we investigated whether such an intervention would produce different results in premenopausal versus menopausal women. In addition, the effects of overweight/obesity on the outcome of the intervention were also assessed.

METHODS

Thirty-five women from Las Huellas and Folilco Family Health Center (Los Lagos city, Chile) were enrolled in this 8 week intervention. Inclusion criteria: female gender, sedentary lifestyle (exercise <30 min/week), glycemia <100 mg/dl, age between 18 and 65 years, body mass index (BMI) between 25 and 35, and absence of contraindication to exercise. Also, direct descendants of parents with diabetes type 2 were included, because there is little scientific evidence regarding their response to a strength training program. All subjects completed a comprehensive medical examination and routine blood tests. Subjects were excluded if they had arrhythmia, tachycardia and/or chronic obstructive pulmonary disease, osteoarticular disease, ischemia; or were taking drugs or medication that affected body weight or metabolic variables. Seventeen participants were premenopausal, 18 were classified menopausal (41 – 68 years). Menopause classification was performed by anamnesis and hormonal analysis. If follicle-stimulating hormone (FSH) and luteinizing hormone (LH) were higher than 20 IU/ml and estradiol <30 pmol/l participants were classified as menopausal[19]. Sixteen participants were classified as overweight (BMI 25-29.8 kg/m^2) and nineteen were classified as obese (BMI 29.9-35 kg/m^2)[1].

Participants were divided into four groups: overweight premenopausal (OvPre, 8 women, age 29.9 ± 5.4 years, BMI 28.0 ± 1.4 kg/m^2), obese premenopausal (ObPre, 9 women, age 31.1 ± 4.8 years, BMI 32.8 ± 2.2 kg/m^2), overweight menopausal (OvM, 8 women, age 48.1 ± 6.4 years, BMI 28.0 ± 1.5 kg/m^2), and obese menopausal (ObM, 10 women, age 51.4 ± 8.5 years, BMI 35.1 ± 2.8 kg/m^2). Sample size was computed according to observed changes in 1RM (delta=5,1 kg; d.s=1) in a group of postmenopausal women submitted to strength training[19]. A total of 8 participants per group would yield a power of 80% and a ά of 0,05.

Written informed consent was given for all subjects; the study protocol was approved by the ethical committee of the Los Lagos Family Health Center (Los Rios Region, Chile) and the Physical Activity Sciences Department of Los Lagos University (Los Lagos Region, Chile).

Data collected at baseline, and at the end of weeks 4 and 8, included body weight, height, BMI, waist circumference, and skinfolds (triceps, subscapular, iliac crest, medial calf). Maximal strength (1RM) in squat (SQ), bent row (BR), shoulder press (ShP) and biceps curl (BC) exercises were also assessed at baseline, and at the end of week 8.

All subjects were instructed not to change their dietary or physical activity habits during the 8 week intervention period.

Anthropometry

Height was measured while subjects were barefoot with a professional stadiometer (Health o Meter®, USA), recorded to the nearest 0.1 cm. Weight was measured with the participants wearing light clothing or underwear, and was recorded to the nearest 0.01 kg using a digital scale (OMRON®, Model HBF-INT). BMI was calculated according to weight divided by height squared (kg/m^2). Waist circumference was measured at the level midway between the lowest rib margin and the iliac crest to the nearest 0.5 cm, with a flexible and inextensible metric tape and precision of 0.1 cm

(Hoechstmass®, West Germany 1-150 cm). All kinanthropometric measurements (including skinfolds and waist circumference) were determined by the ISAK anthropometric protocol[20]. All the measurements were obtained by the same person, with a certified ISAK level III.

Maximal strength test (1RM)

Maximal strength (1RM) of the lower (SQ) and upper body (BC, ShP, BR) was determined with free weight equipment, according to previous recomendations[21]. Previous to the 1RM test, subjects took part in 3 familiarization sessions (over a 1 week period), where the correct execution technique of the exercises performed was stressed. All measurements were taken at baseline and at week 8.

Strength training

Subjects attended twice-weekly 24-40 minute guided low intensity (but metabolically strenuous) strength training sessions during eight weeks. The training sessions were supervised by a trained exercise counselor. Adherence was assessed by participant attendance at the sessions. Adherence was good, as participants attended more than 80% of the sessions. Participants completed 4 strength exercises each session (SQ, BR, ShP and BC). The training program considered the progressive overload principle. During weeks 1-3 subjects completed 3 series for each exercise, with 20%1RM. During weeks 4-6 subjects completed 4 series for each exercise with 25% 1RM. The last 2 weeks, subjects completed 5 series for each exercise with 30%1RM. Repetitions in each series were completed until voluntary exhaustion (usually 1 minute of muscular work). A rest period of one minute was allowed between series and exercises.

Statistical analysis

Data is presented as mean ± standard deviation. The Shapiro-Wilk´s W and Levene´s tests were applied to determine normal distribution and homogeneity of variances, respectively. All study variables had a normal distribution. Therefore, ANOVA 4 × 2 (groups × time) repeated measurements were used to determine differences (in time or between groups) for the dependent variables. When a significant F value was achieved across time or between groups, Ficher LSD post hoc procedures were performed to locate the pairwise differences between the means. One way ANOVA was applied to determine differences between groups for the percentage modifications in time of the dependent variables. T-test for independent samples was used to determine significant differences between the percentage modifications of the dependent variables (variables were treated as independent samples). Pearson´s correlation was used to establish the relationship between age, body weight, BMI, waist perimeter, skinfolds and 1RM modification. All statistical analysis was applied through the computational software STATISTICA (version 6.0, StatSoft, Inc, Tulsa, Oklahoma, USA). Statistical significance was set at $p<0.05$.

RESULTS

Adherence to the 8 week strength training program was good (OvPre 92%, ObPre 93%, OvM 90% and ObM 95%) and no dropouts were reported.

The descriptive characteristics of subjects at baseline and at the end of weeks 4 and 8 are summarized in Table 1.

When grouped for menopausal state (data not shown) at baseline, body weight, BMI, skinfolds, waist circumference, and maximal strength, did not differ between pre- and menopausal women. On the other hand, when grouped per BMI (data not shown), body weight, BMI, waist circumference, and subscapular skinfolds were different at baseline between overweight and obese women.

Body weight, BMI, waist circumference and skinfolds (triceps, subscapular, iliac crest, calf) were reduced in all groups ($p<0.05$), while maximal strength of the upper (BC, ShP, BR) and lower body (SQ) increased significantly ($p<0.05$) after the 8 week strength training intervention (Table 1).

Some of the kinanthropometric variables (body weight, BMI, waist circumference, subscapular fat-fold) showed a rapid modification (week 4) with training (Table 1).

No significant differences were observed between groups for the percentage changes (between weeks 0 to 8) of the dependent variables, except for BR, where ObM and OvM had a more significant increase than OvPre, and OvM had a more significant increase than ObPre.

When grouped per BMI, obese subjects had a more significant increase in maximal strength in the BC (27.3%) and BR (27.5%) exercises vs. overweight subjects (20.1 and 18.7%, respectively). All the other variables modifications were similar between obese and overweight subjects.

When grouped per menopausal state, menopausal women had a more significant increase in maximal strength in the BC (27.2%), ShP (27.7%) and BR (27.9%) exercises vs. premenopausal subjects (20.6, 22.1 and 18.9%, respectively). All the other variables' modifications were similar between menopausal and postmenopausal subjects.

Age and BMI showed no significant correlation with kinanthropometric changes. Only the 1RM increase in SQ showed a significant correlation ($r=0.45$; $p<0.007$) with age. BMI only correlates with 1RM increase in ShP ($r=0.37$; $p=0.03$) and BR ($r=0.47$; $p=0.005$).

When grouped as a whole, the percentage change of body weight (-2.4%) and BMI (-2.4%) during the 8 week intervention was significantly less than the percentage change of waist circumference (-4.3%) and the four skinfolds (-13.5, -14.5, -16.9 and -12.3% for triceps, subscapular, iliac crest and calf, respectively). The waist circumference percentage change was significantly less than the four skinfolds percentage changes. There was no significant difference between the percentage changes of the four skinfolds. The percentage change in maximal strength in BC (24%), ShP (26%), SQ (23.5%) and BR (23.5%) was significantly superior vs. all other variable changes. No significant differences were observed between the percentage changes of maximal strength in the four exercises.

Table 1. Individual, kinanthropometric and strength characteristics of subjects.

Variable	Test	OvPre (n= 8)	ObPre (n=9)	OvM (n= 8)	ObM (n= 10)
Age (years)	Pre	29.9 ± 5.4$^{ObM\ OvM}$	31.1 ± 4.88 $^{ObM\ OvM}$	48.1 ± 6.4 $^{OvPre\ ObPre}$	51.4 ± 8.5 $^{OvPre\ ObPre}$
Height (m)	Pre	1.56 ± 0.05 ^{ObM}	1.58 ± 0.06 ^{ObM}	1.56 ± 0.05	1.50 ± 0.07 $^{OvPre\ ObPre}$
Body Weight (kg)	Pre	68.9 ± 6.55 $^{ObPre\ ObM}$	82.6 ± 11 $^{OvPre\ ObPre}$	68.0 ± 5.2 $^{ObPre\ MAOb}$	79.3 ± 8.7 $^{OvPre\ OvM}$
	Post$_{4week}$	67.7 ± 6.75* $^{ObPre\ ObM}$	81.1 ± 9.1* $^{OvPre\ OvM}$	67.0 ± 5.7 $^{ObPre\ ObM}$	77.6 ± 8.7* $^{OvPre\ OvM}$
	Post$_{8week}$	67.0 ± 6.75* $^{ObPre\ ObM}$	80.4 ± 8.6* $^{OvPre\ OvM}$	66.7 ± 5.6* $^{ObPre\ ObM}$	77.3 ± 8.9* $^{OvPre\ OvM}$
	%	-2.7	-3.1	-1.9	-2.5
BMI (kg/m^2)	Pre	28.0±1.4 $^{ObPre\ ObM}$	32.8±2.2 $^{OvPre\ OvM}$	28.0±1.5 $^{ObPre\ ObM}$	35.1±2.8 $^{OvPre\ OvM}$
	Post$_{4week}$	27.5±1.4* $^{ObPre\ ObM}$	32.2±1.7* $^{OvPre\ OvM}$	27.6±1.5* $^{ObPre\ ObM}$	34.3±2.7* $^{OvPre\ OvM}$
	Post$_{8week}$	27.3±1.3* $^{ObPre\ ObM}$	31.9±1.6* $^{OvPre\ OvM}$	27.5±1.6* $^{ObPre\ ObM}$	34.2±2.7* $^{OvPre\ OvM}$
	%	-2.5	-2.7	-1.7	-2.5
Girth (cm)					
Waist	Pre	95.7±5.3 $^{ObPre\ ObM}$	108.9±5.8 $^{OvPre\ OvM}$	101.9±6.5 $^{ObPre\ ObM}$	113.3±8.2 $^{OvPre\ OvM}$
	Post$_{4week}$	93.6±6.5* $^{ObPre\ ObM}$	106.4±5.8* $^{OvPre\ OvM}$	99.2±6.9* $^{ObPre\ ObM}$	110.3±7.9* $^{OvPre\ OvM}$
	Post$_{8week}$	92.1±6.5* $^{ObPre\ ObM}$	104.3±5.8* $^{OvPre\ OvM}$	97.1±5.9* $^{ObPre\ ObM}$	108.4±7.8* $^{OvPre\ OvM}$
	%	-3.7	-4.2	-4.7	-4.4
Skinfold (mm)					
Triceps	Pre	25.2±7.5	26.9±3.6	22.4±2.2	25.9±1.9
	Post$_{4week}$	21.9±5.5*	25.3±3.7*	21.3±2.3	23.3±2.0*
	Post$_{8week}$	20.3±4.9*	24.2±3.8*	20.3±2.3*	22.1±2.0*
	%	-19.4	-10	-9.4	-14.7
Subscapular	Pre	29.7±10.7 ^{ObPre}	40.9±9.0 $^{OvPre\ OvM}$	29.7±2.8 ^{ObPre}	37.1±3.3
	Post$_{4week}$	25.7±10.1* ^{ObPre}	38.6±8.4* $^{OvPre\ OvM}$	27.5±2.6* ^{ObPre}	32.8±2.8*
	Post$_{8week}$	25.2±10.5* ^{ObPre}	36.6±8.1* $^{OvPre\ OvM}$	25.9±2.5* ^{ObPre}	29.7±2.8*
	%	-15.2	-10.5	-12.8	-19.95
Iliac Crest	Pre	35.0±6.4	37.2±6.6	30.7±2.6	35.6±2.4
	Post$_{4week}$	28.8±8.1*	34.1±5.7* ^{OvM}	26.6±2.7* ^{ObPre}	32.5±2.3*
	%$^{\&\&}$	-17.7	-8.3	-13.4	-8.7
Medial Calf	Pre	18.9±5.9	22.3±4.8 ^{OvM}	16.9±1.9 ^{ObPre}	18.3±1.6
	Post$_{4week}$	16.2±3.0*	20.6±5.3* ^{OvM}	15.3±1.7* ^{ObPre}	17.0±1.5
	Post$_{8week}$	15.3±2.8*	19.9±5.2* ^{OvM}	15.0±1.4* ^{ObPre}	15.9±1.5*
	%	-19	-10.8	-11.2	-13.1
Maximal strength test (1RM, kg)					
Biceps curl	Pre	17.1	20.7	16.7	16.1
	Post$_{8week}$	20.5*	25.7*	20.0*	20.6*
	%	19.8	24.1	19.7	27.9
Shoulders press	Pre	12.5	14.2	12.2	13.4
	Post$_{8week}$	15.2*	17.2*	14.7*	17.4*
	%	21.6	21.1	20.4	29.8
Squat	Pre	29.0	31.3	27.5	28.8
	Post$_{8week}$	34.7*	37.7*	33.2*	37.0*
	%	19.6	20.4	20.7	28.4
Bent row	Pre	29.5	29.3	28.0	27.2
	Post$_{8week}$	34.7*	36.8*	33.5*	34.8*
	%	17.6	25.5	19.6	27.9

OvPre: overweight premenopausal women; ObPre: obese premenopausal women; OvM: overweight menopausal women; ObM: obese menopausal women; *: P<0.05 vs. week 0; ^{OvPre}: P<0.05 vs. OvPre group; ^{ObPre}: P<0.05 vs. ObPre group; ^{MOv}: P<0.05 vs. MOv group; ^{MOb}: P<0.05 vs. MOb group; $^{\&}$: data from week 8 not shown (missing data); $^{\&\&}$: Pre: previous to intervention; Post$_{4week}$: after four weeks of intervention; Post$_{8week}$: after eight weeks of intervention; Percentage modification during weeks 0 to 4; SFF: skinfolds; %: percentage modification during weeks 0 to 8; m: meters; kg: kilograms; cm: centimeter; mm: millimeter; BMI: body mass index; kg/m2: kilograms divided by meter squared; 1RM: maximal strength.

DISCUSSION

We found that an 8 week guided low intensity (but metabolically strenuous) strength training program led to a substantial and significantly favorable reduction in kinanthropometric risk factors in both pre- and menopausal women, with overweight or obesity. Other strength training studies have also demonstrated a beneficial effect on kinanthropometric variables in overweight/obese postmenopausal[16] and premenopausal women[17,18]. Strength training may have a positive impact on weight management as a result of increased fat-free mass (FFM)[22,23] and increased fat oxidation[15,24]. Increased FFM may result in increased resting metabolic rate (RMR)[25] and increased physical activity energy expenditure (PAEE)[26]. Also, strength exercises may acutely elevate the energy expenditure. It has been shown that after a strength training session (similar to the training sessions used in our investigation)[14] RER fell from 0.9 to 0.79-0.84, and the rest oxygen consumption increased from 3.3 ml/kg/min to 3.9 ml/kg/min during 48 h. If this data is extrapolated to our investigation subjects, and considering that mean body weight of subjects was 74.7 kg, this will translate into an extra 129 L of oxygen consumption during a 48 h period. If 1 liter of oxygen is equivalent to 5 kcal[27], subjects have expended an extra 645 kcal during this period. Thus, hypothetically, with 2 strength training sessions per week, for 8 weeks, subjects had expended an extra 10320 kcal during this period, equivalent to 1.2 kg of fat mass[28], close to the mean 1.85 kg of body weight lost by the study subjects. Therefore, it is not unconceivable that the strength training program applied had induced a significant weight reduction, independent of diet modification. These results support recommendations by various health organizations to include RT as part of a healthy Lifestyle[11].

It was observed that the four skinfolds assessed were significantly reduced after training (-13.5, -14.5, -16.9 and -12.3% for triceps, subscapular, iliac crest and calf, respectively). The reduction in the four skinfolds was similar. It may be argued that part of the skinfolds reduction may be attributed to a mechanical effect, where an increased muscle mass following the strength training may compress de skinfolds; but this phenomenon is not significant in women[29]. Thus, the strength training protocol described in this study may provide an attractive alternative to aerobic exercise programs for body composition modification

Obesity-related complications may be compounded by the detrimental consequences of menopause[4,6]. The confluence of aging and obesity may create an ideal environment for skeletal muscle catabolism and decline in muscle mass (sarcopenic obesity), strength and reduced ability to perform daily activities such as walking, chair rising, stair climbing and body transfer[7]. In our study, subjects of all groups exhibit a significant increase in muscle strength (24, 26, 23.5 and 23.5% for BC, ShP, SQ and BR, respectively). In fact, menopausal and obese women showed a significantly superior increase of maximal strength vs. premenopausal or overweight women, indicating that strength training programs may have a positive impact on the increased prevalence of the obesity-aging-disability triad[8].

When subjects were grouped by menopausal state, no significant differences were observed for the dependent kinanthropometric variables, but when grouped for BMI, significant differences were observed, indicating that BMI, not menopausal state, is the major contributing factor to kinanthropometric risk factor.

The study had several limitations. First, we did not control caloric intake during intervention. This may have affected the kinanthropometric variables, although all subjects were instructed not to change their dietary habits during the 8 week intervention period. Secondly, we did not control objectively physical activity level during the intervention period, although all subjects were instructed not to change their physical activity habits during the 8 week intervention period. Finally, the adherence to the intervention program is another confusion factor. For this reason analyses were adjusted per adherence level.

CONCLUSIONS

A guided short duration low intensity (but metabolically strenuous) strength training program induced substantial and significant changes in kinanthropometric parameters in overweight or obesity, pre- or menopausal women with no significant differences between these groups. The obese and/or menopausal women may be particularly respondent to the strength stimulus of strength training exercises.

The results of this study may suggest that programs designed to intervene in overweight or obesity and pre- or menopausal women by means of strength training, should be part of obesity management action in this population group. Implementation of the program described in this study has considerable potential in other situations, given that the physical space required is widely available in other realities and it relies on the use of low-cost, easily obtainable equipment.

Acknowledgements

Financial support obtained from the Department of Physical Activity Sciences, University of Los Lagos (Región de Los Lagos, Chile).

REFERENCES

1. Ministerio de Salud, Gobierno de Chile. Segunda Encuesta Nacional de Salud 2009-2010. Available from: <http://www.minsal.gob.cl/portal/url/item/bcb03d7b-c28b64dfe040010165012d23.pdf> [2012 Mar 17]
2. Kopelman P. Health risks associated with overweight and obesity. Obes Rev 2007;8(Suppl. 1):13-7.
3. Uauy R, Albala C, Kain J. Obesity trends in Latin America: transiting from under-to overweight. J Nutr 2001;131(3):893S-9S.
4. Paolillo FR, Milan JC, Bueno PD, Paolillo AR, Borghi-Silva A, Parizotto NA, et al. Effects of excess body mass on strength and fatigability of quadriceps in postmenopausal women. Menopause 2012;19(5):556-61.

5. Rejeski WJ, Marsh AP, Chmelo E, Rejeski JJ. Obesity, intentional weight loss and physical disability in older adults. Obes Rev 2010;11(9):671-85.
6. Leite RD, Prestes J, Pereira GB, Shiguemoto GE, Perez SE. Menopause: highlighting the effects of resistance training. Int J Sports Med 2010;31(11):761-7.
7. Vincent HK, Raiser SN, Vincent KR. The aging musculoskeletal system and obesity-related considerations with exercise. Ageing Res Rev 2012;11(3):361-73.
8. Manton KG. Recent declines in chronic disability in the elderly U.S. population: risk factors and future dynamics. Annu Rev Public Health 2008;29:91-113.
9. Borg P, Kukkonen-Harjula L, Fogelholm M, Pasanen M. Effects of walking or resistance training on weight loss maintenance in obese, middle-aged men: a randomized trial. Int J Obes 2002;26(5):676-83.
10. Mosca L, Appel LJ, Benjamin EJ, Berra K, Chandra-Strobos N, Williams CL, et al. Evidence-based guidelines for cardiovascular disease prevention in women. Circulation 2004;109(5):672-93.
11. Pate RR, Blair SN, Haskell WL, Macera CA, Bouchard C, Bruchner D, et al. Physical activity and public health: a recommendation from the Centers for Disease Control and Prevention and the American College of Sports Medicine. JAMA 1995;273(5):402-7.
12. Melby C, Scholl C, Edwards G, Bullough R. Effect of acute resistance exercise on postexercise energy expenditure and resting metabolic rate. J Appl Physiol 1993;75(4):1847-53.
13. Phillips WT, Ziuraitis JR. Energy cost of the ACSM single-set resistance training protocol. J Strength Cond Res 2003;17(2):350-55.
14. Schuenke MD, Mikat RP, McBride JM. Effect of an acute period of resistance exercise on excess post-exercise oxygen consumption: implications for body mass management. Eur J Appl Physiol 2002;86(5):411-7.
15. Kirk EP, Donnelly JE, Smith BK, Honas J, Lecheminant JD, Bailey BW, et al. Minimal resistance training improves daily energy expenditure and fat oxidation. Med Sci Sports Exerc 2009;41(5):1122-9.
16. Brochu M, Malita MF, Messier V, Doucet E, Strychar I, Lavoie JM, et al. Resistance training does not contribute to improving the metabolic profile after a 6-month weight loss program in overweight and obese postmenopausal women. J Clin Endocrinol Metab 2009;94(9):3226-33.
17. Hunter GR, Byrne NM, Sirikul B, Fernández JR, Zuckerman PA, Darnell BE, et al. Resistance training conserves fat-free mass and resting energy expenditure following weight loss. Obesity 2008;16(5):1045-51.
18. Byrne HK, Wilmore JH. The effects of a 20-week exercise training program on resting metabolic rate in previously sedentary, moderately obese women. Int J Sport Nutr Exerc Metab 2001;11(1):15-31.
19. Figueroa A, Park SY, Seo DY, Sanchez-Gonzalez MA, Baek YH. Combined resistance and endurance exercise training improves arterial stiffness, blood pressure, and muscle strength in postmenopausal women. Menopause 2011;18(9):980-4.
20. Marfell-Jones MJ, Olds T, Stewart AD, Carter L. International standards for anthropometric assessment. Potchefstroom, South Africa, International Society for the Advancement of Kinanthropometry, 2006.
21. Ritti RM, Serpeloni E, Salvador EP, Nakamura FY, Cheche FL, Ramos de Oliveira A. Impacto de oito semanas de treinamento com pesos sobre a força muscular de homens e mulheres. Rev Bras Med Esporte 2005;11(4):224-8.
22. Donnelly JE, Jakicic JM, Pronk NP, Smith BK, Kirk EP, Jacobsen DJ, et al. Is resistance training effective for weight management? Evid Based Prev Med 2003;1:21-9.
23. Rabelo HT, Bezerra LA, Terra DF, Lima RM, silva MA, Leite TK, et al. Effects of 24 weeks of progressive resistance training on knee extensors peak torque and fat-free mass in older women. J Strength Cond Res 2011;25(8):2298-303.
24. Ormsbee MJ, Choi MD, Medlin JK, Geyer GH, Trantham LH, Dubis GS, et al. Regulation of fat metabolism during resistance exercise in sedentary lean and obese men. J Appl Physiol 2009;106(5):1529-37.

25. Alpert SS. The cross-sectional and longitudinal dependence of the resting metabolic rate on the fat-free mass. Metabolism 2007;56(3):363-72.
26. Ades PA, Savage PD, Broucha M, Tischler MD, Lee NM, Poehlman ET. Resistance training increases total daily energy expenditure in disabled older women with coronary heart disease. J Appl Physiol 2005;98(4):1280-5.
27. Flood DK. Practical math for health fitness professionals. Champaign: Human Kinetics; 1996.
28. Wilmore JH, Després JP, Stanforth PR, Mandel S, Rice T, Gagnon J, et al. Alterations in body weight and composition consequent to 20 wk of endurance training: the HERITAGE Family Study. Am J Clin Nutr 1999;70(3):346-52.
29. Kostek MA, Pescatello L, Seip R, Angelopoulos T, Clarkson P, Gordon P, et al. Subcutaneous fat alterations resulting from an upper-body resistance training program. Med Sci Sports Exerc 2007;39(7):1177-85.

Corresponding author

Cristian Gabriel Álvarez Lepín
Centro de Salud Familiar de Los Lagos.
Centro de Promoción de Salud de la Mujer
Calle Pratt 162, Región de Los Ríos,
Chile.
E-mail: profecristian.alvarez@gmail.com