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The effects of a 12-week resistance training programme on the body composition and resting metabolic rate in a cohort of caucasian and coloured, premenopausal women aged 25-35 years

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Abstract

Resting metabolic rate (RMR) is the largest component of daily energy expenditure, with lower values in the black population. Resistance training is considered to be the most effective exercise modality to increase fat-free mass (FFM), and therefore also the RMR. The objective of this study was to determine the effect of a 12-week resistance training programme on the body composition (FFM, FM) and resting metabolic rate (RMR) in a cohort of South African premenopausal women. An available sample of Caucasian (n = 20) and Coloured women (n = 8) between ages 25 and 30 years completed a 12-week intervention study. Body composition (FFM, FM) and RMR were determined by using the Bod Pod® together with other anthropometric measurements (body mass, stature and waist circumference). Statistical analysis included the Mann-Whitney *U* test as well as the effect size, to determine the significance of the intervention regimen. No statistically significant differences occurred but medium practically significant differences were found between the groups. Coloured women had a greater decrease in body mass (r = 0.25), FM (r = 0.28) and increase in RMR (r = 0.28) than the Caucasians. Both groups showed a decrease in body mass, FM, percentage body fat, waist circumference, body mass index (BMI) and an increase in FFM and RMR after the intervention programme. In conclusion, it therefore seems that a resistance intervention programme can serve as an effective tool in increasing FFM and RMR, which may inter alia be associated with a decrease in FM, percentage body fat and body mass among both groups of premenopausal women.

Keywords: Resistance training, body composition, fat-free mass (FFM), fat mass (FM), resting metabolic rate (RMR).

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Introduction

Daily energy expenditure (DEE) can be divided into three main components, namely resting energy expenditure (REE), activity-induced energy expenditure (AEE) and diet-induced energy expenditure (DEE) (Van Baak, 1999; De Mello Meirelles & Gomes, 2004). The REE also known as resting metabolic rate (RMR) constitutes the main portion (60-70%) of the DEE and displays a positive correlation with the fat-free body mass (FFM) (Heymsfield, Gallagher, Kotler, Wang, Allison & Heshka, 2002). REE per unit FFM is not constant; it varies from the high metabolic active tissue (brain, heart, liver and kidneys) to the low metabolic active tissue (skeletal muscle, bone and adipose tissue) (Wang, Heshka, Gallagher, Boozer, Kotler & Heymsfield, 2000; Műller, Bosy-Westphal, Kutzner & Heller, 2002). Other factors which may also influence the RMR include age, gender, body composition, ethnicity, menstrual cycle, hormones and genetics (Solomon, Kurzer & Calloway, 1982; Webb, 1986; Forman, Miller, Szymanski & Fernhall, 1998; Tershakovec, Kuppler, Zemel & Stallings, 2002). In premenopausal women it is known that the ovarian hormones provide some protection against health disorders, viz. cardiovascular risks (Vitale, Mendelsohn & Rosano, 2009). Obesity, as a major health risk factor, already labelled as a primary risk factor for coronary heart disease (ACSM, 2010) is a cause of great concern globally. Research has proven that after menopause most of the health risks increase in women, which may significantly relate to the decrease in ovarian function (Vitale *et al.*, 2009). Therefore the sooner these health risk factors can be addressed, the better (Lin, Caffrey, Chang & Lin, 2010). Menopause is associated with reduced energy expenditure during rest and physical activity, an accelerated loss of FFM, and increased central adiposity (Poehlman, 2002:603), making these individuals more vulnerable to develop cardiovascular diseases and other metabolic disorders.

Obesity as a major health risk factor is the cause of great concern globally (WHO, 2010). South Africa is no exception and the prevalence is even higher among the female population (Goedecke, Jennings & Lambert, 2006). A further complication in the South African context is that the diverse culture may escalate the problem of obesity, since body composition differs between the various ethnic groups in South Africa (Tershakovec *et al.*, 2002; Gallagher et al., 2006). Research further indicates that in some cultures (black women), obesity is associated with positive outcomes such as attractiveness, beauty, negative HIV-status and wealth (Kruger, Puoane, Senekal & Van der Merwe, 2005). According to literature (Puoane, Steyn, Bradshaw, Laubscher, Fourie, Lambert & Mbananga, 2002), 56% of women in South Africa can be classified as overweight and obese with the highest prevalence among the black women (58.5%) followed by the Coloured (52%), white (49.2%) and Indian (48.9%) women (Goedecke *et al*., 2006).

The cause of this epidemic in South Africa inter alia also reflects the global trend of a diet transition to the Western diet and decreases in daily physical activity (Kruger *et al.*, 2005). In this respect research indicated that 49% of the South African women are physically inactive while 27% and 25% respectively reported to be minimally and sufficiently active (Lambert & Kolbe-Alexander, 2006).

One way of managing the risk of obesity is by reducing the energy intake (diet) and increasing the energy expenditure (exercise), the so called restoration of energy balance (Stiegler & Cunliffe, 2006). However, this method requires long-term commitment and so often results in high drop-out rates which may be related to lack of results and/or motivation (Byrne et al., 2003; ACSM, 2010).

Resistance exercise is regarded as an exercise modality resulting in the fastest increase in FFM, which is associated with an increased REE (Broeder, Burrhus, Svanevik & Wilmore, 1992). It is further claimed that resistance exercise not only leads to an increase in energy expenditure during exercise, but also to the elevated post-exercise oxygen consumption (EPOC) (De Mello Meirelles & Gomes, 2004). Resistance exercise produces a greater EPOC than aerobic exercise (Burleson, O'Bryant, Harold, Stone, Collins & Triplett-McBride, 1998). Although EPOC may not be responsible for a major change in the energy balance of the body, the cumulative effect should not be underestimated (De Mello Meirelles & Gomes, 2004). Therefore, by increasing the FFM, the REE may be enhanced, leading to the effective management of body mass.

Little information is available on the effect of a programme of resistance exercise on the resting metabolic rate of premenopausal women in South Africa. Therefore, the purpose of this study was to determine the effect of a 12-week resistance training programme on body composition and RMR in a cohort of premenopausal Caucasian and Coloured women. Information gained from this study could help to compile effective strategies to conquer the burden of growing obesity statistics. This study was the first of its kind in South Africa, a multi-cultural country with diverse outlooks, to determine the effectiveness of resistance training as a means of weight loss.

Materials and Methods

Study design

This study is based on a quasi-experimental design, using a pre-test-post-test intervention regimen.

Subjects

An availability sample of Coloured and Caucasian premenopausal women (25-35 years) was recruited to participate in the study. They were all employed by two companies (educational and financial institutions) in an urbanized environment. Calculations regarding the desired size of each group indicated that 34 participants should be included. However, it was impossible to recruit that number of the Coloured women and eventually, 26 Coloured and 51 Caucasian women agreed to participate. During the intervention period (12 weeks of resistance training), various participants dropped out and only 8 (average age = 30.5 ±4.63 years) of the Coloured and 20 of the Caucasian (average age = 28.9 ±4.83 years) group completed the intervention regimen.

The following criteria for inclusion in this study were set, viz. healthy, sedentary (on- and off-job), premenopausal women aged 25-35 years, BMI $\geq 18 kg.m^{-2}$, non-smoking, non-hypertensive, non-diabetic and no chronic medication consumption (except for contraceptives). All participants were informed regarding the assessment procedures and all questions were answered to their satisfaction. They were also requested to continue with their normal daily habits (eating and drinking) for the duration of the study, except for the resistance intervention regimen. All of them completed the informed consent form as required. The study was approved by the Ethics Committee of the NWU (NWU-00059-07-S1).

Measurements

Body composition and resting metabolic rate (RMR)

Fat-free mass (FFM), fat mass (FM), percentage body fat (% body fat) as well as resting metabolic rate (RMR) were determined by the BOD POD® system, based on air displacement (Life Measurements Instruments) (Siri, 1961). Participants were allowed only minimal clothing as well as to wear a swimming cap and were requested to sit as still as possible while in the BOD POD®. They were also asked to remove all jewellery and voiding was ensured. A fasting period of 8 hours and a non-exercising period of 12 hours prior to the assessments were required. All measurements were done during the same time slot (6-8 am) with room temperature kept constant (21-23ºC). Prior to every measurement in the BOD POD® all calibrations as suggested by the manufacturers were done in order to ensure high-quality measurements.

The RMR ($kcal.kg^{-1}.day^{-1}$) was calculated indirectly from the body composition parameters, viz. fat-free mass (FFM) and fat mass (FM) content of the body. The equation of Nelson, Weinsier, Long and Schultz (1992) was used, viz: RMR = 11.09 + (0.900) FFM + (0.1314) FM

Anthropometry

The following anthropometric measurements were done as suggested by ISAK (International Society for the Advancement of Kinanthropometry) (Marfell-Jones, Olds, Stewart & Carter, 2006): stature (to the nearest 0.5cm), using a stadiometer; body mass (to the nearest 0.5kg), using an electronic scale (*Krupps*®) calibrated at regular intervals; and the waist circumference (to the nearest 0.5cm), using a steel tape (*Lufkin*®).

Intervention programme

Resistance training

The intervention programme consisted of a resistance circuit training regimen complying with the following programme prescription (Beachle & Earle, 2000):

Frequency: 3 x per week
Duration: 40-60 minutes/session for 12 weeks
Type: Circuit programme using machines and body weight as exercise resistance
Intensity: Low to moderate (12-15 RM)
High volume (3 sets of 12-15 repetitions)
Short rest periods (30-60 sec) between sets and exercises

Table 1 &2: Sequence of the circuit programme [Authors to re-draw Tables 1 & 2 without putting it as pictures but in word only. The way it was presented makes it difficult to format]

Table 1: Sequence of the circuit programme

Order	Body area	Exercise	Intensity	Volume	Rest
1	Chest	Pec Dec	15-RM	3 x 15	30-60 sec
2	Legs (anterior, upper)	Leg press	15-RM	3 x 15	30-60 sec
3	Upper back	Lats pull down	15-RM	3 x 15	30-60 sec
4	Legs (posterior, upper)	Leg curls	15-RM	3 x 15	30-60 sec
5	Shoulders	Seated press	15-RM	3 x 15	30-60 sec
6	Legs and buttocks	Abduction machine	15-RM	3 x 15	30-60 sec
7	Arms (anterior)	Bicep curls	15-RM	3 x 15	30-60 sec
8	Inner thighs	Adduction machine	15-RM	3 x 15	30-60 sec
9	Arms (posterior)	Triceps push downs	15-RM	3 x 15	30-60 sec
10	Lower back	Machine back extensions	15-RM	3 x 15	30-60 sec
11	Legs (lower)	Seated calf raises	15-RM	3 x 15	30-60 sec
12	Abdominal	3-Direction crunches		3 x 15	30-60 sec

RM = Repetition maximum

Table 2: Descriptive statistics of Coloured and Caucasian women who completed a 12-week resistance training regimen (pre-post-test)

	Coloured women (n=8); Age = 30.50 (±4.63)				Caucasian women (n=20); Age = 28.85 (±4.83)					
Variable	**Pre-test Mean (SD)**	**Post-test Mean (SD)**	**Median Diff**	**[Q25; Q75] of Diff**	**Pre-test Mean (SD)**	**Post-test Mean (SD)**	**Median Diff**	**[Q25; Q75] of Diff**	**Mann-Whitney U (p-value)**	**Effect size**
Mass (kg)	89.82 (±19.87)	88.74 (±18.91)	-1.185	[-2.330; 0.705]	71.74 (±17.61)	71.09 (±17.34)	0.540	[-1.210; 1.580]	0.195	**0.25***
BMI (kg.m^{-2})	34.86 (±8.86)	34.42 (±8.34)	-0.439	[-1.108; 0.343]	25.66 (±5.77)	25.57 (±5.59)	0.182	[-0.466; 0.481]	0.297	0.20
Waist (cm)	91.95 (±12.87)	90.04 (12.19)	-1.100	[-3.500; 0.450]	76.16 (±10.04)	75.00 (±9.55)	-0.625	[-1.450; 0.250]	0.611	0.10
FM (kg)	41.45 (±16.66)	39.80 (±16.28)	-1.450	[-3.250; 0.600]	25.79 (±13.66)	25.10 (±13.56)	-0.425	[-1.385; 0.350]	0.140	**0.28***
FFM (kg)	48.23 (±4.91)	49.14 (±5.03)	1.175	[0.750; 2.030]	45.62 (±4.89)	46.25 (±4.78)	0.905	[-0.500; 1.450]	0.431	0.15
Fat (%)	44.56 (±9.44)	43.05 (±10.15)	-2.050	[-2.900; -0.450]	34.35 (±8.56)	33.45 (±8.82)	-0.900	[-2.050; 0.200]	0.286	0.20
RMR (kcal.kg^{-1}.day^{-1})	1361.26 (±202.91)	1425.25 (±168.30)	29.500	[14.00; 50.500]	1278.27 (±173.22)	1289.20 (±166.92)	16.000	[-15.000; 32.000]	0.140	**0.28***

*=Practical significance [Effect size (ES) values: r>0.1=small; r>0.3=medium; r>0.5=large (Field, 2005)] Q25=lower quartile; Q75=upper quartile

Progression

In order to ensure optimal results, each exercise was prescribed according to the participants' ability by using the repetition maximum (RM) technique (ACSM, 2010). The initial prescription started with 15 RM and progressed every four weeks to a 12 RM for the last four weeks of the programme. The construction of the programme ensures a balanced development of all major muscle groups in order to ensure maximum energy expenditure (Beachle & Earle, 2000). Lastly, the aspects of fun and time effectiveness were also considered to ensure compliance.

Exercise log

All participants received a log book which should have been completed after each session. They were requested to record the date, repetitions completed as well as their general feeling. Anything they wished to report to the researchers should also have been stipulated in the log book. This was kept in the gymnasium and signed by the supervisor on completion of each session. The log book was also used to verify the frequency of participation.

Statistical analyses

Descriptive statistics (mean, standard deviation, median as well as upper (Q 75) and lower quartiles (Q 25) were used to present the body composition parameters and RMR values of the participants. The Mann-Whitney *U* test was used to determine whether the changes in body composition and RMR due to the intervention programme differed between Coloured and Caucasian women. Statistical significance was set at $p \leq 0.05$, while practical significance (ES) was regarded as large, ES = > 0.5, moderate, ES = around 0.3 and small, ES = > 0.1 (Field, 2005). All statistical analyses were performed with the Statistica Programme, Version 11 (Statsoft, Inc, 2013).

Results

All pre- and post-test values of the Coloured women were higher than those of the Caucasian women. Coloured women were classified as obese with pre- and post-test values of BMI = 34.86kg.m^{-2} and 34.42kg.m^{-2} respectively, whereas the Caucasian women were overweight (BMI = 25.66 kg.m^{-2} pre-test; 25.57 kg.m^{-2} post-test). Coloured women also showed an increased risk for the development of cardiovascular disease regarding waist circumference (91.95 cm pre-test; 90.04 cm post-test), while the Caucasian women indicated no risk (waist circumference < 88 cm) in this regard. The Coloured women showed a body fat percentage of 44.56% and 43.05% in the pre-and post-assessments respectively, while the Caucasian participants had body fat percentage values of 34.35% and 33.45% respectively.

Both groups responded similarly after completion of the 12-week resistance training intervention programme. It is clear that the body composition parameters used to describe and stratify overweight and obesity (fat percentage, FM, waist circumference and BMI) decreased, whereas FFM and RMR increased in both groups after completion of the 12-week resistance training. Although none of the parameters differed significantly between the groups (pre- and post-test), Coloured women had a medium practically significant greater decrease in body mass (r = 0.25), FM (r = 0.28) and increase in RMR (r = 0.28) than their Caucasian counterparts after the 12-week intervention.

Discussion

In this study the Coloured women presented with greater fat mass and percentage body fat than their white counterparts, irrespective of the fact that they also showed a higher FFM and RMR. One reason for this may be linked to the physical inactivity of this group. Literature indicates that 84% of the Coloured population reported that they do not participate in sport and physical activity (DSR, 2005), which places this ethnic group in the leading position regarding physical inactivity, followed by the Asian (75.6%), black (75.02%) and white (63.4%) groups.

Coloured women also reflect the second highest prevalence of obesity in South Africa (Goedecke *et al*., 2006). This may be linked partially to the epidemiological transition that occurs in many developing countries (Cameron, 2005), resulting in the adoption of the Western diet and decrease in physical activity (Kruger *et al.*, 2005) as well as a sedentary culture (DSR, 2005).

After completion of the 12-week resistance training programme, the two groups responded similarly with a decrease in body mass, FM, fat percentage and an increase in FFM and RMR. This is in agreement with the findings of other studies (Foster, Wadden, Swain, Anderson & Vogt, 1999; Dionne, Mélancon, Brochu, Ades & Poehlman, 2004; Ibanéz, Izquiredo, Argűelles, Forga, Larrión, Garcia-unciti, Idoate & Gorostiaga, 2005. In this regard it must be borne in mind that only a small number of Coloured women had completed the intervention programme and therefore the results need to be interpreted with caution.

In the pre- and post-test assessment both groups could be stratified as obese (Coloureds = fat % 44.56; Caucasians = fat % 34.35) (Heyward & Wagner, 2004), which implies that they may depict an increased health risk resulting in enhanced morbidity and mortality (Lara-Castro, Weinsier, Hunter & Desmond, 2002; Wolfe, 2006). This health risk of employees may not only affect their personal health, but also productivity, absenteeism, presenteeism and health care cost (Grace, Wilders, Strydom & Ellis, 2012), placing them in a vulnerable position of contracting various chronic (non-communicable) diseases associated with obesity (Goedecke *et al.*, 2006) and sedentarism (Blair & LaMonte, 2007), increasing the health care burden of not only the individual but also the employer (Labuschagne, Strydom & Wilders, 2011).

Physical activity as a modality to manage body mass is well describe in the literature (Ross & Janssen, 2007; Erhman, Gordon, Visich & Keteyian, 2009), as it is associated with an increase in energy expenditure resulting in a negative energy balance (Stiegler & Cunliffe, 2006). Manipulation of the various training principles (duration, frequency, intensity and type) may result in a variation in total energy consumption (TEC) (Van Baak, 1999).

Resistance exercise is regarded as an exercise modality responsible for the fastest and most profound increase in FFM, resulting in an increase in resting energy consumption (REC) or resting metabolic rate (RMR). As mentioned earlier, RMR forms the largest part of DEE (daily energy expenditure). It may therefore be valuable to manipulate an increase in the FFM through exercise (resistance training) in order to create a negative energy balance and manage (lose) body mass (Broeder *et al.*, 1992; Coffey & Hawley, 2007). Therefore, through increasing the FFM by means of resistance training, RMR and also DEE can be enhanced, which leads to the decrease in body mass, percentage body fat and FM. Research further suggests that resistance training not only increases energy consumption during the training session, but also after the termination of the session, as a result of the elevated post-exercise oxygen consumption (EPOC) (De Mello Meirelles & Gomes, 2004; Rahimi, 2006). It also seems that resistance training creates a larger EPOC than aerobic exercise (Burleson *et al.*, 1998).

Therefore, if the aim of an exercise intervention programme is to reduce body mass, it is important to include a significant amount of resistance exercise in the exercise prescription (Coffey & Howley, 2007). From this study it was also clear that the drop-out figure was high in both groups (48% in the Caucasians and 70% in the Coloureds). Reasons for this are uncertain but it remains clear that in order for a company to launch a successful intervention programme, some incentives should form part of the programme to increase compliance (Dishman, 1988).

Limitations

In this study the following limitations should be borne in mind when interpreting the results, viz. a small number of non-randomized participants were used and a considerable drop-out figure had occurred.

Conclusion

It appears that a resistance training regimen of 12-weeks at a moderate intensity (3 sets of 12-15 repetitions) with a brief rest period (30-60 seconds) between each set, demonstrated a moderate practically significant increase in RMR in both groups of women. This was also associated with a moderate practically significant decrease in FM and body mass. It was also clear that the two groups did not respond differently to the intervention.

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