

Research article

Self-reported dietary intake following endurance, resistance and concurrent endurance and resistance training

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Abstract

With regards to obesity-related disease the impact of exercise training on health depends on the ability of exercise to promote a negative energy balance. Exercise's effect on promoting a negative energy balance is more likely to occur if exercise can induce a favourable dietary intake such as a reduced relative fat content in the diet. As such, the aim of this study was to evaluate and compare the effectiveness of aerobic training, weight training and concurrent aerobic and weight training on self-reported dietary intake. The effects of 16 weeks of aerobic (n = 12), weight (n = 13) and concurrent aerobic and weight training (n = 13) on self-reported dietary intakes were compared in previously sedentary males using the computer-based Dietary Manager® software programme. Only the concurrent aerobic and weight training group showed significant ($p \leq 0.05$) reductions in total kilocalories, carbohydrates, proteins and fats consumed while the aerobic training group showed significant reductions in fat intake at the completion of the experimental period (before: $91.0 \pm 42.1\text{g}$ versus after: $77.1 \pm 62.1\text{g}$). However, no changes were observed in self-reported dietary intake in the weight training or non-exercising control groups. It is concluded that concurrent aerobic and weight training is the most effective mode of exercise at promoting a favourable improvement in self-reported dietary intake in the short term. This finding provides support for efforts to promote increases in overall physical activity in an attempt to modify the patterns of dietary intake.

Key words: Kilocalories, carbohydrate, diet, exercise, fat, protein.

Introduction

Exercise has frequently been a method used to promote good health. One expected favourable effect of exercise training is a positive change in dietary habits and nutritional status (Ambler et al., 1998; Tremblay and Almeras, 1995). Epidemiological studies have also focused on the interaction between exercise and diet (Sallis, 1993; Sclicker et al., 1994). This is due to the ever-increasing incidences of diseases such as hypertension, dyslipidemia, diabetes mellitus, obesity and cardiovascular disease resulting from sedentary lifestyles (Sallis, 1993; Sclicker et al., 1994) and an increased over-consumption of energy-dense food (whether fat, protein or carbohydrate) (Olivares et al., 2004). Since exercise is known to affect carbohydrate, protein and fat metabolism and/or stores, it is hypothesized that exercise also affects their dietary intake via its metabolic effects (Tremblay and Almeras, 1995). This hypothesis is supported by Saris (1989) who

stated that there is a strong association between daily energy expenditure and dietary intake.

With regards to exercise, Verger et al. (1992) found that energy intake increased from carbohydrate (but not fat or protein) following a two-hour vigorous exercise bout using college-aged males and females. However, a later study of Verger et al. (1994) found that protein (but not carbohydrate or fat) intake increased above rest in a male-only sample following two hours of various athletic activities. These contradictory findings might be explained by Ambler et al. (1998) when they found that fitness is associated with increased energy intakes in males but not females while females consumed greater quantities of fat and lesser quantities of carbohydrate. Additionally, a study by Titchenal (1988) found that while athletes increase energy intake in response to an increased exercise volume, obese subjects did not alter their energy intake. Further confounding the effect of exercise on dietary intake, Costill et al. (1988) found that an increase in swimming training volume over a 10-day period resulted in their sample of athletes failing to increase their dietary carbohydrate intake leading to decreases in muscle glycogen levels and concomitant fatigue. This may be explained by a study by Janssen et al. (1989) who found that carbohydrate intakes increased by 3% to 4% in novice marathon runners but not in champion marathon runners. In this regard, champion athletes may increase energy intake through other dietary sources other than carbohydrates (de Wijn et al., 1979). This is confirmed more recently by Burke et al. (2003) when these researchers found that the dietary behaviour of 167 male and female Australian Olympic athletes following training was sub-optimal with regards to their dietary intake of carbohydrates, fats and proteins. Despite an increasing number of epidemiologic studies being conducted on the effect of aerobic exercise modalities and/or aerobic fitness, relatively few studies have been forthcoming on whether resistance training or a combination of aerobic and resistance training may affect energy intake through dietary sources. As such, the aim of the study was to evaluate and compare the effectiveness of aerobic training, weight training and concurrent aerobic and weight training on self-reported dietary intake.

Methods

Subjects were recruited from the Gauteng region in Johannesburg South Africa. A total of 50 subjects took part in the 16-week study (Table 1). The study was approved

Table 1. Subject descriptive data. Values are means (\pm SD).

	AER	WEI	WEI+AER	CONT
Age (yrs)	25.0 (5.6)	25.0 (3.5)	26.0 (3.1)	25.0 (2.4)
Height (m)	1.77 (.04)	1.76 (.06)	1.79 (.07)	1.79 (.12)
Body Mass (kg)	74.7 (8.2)	69.1 (8.5)	85.0 (12.8)	80.3 (12.8)

AER: aerobic training; WEI: weight training; AER+WEI: concurrent aerobic and weight training; CONT: control group

by the Rand Afrikaans University, Department of Human Movement Studies' Research Committee and informed consent was obtained from each subject. The subjects included were all males (mean age: 25 years and six months). The subjects were screened and only those who were previously sedentary, free of preexisting disease and not on any prescribed diet or supplement which could have altered their dietary intake or energy expenditure were allowed to enter the study. To account for the effect of exercise training on dietary intake, the subjects had to complete a self-reported dietary intake form specifying the type and quantity of food and fluids consumed over seven days before and after the experimental period. Portion sizes were illustrated with the aid of measuring cups, glasses, bowls and food items. The records were reviewed in detail with each subject upon completion to ensure completeness. The dietary records were analyzed for total kilocalories consumed, carbohydrates, proteins and fats. The Dietary Manager® computer-based software programme (Dietary Manager, Program Management, South Africa) was used to analyze the data. The body mass of the subjects was measured to the nearest 0.1 kilogramme on a calibrated medical scale (Mettler DT Digitol, Mettler-Toledo AG, Ch-8606 Greifensee, Switzerland) wearing only running shorts. Percentage body fat was assessed using the seven-skinfold method of Jackson and Pollock (1978) which has a correlation of 0.915 when compared to hydrostatic weighing to estimate body density. The standard error of estimate was 0.008 expressed in body density and a standard error of estimate of 3.5 when expressed in % BF using the equation of Siri (1961) and standard errors of their formulae ranged from 3.6% to 3.8%.

After the initial completion of the dietary intake, no dietary advice was given to the subjects and the subjects were randomly assigned to either an aerobic training group (AER) ($n = 12$), weight training group (WEI) ($n = 13$), concurrent aerobic and weight training group (WEI+AER) ($n = 13$) or control group (CONT) ($n = 12$) which remained sedentary throughout the study. All the subjects performed a five minute warm-up before starting each training session and concluded with stretching and a five minute cool-down. The subjects in the AER group trained for a total of 60 minutes; 45 minutes at 60% heart rate maximum (target heart rate was increased by 5% every four weeks and was monitored via a telemetry strap (Polar Fitwatch, Polar Electro Oy, Finland) and confirmed manually at the radial artery via palpation). Each workout of the WEI group was designed according to National Strength and Conditioning Association (NSCA) guidelines (Baechle et al., 2000; Earle and Baechle, 2000) and consisted of three sets of seated machine shoulder press, latissimus dorsi pull-downs, vertical chest press, seated rows, unilateral leg press, unilateral knee extensions and unilateral hamstring curls at 60% of the individual's one-

repetition maximum for 15 repetitions each. Each WEI group subject had to perform bent-knee sit-ups for three sets of 15 repetitions at 60% of the maximum performed during the initial evaluation. The WEI+AER group had to perform similar exercises to the WEI group but instead had to perform two sets of 15 repetitions each and 22 minutes of aerobic training at the same target heart rate as AER. The weight training intensity was reevaluated through 10-repetition maximum (RM) testing and the training programmes adjusted by increasing the resistance accordingly to maintain 60% of the estimated 1-RM every four weeks.

The Kruskal-Wallis test was utilized to determine whether the four groups within the study were significantly different (i.e. heterogeneous) or statistically the same (i.e. homogenous) at pre-test. The dietary intake records that were obtained before and after the 16-week period were analyzed using a mixed factorial analysis of variance. $P \leq 0.05$ was selected as being indicative of statistical significance. Values are expressed as means \pm standard deviation (SD). The control group's self-reported dietary intake was utilized to calculate test-retest reliability by quantifying test-retest reliability using the intraclass correlation coefficient. Spearman's correlation coefficient was also utilized to measure the strength of the linear relationship between the measured dietary intake variables and body mass and percentage body fat.

Results

The three exercising groups and the non-exercising control group were found to be homogeneous at the start of the study regarding their mean self-reported dietary intakes for total kilocalories ($p = 0.686$), carbohydrates ($p = 0.627$), proteins ($p = 0.729$) and fats ($p = 0.517$). At the end of the 16-week experimental period, the mean kilocalorie, carbohydrate and protein intakes for the AER remained unchanged despite the finding of a significant decrease the dietary intake of fat (91.0 ± 42.1 grammes (g) at baseline versus 77.1 ± 62.1 g at post-test). In the WEI, no significant alterations were found in the measured dietary variables. However, following 16 weeks of concurrent aerobic and weight training, the WEI+AER was found to have had significant ($p \leq 0.05$) decreases in total kilocalories (2228 ± 598 kilocalories versus 1711 ± 675 kilocalories), carbohydrates (236.4 ± 107.2 g versus 185.5 ± 86.0 g), proteins (103.5 ± 38.2 g versus 80.2 ± 33.0 g) and fats (91.9 ± 27.6 g versus 67.9 ± 26.2 g). As expected, the CONT were found to have had no significant ($p \leq 0.05$) decreases in their total kilocalories, carbohydrates, proteins and fats consumed.

Despite the four groups being found to be heterogeneous ($p = 0.008$) at the start of the study, the subjects assigned to the AER weighed significantly ($p \leq 0.05$) less than at the start of the experimental period (74.7 ± 8.2

kilogrammes (kg) versus 72.3 ± 7.4 kg) whereas the WEI weighed significantly more at the completion of the study (69.1 ± 8.5 kg versus 70.7 ± 9.5 kg). In contrast, the mean body mass values of the WEI+AER and CONT were unchanged (85.0 ± 12.8 kg versus 85.1 ± 11.0 kg and 80.3 ± 12.8 kg versus 79.6 ± 10.9 kg, respectively). No significant relationship was found between body mass and total kilocalories ($r = 0.078$; $p = 0.591$), carbohydrates ($r = -0.118$; $p = 0.413$) and fats ($r = 0.201$; $p = 0.162$), indicating that these dietary intake variables had no impact on body mass. However, a significant relationship was found between the dietary intake of protein and body mass ($r = 0.308$; $p = 0.029$) indicating that a significant decrease in protein intake could have assisted in a concomitant significant decrease in body mass. However, only the WEI+AER significantly decreased their intake of protein, but this was in the absence of a significant change in body mass.

Percentage body fat (%BF) decreased significantly ($p \leq 0.05$) following all of the exercise interventions. The AER displayed a significantly decreased %BF ($15.6 \pm 6.7\%$ versus $11.9 \pm 4.6\%$; $p = 0.002$) as did the WEI and WEI+AER ($9.3 \pm 7.3\%$ versus $6.9 \pm 5.2\%$; $p = 0.009$ and $22.0 \pm 11.9\%$ versus $17.0 \pm 9.0\%$; $p = 0.002$, respectively). However, the CONT's %BF remained unchanged from pre- to post-test ($17.9 \pm 7.9\%$ versus $17.8 \pm 8.0\%$; $p = 1.000$). Further, no significant relationship was detected between %BF and total kilocalories ($r = 0.204$; $p = 0.156$), carbohydrates ($r = 0.124$; $p = 0.399$), proteins ($r = 0.172$; $p = 0.232$) and fats ($r = 0.234$; $p = 0.103$), indicating that dietary intake had no impact on %BF.

Discussion

According to the findings of the present study, engaging in concurrent aerobic and weight training appears to result in a decreased consumption of the usual self-reported dietary intakes regarding total kilocalories consumed and from carbohydrates, proteins and fats in the short term. Aerobic training resulted in a decreased self-reported dietary intake of fats only, and weight training alone did not result in any change in self-reported dietary macronutrient intake in the short term. This finding is of interest because frequently the reduction in body mass associated with exercise is less than is expected due to compensation for the increased energy expenditure during exercise by either eating more food or having less spontaneous physical activity throughout the day (Donnelly and Smith, 2005). When combining this study's finding of a decreased self-reported dietary consumption following concurrent aerobic and weight training with the findings of a decreased %BF, the present data therefore suggests that the most favourable technique for stimulating a negative energy balance that might lead to reduced body mass is a combination of aerobic and resistance exercise.

The accuracy of self-reported dietary intake is questionable, as people tend to report nutrient intakes that may more closely approximate perceived norms than actual intake and people tend to underreport their dietary energy intake (Hoidrup et al., 2002; Schoeller, 1990). In the present investigation, the participants were given

detailed instructions on how to measure and report their dietary intake, and the dietary records were individually reviewed prior to analysis. The lack of change in self-reported dietary macronutrient intake and body composition in the control group suggests that the subjects were consistent in their dietary recording, regardless of the tendency for people to underreport energy intake. Additionally, using the control group's self-reported dietary intake, test-retest reliability using the intraclass correlation coefficient yielded a value of 0.444 for kilocalories, carbohydrate, protein and fat, indicating an overall reliability. When considering the individual self-reported dietary intake variables, the intraclass correlation coefficient yielded values of 0.361 for kilocalories, 0.792 for carbohydrates, 0.613 for protein and 0.800 for fats, again indicating test-retest reliability. It has been suggested that males (as used in this study) maintain or decrease their energy intake in response to exercise more so than do females (Donnelly and Smith, 2005; Janssen et al., 1989). Furthermore, females are more likely to compensate for the increased energy expenditure through exercise by increasing their energy intake (Donnelly and Smith, 2005). There are several reasons why the concurrent resistance and aerobic exercise may have produced a favourable change in dietary composition. Firstly, the WEI+AER group subjects weighed significantly more and consumed slightly more kilocalories than the other two training groups. As such, the subjects in this group had a greater opportunity to decrease their macronutrient intake. The favourable change in the self-reported dietary macronutrient intake caused by concurrent aerobic and weight training in the present study may physiologically have been due to this mode of exercise inhibiting short-term eating via increased levels of fat being broken down and released into the blood stream (Lipostatic theory), improvements in blood sugar levels (Glucostatic theory) and/or alterations in amino acid levels in the blood (Aminostatic theory) all leading to an increased satiety. Further, this intervention may also have increased satiety by elevating postprandial levels of the satiety hormones; polypeptide YY, glucagon-like peptide-1 and pancreatic polypeptide (Martins et al., 2008). Also, the findings of Rivest and Richard (1990) demonstrated that exercise may have a direct effect on a specific neurosystem influencing feeding behaviour leading to an increased carbohydrate preference due to the composition of the fuel mix oxidized during this mode of exercise.

Exercise is of paramount importance in improving overall health and most, if not all, adults should engage in regular exercise to prevent numerous untoward health complications (Haskell et al., 2007). Furthermore, in order to treat obesity and its numerous comorbidities including type 2 diabetes and heart disease, exercise should induce a negative caloric balance (Braun and Brooks, 2008). The present data suggest that weight training alone and aerobic training alone do not induce changes in self-reported dietary energy intake in the short term, such that the negative caloric balance would be due solely to the energy expenditure during exercise. In contrast, concurrent aerobic and resistance training induces a negative caloric balance through both the energy expenditure during exercise and reduced self-reported dietary

energy intake, which is a key common factor observed in those with long weight loss success (Hill et al., 2005).

The results of the study supports previous research findings that an increase in energy expenditure through exercise was not compensated for by an increase in self-reported dietary intake as compared to the male subject's usual diets and this can be viewed as a favourable short-term adaptation to concurrent aerobic and weight training.

Conclusion

Concurrent aerobic and weight training is the most effective mode of exercise at promoting a favourable improvement in self-reported dietary intake in the short term. As such, efforts should be increased to promote increases in overall physical activity in an attempt to modify the patterns of dietary intake.

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Key points

- Concurrent aerobic and weight training can significantly reduce the amount of total kilocalories, carbohydrates, proteins and fats consumed.
- Aerobic training can significantly reduce fat intake.
- Weight training resulted in no changes in dietary intake.
- Concurrent aerobic and weight training is the most effective mode of exercise at promoting a favourable improvement in self-reported dietary intake.

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