Cardiovascular Topics

Consequence of resistance training on body composition and coronary artery disease risk

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Summary

Coronary artery disease (CAD) is a substantial cause of death and disability in South Africa and Western society, with research showing obesity to be one of the most common CAD risk factors. Furthermore, obesity is speculated to be the fastest-growing CAD risk factor and to become the most prevalent CAD risk factor. Research on obesity is therefore essential, and we propose some preventative measures that will hopefully limit the expansion of this risk factor for CAD. Most of the literature has focused primarily on aerobic modes of exercise. The aim of this study, therefore, was to investigate whether resistance training would improve body composition.

Twenty-eight males were matched by age, percentage of body fat and waist-to-hip ratio and randomly assigned either to a resistance-training group (n = 13) or a control group (n = 15). Each subject's body mass, percentage body fat, lean mass, fat mass, waist-to-hip ratio and body mass index were assessed both pre- and post-experimentally following the eight-week experimental period. The resistance-training group trained three times weekly at 60% of their one-repetition maximum using nine resistance exercises. Each exercise was performed for three sets of 15 repetitions each, whereas the control group did not exercise over this period.

The dependent *t*-test indicated that resistance training significantly changed body mass, percentage of body fat, lean mass and fat mass (all had a *p*-value of 0.00; $p \leq 0.01$). Furthermore, the independent *t*-test demonstrated that lean mass, fat mass and percentage of body fat were statistically significantly different between the control and resistance-training groups.

In conclusion, resistance training improved four of the six measured body composition variables, therefore implying that resistance training does in fact improve the majority of body composition variables and therefore CAD risk.

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Obesity as a modifiable risk factor for coronary artery disease (CAD) has become well recognised and represents one of the most profound of these modifiable risk factors.[1-3] Obesity is an excess of body fat or adipose tissue that frequently results in a significant impairment of health. Obesity is a situation of being 'overfat' and not just overweight.[4] The accumulation of excess body fat is a delicate balance between caloric intake (via diet) and caloric expenditure (via exercise and metabolism) and therefore any increase in caloric intake and/or decrease in caloric expenditure will result in excess calories being stored as fat, increasing the risk of developing obesity and CAD.[5] The etiology of obesity is complex and it is generally recognised that excess adiposity is caused by an interaction between one's genetic predisposition and one's environmental conditions.[6]

Literature examining the effects of exercise training on the prevention of obesity and the related development of CAD has focused primarily on aerobic modes of exercise, despite the increasing popularity in recent years of weight or resistance training.[7,8] However, although the specific cardioprotective benefits of aerobic training are well known, resistance training has additional benefits for an individual. Some of the additional benefits to be gained from resistance training include: increased muscle strength, neuromuscular control and co-ordination, increased lean tissue mass, and increased maintenance of metabolically active tissue in the elderly.[3,9-11] Therefore, in an attempt to determine whether resistance training is an effective modality to prevent the development of obesity as a CAD risk factor, the present study investigated the effects of resistance training on body composition.

Methods

Twenty-eight untrained male volunteers between the ages of 20 and 35 years (mean age: 28 years, 7 months) were used. On enrollment in the investigation, each subject signed an informed consent form and subjects were matched according to age, percentage of body fat and waist-to-hip ratio. Subjects were randomly assigned to either a non-exercising control group (CG) (n = 15) or a resistance-trained experimental group (RT) (n = 13) following the completion of retrospective questionnaires regarding health status, medical history and lifestyle habits.

Subjects in both the RT and CG were not permitted to engage in any form of exercise other than the prescribed experimental training programme for the RT.[12] All subjects within the study met the following criteria for participation in the study: (1) no participation in any regular exercise programme six months prior to the study;[13,14] (2) no use of androgens or other drugs known to affect body composition measurements;[15-17] (3) all subjects were weight stable for at least six months prior to the study;[18] and (4) all subjects were free of medical conditions prohibiting exercise.[15]

All subjects were evaluated in the post-absorptive state following a 12- to 14-hour fast,[16] and prior to any exercise. Subjects were weighed in kilograms (to the nearest 0.1 kg) on a calibrated medical scale (Mettler DT Digitol, Mettler-Toledo AG, Ch-8606 GreiFensee, Switzerland), wearing only running shorts. Each subject's stature was measured in centimetres (to the nearest 0.1 cm) via a standard wall-mounted stadiometer. In addition to each subject's body mass and stature these indices were used to calculate body mass index (BMI). The percentage body fat was calculated from seven-skinfold measurements (triceps, subscapular, supra-iliac, abdominal, frontal thigh, mid-axilla and pectoral skinfolds) according to Jackson and Pollock.[18] The equation utilised by Jackson and Pollock is as follows:

Percentage fat = 100 [4.95/body density (Db) – 4.5],

where Db (g/cc) = 1.120 – 0.00043499 [sum of the seven skinfolds in millimetres (Σ7)] + 0.00000056 (Σ7) – 0.00028826 (age).

Skinfolds and waist and hip circumferences [as utilised in the waist-to-hip ratio (WHR)] were measured prior to any exercise using a manual skinfold calliper (Harpenden John Bull, British Indicators Ltd., England) and a non-distendable measuring tape and sliding vernier callipers (Holtain Ltd.). The subjects' one-RM (repetition maximum) was estimated following a 10-RM bout. Each subject's one-RM was re-evaluated after four weeks and their programmes adjusted accordingly. All measurements were repeated eight weeks later, after the experimental group had completed its training programme. The same technician measured all variables pre- and post-experimentally.

Technical information

In the present investigation, only the members of the RT group were allowed to take part in the eight-week structured exercise programme. The subjects each trained three times a week non-consecutively.[12,13,20] The resistance training sessions were preceded by five minutes of easy cycling [heart rate (HR) < 100 beats per minute][20] and followed by eight stretching exercises, which were all performed for 30 seconds on each muscle/limb. The subjects trained at a workload of 60% of their one-repetition maximum.[19] The exercises included (1) dumbbell shoulder shrugs;[20] (2) dumbbell lateral shoulder raises;[17] (3) seated chest press;[20] (4) latissimus dorsi pulls;[12] (5) seated rows;[20] (6) biceps curls;[14] (7) triceps extensions;[8] (8) crunches[19] and (9) unilateral leg press.[12] Each exercise had to be performed for three sets of 15 repetitions each.[13] For crunches, each subject was required to perform three sets of 60% of the maximum number of repetitions that he performed during testing.[19] The resistance training sessions were concluded with a five-minute easy cycle at a heart rate of less than 100 beats per minute.[20]

To account for the effect of nutrient intake over the eight-week experimental period, a three-day dietary analysis took place.[16] These dietary record forms were distributed the week prior to the pre-test and the week prior to the post-test. The forms were to be completed and returned at the pre- and post-experimental evaluations, checked for completeness and analysed using the 'Dietary manager, program management' programme, which analysed the dietary records for total carbohydrates, proteins, cholesterol and fats derived from mono-unsaturated, polyunsaturated and saturated fatty acids.[16]

Statistics

Subjects were only included in the subsequent data analysis if they had taken part in exercising for the required 90% or more sessions. Subjects included in the data analysis completed a mean of 22 (range 20–24) of a possible 24 sessions (91.1% compliance). On completion of the study, the data were analysed by the Rand Afrikaans University's (currently University of Johannesburg) Statistical Consultation Services (STATCON), using the 'Statistical package for social sciences (SPSS) II'. STATCON recommended and made use of the independent and dependent t-tests. The samples were used to determine whether a significant difference (significance level of 99% or $p \leq 0.01$) existed between the RT and CG. The sizes of the present study's changes were also calculated as a percentage change.

Results

As expected, the CG demonstrated no statistically significant change in body mass from pre- to post-test (p = 0.063) (Table I). The mean mass of the CG was 85.17 kg (SEM = 5.69) and 85.76 kg (SEM = 5.58), pre- and post-test, respectively. The CG also demonstrated no statistically significant difference in the mean %BF (p = 0.548) (Table I), which changed from 27.94% (SEM = 1.68) pre-test to 27.55% (SEM = 1.60) post-test (1.41% decrease). As the above results show, lean mass and fat mass also showed no statistically significant differences pre- to post-test (p = 0.234 and p = 0.750, respectively) (Table I). Furthermore, WHR in the CG remained at a mean of 0.87 (SEM pre-test = 0.02; SEM post-test = 0.02) throughout the duration of the study (Table I). The BMI of the CG also remained unchanged when comparing their pre- (26.44 kg/m^2, SEM = 1.66) and post-test values (26.65 kg/m^2, SEM = 1.63) following the eight-week experimental period (p = 0.074) (Table I).

In contrast to the CG, the RT group demonstrated significant favourable changes in most of their measured body composition variables, barring WHR and BMI (Table I). The change in mean body mass from pre- (77.78 kg, SEM

TABLE 1. STATISTICAL DESCRIPTIVES AND MEAN BODY COMPOSITION PARAMETERS

	Variable	*Pre/post*	*Mean*	*Dependent samples* t-*test* (p-*value*)	*Independent samples* t-*test* (p-*value*)
CG	Body	Pre	85.168		
	mass (kg)	Post	85.763		
		% change	0.691%	0.063	
			increase		
RT	Body	Pre	77.781		0.764
	mass (kg)	Post	78.235		
		% change	0.580%	0.000*	
			increase		
CG	%BF	Pre	27.943		
		Post	27.548		
		% change	1.415%	0.548	
			decrease		0.002*
RT	%BF	Pre	26.834		
		Post	23.331		
		% change	13.054%	0.000*	
			decrease		
CG	Lean	Pre	60.335		
	mass (kg)	Post	61.103		
		% change	1.258%	0.234	
			increase		0.012*
RT	Lean	Pre	56.251		
	mass (kg)	Post	59.311		
		% change	5.058%	0.000*	
\			increase		
CG	Fat	Pre	24.833		
	mass (kg)	Post	24.660		
		% change	0.698%	0.750	
			decrease		0.006*
RT	Fat	Pre	21.530		
	mass (kg)	Post	18.924		
		% change	12.105%	0.000*	
			decrease		
CG	WHR	Pre	0.871		
		Post	0.867		
		% change	0.391%	0.371	
			decrease		0.227
RT	WHR	Pre	0.840		
		Post	0.827		
		% change	1.560%	0.101	
			decrease		
CG	BMI	Pre	26.441		
	(kg/m^2)	Post	26.64		
		% change	0.781%	0.074	
			increase		0.998
RT	BMI	Pre	24.249		
	(kg/m^2)	Post	24.457		
		% change	0.852%	0.147	
			increase		

RT: resistance training group; CG: control group; BMI: body mass index; WHR: waist-to-hip ratio *significant at $p = 0.01$.

= 5.48) to post-test (78.23 kg, SEM = 5.43) was found to be statistically significant ($p = 0.000$) (Table I). Percentage BF also changed significantly in the RT group from a pre-experimental value of 26.83% (SEM = 1.52) to a post-experimental value of 23.33% (SEM = 1.73) ($p = 0.000$) (Table I). This represented a 13.05% decrease in %BF. This was the result of a decrease in fat mass from 21.53 kg (SEM = 2.66) to 18.92 kg (SEM = 2.54) ($p = 0.000$) (Table I). The RT group's lean body mass also changed significantly from 56.25 kg (SEM = 2.98) to 59.31 kg (SEM = 3.19), representing a 5.06% increase ($p = 0.000$) (Table I). In the RT group, WHR and BMI did not significantly change from pre- to post-test ($p = 0.101$; 0.147, respectively) (Table I).

When the independent *t*-test was applied to the body mass data, no significant difference was observed between the CG and RT groups ($p = 0.764$) (Table I). Similar, non-significant, independent *t*-test findings were found concerning WHR ($p = 0.227$) and BMI ($p = 0.998$) (Table I). On the other hand, post-test lean mass ($p = 0.002$), fat mass ($p = 0.012$) and %BF ($p = 0.006$) demonstrated significant differences between the CG and RT groups (Table I) with the resistance training simultaneously increasing lean mass, decreasing fat mass and decreasing overall %BF.

When analysing each group's nutrient intake as recorded in the pre- and post-test dietary record forms, the independent *t*-test revealed no significant alterations in any of the recorded nutrient sub-components. Specifically, both the CG and RT groups' mean protein (p = 0. 512; $p = 0.137$, respectively), total fat ($p = 0.589$; $p = 0.945$, respectively), saturated fat ($p = 0.897$; 0.971, respectively), mono-unsaturated fat ($p = 0.781$; $p = 0.968$, respectively), polyunsaturated fat ($p = 0.561$; $p = 0.247$, respectively), cholesterol ($p = 0.098$; $p = 0.732$, respectively) and carbohydrate ($p = 0.256$; $p = 0.134$, respectively) intake changes were non-significant. Furthermore, the independent *t*-test demonstrated no significant differences between the CG and RT group's pre- and post-test differences in all the dietary intake variables (Table II). Therefore, nutrient intake could not have had any influence on the changes observed with regard to the body composition parameters.

Discussion

Many health professionals consider exercise as the single most-important predictor of long-term weight control. Research also shows that individuals who exercise regularly maintain their weight losses better than sedentary individuals, effectively preventing the development of obesity.[21] Exercise is known to initiate a complex series of metabolic and psychological outcomes, such as alterations in body weight, body composition, appetite and basal metabolic rate.[22]

As was expected, following the RT group, the present investigation demonstrated a significant increase in mean body mass from pre- to post-test. Although such a finding could be deemed unfavourable, the increase in body mass was accompanied by a significant decrease in fat mass from pre- to post-test. This increase in mean body mass was due to the favourable significant increase in the RT group's lean body mass. Interestingly, resistance training can increase lean body mass in even the obese.[5] By using body mass in conjunction with fat mass and lean mass values (and other body composition parameters), a more sensitive view of an individual's body composition profile may be ascertained. The use of only body mass in risk calculations should therefore be avoided, especially in individuals engaged in RT.

Furthermore, as can be expected following a significant decrease in fat mass, %BF also decreased significantly in the

TABLE II. STATISTICAL DESCRIPTIVES AND MEAN DAILY DIETARY INTAKE

	Variable	*Pre/post*	*Mean*	*Standard deviation (SD)*	*Standard error mean (SEM)*	*Dependent samples* t-*test* (p-*value)*	*Independent samples* t-*test* (p-*value)*
CG	Protein pd (g)	Pre	105.7087	39.0853	10.0918	0.512	0.100
		Post	111.3633	36.6759	9.4697		
		% change	5.3492% increase				
RT	Protein pd (g)	Pre	121.7000	42.9300	11.9066	0.137	
		Post	103.7500	34.2642	9.5032		
		% change	14.7494% decrease				
CG	Total fat pd (g)	Pre	107.6100	43.4309	11.2138	0.589	0.854
		Post	103.0567	27.2984	7.0484		
		% change	4.2313% decrease				
RT	Total fat pd (g)	Pre	104.3938	44.1819	12.2539	0.945	
		Post	103.2085	36.7123	10.1822		
		% change	1.1354% decrease				
CG	Saturated fat pd (g)	Pre	36.8913	17.7414	4.5808	0.897	0.967
		Post	37.3713	11.1319	2.8743		
		% change	1.3011% increase				
RT	Saturated fat pd (g)	Pre	39.7277	17.6095	4.8840	0.971	
		Post	39.9346	13.6605	3.7887		
		% change	0.5208% increase				
CG	Mono-unsaturated fat pd (g)	Pre	37.2773	15.4651	3.9931	0.781	0.748
		Post	36.1280	8.9054	2.2994		
		% change	3.0831% decrease				
RT	Mono-unsaturated fat pd (g)	Pre	38.6500	19.4674	5.3993	0.968	
		Post	35.1338	14.4289	4.0019		
		% change	9.0975% decrease				
CG	Polyunsaturated fat pd (g)	Pre	19.8327	12.7270	3.2861	0.561	0.208
		Post	18.1393	8.8768	2.2920		
		% change	8.5384% decrease				
RT	Polyunsaturated fat pd (g)	Pre	13.8723	6.2517	1.7339	0.247	
		Post	17.5277	9.1676	2.5426		
		% change	26.3504% increase				
CG	Cholesterol pd (mg)	Pre	354.5120	167.9860	43.3738	0.098	0.160
		Post	440.7113	164.8685	42.5689		
		% change	24.3149% increase				
RT	Cholesterol pd (mg)	Pre	381.7692	145.0544	40.2308	0.732	
		Post	362.6915	159.7360	44.3028		
		% change	4.9972% decrease				
CG	Carbohydrates pd (g)	Pre	300.1393	120.1333	31.0183	0.134	0.160
		Post	268.6280	116.4983	30.0797		
		% change	10.4989% decrease				
RT	Carbohydrates pd (g)	Pre	293.6569	107.5266	29.8225	0.246	
		Post	242.1408	47.6507	13.2159		
		% change	17.5430% decrease				

RT: resistance training group; CG: control group; pd: per day.

RT group from pre- to post-test. This finding is supported by a literature survey, which also yielded evidence that 15 weeks of twice-weekly resistance training was effective in reducing fat mass and %BF even when not attenuating total body weight, waist circumference or resting metabolic rate.[22,23] The present investigation's decrease in %BF together with other corroborating research demonstrate that decreases in %BF range from 2.53%[25] to 15.12%,[26] thus indicating how the literature is divided on the issue of whether or not resistance training does indeed impact positively on %BF. This is further complicated by demonstrations of a decreased %BF following low-intensity, but not high-intensity RT.[27]

The use of the WHR in determining CAD risk is thought to be useful, since it has been shown that individuals with upper body fat are more inclined to be associated with an increased risk for hyperlipidaemia and other lipid abnormalities.[1,5,19] It has been demonstrated that femoral fat distribution in both women and men is associated with increased high-density lipoprotein cholesterol (HDL-C) levels.[20] Conversely, abdominal adipocytes have been associated with increased low-density lipoprotein cholesterol (LDL-C), very low-density lipoprotein cholesterol (VLDL), triglycerides and lipoprotein lipase activity.[5] Hence the assumption that the WHR is important in predicting CAD risk and the finding that even a 0.05 decrease in WHR can decrease an individual's CAD risk classification by one category (ie high risk to moderate risk).[20]

Unfortunately, WHR is poorly related to the visceral adipose tissue volume as compared with computed topography (CT) techniques.[4] Furthermore, exercise is deemed ineffective in mobilising abdominal fat[20] and it has also been demonstrated that WHR is influenced by the amount of faeces and gas contained within the bowel, hence the present study's inability to significantly alter WHR following resistance training. Similar to the findings in our study, 15 weeks of twice-weekly resistance training was also found to be ineffective in reducing waist circumference, even when total fat mass, %BF and total body mass were reduced.[20]

It appears that there is a consistent absence of a relationship between resistance training and BMI, as indicated by Joseph *et al*. and our present study, which both demonstrated a non-significant increase in BMI.[28] Evidence also demonstrates that BMI should not be utilised in calculating CAD risk since BMI represents an undefined mixture of risk index and body fat index; body weight is positively associated with CAD risk while height is negatively associated with this risk.[4] Therefore the combination of these two variables should be avoided in risk calculations.[4] The use of BMI in ascribing CAD risk should also be used with caution in those individuals with an increased lean mass, as would be expected following resistance training.

Although an increase in lean mass will mathematically reduce %BF, the reduction in absolute fat mass found in this study can possibly be ascribed to a lean body mass-induced increase in metabolic rate.[29] The literature has indicated decreases in %BF that range from 0.41%[30] to 8.33%[31] following 10 weeks and six months of training, respectively.

Since over-consumption of macronutrients or inadequate energy expenditure can lead to excess energy being stored as fat in the adipose cells, the authors recommended that health professionals advise their patients about their diet in addition to recommending resistance training to change their body composition. This study has demonstrated that eight weeks of resistance training can effectively be used to change a sedentary male's body composition, even without dietary intervention, in an attempt to reduce his chance of becoming obese and thereby reduce the risk of developing CAD. Furthermore, by emphasising the primary prevention of obesity, associated costs of morbidity and mortality, the loss of productivity and other indirect costs resulting from obesity and concomitant CAD could be reduced.

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