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The prospective association between different types of exercise and body composition

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Abstract

Purpose—Despite the widely accepted benefits of exercise on chronic disease risk, there remains controversy on the role of exercise in weight loss. This study examined the effect of different exercise types on measures of adiposity across different fat categories.

Methods—A total of 348 young adults (49% male; 28±4 years), participating in an ongoing observational study, provided valid data over a period of 12 months. Fat mass (FM) and lean mass (LM) were measured via dual x-ray absorptiometry every 3 months. Percent body fat (BF) was calculated and used to differentiate between normal fat, over fat and obese participants. At each measurement time point participants reported engagement (min/week) in aerobic exercise, resistance exercise and other exercise.

Results—Most participants (93%) reported some exercise participation during the observation period. Total exercise or specific exercise types did not significantly affect subsequent BMI after adjusting for sex, ethnicity, age and baseline values of adiposity and exercise. Resistance exercise affected lean mass ($p<0.01$) and fat mass ($p<0.01$), while aerobic exercise only affected fat mass ($p<0.01$). Any exercise type positively affected lean mass in normal fat participants ($p<0.04$). In overfat and obese participants fat mass was reduced with increasing resistance exercise ($p=0.02$) but not with aerobic exercise ($p=0.09$). Additionally adjusting for objectively assessed total physical activity level did not change these results.

Conclusion—Despite the limited effects on BMI, exercise was associated with beneficial changes in body composition. Exercise increased lean mass in normal fat participants and reduced

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Conflict of Interest.

The remaining authors have no conflict to declare.

fat mass in overfat and obese adults. Adults with excess body fat may benefit particularly from resistance exercise.

Keywords

resistance training; aerobic training; body fat; lean mass; fat mass

INTRODUCTION

An increasingly sedentary lifestyle has been suggested to be a key contributor to the high prevalence of overweight/obesity and associated co-morbidities (43). With a decline in physical demands at work and for activities of daily living over the past several decades (2, 7), exercise during leisure time has been emphasized as an integral part of a healthy lifestyle by various public health organizations (14, 47). A recent meta-analysis further showed that leisure time exercise has a stronger association with mortality than does occupational physical activity (PA) or transport-related PA (34). Despite the well-established benefits of exercise on health, there remains controversy on the role of exercise for weight loss (39). The lack of conclusive evidence regarding the role of exercise in the regulation of body weight may in part be due to the selected outcome measure; body weight or BMI may not reflect changes in fat mass and lean mass, which are likely to occur in response to sustained exercise engagement. For example, there is an inverse dose-response relationship between visceral fat and exercise (25, 28). There is also a difference in the association between PA/exercise and adiposity by weight status (11), which may be due to the ability to engage in various types of exercise at different intensities. Excess body weight, for example, may hinder the ability to engage in a sufficient amount of aerobic exercise to induce changes in body composition in an overweight/obese population (46).

Nevertheless, exercise-based interventions for weight loss and weight management have predominantly focused on aerobic exercise. This may in part be due to a higher energy expenditure in aerobic exercise compared to resistance exercise (38). Resistance exercise, however, has been associated with an increase in functional capacity, which could affect total daily energy expenditure (TDEE) by an increase in total PA (16, 22), subsequently affecting body weight. The effect of exercise on habitual PA has been shown to be an important contributor regarding the effectiveness of exercise-based weight management programs (26). In response to superimposed exercise programs there has been a large variability in compensatory adaptations, which may contribute to inconsistent results of exercise-based interventions (19, 26). Clinical exercise interventions have been associated with a reduction in non-exercise activity thermogenesis or an increase in energy intake, which minimizes the effect of exercise on body composition (8). Examining the effects of habitual exercise, rather than a superimposed exercise program, may help to attenuate compensatory metabolic and behavioral changes and enhance the understanding of the effect of chronic exercise participation on body weight and body composition. Thus, the purpose of the present study was to examine the effects of various self-selected exercise types, rather than a specific exercise program, on measures of body composition. Further, differences in the effect of various exercise types on adiposity measures between healthy fat, overfat and obese adults were examined.

METHODS

The present analyses include data from an ongoing observational study. Specifics of the Energy Balance Study, which examines primary and secondary determinants of weight change, have been described previously (13). Briefly, 430 young adults (49% male; 27.7 ± 3.8 years) with a BMI between 20 and 35 kg/m^2 were recruited. Participants were free of major acute or chronic conditions and did not report any large changes in their health behaviors in the previous three months. Women who were pregnant in the previous 12 months, planning on getting pregnant and those planning to change their use of contraceptive medications during the study were excluded. The study protocol was approved by the University of South Carolina Institutional Review Board and is in accordance with the declaration of Helsinki. All participants signed informed consent prior to data collection.

Measurements were repeated every 3 months over a period of 1 year. In order to be included in the analyses participants needed to provide data during at least 3 measurement times, including baseline and 12-months follow-up.

Anthropometrics and Body Composition

Height (cm) and weight (kg) were measured with participants in surgical scrubs and bare feet. Height was measured to the nearest 0.1 cm via a wall-mounted stadiometer (Model S100, Ayrton Corp., Prior Lake, MN, USA) and weight was measured to the nearest 0.1 kg using an electronic scale (Healthometer® model 500KL, McCook, IL, USA). BMI (kg/m^2) was calculated using the average of 3 measurements. In addition, fat mass, fat free mass and lean tissue mass were measured via dual energy x-ray absorptiometry (DXA; GE Healthcare Lunar model 8743, Waukesha, WI). Percent body fat (%BF) was calculated (fat mass/body weight) and participants were classified as normal fat, overfat or obese based on sex, age and ethnicity specific cutpoints (12). Specifically, %BF ranges were less than 20% and 33% for healthy fat, 20% to 25% and 33% to 39% for overfat and equal or more than 33% and 39% for obese in men and women, respectively.

Exercise Participation and Physical Activity Level

Every 3 months participants reported their habitual self-selected engagement in different exercise types. Specifically, frequency (days/week) and time (min/session) was reported for sports, cycling, running, swimming, aerobics/group exercise, upper body resistance exercise, lower body resistance exercise and other forms of structured PA. Subsequently, time spent engaging in endurance exercise (sum of running, cycling and swimming), resistance exercise (sum of upper body and lower body resistance exercise), other exercise (sum of sports, aerobics/group exercise and other structured forms of PA) and total exercise was calculated (min/week).

In addition, TDEE was assessed with a multi-sensor device (SWA, SenseWear Mini Armband, Body Media, Pittsburgh, PA), which was worn over a period of 10 days every 3 months. Using, tri-axial accelerometry, galvanic skin response, heat flux, skin temperature and near body temperature the SWA has been shown to provide accurate estimations of TDEE in free-living conditions (18, 37). Resting metabolic rate (RMR) was measured after

an overnight fast and a minimum of 24-hour abstention from exercise. Physical Activity Level (PAL=TDEE/RMR) was calculated and used as an indicator of overall PA, including planned exercise.

Energy intake was calculated based on changes in body composition and objectively determined energy expenditure due to limitations in the accuracy of self-reported dietary intake and the effect of body composition on dietary misreporting (24, 30). Specifically, change in fat mass and fat free mass was used to calculate the energy gap for each 3-months interval (i.e. difference in EI and TDEE) (40, 41), which was subsequently added to average TDEE of the respective measurement period:

$$\text{Energy Intake} = 1,020 \frac{\Delta FFM}{\Delta t} + 9,500 \frac{\Delta FM}{\Delta t} + TDEE$$

FFM... change in fat free mass (kg) over time; *FM*... change in fat mass (kg) over time; TDEE... total daily energy expenditure; *t*... days between respective measurement times

Statistical Analysis

Descriptive statistics were calculated for the total sample and separately for normal fat, overfat and obese participants. Individual change in exercise engagement, energy intake and PAL was determined via linear mixed modelling (LMM). Subsequently, linear regression analysis, adjusting for sex, ethnicity, age, baseline exercise time, and baseline adiposity measures was used to examine the effect of change in total exercise time (Model 1) and change in specific exercise types (Model 2) on measures of adiposity at follow-up. In a second analysis change in energy intake and PAL were included as additional covariates to adjust for potential changes in diet and PA outside the reported exercise. All analyses were performed for the total sample and separately for normal fat, overfat and obese participants using IBM SPSS Statistics for Windows (version 21.0; IBM Corp., Armonk, N.Y., USA).

RESULTS

A total of 348 participants (49% male) provided valid data for at least 3 measurement time points including baseline and 12-months follow-up. There was no difference in baseline characteristics between those included in the analysis and those excluded due to incomplete data. Baseline characteristics of participants included in the analysis are shown in Table 1. Two thirds of the participants were white with the majority (86%) having a college degree. The prevalence of white participants decreased across fat categories (*p* for trend = 0.02) but there was no difference in education between normal fat, overfat and obese participants. Sex distribution differed significantly across fat categories with an increase in male participants from normal fat to obese (*p* for trend < 0.01). Age also increased with increasing fatness (*p* for trend = 0.01). As expected, BMI and fat mass increased across fat categories (*p* for trend < 0.01) but there was no difference in lean mass after adjusting for sex, ethnicity and age. There was no significant difference in TDEE, RMR and calculated energy intake between fat categories.

Over 12 months average BMI increased by 0.5 kg/m^2 ($p < 0.01$) with individual changes ranging between -1.4 and 1.7 kg/m^2 . The average weight gain was associated with an increase in fat mass ($p < 0.01$) while there was no change in average lean mass ($p = 0.38$), resulting in an increase in %BF ($p < 0.01$). Individual change in lean mass ranged from a loss of 1.2 kg to a gain of 2.3 kg . Change in fat mass and %BF ranged from -3.9 kg to 2.6 kg and -3.2% to 2.3% , respectively. Change in adiposity measures did not differ between fat categories after adjusting for ethnicity, sex, age, and baseline values.

Most of the participants (93%) reported some exercise during the observation period and 60% of the participants met current PA guidelines (14) with a decline in the prevalence of participants meeting guidelines with increasing body fatness. Exercise participation did not differ between men and women and there was no difference in age between exercisers and non-exercisers. Non-exercisers had significantly higher %BF ($p < 0.01$) due to lower lean mass ($p < 0.01$) but there was no difference in BMI at baseline. Energy intake, TDEE and PAL was higher in exercisers compared to non-exercisers ($p = 0.01$). The prevalence of non-exercisers increased with increasing fatness (p for trend < 0.01). Total exercise time as well as the number of total exercise sessions decreased across fat categories (p for trend < 0.01). Time spent in specific exercise categories also decreased across fat categories (p for trend 0.03) but the number of exercise sessions differed only for other exercise (p for trend < 0.01). The difference in aerobic and resistance exercise between fat categories was due to a difference in exercise time during single sessions. Interestingly, there was no difference in objectively determined PAL (Table 2).

Exercise time decreased during the observation period ($p < 0.01$) but there was no significant change in TDEE and energy intake. On an individual level change in energy intake over a period of 12 months, however, ranged from a reduction of 580 kcal/day to an increase of 599 kcal/day . The range for change in total exercise time was from a reduction of 79 min/week to an increase of 67 min/week . Change in specific exercise types ranged from -41 to 28 min/week , -47 to 48 min/week and -69 to 30 min/week for aerobic, resistance and other exercise, respectively. Change in exercise time, TDEE and energy intake did not differ between fat categories after adjusting for ethnicity, sex, age and the respective baseline measures.

Regression analysis for the total sample showed a significant inverse effect of change in total exercise time on subsequent fat mass and a significant direct effect on subsequent lean mass ($p < 0.01$), resulting in an inverse effect of total exercise time on %BF ($p < 0.01$) (Table 3). There was no effect of change in total exercise on BMI. These results remained essentially unchanged after including change in PAL and energy intake into the respective models. There was a direct effect of change in energy intake on BMI ($\beta = 0.05$, $p < 0.01$) while no significant effect of change in energy intake was observed for fat mass and %BF. An increase in energy intake, however, was directly associated with lean mass at 12 months ($\beta = 0.05$, $p < 0.01$). Regarding specific exercise types, there was an inverse association of change in aerobic exercise and resistance exercise with subsequent fat mass and %BF ($p < 0.01$). Change in resistance exercise additionally affected lean mass ($p < 0.01$). There were no significant effects of change in time spent in other exercise on any adiposity

measures at follow-up. Additionally adjusting for change in PAL did not change the previously reported results.

The effects of change in exercise time separately for healthy fat, overfat and obese participants are shown in table 4. Change in total exercise time or any specific exercise type was directly associated with subsequent lean mass in healthy fat participants ($p<0.05$), while there was no effect of total exercise or specific exercise types on fat mass, %BF and BMI. In overfat and obese participants, there was an inverse effect of change in total exercise time on fat mass and %BF ($p<0.05$). Particularly, change in resistance exercise affected subsequent fat mass and %BF, with results being more pronounced in obese compared to overfat participants. Aerobic exercise affected only %BF in overfat participants ($p<0.05$) and there was no significant effect of aerobic exercise in obese. There was no effect of change in total exercise time or any specific exercise time on lean mass in overfat and obese participants. No significant effects on measures of adiposity were observed for time spent in other exercise. As was shown for the total sample, change in exercise did not affect subsequent BMI and results remained essentially unchanged after additionally controlling for PAL.

DISCUSSION

Health benefits of regular exercise are well documented (1) but research on differential effects of various exercise types on measures of adiposity has been limited. In order to evaluate the growing number of exercise programs in various settings, scientific evidence on the effects of specific exercise types on body weight and body composition is warranted. Results of the present study show that habitual exercise engagement predominantly affects fat mass and lean mass, while the effect on BMI is minimal. An increase in resistance exercise was associated with an increase in lean mass and a decrease in fat mass. An increase in aerobic exercise, on the other hand, was only associated with a reduction in fat mass. Effects of various exercise types, however, differed by adiposity level. In normal fat participants exercise predominantly affected lean mass, independent of exercise type. In overfat and obese participants change in exercise engagement predominantly affected fat mass. Interestingly, resistance exercise had a greater effect on fat mass in overfat and obese participants, than did aerobic exercise. In fact, aerobic exercise affected %BF only in overfat but not in obese participants.

The limited effect of exercise on BMI has been addressed previously (39) and results of the present study support the argument for energy restriction as an important component for weight loss (10). Caloric restriction, however, has been associated with a decline in lean body mass (31) and habitual physical activity (23, 32). The according decline in energy expenditure could make it difficult to achieve a sustainable weight loss relying entirely on low energy intake. The present study further showed no difference in energy intake between normal fat, overfat and obese participants, which emphasizes the importance of exercise or PA in longterm weight management. It should also be considered that the proportion of lean mass lost during caloric restriction is greater than the amount regained, resulting in a lean mass deficit, which negatively affects various health outcomes (3, 31). Exercise engagement during weight loss, on the other hand, has been shown to attenuate the loss in lean mass (27), which would allow individuals to maintain resting metabolic rate (45). This sustained

energy expenditure during sedentary pursuits could facilitate long-term weight maintenance. In addition, exercise is associated with increased cardiorespiratory fitness and functional capacity, which increases quality of life and improves health (35). It should also be considered that adiposity has a stronger association with health outcomes than does BMI (29). Both aerobic and resistance exercise have beneficial effects on visceral adiposity, which is associated with cardiovascular disease risk, independent of change in body weight (25). Therefore, a stronger focus on change in body composition, rather than on weight or BMI, is warranted when evaluating health-effects of exercise-based interventions (33).

This study further shows that the association between exercise and body composition differs by body fatness categories. In normal fat participants, any type of exercise affected lean mass, while there was no significant effect on fat mass. This may in part be explained by the observational nature of the study. Without an attempt to lose weight, participants potentially compensated for a change in exercise regimen by dietary adjustments. Particularly in lean individuals, energy intake has been shown to increase in response to long-term exercise, while such compensatory changes in energy intake are less likely in overweight and obese adults (20). With a lack of compensatory adjustments in dietary intake an increase in exercise induces a negative energy balance resulting in fat loss. This was observed in participants with excess body fat exercise who lost fat mass with increased exercise while maintaining lean mass. Interestingly, resistance exercise had a greater effect on fat mass than did aerobic exercise. A 12-year cohort study also showed a stronger effect of resistance exercise on waist circumference compared to moderate-to-vigorous aerobic exercise (25). The lower effect of aerobic exercise on adiposity, particularly in overfat and obese participants, may be due to a limited ability of achieving a sufficient exercise intensity and volume (28, 44). Despite the positive effects of moderate intensity aerobic exercise on various health outcomes (25) higher exercise intensities may be necessary to induce changes in body composition (4). Accordingly, high-intensity interval training has been shown to induce a significant loss in fat mass while continuous moderate-intensity exercise had a limited effect on various measures of adiposity (5, 42). Resistance exercise may result in similar physiological responses as it is similar in nature to high-intensity interval training. Resistance exercise has been associated with an increase in fat oxidation (21), which potentially contributes to a greater reduction in fat mass while maintaining lean mass. The positive effects of resistance exercise on non-exercise activity thermogenesis may further contribute to changes in body composition (15) despite the lower energy expenditure during resistance exercise compared to aerobic exercise (38).

In contrast to the results of this study, clinical exercise studies in overweight/obese adults generally show a greater effect of aerobic exercise on fat mass, while resistance exercise induces greater changes in lean mass (35). DiPietro, however, argues that effects of self-selected exercise regimen in a free living population (as in the present study) most likely differ from those in the controlled environment of intervention studies (9). With the majority of individuals participating in clinical studies not being able to maintain exercise-induced changes in body composition (17), results of observational studies could provide valuable insights into the role of exercise for long-term weight management. In a 12-year cohort study a greater effect of resistance exercise on waist circumference was observed compared to aerobic exercise (25). Further, resistance exercise has been shown to be better

tolerated and more enjoyable in overweight adults (46), which could facilitate a sustained exercise engagement. Accordingly, resistance exercise was the second most reported exercise type following walking in overweight/obese participants in the National Weight Control Registry (6). Aerobic exercise, however, provides valuable health benefits (14) and a combined exercise regimen (i.e. aerobic and resistance exercise) has been suggested as the optimal approach to induce positive changes in body composition (25, 35). A combined exercise approach would also provide the largest health benefits as there is no single exercise type that provides the best benefit for every health indicator (36).

Some limitations of the present study, however, should be considered when interpreting the results. Even though overall activity level (PAL) was assessed objectively, participants self-reported their exercise participation and there was limited information on specific exercise intensities. More detailed information on specific sports (i.e. soccer vs. golf) may also have contributed to the limited effect of other exercise types. Relying on multiple measures of exercise and the utilization of LMM to determine change in exercise behavior should mitigate the limitations associated with self-report and the inclusion of an objective measure of total physical activity and energy intake further strengthens the results. The sample, however, consisted of predominantly well-educated adults with a high activity level (avg. PAL = 1.7). Despite these limitations regarding generalizability this study provides valuable information on the effects of various exercise types on adiposity.

Exercise has been emphasized as an important component of a healthy lifestyle, due to the well documented benefits for various health outcomes (1). There remains, however, uncertainty on the role of exercise in weight loss and weight management due to potential compensatory adaptations in energy intake and/or other components contributing to total daily energy expenditure. The present study shows that exercise induces positive changes in body composition even in the absence of weight loss. Of greater interest, however, is that the effects of exercise on body composition vary by body fatness. Any type of exercise positively affected lean mass in normal fat participants while particularly resistance exercise was shown to reduce fat mass in overfat and obese young adults. This should be considered in the development of weight management programs as aerobic exercise is generally the most commonly prescribed form of exercise. More research on separate effects of volume, intensity, type and pattern of exercise in various sub-populations, however, is needed to clarify the benefits of exercise regarding weight loss and weight management. Population specific, evidence-based recommendations for exercise participation along with reasonable expectations may help with the promotion of exercise participation that can be sustained over a prolonged period of time.

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Table 1

Baseline characteristics along with 12-month change in measures of adiposity and energy expenditure by fat category. Values are Prevalence or Mean $\pm$ SD.

	Total Sample (N=348)	Healthy Range (N=135)	Overfat (N=99)	Obese (N=114)
% Male	49.1 %	42.2 %	46.5 %	59.6 %
% White	66.1 %	74.8 %	59.6 %	61.4 %
% College Degree	86.2 %	88.9 %	83.8 %	85.1 %
Age at baseline (yrs)	27.7 $\pm$ 3.7	27.2 $\pm$ 3.6	27.6 $\pm$ 3.9	28.5 $\pm$ 3.7
Height (cm)	171.9 $\pm$ 9.5	171.9 $\pm$ 9.8	171.7 $\pm$ 9.8	172.0 $\pm$ 8.9
Weight (kg) ^I	74.7 $\pm$ 13.7	67.5 $\pm$ 11.2	74.0 $\pm$ 12.0	84.0 $\pm$ 12.5
BMI (kg/m ²) ^I	25.2 $\pm$ 3.8	22.7 $\pm$ 2.2	25.1 $\pm$ 3.2	28.4 $\pm$ 3.6
Fat Mass (kg) ^I	21.5 $\pm$ 8.8	14.4 $\pm$ 4.0	21.6 $\pm$ 6.1	29.7 $\pm$ 7.7
Fat Free Mass (kg)	51.2 $\pm$ 10.6	51.1 $\pm$ 11.9	50.3 $\pm$ 10.4	52.0 $\pm$ 8.9
Body Fat (%) ^I	28.5 $\pm$ 9.1	22.0 $\pm$ 7.2	29.5 $\pm$ 7.5	35.3 $\pm$ 6.9
TDEE (kcal/day)	2726 $\pm$ 495	2688 $\pm$ 532	2713 $\pm$ 499	2784 $\pm$ 440
RMR (kcal/day)	1581 $\pm$ 266	1546 $\pm$ 278	1562 $\pm$ 256	1640 $\pm$ 254
Calculated EI (kcal/day)	2704 $\pm$ 512	2675 $\pm$ 550	2664 $\pm$ 501	2773 $\pm$ 473

TDEE... total daily energy expenditure; RMR... resting metabolic rate; PA... Physical Activity EI... energy intake

^I significant difference between all fat categories, controlling for sex, ethnicity and age (p<0.01)

Table 2

Exercise participation rate, exercise time, and frequency of exercise engagement per week at baseline. Values are prevalence for participation rate and Mean±SD.

	Total Sample	Healthy Range	Overfat	Obese
Meeting PA Guidelines (%) [†]	59.8 %	82.2 %	58.6 %	34.2 %
Never any Exercise (%)	6.9 %	2.2 %	4.0 %	14.9 %
Never Endurance EX (%)	16.4 %	8.1 %	16.2 %	26.3 %
Never Resistance EX (%)	30.7 %	21.5 %	29.3 %	43.0 %
Never Other EX (%)	19.5 %	10.4 %	19.2 %	30.7 %
Total EX time (min/wk) * ^{1,2}	346.5 ± 267.6	408.3 ± 286.7	353.7 ± 280.2	251.6 ± 192.8
Total EX (sessions/wk) * ³	6.2 ± 4.4	7.5 ± 4.4	6.1 ± 4.4	4.7 ± 4.0
Endurance EX time (min/wk) * ¹	135.5 ± 135.2	155.7 ± 155.6	136.5 ± 139.5	103.6 ± 82.8
Endurance EX (sessions/wk) *	3.4 ± 2.3	3.6 ± 2.7	3.4 ± 2.1	3.2 ± 1.9
Resistance EX time (min/wk) *	143.2 ± 115.7	142.9 ± 107.3	163.9 ± 144.2	120.4 ± 90.1
Resistance EX (sessions/wk) *	3.7 ± 1.4	3.9 ± 1.4	3.7 ± 1.6	3.4 ± 1.4
Other EX time (min/wk) * ¹	192.7 ± 169.9	212.2 ± 166.6	202.3 ± 186.5	149.3 ± 150.8
Other EX (sessions/wk) * ¹	3.4 ± 2.3	3.8 ± 2.4	3.4 ± 2.4	2.9 ± 2.0
PAL (TEEE/RMR)	1.73 ± 0.20	1.74 ± 0.20	1.74 ± 0.22	1.71 ± 0.19

EX... exercise

* excluding participants not reporting this type of exercise

[†] At least 150 min/week of MVPA in 10 minute bouts on 5 days per week

¹ obese significantly different from healthy range after controlling for sex, age and ethnicity (p<0.05)

² obese significantly different from overfat after controlling for sex, age and ethnicity (p<0.05)

³ significant difference between all fat categories, controlling for sex, ethnicity and age (p<0.05)

Table 3

Effect of baseline exercise levels and change in exercise on measures of body fatness at 12 months. Values are standardized coefficients, adjusted for baseline sex, ethnicity, age and baseline measures of body fatness.

Dependent Variable	Baseline Exercise (min/week)						Exercise (min/week)					
	Total EX ¹	Aerobic EX ²	Resist. EX ²	Other EX ²	Total EX ¹	Other EX ²	Aerobic EX ²	Resist. EX ²	Other EX ²	Total EX ¹	Aerobic EX ²	Resist. EX ²
BMI (kg/m ²)	β .029	β .173	β -.028	β .200	β .040	β .101	β -.026	β .219	β .013	β .539	β .001	β .995
% Body Fat	p <.001	p <.001	p <.001	p <.001	p <.001	p <.001	p <.001	p <.001	p <.001	p <.001	p <.001	p <.001
Fat mass (kg)	β -.046	β .031	β -.039	β .067	β -.051	β .032	β -.060	β .004	β -.081	β <.001	β -.011	β .640
Lean mass (kg)	p <.001	p <.001	p <.001	p <.001	p <.001	p <.001	p <.001	p <.001	p <.001	p <.001	p <.001	p <.001

Exercise... change in exercise over 12-months based on LMM

1,2 separate regression models

Table 4

Effect of baseline exercise levels and change in exercise on measures of body fatness at 12 months separately for healthy fat, overfat and obese participants. Values are standardized coefficients, adjusted for sex, ethnicity, age and baseline measures of body fatness.

HEALTHY F.	Baseline Exercise (min/week)				Exercise (min/week)			
	Total EX ¹	Aerobic EX ²	Resist. EX ²	Other EX ²	Total EX ¹	Aerobic EX ²	Resist. EX ²	Other EX ²
Dependent Variable	β	p	β	p	β	p	β	p
BMI (kg/m ²)	.113	.040	.001	.994	.088	.158	.100	.159
% Body Fat	-.053	.194	-.035	.324	.023	.619	-.075	.270
Fat mass (kg)	-.020	.731	-.045	.374	.052	.445	-.039	.625
Lean mass (kg)	.088	<.001	.013	.422	.056	.012	.072	.006
OVERFAT	Baseline Exercise (min/week)				Exercise (min/week)			
	Total EX ¹	Aerobic EX ²	Resist. EX ²	Other EX ²	Total EX ¹	Aerobic EX ²	Resist. EX ²	Other EX ²
Dependent Variable	β	p	β	p	β	p	β	p
BMI (kg/m ²)	.030	.498	-.046	.336	-.020	.756	.060	.413
% Body Fat	-.076	.104	-.060	.235	-.114	.098	.026	.657
Fat mass (kg)	-.082	.141	-.078	.202	-.144	.082	.040	.568
Lean mass (kg)	.058	.001	-.002	.903	.047	.067	.027	.229
OBESE	Baseline Exercise (min/week)				Exercise (min/week)			
	Total EX ¹	Aerobic EX ²	Resist. EX ²	Other EX ²	Total EX ¹	Aerobic EX ²	Resist. EX ²	Other EX ²
Dependent Variable	β	p	β	p	β	p	β	p
BMI (kg/m ²)	.007	.874	-.081	.116	.068	.123	-.011	.812
% Body Fat	-.093	.009	-.033	.417	-.081	.021	-.019	.601
Fat mass (kg)	-.075	.068	-.064	.173	-.063	.121	.006	.879
Lean mass (kg)	.030	.137	-.027	.223	.059	.002	.001	.968

Exercise... change in exercise over 12-months based on LMM

1,2 separate regression models