

# Participant Characteristics Associated with Changes in Mental Health in a Trial of Behavioural Weight Management Programmes: Secondary Analysis of the WRAP Trial

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## Keywords

Obesity · Weight management · Interventions · Mental health

## Abstract

**Introduction:** On average, aspects of mental health improve following behavioural weight management programmes, yet this is not the case for all participants. It is important to identify those at risk of harm to provide more effective psychological support. We aimed to identify participant characteristics associated with changes in depression and anxiety in participants of a behavioural weight management programme. **Methods:** In the Weight loss Referrals for Adults in Primary care trial, 1,267 adults with body mass index  $\geq 28$  kg/m<sup>2</sup> were randomized to brief intervention, or WW (formerly weight watchers) for 12-weeks or 52-weeks and followed for 5 years. We used linear and multinomial regression to explore the association between participant characteristics and changes in depression and anxiety (measured by the hospital anxiety and depression scale). Where possible, the impact of missing data was investigated using multiple imputation. **Results:** Higher baseline anxiety was associated with decreases in anxiety symptoms and increases in depres-

sion symptoms from baseline to follow-up. Higher baseline depression was associated with decreases in depression symptoms and increases in anxiety symptoms from baseline to follow-up. The magnitude of the associations was small. No further characteristics were consistently associated with changes in mental health. **Discussion:** Evidence suggests that baseline depression and anxiety may indicate how depression and anxiety symptoms change during and after attending WW. Measurement of depression and anxiety at the start of a behavioural weight management programme and subsequent monitoring may facilitate timely psychological support if a deterioration in mental health is identified. Further research in large and diverse participant samples is required to clarify the findings.

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## Introduction

Behavioural weight management programmes are recommended by national guidelines across the world [1]. A recent systematic review found that, on average, programmes have small benefits for some aspects of mental health (e.g., depression and self-esteem) and do not ap-

pear to negatively impact any aspect of mental health at the end of the intervention [2]. However, it is likely that this is not the case for all participants. It is important to identify those at risk of worsening mental health during and after behavioural programmes to provide more effective support for these participants [2].

We can seek to identify those at risk of psychological harm during and after a behavioural weight management programme by investigating how participant characteristics are associated with changes in mental health. Various baseline participant characteristics may be associated with changes in mental health, including age, gender, education, habit strength, and self-regulation. Despite much research investigating how these characteristics are associated with weight changes during and after behavioural weight management programmes [3–14], there is a scarcity of research investigating the association with mental health changes [15–18]. Previous research has identified paid work, social support, and self-determination, among others, to be associated with quality of life and wellbeing during and after behavioural weight management treatments [15–17]. However, to our knowledge, no research has investigated the association of participant characteristics with changes in adverse mental health outcomes (i.e., depression, anxiety), therefore making it difficult to identify those at risk of detrimental impacts on mental health.

Some participant characteristics are considered modifiable by the behavioural programme, such as habit strength, dietary restraint, and self-regulation. These are often targeted by behavioural weight management programmes in order to reduce risk factors for disease and improve health outcomes [1]. Previous research has shown that early changes in modifiable participant characteristics during a behavioural programme are associated with subsequent improvements in health behaviours (e.g., emotional eating, dietary adherence) and weight loss [8, 19], yet it is unclear how early changes in participant characteristics are associated with changes in mental health. Investigating how changes in participant characteristics during the early stages of a behavioural weight management programme relate to subsequent changes in mental health may inform the development of future programmes. For example, if decreases in dietary restraint are associated with worsening mental health, then programmes could be adapted to mitigate this risk. This may involve changes to programme content, provider training, or referrals to external support.

Previous research has investigated a small number of participant characteristics in samples unrepresentative of

the general population of adults with obesity (i.e., exclusively hospital patients or those with type 2 diabetes) [15–17]. It is important to include a diverse range of participant characteristics potentially associated with mental health to broaden our understanding and increase the odds of identifying those at a greater risk of harm. Previous research has also lacked clarity of detail in the research methods used, resulting in difficulty in replicating study methods and comparing findings [15–17]. Specifically, previous research has often not clearly stated the timepoint at which the participant characteristics were assessed (e.g., baseline or early changes) [15–17].

Overall, we identified a scarcity of research investigating how participant characteristics are associated with changes in adverse mental health outcomes (i.e., depression and anxiety) during and after behavioural weight management programmes. We aimed to assess how baseline participant characteristics are associated with changes in mental health in participants of a behavioural weight management programme to identify those at most risk of worsening mental health. We also assessed the association of early changes in participant characteristics with changes in mental health to inform the development of future programmes. We did not have specific, directional hypotheses relating to which participant characteristics may be associated with changes in mental health due to the lack of existing literature to inform such hypotheses. As such, this secondary data analysis is an exploratory study.

## Methods

### *Study Design*

This study is a secondary data analysis of the “Weight loss Referrals for Adults in Primary care” (WRAP) randomized controlled trial. In WRAP, participants were randomized in a 2:5:5 ratio to one of three groups: (1) Brief intervention, (2) 12-week commercial weight management programme (CP12), and (3) 52-week commercial weight management programme (CP52) [20, 21]. The randomization sequence was generated by the trial statistician and programmed into the database by the research manager; research staff and participants were blinded to the sequence. The commercial weight management intervention was provided by WW (formerly weight watchers). Ethical approval was received from the NRES Committee East of England Cambridge East and local approvals from the NRES Committee North West Liverpool Central, the NRES Committee South Central Oxford, and the West Midlands-Coventry and Warwickshire Research Ethics Committee. All participants provided written informed consent for their participation in the trial. This trial was registered with Current Controlled Trials (ISRCTN82857232; ISRCTN64986150). Further information on trial methods is reported elsewhere [20].

### Participants

Eligible participants were identified and recruited by local primary care practices across England, and all study participants gave written informed consent. Adults with a body mass index (BMI) of 28 kg/m<sup>2</sup> or greater, residing in the UK, were eligible for inclusion. Individuals were excluded if they had a planned or current pregnancy in the next two years, previous or planned bariatric surgery, currently followed a weight-loss programme, were non-English speaking or had communication needs precluding them from understanding the study or intervention materials, or were GP-defined inappropriate for participation. Further details of participant eligibility criteria can be found elsewhere [20].

### Intervention

Participants randomly assigned to attend WW were provided with either 12 or 52 vouchers, dependent on group assignment, for weekly local WW meetings. WW meetings are group-based behavioural weight management programmes operating on a rolling basis and led by a nonspecialist trained in weight loss and nutrition. Participants were provided with a unique code to access the digital tools for either 12 or 52 weeks accordingly. The WW digital tools are an online service that includes access to support materials (e.g., recipes, videos, and community area) and tracking tools. Participants assigned to the brief intervention control group were read a scripted booklet introduction by research staff and were given a 32-page printed British Heart Foundation booklet containing self-help weight-management strategies [21].

### Measures

Study participants completed outcome assessments at baseline, 3-, 12-, 24-, and 60-months. Baseline participant characteristics were assessed for their association with changes in depression and anxiety symptoms from baseline to 3-, 12-, 24-, and 60-months. Early changes (from baseline to 3-months) in participant characteristics were assessed for their association with changes in symptoms of depression and anxiety from (i) baseline to 3-months and (ii) from 3-months to 12-, 24-, and 60-months. Further outcome details can be found in the published trial protocol [20].

### Outcomes

The outcomes of interest in this study, symptoms of depression and anxiety, were measured by the 14-item validated Hospital Anxiety and Depression Scale, which creates symptom scores for anxiety and depression that each range from 0 to 21 [22–24].

### Exposure Variables

Participant characteristics assessed were demographics (age, sex, BMI, education, socioeconomic status [25]), psychological factors (baseline depression and anxiety by Hospital Anxiety and Depression Scale [22], quality of life by EQ5D summary score [26], satisfaction with life by the Satisfaction with Life Scale [27], cognitive dietary restraint by the Eating Inventory [28], self-regulation by Treatment Self-Regulation Questionnaire [29], habit strength by the Self-Report Habit Index [30]), programme attendance in the first 3-months of WW sessions (objectively measured by data collected by WW at weekly meetings), and self-reported weekly engagement with WW digital resources. Programme attendance was calculated by WW as participants were provided booklets of vouchers to attend meetings, and WW reported how many vouchers were used. Data related to vouchers issued during a specific

time period were not recorded due to a computer system error (pertinent to 63 participants); as the only difference between those with and without data was the referral date, missing data was considered to be missing at random. Due to the lack of relevant literature to inform the selection of exposure variables to investigate, we determined exposure variables using investigator expertise with the aim of assessing a broad range of potentially associated characteristics.

### Statistical Analysis

Stata (version 16) was used for all statistical analyses [31]. Descriptive summary statistics were calculated for baseline characteristics, with number of participants, mean, and standard deviation presented for continuous variables and number and percentage of participants presented for categorical variables. Withdrawal from the study was presented as the number and percentage of participants by randomized group, and WW attendance and engagement were presented as the number and percentage of participants by randomized group.

### Analysis Methods

Analyses of the association between changes in depression/anxiety and (1) baseline participant characteristics and (2) early changes in participant characteristics were conducted and presented separately, with findings discussed and critiqued simultaneously for integrated interpretation. The residuals from the linear regression models were normally distributed.

*The Association between Baseline Participant Characteristics and Changes in Depression and Anxiety.* Linear regression was used to estimate the association between participant characteristics at baseline and changes in symptoms of depression and anxiety between baseline and 3-, 12-, 24-, and 60-months, controlling for randomized group. Baseline participant characteristics whose *p* value for association with changes in depression/anxiety was <0.05 were included in mutually adjusted models. Robust standard errors were calculated in all models to allow for clustering by general practice.

*The Association between Early Changes in Participant Characteristics and Changes in Depression and Anxiety.* Linear regression was used to estimate the association between early changes (i.e., from baseline and 3-months) in participant characteristics and changes in symptoms of depression and anxiety from baseline to 3-months, and from 3- to 12-, 24-, and 60-months, controlling for randomized group. Early changes in participant characteristics whose *p* value for association with changes in depression/anxiety was <0.05 were included in mutually adjusted models. Robust standard errors were calculated in all models to allow for clustering by general practice.

### Additional Analyses

*Sensitivity Analyses.* Participants with missing values were excluded (i.e., complete-case analysis), assuming data are missing at random conditional on covariates in the model. A sensitivity analysis was performed using multiple imputation by chained equations, which also assumes data are missing at random but provides increased precision compared with complete-case analysis. For sensitivity analyses, we imputed data for variables with ≥5% missing data by multiple imputation by chained equations; variables with ≥25% missing data were excluded from sensitivity analyses.

**Table 1.** Participant characteristics at baseline, presented by study arm

Baseline characteristics	BI (n = 211)	CP12 (n = 528)	CP52 (n = 528)
Age, years (mean±SD)	51.91±14.07	53.63±13.26	53.30±13.96
Female	143 (68)	357 (68)	359 (68)
BMI, kg/m <sup>2</sup> (mean±SD)	34.43±4.63	34.68±5.39	34.45±5.05
Self-reports taking antidepressant medication	26 (19)	81 (21)	81 (23)
Anxiety (mean±SD)	7.25±4.29	6.89±3.97	7.29±4.09
Depression (mean±SD)	5.58±3.77	5.24±3.38	5.20±3.64
Ethnicity			
White or White British	181 (86)	480 (91)	475 (90)
Asian or Asian British	9 (4)	11 (2)	15 (3)
Black or Black British	5 (2)	12 (2)	6 (1)
Mixed or multiple ethnic group	4 (2)	4 (1)	7 (1)
Other, missing, or prefer not to say	12 (6)	21 (4)	25 (4)
IMD decile			
1 (least deprived)	16 (8)	45 (8.52)	44 (8.37)
2	8 (4)	16 (3)	26 (5)
3	12 (6)	38 (7)	32 (6)
4	17 (8)	37 (7)	38 (8)
5	31 (15)	49 (9)	50 (10)
6	19 (9)	61 (12)	57 (11)
7	32 (15)	67 (13)	63 (12)
8	19 (9)	69 (13)	75 (14)
9	12 (6)	51 (10)	47 (9)
10 (most deprived)	45 (213)	95 (18)	94 (18)
Level of education			
None	7 (3.57)	25 (5.27)	27 (5.78)
GCSE or equivalent	55 (28)	153 (32)	155 (33)
A-level or equivalent	53 (27)	95 (20)	110 (24)
Postsecondary study	10 (5)	14 (3)	10 (2)
University degree or equivalent	48 (24)	108 (23)	97 (21)
Higher degree or equivalent	23 (12)	79 (17)	68 (15)
Household income			
£0–£19,999	65 (33)	125 (25)	138 (28)
£20,000–£49,999	66 (33)	173 (34)	176 (35)
£50,000+	41 (21)	91 (18)	84 (17)
Do not know/prefer not to say	27 (14)	113 (23)	101 (20)

Data are number and percentage, unless otherwise stated. BI, brief intervention; CP12, 12-week Commercial Weight Management Programme; CP52, 52-week Commercial Weight Management Programme; BMI, body mass index; IMD, index of multiple deprivation.

*Additional Analyses Not Included in the Original Statistical Analysis Plan.* Changes in depression/anxiety were continuous outcomes in the primary analyses. Since changes can be positive or negative, the precise nature of any exposure/outcome association may not be obvious using this approach. Therefore, we also fitted multinomial regression models to further illuminate the interpretation of the results of the primary analysis. We fitted these models for the primary analysis showing consistent associations across all timepoints (i.e., baseline participant characteristics) and did not fit these models where there were no consistent associations to be interpreted (i.e., early changes in participant characteristics). Estimates from the multinomial regression models were reported as relative risk ratio and 95% confidence interval (CI).

A minimal important difference (MID) for change in the hospital anxiety and depression scale score has not been determined in a population of adults with overweight and obesity. The minimal important difference in alternative populations (adults with cancer, cardiovascular disease, bronchiectasis, and chronic obstructive pulmonary disease) has most commonly been defined as a change of 2 points [32–36]. Therefore, we categorized changes in depression/anxiety as “decrease in symptoms” ( $\leq -2$ ), “no change in symptoms” ( $-1.99$  to  $1.99$ ), or “increase in symptoms” ( $\geq 2$ ) in the multinomial regression models. As in the primary analysis, these models were adjusted for randomized groups, and robust standard errors were calculated to allow for clustering by general practice.

## Results

### Participant Characteristics

By February 2014, 1,267 participants were randomized to one of three groups. At baseline, across study arms, participants had a mean BMI between 34.4 ( $\pm 4.63$ ) and 34.7 kg/m<sup>2</sup> ( $\pm 5.39$ ), and 68% of all participants were female. A similar proportion of participants in each study arm self-reported taking antidepressant medication at baseline (between 19 and 23%). The majority of study participants were White or White British (between 86 and 91% across study arms). Further information on baseline participant characteristics is detailed in Table 1. A proportion of participants experienced a decrease, no change, or increase in symptoms of depression and anxiety at all time points (Table 2).

The number of participants attending study assessment visits was 1,004 participants at 3-months (79%), 823 participants at 12-months (65%), 856 participants at 24-months (68%), and 643 participants at 60-months (51%). Across study arms, the main reasons for study withdrawal were “changed mind about participating” (between 19 and 28%), “moved away” (between 12 and 15%), and “health issues” (between 9 and 15%).

### The Association between Baseline Participant Characteristics and Changes in Depression and Anxiety

Baseline scores for entering treatment self-regulation (amotivation and autonomous self-control domains), age, BMI, gender, socioeconomic status, attendance at WW sessions, and exercise self-regulation (amotivation domain) were associated with changes in mental health; however, changes were smaller than the MID (2), associations were not consistent across timepoints, and associations were not evident for both depression and anxiety symptoms (Tables 3, 4).

Baseline depression and anxiety symptoms were the only characteristics consistently associated with changes in depression and anxiety symptoms from baseline to 3-, 12-, 24-, and 60-months (online suppl. Table S1; see [www.karger.com/doi/10.1159/000522083](http://www.karger.com/doi/10.1159/000522083) for all online suppl. material) and remained associated after mutual adjustment (Tables 3, 4). Changes in depression and anxiety were smaller than the MID (2) across all timepoints. When considered alongside the associations with categorized changes in depression/anxiety (Depression – online suppl. Table S2A; Anxiety – online suppl. Table S2B), higher levels of anxiety at baseline were associated with decreases in anxiety symptoms and increases in depres-

**Table 2.** Proportion of participants experiencing a decrease, no change, or increase in depression and anxiety symptoms at all time-points

	Participants by categorized change in HADS score (anxiety/depression symptoms), n (%)		
	decrease in symptoms ( $\leq -2$ )	no change in symptoms ( $-1.99$ to $1.99$ )	increase in symptoms ( $\geq 2$ )
<b>Depression symptoms</b>			
3-months	282 (30)	473 (51)	180 (19)
12-months	221 (29)	372 (49)	163 (22)
24-months	201 (27)	375 (50)	178 (24)
60-months	140 (30)	205 (43)	129 (27)
<b>Anxiety symptoms</b>			
3-months	305 (33)	446 (48)	184 (20)
12-months	234 (31)	336 (44)	186 (25)
24-months	212 (28)	344 (46)	198 (27)
60-months	155 (33)	193 (41)	126 (27)

HADS, hospital anxiety and depression scale.

sion symptoms from baseline to follow-up visits. Similarly, higher levels of depression at baseline were associated with decreases in depression symptoms and increases in anxiety symptoms from baseline to follow-up visits.

### Sensitivity Analyses

We prespecified that a sensitivity analysis using multiple imputation would not be deemed appropriate if the level of missingness was 25% or more (as it was for changes in depression and anxiety from baseline to 12-, 24-, and 60-months). Sensitivity analyses using multiple imputation for change in depression and anxiety outcomes from baseline to 3-months found comparable results to primary analyses (i.e., complete-case analyses) (online suppl. Tables S3, S4). Higher levels of depression symptoms and lower levels of anxiety symptoms at baseline were associated with an increase in anxiety symptoms from baseline to 3-months (online suppl. Tables S3, S4). Additionally, lower levels of depression symptoms and lower history of dietary behavioural repetition scores at baseline were associated with increases in depression symptoms from baseline to 3-months (online suppl. Tables S3, S4).

### The Association between Early Changes in Participant Characteristics and Changes in Depression and Anxiety

For every unit of early changes in global quality of life and satisfaction with life, changes in both depression and

**Table 3.** The association of baseline participant characteristics with changes in symptoms of depression – controlled for study arm and clustering by GP practice, and mutually adjusted for covariates in the model

Estimated association with outcome per 1 unit of baseline characteristic, unless otherwise indicated (unstandardized coefficient, 95% CI)	
participant characteristic at baseline	change in depression from baseline to 3-months
Age, years	0.01 (−0.00, 0.02)
Baseline anxiety	0.11 (0.05, 0.17)*
Baseline depression	−0.29 (−0.36, −0.23)*
Total dietary restraint	0.01 (−0.05, 0.08)
Entering treatment self-regulation: autonomous regulation score	−0.03 (−0.18, 0.11)
Entering treatment self-regulation: amotivation score	0.18 (0.06, 0.31)*
Self-reported dietary habits: history of behavioural repetition	−0.18 (−0.50, 0.14)
Self-reported dietary habits: lack of awareness	0.16 (−0.16, 0.48)
Participant characteristic at baseline	Change in depression from baseline to 12-months
Baseline depression	−0.20 (−0.28, −0.12)*
Weekly use of WW e-tools/online resources (never as reference group): 3–5 times per week	−0.48 (−1.22, 0.27)
Socioeconomic status	−0.10 (−0.18, −0.03)*
WW sessions attended in the first 3 months, <i>N</i>	−0.07 (−0.17, 0.03)
Participant characteristic at baseline	Change in depression from baseline to 24-months
Education (none as reference group): postsecondary study	−0.42 (−1.61, 0.77)
Baseline depression	−0.26 (−0.36, −0.16)*
Baseline anxiety	0.06 (−0.03, 0.16)
WW sessions attended in the first 3 months, <i>N</i>	−0.15 (−0.27, −0.03)*
Weekly use of WW e-tools/online resources (never as reference group): daily/almost daily	0.32 (−0.31, 0.94)
Male gender (female as reference group)	0.72 (0.18, 1.26)*
Self-reported exercise habits: lack of control	0.04 (−0.13, 0.22)
Participant characteristic at baseline	Change in depression from baseline to 60-months
Exercise self-regulation: amotivation score	0.35 (0.09, 0.61)*
Baseline depression	−0.40 (−0.50, −0.30)*
Baseline anxiety	0.10 (0.04, 0.15)*

CI, confidence interval; BMI, body mass index; WW, formerly weight watchers. Asterisk signifies a statistically significant association as determined by the coefficient CI.

anxiety reduced from baseline to 3-months; the estimated association of early changes in quality of life with changes in depression and anxiety from baseline to 3-months ( $b = -2.57$ , 95% CI:  $-4.18, -0.95$ ) exceeded the minimal importance difference of two units of change (online suppl. Table S5). The estimated association of early changes in satisfaction with life with changes in depression and anxiety from baseline to 3-months ( $b = -0.09$ , 95% CI:  $-0.13, -0.05$ ) did not meet the minimal important difference to represent meaningful change. Notably, there were no early changes in characteristics consistently associated with changes in depression and anxiety across all timepoints (Table 5).

### Sensitivity Analyses

We prespecified that sensitivity analysis using multiple imputation would not be appropriate if the level of missingness were 25% or more (as it was for change in depression and anxiety from baseline to 12-, 24-, and 60-months, and numerous early changes in participant characteristics (online suppl. Table S6).

### Discussion

We aimed to identify whether participant characteristics at baseline or early changes in characteristics were associated with changes in symptoms of depression and

**Table 4.** The association of baseline participant characteristics with changes in symptoms of anxiety – controlled for study arm and clustering by GP practice, and mutually adjusted for covariates in the model

Estimated association with outcome per 1 unit of baseline characteristic, unless otherwise indicated (unstandardized coefficient, 95% CI)	
participant characteristic at baseline	change in anxiety from baseline to 3-months (model 1)
Education (none as reference group): postsecondary study	−0.10 (−0.47, 0.26)
Baseline depression	0.09 (0.04, 0.14)*
Baseline anxiety	−0.24 (−0.30, −0.17)*
Participant characteristic at baseline	Change in anxiety from baseline to 3-months (model 2)
Education (no formal education as reference group): GCSE or equivalent	−0.19 (−0.56, 0.18)
Baseline depression	0.09 (0.04, 0.14)*
Baseline anxiety	−0.24 (−0.30, −0.17)*
Participant characteristic at baseline	Change in anxiety from baseline to 12-months
Baseline depression	0.05 (−0.05, 0.15)
Baseline anxiety	−0.18 (−0.28, −0.08)*
Weekly use of WW mobile phone app (never as reference group): daily/almost daily	0.96 (0.00, 1.92)*
WW sessions attended in the first 3 months, <i>N</i>	−0.04 (−0.16, 0.07)
Participant characteristic at baseline	Change in anxiety from baseline to 24-months
Baseline anxiety	−0.36 (−0.46, −0.27)*
Baseline depression	0.16 (0.04, 0.28)*
Participant characteristic at baseline	Change in anxiety from baseline to 60-months
Baseline anxiety	−0.32 (−0.42, −0.23)*
Total restraint	−0.03 (−0.27, 0.21)
Rigid dietary restraint	0.01 (−0.30, 0.32)
Exercise self-regulation: autonomous self-control score	−0.32 (−0.62, −0.03)*
Age, years	−0.05 (−0.07, −0.03)*
BMI, kg/m <sup>2</sup>	0.07 (0.02, 0.12)*

CI, confidence interval; BMI, body mass index; WW, formerly weight watchers. \* Signifies a statistically significant association as determined by the coefficient CI.

anxiety during and after a commercial weight management programme. We found that those reporting higher baseline anxiety were likely to experience decreases in anxiety symptoms and increases in depression symptoms up to 5 years from baseline, whereas those reporting higher baseline depression were likely to experience decreases in depression symptoms and increases in anxiety symptoms up to 5 years from baseline. No further characteristics were consistently associated with changes in mental health.

Study findings should be interpreted with consideration to the distinct difference between statistical significance and clinical significance. Statistically, baseline de-

pression and anxiety were associated with very small changes in depression and anxiety up to 5 years from baseline, though these changes were smaller than the MID. The MID represents the smallest change that is perceived by participants to be important, suggesting that the associations found may not represent meaningful change to those attending the weight management programme.

Our findings suggest that baseline depression and anxiety may indicate future mental health needs; in particular, those reporting higher baseline depression or anxiety symptoms may benefit from ongoing monitoring to identify early any deterioration in mental health. However, we are unsure of the mechanisms underpinning these findings. For

**Table 5.** The association of early changes in participant characteristics with changes in symptoms of depression and anxiety – controlled for study arm and clustering by GP practice, and mutually adjusted for covariates in the model

Estimated association with outcome per 1 unit of change in participant characteristic, unless otherwise indicated (unstandardized coefficient, 95% CI)	
change from baseline to 3-months in:	change in depression from baseline to 3-months ( <i>n</i> = 772)
BMI, kg/m <sup>2</sup>	0.24 (0.07, 0.42)*
Global quality of life	−2.57 (−4.18, −0.95)*
Satisfaction with life	−0.09 (−0.13, −0.05)*
Total dietary restraint	−0.07 (−0.17, 0.03)
Flexible dietary restraint	(omitted because of collinearity)
Rigid dietary restraint	0.01 (−0.14, 0.17)
Treatment self-regulation: autonomous regulation score	−0.02 (−0.14, 0.10)
Self-reported dietary habits: history of behavioural repetition	0.12 (−0.09, 0.34)
Self-reported dietary habits: lack of control	−0.11 (−0.21, −0.02)*
Self-reported dietary habits: lack of awareness	0.14 (−0.07, 0.35)
Self-reported exercise habits: history of behavioural repetition	0.04 (−0.18, 0.26)
Self-reported exercise habits: lack of control	0.04 (−0.10, 0.18)
Self-reported exercise habits: lack of awareness	−0.05 (−0.30, 0.20)
Change from baseline to 3-months in:	Change in depression from 3- to 24-months ( <i>n</i> = 620)
Satisfaction with life	0.05 (0.00, 0.10)*
Rigid dietary restraint	0.18 (0.02, 0.35)*
Treatment self-regulation: autonomous regulation score	0.14 (−0.05, 0.32)
Change from baseline to 3-months in:	Change in depression from 3- to 60-months ( <i>n</i> = 684)
Total dietary restraint	0.16 (−0.01, 0.33)
Flexible dietary restraint	0.00 (−0.10, 0.11)
BMI, kg/m <sup>2</sup>	−0.07 (−0.27, 0.12)
Change from baseline to 3-months in:	Change in anxiety from baseline to 3-months ( <i>n</i> = 753)
Global quality of life	−1.95 (−3.36, −0.55)*
Satisfaction with life	−0.08 (−0.12, −0.03)*
Treatment self-regulation: controlled regulation score	0.04 (−0.15, 0.23)
Diet self-regulation: controlled self-control score	0.17 (−0.05, 0.39)
Diet self-regulation: amotivation score	0.08 (−0.08, 0.25)
Exercise self-regulation: autonomous self-control score	−0.17 (−0.33, −0.01)*
Self-reported exercise habits: history of behavioural repetition	−0.01 (−0.27, 0.24)
Self-reported exercise habits: lack of control	0.10 (−0.04, 0.24)
Self-reported exercise habits: lack of awareness	0.00 (−0.19, 0.20)
Change from baseline to 3-months in:	Change in anxiety from 3- to 60-months ( <i>n</i> = 390)
Treatment self-regulation: controlled regulation score	−0.32 (−0.68, 0.05)
Diet self-regulation: autonomous self-control score	−0.26 (−0.69, 0.18)
Diet self-regulation: controlled self-control score	−0.11 (−0.42, 0.20)
Exercise self-regulation: autonomous self-control score	−0.17 (−0.44, 0.09)

CI, confidence interval, BMI, body mass index; WW, formerly weight watchers. \* Signifies a statistically significant association as determined by the coefficient CI.



example, we are uncertain why those with higher baseline anxiety would experience reductions in anxiety yet increases in depression symptoms. We suggest that qualitative research may help to better understand why participants appear to simultaneously experience an improvement in one aspect of mental health while experiencing a decline in another aspect of mental health. It is also possible that the findings may be explained by regression to the mean, which is a common phenomenon in which individuals reporting a score at the extreme end of a scale are likely to show a change towards the centre of the scale [37]. The high proportion of missing data in this study increases the likelihood that regression to the mean may influence study findings as the sample may not represent the true population distribution [37, 38]. Future research may wish to explore the patterning between anxiety and depression symptoms to better understand this relationship, and qualitative research may help to elicit an understanding of why these changes occur by exploring the potential factors that influence mental health. In addition, the large number of analyses increases the risk of type 1 error, so it would be important to replicate the associations we have reported in other studies.

Previous research has sought to identify factors associated with changes in positive mental health outcomes (e.g., quality of life and wellbeing [15–18]), yet to our knowledge, this is the first study investigating the factors associated with negative aspects of mental health (i.e., depression and anxiety). In previous research, factors found to be associated with quality of life and wellbeing included paid work, social support, self-determination, small weight loss, and an active lifestyle [15–18]. The findings of the current study differ with symptoms of depression and anxiety at baseline found to be the only characteristics consistently associated with changes in depression and anxiety symptoms during and after WW. Comparisons of the current study findings with previous research must be considered with caution due to differing study eligibility criteria, outcomes of interest, and exposures assessed for association. For example, the participant eligibility criteria of previous research greatly differ as studies focused on those at risk of type 2 diabetes [17], women only [15], those with obesity waiting for bariatric surgery [16], and excluded participants with psychological conditions [18].

More research is needed to assess how participant characteristics are related to changes in depression and anxiety symptoms in a range of different participants, with trials including large samples with broad diversity in characteristics to enable these investigations. While we recognize that the current findings are not conclusive and more research is required, we suggest a cautious approach

to minimize the risk of possible harm to the mental health of programme participants. Therefore, trialists and healthcare practitioners may consider measuring depression and anxiety more regularly to implement preventive care if a decline in symptoms is identified; any changes in measurement frequency should involve consultation with patient and public involvement representatives to ensure that participant burden is considered and that the proposed changes are deemed acceptable.

### *Strengths and Limitations*

This study assessed a broad range of potentially associated participant characteristics at baseline as well as early changes in characteristics. A formal statistical analysis plan for the a-priori aims was approved by all study authors before commencing analyses, minimizing the potential of being influenced to seek significant findings rather than guided by the predetermined research aims and rationale. We conducted an additional analysis to inform the interpretation of the results, which strengthened the meaningfulness of the conclusions.

The study was limited by the proportion of missing data, particularly at longer-term follow-up visits (online suppl. Table S6). Despite this, the WRAP trial reports a smaller attrition rate than is common in weight-loss trials [39–41], and best efforts were made to transparently and clearly report missingness. A high proportion of missing data increases the risk of sample bias and may reduce study generalizability. Where possible, we investigated the impact of missing data on the results using multiple imputation. In future trials, engagement strategies should be considered to improve participant retention at study follow-up visits. Furthermore, some characteristics, such as ethnicity, had limited variability, meaning that they were unable to be investigated for their potential association with changes in mental health.

A recent secondary data analysis of the WRAP trial found that follow-up participant samples may not represent the true range of mental health experiences; those reporting poorer mental health at baseline were less likely to attend study follow-up visits, although the magnitude of associations was small [42]. Study findings should be interpreted with consideration of this.

### **Conclusion**

Evidence suggests that baseline depression and anxiety symptoms may be indicative of how symptoms of depression and anxiety change during and after a commercial

weight management programme. Specifically, higher levels of anxiety symptoms at baseline were associated with decreases in anxiety and increases in depression symptoms, while higher levels of depression symptoms at baseline were associated with decreases in depression and increases in anxiety symptoms. We did not identify any further characteristics to be consistently associated with changes in depression and anxiety symptoms. Measurement of depression and anxiety symptoms at the start of a behavioural weight management programme and subsequent monitoring may facilitate timely psychological support if a deterioration in mental health is identified. Further research in large and diverse participant samples is required to clarify the findings and determine the underpinning mechanisms.

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### Statement of Ethics

Ethical approval for up to 2-year post-randomization assessment was received by East of England Cambridge East and local approvals from NRES Committee North West Liverpool Central and NRES Committee South Central Oxford. Ethical approval for the 5-year post randomization assessment was received from the West Midlands-Coventry and Warwickshire Research Ethics Committee on 8th December 2017. The original trial (ISRCTN82857232) and 5-year follow-up (ISRCTN64986150) were prospectively registered with Current Controlled Trials on October 15, 2012 and February 1, 2018 (<https://doi.org/10.1186/ISRCTN82857232>; <https://doi.org/10.1186/ISRCTN64986150>). All participants provided written informed consent for their participation in the trial.

### Conflict of Interest Statement

R.A.J., J.M., and S.J.S. declare that they have no competing interests. A.L.A. and S.J.G. are the chief investigators on two publicly funded (MRC, NIHR) trials where the intervention is provided by WW (formerly Weight Watchers) at no cost outside the submitted work.

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### Author Contributions

R.A.J. designed the study, analysed and interpreted the data, and drafted the manuscript. J.M. and S.J.S. contributed to the design of the study, interpretation of the data, and critically reviewed the manuscript. R.D. and S.J.G. provided critical appraisal of the study and manuscript. A.L.A. designed and supervised the study, interpreted the data, and critically appraised and reviewed the manuscript. All the authors read and approved the final manuscript.

### Data Availability Statement

The dataset analysed during the current study is not publicly available. Participant consent allows for data to be shared in future analyses with appropriate ethical approval, and the host institution have an access policy ([https://www.mrc-epid.cam.ac.uk/wp-content/uploads/2019/02/Data-Access-Sharing-Policy-v1-0\\_FINAL.pdf](https://www.mrc-epid.cam.ac.uk/wp-content/uploads/2019/02/Data-Access-Sharing-Policy-v1-0_FINAL.pdf)) so that interested parties can obtain the data for replication or other research purposes that are ethically approved. Data access is available from the senior author, who is also the principal investigator of the WRAP trial, upon reasonable request ().

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