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**Determinants of Weight Loss Success Utilising a Meal Replacement Plan and/or
Exercise, in Overweight and Obese Adults With Asthma**

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Summary at a Glance: This study is the first to demonstrate that more severe asthma at baseline, male sex, and improvements in eating behaviours during weight loss, are associated with greater weight loss success in overweight and obese adults with asthma. Our findings may inform the development of asthma-specific weight management guidelines.

ABSTRACT

Background: While weight loss has been shown to reduce obesity-related comorbidity, many weight loss treatments fail. Factors that enhance weight loss success are unknown, particularly in those with asthma.

Objective: To identify patient characteristics that predict weight loss success in adults with asthma.

Methods: Baseline and change in asthma characteristics and eating behaviours were investigated for relationships with weight loss and fat loss using multiple linear regression, in 38 overweight and obese adults with asthma randomised to dietary, exercise or combined interventions targeting weight loss for 10 weeks.

Results: Mean $\pm$ SD weight loss was 6.6 $\pm$ 5.1kg. Greater %weight loss and %fat loss was achieved in those with poorer asthma-related quality of life at baseline [($r_s=0.398$, $p=0.015$) and ($r_s=0.455$, $p=0.005$) respectively], with 1.7% greater absolute weight loss at week 10 corresponding to each 1 unit reduction in the asthma-related quality of life score at baseline. Furthermore, a lower baseline FEV₁/FVC correlated with greater weight loss ($r_s=0.398$, $p=0.015$). Male sex was associated with a 3.6kg greater weight loss ($p=0.087$). Reducing emotional eating during the program was associated with greater weight loss in women ($r_s=0.576$, $p=0.010$).

Conclusion: This study demonstrates that individuals with more severe asthma at baseline are more successful in achieving weight loss, which could be a consequence of greater motivation and could be used as a motivational tool within the clinical setting. Gender-tailoring of weight loss programs may be useful to enhance weight loss success. Future studies are urgently needed to establish predictors of long-term weight loss maintenance in those with asthma.

Key Words: asthma, eating behaviours, lung function, obesity, weight loss

Short Title: Predictors of Weight Loss in Asthma

INTRODUCTION

Obesity is an increasingly prevalent condition that is progressive and relapsing. Asthmatics who are obese experience poorer lung function and asthma control, and more frequent exacerbations of their asthma compared to asthmatics of a healthy weight.¹⁻³ While weight loss is recommended for reducing the risk of obesity-related comorbidity⁴ and appears to improve asthma outcomes,^{5, 6} many weight loss treatments are suboptimal⁷ and factors that enhance success are poorly defined. Furthermore, only 20% of people who do successfully lose weight are able to maintain this weight loss for five or more years.⁸ Currently, weight loss guidelines for those with asthma do not exist. We recently recommended a 5-10% weight loss target, as this degree of weight loss corresponded to a clinically important improvement in asthma-related quality of life in 83% of subjects and asthma control in 58% of subjects.⁵ It is important to gain insight into factors that can enhance weight loss success in those with asthma, to improve the clinical outcomes of this population.

One weight loss strategy showing potential is a partial meal replacement plan, which involves following a low-energy diet while replacing 1-2 main meals each day with meal replacements. Low-energy diets without the use of meal replacements produce an average weight loss of 3-7% over a 3-12 month period,⁹ while a low-energy diet in combination with a partial meal replacement plan is more efficacious, resulting in a short-term weight loss (3-12 months) of 9-12% and long-term weight loss maintenance (1-5 years) of 6-8%.⁹⁻¹³ Partial meal replacement programs are most successful when there is involvement from a dietitian. For example, Ashley et al¹³ demonstrated a 9.1% weight loss in a dietitian-led partial meal replacement program

compared with a 4.3% weight loss in a physician-led partial meal replacement program.

Increasing exercise also contributes to weight loss and is associated with long-term weight loss maintenance.¹⁴ While exercise alone results in a very modest weight loss of approximately 1kg over a 3-12 month period,¹⁵ physically inactive adults of a healthy weight have a higher rate of morbidity and mortality compared with obese but physically active adults,¹⁶ suggesting that the health consequences of physical inactivity should not be ignored in the current debate on the health consequences of obesity.

This study sought to identify predictors of weight loss success within a previously reported weight loss intervention that used three different approaches: dietary intervention, exercise intervention and combined dietary and exercise intervention, in overweight and obese adults with asthma.⁵ We hypothesised that in addition to intervention type, participant characteristics including age, sex, asthma status and eating behaviours, would predict the degree of weight loss success.

METHODS

Study Design

Subjects with stable asthma were assessed at baseline and after a 10-week weight loss intervention, which has been described in detail previously.⁵ At each time point, anthropometric, dietary, physical activity and asthma-related measures were collected for assessment of participant characteristics that could be related to weight loss success. This research was approved by the Hunter New England Human Research Ethics Committee (HREC/09/HNE/77) and was registered with the Australian Clinical Trials Registry (<http://www.actr.org.au>), Registration Number: ACTRN12611000235909. Written informed consent was provided by all participants.

Anthropometric, Dietary and Physical Activity Measures

Body weight, height and waist circumference were measured, and body composition was quantified by dual energy x-ray absorptiometry (DXA; Lunar Prodigy Series, GE Medical Systems, Madison, WI, USA) as described previously.⁵ Participants completed the Three-Factor Eating Questionnaire Revised 18-Item (TFEQ-R18) to measure eating behaviours.¹⁷ The TFEQ-R18 is divided into three categories: emotional eating (inability to resist emotional cues); uncontrolled eating (subjective feelings of hunger accompanied by a loss of control over food intake); and cognitive restraint (a conscious restriction of food intake in order to lose/control weight).¹⁷ The raw score for each category was transformed into a 0-100 scale; the higher the score, the greater the emotional eating, uncontrolled eating and cognitive restraint. A four-day semi-quantitative food diary was completed to estimate participant's dietary intake. Dietary analysis was performed using nutrient analysis software (FoodWorks Professional Edition Version 6.0, Xyris Software Pty Ltd, Australia). Complete

dietary data were available for 26 participants (68%), who returned their food diaries both pre- and post-intervention. Seven days of pedometry was recorded.

Asthma Characterisation

Forced expiratory volume in 1 second (FEV₁) and forced vital capacity (FVC) were measured using a Koko Spirometer (POS Instrumentation, Inc, Louisville, KY, USA). Asthma-related quality of life was determined using the Juniper Asthma Quality of Life Questionnaire (AQLQ),¹⁸ while asthma control was measured by the Juniper Asthma Control Questionnaire (ACQ).¹⁹ An ACQ score ≤ 0.75 defined well controlled asthma, a score >0.75 and <1.5 partially controlled asthma, and a score ≥ 1.5 poorly controlled asthma.²⁰

Intervention Protocol

The intervention protocol has been described in detail previously.⁵ The dietary intervention utilised a partial meal replacement plan coupled with a low energy diet, while the exercise intervention included a gymnasium membership with participants expected to attend three times each week. The combined intervention involved the dietary and exercise interventions being undertaken concurrently.

Statistical Analysis

Data were analysed using Intercooled Stata version 11.1 (Stata Corporation, College Station TX USA). Pre- and post-intervention change in eating behaviours and dietary intake was examined using Wilcoxon signed rank test or a paired *t*-test. The correlations between weight and fat tissue change with baseline eating behaviours and asthma characteristics were assessed using the Spearman rank test (r_s). Analysis of

covariance (ANCOVA) was used to examine sex differences in changes to body composition, eating behaviours, dietary intake and physical activity (pedometer steps) (Table 2). Multiple linear regression analysis was used to examine baseline variables including asthma status, eating behaviours, physical activity, intervention allocation, age, sex and BMI as predictors of weight loss success, with the percentage of weight and fat loss used as outcomes of the models (Table 3). Additionally, regression analysis was conducted to examine changes to eating behaviours and asthma characteristics as mediators of weight loss success (Table 5). Variables with p -values ≤ 0.2 entered the multivariate model and only these variables are listed in the relevant table. P -values < 0.05 were considered statistically significant.

RESULTS

Baseline Characteristics and Changes Following the Intervention

Baseline characteristics of the 38 subjects are presented in Table 1. Women had a higher BMI and body fat levels than men, and were less likely to be atopic (Table 1). There was a mean weight loss of 6.6 ± 5.1 kg after the 10-week intervention, with men losing an additional 3.6 kg ($p=0.087$) and having a 3.3 cm greater reduction to their waist circumference ($p=0.022$) (Table 2). Baseline muscle mass was not associated with percentage weight loss in men ($r_s=-0.064$, $p=0.808$), women ($r_s=0.020$, $p=0.935$) or overall ($r_s=-0.231$, $p=0.169$). At baseline, women reported a significantly higher level of emotional eating compared with men ($p<0.001$) but there were no significant gender differences in uncontrolled eating ($p=0.251$) or cognitive restraint ($p=0.214$) (Table 2). Emotional eating, uncontrolled eating and cognitive restraint were significantly improved after the 10-week intervention (Table 2). Dietary energy intake was reduced post-intervention, with a reduction in the proportion of energy obtained from fat in women (Table 2). At baseline, Vitamin D was only approximately half of the recommended intake (Table 2).²¹ Women older than 50 years and men were consuming approximately 80% of their recommended intake of calcium; however, women younger than 50 were only meeting approximately half of this recommendation.²¹ Post-intervention, women had significantly improved their calcium intake ($p=0.046$), with those younger than 50 years achieving 90% of their recommended dietary intake (Table 2). There was a significant reduction in sodium intake and increase in Vitamin D intake (Table 2). Physical activity increased significantly ($p=0.013$) from 8210 ± 3380 steps per day at baseline to 9705 ± 3198 steps per day post-intervention (Table 2).

Baseline Predictors of Weight Loss Success

Lower FEV₁/FVC at baseline correlated with greater weight loss ($r_s=0.398$, $p=0.015$) and fat loss ($r_s=0.455$, $p=0.005$) (Figure 1). As expected, intervention group allocation was a predictor of weight loss success, with subjects randomised to either the dietary or combined interventions losing significantly more weight and fat tissue than subjects randomised to the exercise intervention (Table 3). Regression analysis indicated that men were more successful at losing weight than women, whereas age had no influence (Table 3). A poorer baseline asthma-related quality of life predicted greater weight loss success; absolute weight loss increased by 1.7% and absolute fat loss increased by 3.9% for each one unit poorer the AQLQ score at baseline (Table 3). A lower BMI and higher level of uncontrolled eating at baseline were associated with a greater fat loss (Table 3). Those with uncontrolled asthma at baseline, as indicated by the ACQ, lost twice as much weight as those who had well controlled or partially controlled asthma [-8.7(-6.5, -10.4)% versus -4.5(-1.1, -9.3)% weight loss], although this did not reach statistical significance ($p=0.079$).

Change in Asthma Characteristics and Eating Behaviours as Mediators of Weight Loss

In women there was a correlation between a reduction in emotional eating and weight loss and fat loss, but this relationship was not evident in men (Table 4). Also, women who had a larger decrease in uncontrolled eating had a greater weight loss, but again this was not observed in men (Table 4). However, in men there was a strong association between an increase in cognitive restraint and a greater weight loss but this relationship was not evident in women (Table 4). There was no association between change in pedometer steps and weight loss ($r_s=0.234$, $p=0.251$). An

improvement in asthma-related quality of life was associated with greater weight loss, whereby each 1 unit increase in the AQLQ score during the intervention corresponded to a 1.5% greater absolute weight loss (Table 5). Changes to lung function and asthma control were not mediators of weight loss (data not shown). Changes to asthma-related variables and eating behaviours were not mediators of fat tissue change (Table 5).

DISCUSSION

This study demonstrates that those with a worse quality of life due to their asthma achieved greater weight loss success, while men were more successful than women. Furthermore, a reduction in emotional eating and uncontrolled eating in women, and an increase in cognitive restraint in men, was associated with greater weight loss success.

Interestingly, we found that those with more severe airway obstruction and poorer asthma-related quality of life were more successful in losing weight. Berthon et al²² have demonstrated that adults with a severe persistent pattern of asthma consume a poorer quality diet that is higher in fat and lower in fibre than healthy adults, which suggests that those with severe asthma could plausibly find dietary modification more difficult to achieve; however, our study demonstrates that this may not be the case. Our findings may be explained by the fact that a poorer asthma status could be an important motivator for weight loss, as prior to commencing the intervention patients were made aware that weight loss has been shown to improve clinical asthma status. This finding warrants further investigation, as this is a simple motivational technique that could be utilised in the clinical setting. Whether those with more severe asthma are more likely, or indeed less likely, to maintain weight loss long-term compared with mild asthma is an important question that should be investigated in future trials.

Nutrient intake was improved as result of this trial, including a reduction in dietary fat intake and increase in Vitamin D and calcium. However, fibre intake was reduced overall which is likely an undesirable consequence of the low fibre content of meal replacements. Reductions in both emotional eating and uncontrolled eating in women,

and an increase in restrained eating in men, were associated with greater weight loss success. Baseline emotional eating scores were more than twice as high in women compared to men. Similarly, in the NutriNet-Santé cohort of 35,641 adults, women were more likely than men to report emotional eating.²³ Also, Teixeira et al²⁴ conducted a weight loss intervention and found that reducing emotional eating and increasing flexible dietary restraint were two of the most important predictors of weight loss success in 239 overweight and obese women. These studies support our observations and highlight the need to specifically target eating behaviours in weight loss programs designed for those with asthma.

The greater weight loss success we observed in men could be attributed to the fact that they have a higher muscle mass, resulting in an increased basal metabolic rate thus producing a greater kilojoule deficit. However we found no correlation between baseline muscle mass and weight loss success, suggesting that, at least in this cohort, other factors are responsible. Indeed, our results suggest that eating behaviours appear to be more important. Another explanation may be the different physiological responses of men and women to exercise, with exercise inducing a greater weight loss in men.²⁵ In women, exercise training stimulates an increased production of the appetite hormone ghrelin and reduces insulin and leptin compared to men.²⁵ These hormonal responses promote an increased energy intake and may explain the smaller weight loss in women undertaking exercise training. These studies suggest that gender-specific weight loss programs or approaches may be necessary to enhance weight loss success. Further research should examine gender-specific behavioural mediators of weight loss in those with asthma to confirm these observations.

This study has a number of limitations. Firstly, this study included a relatively small sample size. Nonetheless, the aim of this investigation was to examine predictors of weight loss success, which was achieved within the given sample size. Another limitation is that long-term follow-up was not performed. However, our study has made some novel observations that provide direction for the design of such studies in the future. Lastly, morbidly obese ($\text{BMI} \geq 40 \text{ kg/m}^2$) asthmatics were not recruited as part of this program and therefore our findings may not be applicable to this population.

In conclusion, this study shows for the first time that those with more severe airway obstruction and a poorer asthma-related quality of life are more successful in achieving weight loss when utilising a partial meal replacement plan and increasing exercise. This finding has important implications, as it suggests that acknowledging potential improvements to asthma status could be used as a source of weight loss motivation in the clinical setting. Reducing emotional eating and uncontrolled eating in women, and increasing restrained eating in men, was associated with greater weight loss success, while men had a greater weight loss than women. These findings suggest that gender-specific programs may be of benefit to those with asthma, particularly women. This study highlights the urgent need to examine the long-term efficacy of weight loss intervention in adults with asthma, and in particular establish predictors of long-term weight loss maintenance, because sustaining weight loss is important for health. This will enable better clinical management of this population and assist in the development of weight loss guidelines for this population.

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Table 1. Subject baseline characteristics, stratified by sex.

	Women (n=20)	Men (n=18)	P-value	Total (n=38)
Intervention (D/E/D+E)	8/5/7	7/5/6	0.981	15/10/13
Age (years)	39.0±15.1	41.8±11.4	0.530	40.3±13.4
Weight (kg)	94.8±12.4	102.8±12.7	0.060	98.6±13.0
BMI (kg/m²)	34.9±3.4	32.1±3.1	0.011	33.6±3.5
Waist Circumference (cm)	108.4±9.9	112.8±10.5	0.191	110.5±10.3
%Body Fat	51.2 (48.3, 52.7)	36.1 (32.9, 37.2)	<0.001	44.8 (36.7, 51.8)
Android	55.8 (52.1, 60.3)	46.2 (41.6, 51.3)	0.397	51.5 (46.8, 56.2)
Gynoid	56.0±4.1	36.7±4.8	<0.001	46.8±10.7
Thoracic	46.2±5.0	35.3±5.1	<0.001	41.0±7.4
Arms	48.6 (46.1, 51.5)	26.2 (22.1, 30.5)	<0.001	40.3 (26.5, 48.6)
Legs	53.7 (50.5, 56.5)	32.1 (28.0, 34.7)	<0.001	47.3 (32.9, 54.6)
FEV1 %predicted	83.5±15.4	79.9±19.5	0.541	81.8±17.2
FVC %predicted	94.9±14.5	92.9±12.5	0.649	94.0±13.5
%FEV₁/FVC	72.7 (67.1, 78.4)	66.5 (58.7, 76.3)	0.211	71.6 (63.9, 78.1)
ACQ Score	1.36±0.53	1.06±0.70	0.148	1.21±0.63
AQLQ Score	5.7 (5.0, 6.1)	6.0 (5.4, 6.4)	0.144	5.8 (5.0, 6.3)
GINA Classification (%) (Intermittent/Mild/Moderate/Severe)	15/30/50/5	28/22/28/22	0.233	21/26/39/13
Age at Asthma Diagnosis (years)	8 (3, 18)	7 (2, 22)	0.587	8 (2, 18)
Ever Smokers (%)	30.0	33.3	0.825	31.6
Pack Years of Ever Smokers	3 (1, 8)	8 (1, 15)	0.749	6 (1, 12)
Atopy (%)	75.0	100.0	0.027	86.5
ICS Dose (µg/day) *	1000 (250, 1000)	1000 (0, 1000)	0.902	1000 (0, 1000)
PD15†	6.7 (5.5, 11.2)	6.7 (2.3, 12.8)	0.621	6.7 (4.3, 11.4)

P-value represents the comparison between women and men. *Beclomethasone equivalents; † Provocation dose of hypertonic saline required to induce a drop in FEV₁ of 15% from baseline. D – dietary intervention; E – exercise intervention; D+E – combined (dietary + exercise intervention) ; BMI – body mass index; FEV₁ – forced expiratory volume in 1 second; FVC – forced vital capacity; ACQ – asthma control questionnaire; AQLQ – asthma-related quality of life questionnaire; GINA – global initiative for asthma; ICS – inhaled corticosteroid.

Table 2. Change in body composition, eating behaviours, dietary intake and physical activity, stratified by sex.

	Women (n=20)		Men (n=18)		Sex Effect (<i>P</i> -value)	Total (n=38)	
	Pre-Intervention	Post-Intervention	Pre-Intervention	Post-Intervention		Pre-Intervention	Post-Intervention
Body Composition							
Weight (kg)	94.8±12.4	89.9±12.9‡	102.8±12.7	94.3±12.2‡	0.087	98.6±13.0	92.0±12.6‡
Waist Circumference (cm)	108.4±9.9	102.1±10.4‡	112.8±10.5	103.2±11.4‡	0.022	110.5±10.3	102.6±10.7‡
Body Fat (%)	51.2 (48.3, 52.7)	49.9 (47.8, 52.3)*	36.1 (32.9, 37.2)	30.4 (26.7, 34.6)‡	0.532	44.8 (36.7, 51.8)	41.8 (30.4, 51.0)‡
Eating Behaviours							
Emotional Eating	78 (67, 89)	56 (22, 67)‡	33 (22, 44)	11 (0, 33) ‡	0.959	56 (33, 89)	33 (11, 56)‡
Uncontrolled Eating	52±17	33±17‡	44±21	27±19‡	0.822	48±19	30±18‡
Cognitive Restraint	50 (39, 67)	61 (50, 78)*	42 (33, 56)	67 (50, 83)‡	0.213	44 (39, 61)	67 (50, 78)‡
Dietary Intake							
Energy (kJ)	8910 (8128, 10301)	5138 (4554, 6716)†	11855 (9825, 12910)	5086 (4400, 7603)†	0.482	10027 (8534, 11874)	5138 (4488, 6716)‡
%Fat	36.5±4.4	26.7±7.6‡	33.5±6.2	26.4±7.4*	0.859	35.0±5.5	26.5±7.4‡
%SFA	41.5±6.0	36.5±3.5*	39.5±7.0	36.8±5.1	0.682	40.5±6.5	36.7±4.3*
%MUFA	38.8±4.1	39.4±4.8	38.6±3.3	36.9±5.0	0.216	38.7±3.6	38.2±5.0
%PUFA	13.6±3.1	18.3±4.3†	14.8±4.9	18.8±4.3	0.860	14.2±4.1	18.5±4.2‡
%Carbohydrate	41.6±7.5	40.3±5.5	43.2±9.2	37.3±8.0	0.464	42.4±4.1	38.9±6.9
Sugars (g)	98 (83, 121)	73 (59, 97)*	111 (90, 164)	68 (47, 87)	0.703	104 (87, 146)	70 (58, 88)†
Fibre (g)	20 (18, 24)	16 (15, 26)	33 (17, 35)	20 (14, 25)	0.675	24 (17, 33)	16 (14, 25)*
%Protein	20.1±4.8	27.5±6.7†	19.4±3.1	30.4±9.0†	0.448	19.7±4.0	28.9±7.9‡
Vitamins							
β-carotene (μg)	2518 (1450, 4058)	5398 (2264, 8651)*	3195 (1284, 4784)	2581 (1426, 4971)	0.496	2816 (1419, 4517)	4455 (1505, 6877)
Thiamin (mg)	1.8 (1.4, 2.2)	1.5 (1.3, 1.7)	2.7 (2.3, 4.6)	1.9 (1.6, 2.4)	0.954	2.3 (1.6, 2.9)	1.6 (1.4, 2.2)*
Riboflavin (mg)	2.2 (1.6, 3.1)	2.3 (1.6, 2.5)	2.8 (2.6, 3.9)	2.4 (2.3, 2.9)	0.999	2.6 (1.7, 3.7)	2.4 (2.2, 2.6)
Niacin (mg)	57 (47, 65)	36 (32, 42)*	65 (61, 93)	47 (40, 52)†	0.270	64 (55, 74)	40 (36, 48)‡
Vitamin C (mg)	95 (69, 124)	126 (86, 151)*	134 (74, 159)	92 (72, 158)	0.179	106 (69, 150)	106 (81, 151)
Vitamin D (μg)	2.6 (1.8, 3.7)	5.5 (3.7, 6.0)*	3.0 (2.2, 4.1)	5.8 (4.3, 8.1)*	0.525	2.7 (2.1, 4.1)	5.5 (4.3, 7.0) †
Vitamin E (mg)	8.3 (6.2, 10.2)	13.6 (11.2, 14.1)*	10.4 (8.2, 17.2)	11.9 (9.0, 14.2)	0.433	8.5 (6.3, 12.5)	12.7 (10.0, 14.1)
Minerals							
Sodium (mg)	2794 (2237, 3282)	1491 (1188, 1977)†	3471 (3203, 4176)	1950 (1409, 2359)†	0.099	3230 (2767, 3812)	1668 (1339, 2271)‡
Potassium (mg)	3084 (2536, 3484)	3193 (2848, 3532)	3993 (3294, 4704)	3333 (2984, 3446)	0.828	3477 (2536, 4227)	3251 (2984, 3446)
Calcium (mg)	654 (540, 946)	920 (814, 1080)*	875 (758, 1201)	868 (771, 1043)	0.784	807 (608, 1062)	883 (814, 1063)
Iron (mg)	12.0 (9.4, 12.9)	17.1 (12.1, 19.6)†	17.1 (12.8, 18.7)	15.3 (14.0, 17.4)	0.214	12.8 (9.6, 17.1)	16.3 (14.0, 18.2)†
Physical Activity							
Pedometer Steps/Day	7903±2864	9540±3392	8517±3923	9870±3121	0.972	8210±3380	9705±3198*

**P*<0.05 vs pre-intervention score; †*P*<0.01 vs pre-intervention score; ‡ *P*<0.001 vs pre-intervention score. Sex effect analysed by ANCOVA.

Table 3. Multiple linear regression examining baseline characteristics as predictors of % weight change and % fat change.

%Weight Change		Unadjusted Model		Final Model	
				$R^2 = 0.515$	$p < 0.001$
Variable (pre-intervention)	Coefficient (95% CI)	p -value	Coefficient (95% CI)	p -value	
Female Sex	-3.0 (-5.6, -0.5)	0.021	-3.7 (-6.2, -1.2)	0.005	
Intervention:					
E vs D	-6.8 (-9.8, -3.9)	<0.001	-6.9 (-9.4, -4.3)	<0.001	
E vs D+E	-6.7 (-9.5, -3.8)	<0.001	-6.2 (-9.0, -3.4)	<0.001	
Baseline AQLQ Score	1.7 (0.2, 3.2)	0.027	1.7 (0.2, 3.2)	0.027	
Baseline FEV ₁ /FVC	0.11 (-0.03, 0.26)	0.117			
Baseline ACQ Score	-1.4 (-3.4, 0.6)	0.155			

%Fat Change		Unadjusted Model		Final Model	
				$R^2 = 0.700$	$p < 0.001$
Variable (pre-intervention)	Coefficient (95% CI)	p -value	Coefficient (95% CI)	p -value	
Female Sex	-12.9 (-19.1, -6.8)	<0.001	-11.5 (-16.8, -6.1)	<0.001	
Intervention:					
E vs D	-13.5 (-21.2, -5.8)	0.001	-17.0 (-23.5, -10.5)	<0.001	
E vs D+E	-14.6 (-20.3, -8.9)	<0.001	-13.4 (-18.6, -8.1)	<0.001	
Baseline BMI (kg/m ²)	1.2 (0.3, 2.1)	0.011	1.2 (0.5, 2.0)	0.002	
Baseline AQLQ Score	3.3 (0.4, 6.2)	0.028	3.9 (1.5, 6.3)	0.003	
Baseline FEV ₁ /FVC	0.3 (-0.004, 0.678)	0.053			
Baseline Uncontrolled Eating Score	-0.2 (-0.30, -0.04)	0.011	-0.1 (-0.25, -0.01)	0.038	
Baseline Cognitive Restraint Score	-0.1 (-0.3, 0.1)	0.154			
Baseline Step Count (1000 steps/day)	-0.008 (-0.0017, 0.0001)	0.073			

Univariate models adjusted for the effects of intervention allocation and sex. The coefficients represent the difference in the outcome associated with an absolute change in weight or fat tissue of 1%. E – exercise intervention; D – dietary intervention; D+E – combined (dietary+exercise intervention) ; AQLQ – asthma quality of life questionnaire; FEV₁ – forced expiratory volume in one second; FVC – forced vital capacity; ACQ – asthma control questionnaire; BMI – body mass index.

Table 4. Relationship between changes in eating behaviours with %weight change and %fat change, in men and women with asthma.

	Women (n=20)		Men (n=18)	
	%Weight Change	%Fat Change	%Weight Change	%Fat Change
Emotional Eating	0.576*	0.579†	-0.159	0.020
Uncontrolled Eating	0.539*	0.571*	0.118	0.196
Cognitive Restraint	-0.059	0.081	-0.712†	-0.462

* $p < 0.05$; † $p < 0.01$.

Table 5. Multiple linear regression examining change in asthma characteristics and eating behaviours as predictors of % weight change and % fat change.

%Weight Change	Unadjusted Model		Final Model	
			$R^2 = 0.502$	$p < 0.001$
Variable	Coefficient (95% CI)	p-value	Coefficient (95% CI)	p-value
Female Sex	-3.0 (-5.6, -0.5)	0.021	-3.1 (-5.6, -0.5)	0.019
Intervention:				
E vs D	-6.8 (-9.8, -3.9)	<0.001	-6.5 (-9.2, -3.9)	<0.001
E vs D+E	-6.7 (-9.5, -3.8)	<0.001	-6.7 (-9.6, -3.9)	<0.001
AQLQ Score Change	-1.50 (-2.99, -0.01)	0.048	-1.50 (-2.99, -0.01)	0.048
Uncontrolled Eating Score Change	0.10 (-0.05, 0.26)	0.117		
Emotional Eating Score Change	0.04 (-0.02, 0.10)	0.175		

%Fat Change	Unadjusted Model		Final Model	
			$R^2 = 0.517$	$p < 0.001$
Variable (pre-intervention)	Coefficient (95% CI)	p-value	Coefficient (95% CI)	p-value
Female Sex	-12.9 (-19.1, -6.8)	<0.001	-12.9 (-19.1, -6.8)	<0.001
Intervention:				
E vs D	-13.5 (-21.2, -5.8)	0.001	-13.5 (-21.2, -5.8)	0.001
E vs D+E	-14.6 (-20.3, -8.9)	<0.001	-14.6 (-20.3, -8.9)	<0.001
AQLQ Score Change	-2.1 (-5.3, 1.1)	0.186		

Univariate models adjusted for the effects of intervention allocation and sex. The coefficients represent the difference in the outcome associated with an absolute change in weight or fat tissue of 1%. E – exercise intervention; D – dietary intervention; D+E – combined (dietary+exercise intervention) ; AQLQ – asthma quality of life questionnaire; FEV₁ – forced expiratory volume in one second; FVC – forced vital capacity; ACQ – asthma control questionnaire; BMI – body mass index.

Figure 1. Correlations between baseline FEV₁/FVC and a) %weight change ($r_s=0.398$, $p=0.015$), and b) %fat tissue change ($r_s=0.455$, $p=0.005$).