The active ingredients of physical activity and / or dietary workplace-based interventions to achieve weight loss in overweight and obese healthcare staff: a systematic review

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Abstract

This systematic review aims to synthesize the active ingredients, and identify a list of promising behaviour change techniques (BCTs), likely to be present within physical activity and / or dietary interventions in achieving weight loss in overweight and obese healthcare staff. Four electronic databases were searched in February 2021: PsychINFO, CINAHL, PubMed and MEDLINE (no start date-2021). Studies were eligible for inclusion if they: (1) described a quasi-experimental or cluster, cohort or randomised control trial; (2) implemented workplace-based physical activity and / or dietary interventions versus a less intensive intervention or usual care; (3) targeted predominantly (>50% of participants) overweight or obese healthcare professionals; and (4) reported a weight loss related outcome and included data on that outcome at least 3 months after the intervention began. Three reviewers used the Behaviour Change Technique Taxonomy v1 to extract BCTs with the aim of identifying a list of "promising" BCTs, which were those that were present in interventions that reported a statistically significant difference in weight loss. Nine studies were included in the review. The majority (n=7) reported a significant reduction in weight post-intervention. A combined physical activity and dietary intervention (n=8) was the most common type of intervention. Twenty-five BCTs were identified as "promising". Instruction on how to perform the behaviour (n=9), behaviour practice/rehearsal (n=8) and self-monitoring of behaviour (n=6) were the most promising BCTs. The contents of behaviour change interventions are complex and rely on accurate reporting of intervention components and BCTs to allow concrete and robust assumptions to be made regarding which factors are most effective at achieving a desired outcome. Fundamentally the lack of research exploring the effectiveness of physical activity and dietary interventions on weight

loss in overweight and obese healthcare staff and the poor quality of existing research, warrant more investigation.

Keywords: systematic review; behaviour change techniques; weight loss; physical activity; dietary; interventions; healthcare staff

Introduction

Obesity is a major public health concern globally, with the prevalence tripling between 1975 and 2016 (World Health Organisation, 2020), and around 52% of the population being overweight or obese. While societal messages often place blame on the individual, creating stigma and bias, and suggest that there is one simple cause to obesity with an acute solution, the behaviours that contribute to the underlying energy imbalance leading to obesity are influenced by a complex combination of biological, psychological, environmental, and social factors.

Overweight and obesity has a strong association with multiple co-morbidities, such as hypertension, cancer, diabetes, stroke and coronary heart disease (Guh et al., 2009). It is estimated that being overweight reduces life expectancy by approximately 3.3 years; rising to between 5.6–10.3 years for those who are obese or severally obese (Lung et al., 2019). Obesity and diabetes are inherently linked, with obesity *"believed to account for 80-85% of the risk of developing type 2 diabetes"* (Diabetes.co.uk, 2019) and contributing to increased risk of cardiovascular complications following diagnosis. Further, complications arising from diabetes, including cardiovascular disease, such as heart disease, heart failure and myocardial infarction, account for around 80% of the cost associated to diabetes (Hex et al., 2012).

Clinically significant weight loss, defined as losing 5% or more of baseline body weight, has been found to be effective at reducing Type 2 Diabetes and cardiovascular risk factors (Wing et al., 2011). Although more significant weight loss has a beneficial metabolic impact, smaller degrees of weight loss are still beneficial to managing diabetes and improving health (Hamman et al., 2011). Losing weight reduces the risk of developing serious complications, like heart disease and stroke (Diabetes UK, 2019) and can even result in going into diabetes remission, which could mean no longer requiring diabetes medication (Lean et al., 2018). The benefits of weight loss as a treatment modality in the prevention and management of diabetes has been well established and documented, however achieving and maintaining weight loss remains a challenge, particularly for those who are already obese (Fildes et al., 2015). Fildes et al. (2015) report that the probability of achieving 5% weight loss is only 1 in 12 for obese men and 1 in 10 for obese women, highlighting the importance of taking a preventive approach.

Considering that economically active adults spend around one third of their time at work (World Health Organisation, 2017), workplaces can be potential settings to implement interventions and strategies to reduce overweight and obesity. However, the relationship between workplaces and obesity is complex. Overweight and obesity has an adverse effect on workplace absenteeism and productivity with obese workers having higher incidences and longer periods of sick days compared to non-obese workers (Finkelstein et al., 2009; Ostbye et al., 2007; Schulte et al., 2007). Thus, workplaces, and in particular large organisations such as the National Health Service (NHS) in the UK, could contribute to addressing the issues surrounding preventing and managing obesity in their workforce (NICE, 2006). Despite this, workplaces have ironically been found to contribute to the

obesity problem. Specific characteristics, such as stress, long work hours and shift work (Buss, 2012; Schulte et al., 2007) have been found to increase the incidences of obesity. One explanation is that these characteristics impact sleep quality (Shao et al., 2010) and consequently increase appetite (Spiegel et al., 2004). Interestingly, these characteristics are particularly common, but not exclusive, to healthcare workers.

Recent research, conducted in Australia, New Zealand (Bogossian et al., 2012) and the United Kingdom (Bogossian et al., 2012; Kyle et al., 2016), investigating the prevalence of overweight and obesity among healthcare professionals identified that nursing staff had the highest levels of overweight and obesity (69.1%) compared to other healthcare professionals (51.3%), unregistered care workers (68.5%) and non-health related occupations (68.9%) (Kyle et al., 2016), and increased levels of obesity compared to the general population by 1.73% up to 3.74% (Bogossian et al., 2012). Such high prevalence of overweight and obesity in healthcare staff not only raises concerns regarding the health of the workforce, but also the adverse effect this has on the provision of care to address obesity through healthcare staff's role in health promotion (Bücher, et al., 2009; Whitehead, 2005). Healthcare professionals play a pivotal role in addressing obesity through providing advice and information on protective behaviours, such as physical activity and healthy eating. However, evidence suggests that healthcare staff's own health behaviours influence their engagement in public health promotion and confidence to offer advice and deliver interventions (Lobelo & de Quevedo, 2016). Overweight healthcare professionals have also been found to perceive their patients as having more barriers to weight management and have fewer positive expectations for their patients' outcomes compared to their healthy weight colleagues (Zhu et al., 2011). Unsurprisingly, this has been found to result in patients

feeling less confident in overweight and obese nurses' ability to provide health education advice on topics such as diet and physical activity (Hicks et al.., 2008).

Considering the prevalence of obesity in healthcare staff and the direct effects on service delivery and health outcomes, there is a considerable need for the development of effective interventions. Diet and physical activity are the most common and effective interventions utilised to achieve weight loss. Combined dietary and physical activity interventions have been found to produce superior results (Power et al., 2014; Racette et al., 2009) compared to physical activity (Han et al., 2011) and dietary interventions alone (Zapka et al., 2007). Similarly, a meta-analysis reported that participants achieved greater weight-loss in the long-term with combined dietary and physical activity interventions compared to diet or physical activity only interventions (Johns et al., 2014).

The popularity and interest of workplace-based interventions has grown significantly over recent years (Schröer, Haupt & Pieper, 2014). Two systematic reviews evaluated the effectiveness of dietary and / or physical activity workplace-based interventions with healthcare professionals (Chan & Perry, 2012; Power et al., 2014). Chan & Perry (2012) evaluated the effectiveness of a variety of health promotion interventions for nursing staff, including diet, physical activity, smoking and alcohol consumption. Power et al. (2014) focused specifically on dietary and physical activity interventions for healthcare workers, and reported a significantly greater weight loss for those in the intervention condition compared to the controls. The reviews identified the workplace as a fruitful setting for such interventions but reported that interventions targeting healthcare professionals are limited and diverse, and require more adequate reporting of the intervention content. Neither reviews explored, in detail, the nuances of the complex interventions, such as the mode of

delivery, duration or theory used within the interventions in their analysis nor did they focus on overweight or obese healthcare staff, which this review intends to explore.

Interventions targeting behaviour change implement different strategies and techniques to achieve the desired outcome. Inconsistent reporting of behaviour change techniques makes it difficult to accurately evaluate and replicate the effective components of interventions. Michie et al. (2013) developed the Behaviour Change Technique (BCT) Taxonomy, an extensive taxonomy of 93 behaviour change techniques, commonly referred to as the "active ingredients" of interventions, which are defined as "observable, replicable and irreducible" components of interventions with the potential to change behaviour (p.82). An additional tool, the Template for Intervention Description and Replication (TIDieR) checklist (Hoffmann et al., 2014), was developed to improve the replicability of interventions by providing a process of reporting aspects of an intervention that may contribute to its effectiveness. Using TIDieR and BCTTv1 concurrently to evaluate studies helps ensure the content and nuances of each intervention are described in sufficient detail.

The objective of this systematic review is to a) synthesize the active ingredients, in line with TIDieR guidelines, of physical activity and dietary interventions to achieve weight loss in overweight and obese healthcare staff and b) identify a list of promising BCTs likely to be present within physical activity and / or dietary interventions in achieving weight loss in overweight and obese healthcare staff.

Methods

Protocol and registration

A formal protocol was developed and registered on PROSPERO [CRD42020196094]. The systematic review was reported and adhered to the criteria of the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analysis) Statement (Page et al., 2021).

Eligibility criteria

Studies were eligible for inclusion if they described a quasi-experimental or cluster, cohort or randomised control trial, workplace-based physical activity and / or dietary interventions versus usual care or standardised advice, targeting predominantly (>50% of participants) overweight or obese healthcare professionals (Table 1). Studies were required to report a weight loss related outcome, such as change in weight or BMI, and include data on that outcome at least 3 months after the intervention began. There was no restriction on intervention duration.

Studies were excluded if interventions measured change in intentions or behaviour opposed to weight loss. Studies with interventions conducted outside of the workplace were not included. There was no restriction on year of publication.

Table 1: Article selection criteria

	Inclusion criteria	**Exclusion criteria**
Participants	Adults (18+), >50% identified as obese or overweight, healthcare workers	
Intervention	Physical activity and or dietary intervention	Other
Comparison	Usual care or standardised advice	
Outcome	Weight loss	Studies that do not report weight loss as an outcome
Setting	Workplace-based	Interventions conducted in other settings i.e. Community, home, gym
Study design	Cluster, Cohort or Randomised Control Trials, Quasi-Experimental	
Year	No restriction	
Other	Data available on weight loss outcome at least 3 months from the start of the intervention	No data available on weight loss outcome at least 3 months from the start of the intervention

Information sources and search strategy

A limited search of PubMed was undertaken to identify keywords contained in titles, abstracts and subject descriptors. Terms identified during this stage were used to develop the search strategy. The electronic search strategy was developed based on the PICO framework (Table 2) and adapted between databases (Appendix A). Four electronic databases were searched in February 2021: PsychINFO, CINAHL, PubMed and MEDLINE (no start date-2021). Reference lists of studies were also searched. Animal studies were excluded and articles were limited to those published in the English language and in peer-reviewed articles. All articles were exported to Rayyan (Ouzzani et al., 2016) (N = 1,602) where duplicates were removed (N = 1,067).

Table 2: Electronic search strategy example

PICO construct	**Example search terms**
Population	Obes* OR overweight OR weight gain OR body weight OR healthcare OR health-care OR prediabet*
Intervention	Physical activity OR exercise OR walking OR movement OR physical fitness OR diet OR health* eating OR dietary OR dietary prog* OR nutrition or dietary regime OR intervention OR behav* change
Comparison	
Outcome	Weight loss OR weight manage* OR weight change OR hba1c OR fasting plasma glucose
Setting	Workplace OR work-place OR work based OR work-based OR worksite OR work-site OR work site

Study selection and screening

One author (AM) screened all titles and abstracts from generated articles to initially identify studies as relevant. A second and third reviewer (KW & NCP) independently screened 10% of titles and abstracts to identify relevant or potentially relevant studies. Reference lists of relevant studies were also checked. Discrepancies in reviewer selections were not formally assessed but were resolved at a meeting among reviewers prior to moving on to the next stage of selection. Full text articles were screened for inclusion using an inclusion and exclusion log, including the reasons for exclusion.

Data extraction

Studies were coded using BCTTv1 taxonomy and the Template for Intervention Description and Replication (TIDieR) guidelines. Three researchers (AM, KW & NCP) completed BCTTv1 training (www.bct-taxonomy.com) to ensure consistency in extraction, coding and recording. Each paper was coded by three reviewers for BCTs. Discrepancies in coding were resolved by consensus at a meeting between reviewers. If studies employed both physical activity and dietary interventions, BCTs were coded separately. Only BCTs included in the intervention and absent in the control group were included and recorded. Following BCTTv1 coding principles, BCTs were coded depending on whether they were definitely (++) or probably (+) present. Similarly, three researchers (AM, KW, NCP) extracted the TIDieR characteristics from each paper and resolved any discrepancies in extraction at a meeting. Similar to Brown et al.'s approach (2019), the frequency of BCTs across significant studies were recorded to identify a list of "promising" BCTs present in interventions most successful at reducing weight in overweight and obese healthcare professionals. However, the approach was adapted so that promising BCTs were defined as those being present in

interventions that were deemed significant (those found to have a statistically significant difference in weight loss). The justification for this approach was to only consider BCTs in terms of their presence within significant studies.

Risk of bias

One researcher (AM) assessed the risk of bias within studies by employing the ROBINS-I tool (Sterne et al., 2016) for quasi-experimental studies and the RoB2 tool (Sterne et al., 2019) for randomised studies. The RoB2 tool is structured into 5 domains exploring bias arising from: the randomization process, deviations from intended interventions, missing outcome data, measurement of the outcome and the selection of the reported result. Judgments are initially made at a domain level and categorised as either low risk of bias, some concerns or high risk of bias. An overall risk of bias judgment, using the same categories, is then calculated. The ROBINS-I tool employs a similar strategy, whereby 7 domains of risk are explored: confounding, participant selection, classification of interventions, deviation from intended interventions, missing data, measurement of outcomes and the selection of reported results. Judgements of risk are made at domain level and categorised as; low risk, moderate risk, serious risk, critical risk or no information. An overall risk of bias judgment, using the same categories, is then calculated.

Synthesis

Due to the heterogeneity of interventions a meta-analysis was not performed, however results are presented in line with the TIDieR guidelines in a rigorous and transparent narrative form.

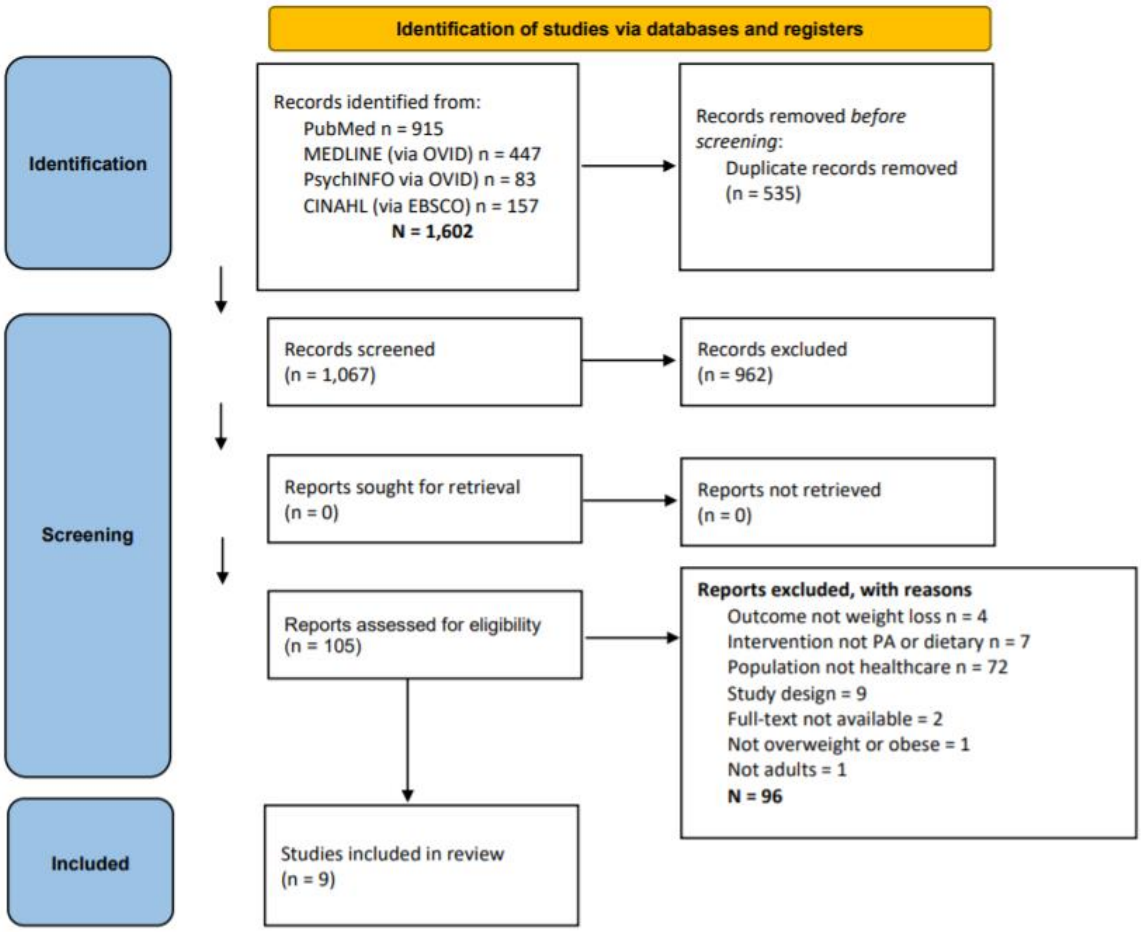
Results

Study selection

The electronic database and reference list search resulted in the identification of 1,067 studies after duplicates were removed. After screening titles and abstracts, 962 articles were excluded, resulting in 105 full-text articles to be assessed for eligibility. Ninety-six studies were excluded for not meeting the inclusion criteria. Nine studies examining physical activity and / or dietary workplace-based interventions were identified and included for qualitative synthesis (

Figure **1**).

Figure 1: PRISMA Flowchart



Study characteristics

Study and intervention characteristics were extracted in alignment with the TIDieR checklist for describing an intervention (Table 3), including data on diet and physical activity related interventions and weight related outcome measures. Additional data on study design and whether theory was mentioned or not were also extracted.

Two papers (Christensen et al., 2011, 2012) included within the review reported analysis from different time points and different interventions, with the same participants, and were therefore included as two interventions. An additional two papers (Thorndike et al., 2011, 2012) reported the same population with different interventions and outcomes: a 3-month intervention with an outcome of weight loss (Thorndike et al., 2011) and a follow-up 9-

month weight maintenance intervention (Thorndike et al., 2012), and were therefore included as separate interventions.

Table 3: TIDieR characteristics

Author/year /country	Why; rationale/goal	What; materials/procedures	Who; provider details	How; modes of delivery (face-to-face vs. online; individual vs. group)	Where; location(s)	When and how much	How well; fidelity, planned vs. actual
Balk-Møller et al. (2017) Denmark	Weight loss	Access to the SoSu-life website and app; 10-15 minutes personal introduction to the SoSu-life tool; paper pamphlet describing main features of the web and app; weekly and bi-weekly text messages; monthly emails with who had won the monthly competition.	Personnel from the research group, trained to measure clinical measures. Dietician, smoking cessation consultant or sport trainer background.	Online; individual; group	Workplace	Access to tool for 38 weeks, participants received weekly and bi - weekly messages	Intervention implemented as planned
LaCaille et al. (2016) Unites States of America	Prevent weight gain	Nutritional labelling; reducing serving spoons; portion reduction; half portions for half price; moving dessert case to less visible area; increasing "green" foods; introduce "grab & go" healthy food cooler; pedometer; "energy balance" facts.	N/A	Face-to-Face; individual; group	Workplace	Gradual changes over 12 months	Intervention implemented as planned

Christensen et al. (2012) Denmark	Weight loss	Dietary records to inform preferences to create exemplary courses with specific calorie amounts adjusted to suit individual. 10-15 minute weekly exercise sessions (month 3-6) fitness gym with circuit training + heart-rate monitors (month 6-9), PA at local sport centres (month 9-12) ; strength training programme to perform 2 x pw; self-monitoring leisure time activity.	Project Manager & 2 x instructors (with sport degrees).	Face-to-Face; group; individual	Workplace / Local fitness centres	One hour per week for 12 months	N/A
Christensen et al. (2011) Denmark	Weight loss and increase physical capacity	Subsample completed dietary records to inform dietary preferences which were then used to create exemplary courses with specific calorie amounts adjusted to suit individual calorie prescriptions. Planned reduction in calorie intake. 10-15 minute exercise sessions per week; strength training programmes for home-workouts and self-monitored log books for leisure time activity.	Project Manager & 2 x instructors (with sport degrees).	Face-to-Face; group; individual	Workplace	1 hour per week for 3 months	N/A
Racette et al. (2009) United States of America	Reduce cardiovascular disease risk	Weekly healthy snack cart, on-site Weight Watchers group meetings; pedometers, on-site group exercise program, walking	WOW worksite coordinator; registered dietician;	Face-to-Face; individual; group	Workplace	Weekly snack cart and contact with provider, monthly seminars - others unknown	N/A

		maps; participation rewards.	exercise specialist.				
Ribeiro, et al. (2014) Brazil	Increase physical activity	Pedometer-based individual counselling.	Health professionals with PA counselling experience.	Face-to-Face; individual	Workplace	Three, 15 minute sessions, once per month	N/A
		Pedometer-based group counselling.	Health professionals with PA counselling experience.	Face-to-Face; group	Workplace	Eight, 60 minute sessions, once per week for 6 weeks, then once per 2 weeks	N/A
		Aerobic training.	Experienced exercise professional.	Face-to-Face; group	Workplace	24 sessions, two times per week, 30 mins (1st month), 35 mins (2nd month), 40 mins (3rd month)	N/A
Thorndike et al. (2011) United States of America	Determine whether baseline BMI was associated with program completion and weight loss	Team and group weekly meetings; encouraged to rank weight loss and create competition between teams; taught goal-setting, self-monitoring and relapse prevention strategies, pedometer.	N/A	Face-to-Face; group	Workplace	2 x per week	N/A
Thorndike et al. (2012) United States of America	Prevent weight gain	Website access, personal contact, pedometer.	Nutritionist and Personal Trainer.	Online; individual	Workplace	Access to tool for 9 months, weekly feedback and email notification every 3 months with option for	

						personal contact	N/A
Nepper et al. (2020) United States of America	Weight loss	Weekly group meetings / activities focusing on nutrition and physical activity. Individual goal setting sessions.	Nurse Practitioner, Registered Dietician, Exercise Specialist, Chef & Motivational speaker	Face-to-face; online; group; individual	Workplace	Group meetings 1 x per week, 1:1 appointments 1 x per week	N/A

Abbreviations: PA = physical activity; WOW = Worksite Opportunities for Wellness

Participant characteristics

Participants' mean age ranged from 42-48 years old. One study (Christensen et al., 2012) did not include data on participant's age. Three studies (Christensen et al., 2011, 2012; Ribeiro et al., 2014) limited recruitment to women only. The remaining five studies ranged from 86%-95.1% women. The majority of studies (n = 5, 62.5%) did not include data on participants' ethnicity. In the remaining studies (LaCaille et al., 2016; Nepper et al., 2020; Thorndike et al., 2011, 2012), participants were predominantly white (81%-95.5%). Three studies (33.33%) required all participants to be at least overweight or obese (Christensen et al., 2011, 2012; Nepper et al., 2020). In the remaining studies, prevalence of overweight and obesity varied between 51% (Ribeiro et al., 2014) to 81% (Racette et al., 2009). Levels of obesity in Balk-Møller et al.'s (2017) study was derived from calculating the mean BMI of participants using weight and height data.

Participants were mostly hospital workers (LaCaille et al., 2016; Nepper et al., 2020; Ribeiro et al., 2014; Thorndike et al., 2011, 2012). The remaining studies reported participants being healthcare workers with the elderly (Christensen et al., 2011, 2012), medical centre staff (Racette et al., 2009) and nursing home staff (Balk-Møller et al., 2017).

Study design and conditions

Three of the nine studies included for analysis were randomised control trials (Balk-Møller et al., 2017; Ribeiro et al., 2014; Thorndike et al., 2012), three of the remaining studies (LaCaille et al., 2016; Nepper et al., 2020; Thorndike et al., 2011) were quasi-experimental trials, two (Christensen et al., 2011, 2012) were cluster-randomised trials and one (Racette et al., 2009) was a cohort randomised trial. All studies, apart from two that did not have

comparison groups (Nepper et al., 2020; Thorndike et al., 2011), were compared with usual care or standardised advice.

One study (Ribeiro et al., 2014) employed three interventions (pedometer based individual counselling; pedometer-based group counselling; aerobic training) and compared each to a control group receiving standard advice about the benefits of physical activity and how to increase physical activity in their daily lives.

Risk of bias

AM assessed the risk of bias of the studies in the review. Six studies were rated as high risk of bias (Balk-Møller et al., 2017; Christensen et al., 2011, 2012; Racette et al., 2009; Ribeiro et al., 2014; Thorndike et al., 2012) (Table 4), two as serious risk of bias (LaCaille et al., 2016; Thorndike et al., 2011) (Table 5) and one as moderate risk of bias (Nepper et al., 2020).

Table 4: Rob2 risk of bias appraisal

Paper	Randomisation Process	Deviation from the intended interventions	Missing outcomes	Measurement of the outcomes	Selection of reported results	Overall judgment
Balk-Møller et al. (2017)	L	H	S	S	S	H
Christensen et al. (2012)	L	H	H	L	S	H
Christensen et al. (2011)	L	H	H	L	S	H
Racette et al. (2009)	H	H	H	L	S	H
Ribeiro et al. (2014)	L	H	H	S	S	H
Thorndike et al. (2012)	L	S	H	S	S	H

Table 5: ROBINS-I risk of bias appraisal

Paper	Confounding	Participant selection	Classification of interventions	Deviation from the intended interventions	Missing data	Measurement of the outcomes	Selection of reported results	Overall judgment
LaCaille et al. (2016)	Serious	Serious	Low	NI	Moderate	Moderate	Moderate	Serious
Nepper et al. (2020)	Low	Low	Low	NI	Moderate	Moderate	Low	Moderate
Thorndike et al. (2011)	Serious	NI	Low	NI	Serious	NI	Moderate	Serious

Abbreviations: L = low risk, H = high risk, some concerns; NI = no information

Use of theory in development of interventions

The majority of studies (n = 6) made no mention of the use of a theory in their study. LaCaille et al.'s (2016) intervention drew on three theories; Theory of Planned Behaviour (Azjen, 1991), Social Cognitive Theory (Bandura, 1986) and the Extended Parallel Process Model (Witte, 1992). Racette et al. (2009) designed the interventions included within their study around the framework of the Transtheoretical Model of Behaviour Change (Prochaska & DiClemente, 1983). Nepper et al. (2020) drew on Social Cognitive Theory (Bandura, 1986) for the design of the "Better Living" programme employed in their study.

Study rationale

More than half (55.6%) of the studies reported weight loss as the main goal of their intervention (Balk-Møller et al., 2017; Christensen et al., 2011, 2012; Nepper et al., 2020) or as part of a larger goal such as reducing cardiovascular disease risk (Racette et al., 2009). The primary goal of two studies was to prevent weight gain (LaCaille et al., 2016; Thorndike et al., 2012), one was to increase physical activity (Ribeiro et al., 2014) and the final study aimed to determine the association between baseline BMI, programme completion and weight loss (Thorndike et al., 2011).

Modes of delivery

The majority (77.8%) of studies delivered interventions face to face (Christensen et al., 2011, 2012; LaCaille et al., 2016; Nepper et al., 20202; Racette et al., 2009; Ribeiro et al., 2014; Thorndike et al., 2011), with the remaining two interventions delivered via online platforms (Balk-Møller et al., 2017; Thorndike et al., 2012). Most studies (77.8%) delivered interventions using a combined group and individual method (Balk-Møller et al., 2017;

Christensen et al., 2011, 2012; ; LaCaille et al., 2016; Nepper et al., 2020; Racette et al., 2009; Ribeiro et al., 2014), with the remainder delivered in a group (Thorndike et al., 2011) or individual (Thorndike et al., 2012) format only.

Intervention provider details

Provider details were included in 77.8% (n = 7) of studies, in the remaining two studies it was unclear of the provider details or qualifications (LaCaille et al., 2016; Thorndike et al., 2011). A combination of health professionals were involved in the delivery of interventions including counsellors (n= 1) (Ribeiro et al., 2014), nursing staff (n=1) (Nepper et al., 2020), dietician / nutritionist (n = 4) (Balk-Møller et al., 2017; Nepper et al., 2020; Racette et al., 2009; Thorndike et al., 2012), smoking cessation specialist (n = 1) (Balk-Møller et al., 2017) and sport trainer (n = 7) (Balk-Møller et al., 2017; Christensen et al., 2011, 2012; Nepper et al., 2020; Racette et al., 2009; Ribeiro et al., 2014; Thorndike et al., 2012;). Non health-related staff were present in three studies, such as project managers (n=2) (Christensen et al., 2011, 2012) chefs (n=1) and motivational speakers (n=1) (Nepper et al., 2020).

When and how much

Intervention length ranged from 10 weeks (Thorndike et al., 2011) to 12 months (Christensen et al., 2012; LaCaille et al., 2016; Racette et al., 2009), with most interventions ranging between 3-9 months in duration (Balk-Møller, et al., 2017; Christensen et al., 2011; Nepper et al., 2020; Ribeiro et al., 2014; Thorndike et al., 2012). The majority of interventions (Balk-Møller et al., 2017; Christensen et al., 2011, 2012; LaCaille et al., 2016; Nepper et al., 2020; Racette et al., 2009) relied on outcome assessments immediately after the end of the interventions, and only three interventions included following up-

assessments of between 3 (Ribeiro et al., 2014; Thorndike et al., 2012) and 12 months (Thorndike et al., 2011). Retention rates varied, with six of studies (Christensen et al., 2011, 2012; LaCaille et al., 2016; Nepper et al., 2020; Ribeiro et al., 2014; Thorndike et al., 2011) achieving over 80% retention rate. Thorndike et al. (2012) achieved 78.5% retention, Racette et al. (2009) achieved 77.5% and Balk-Møller et al. (2017) achieving only 47.5%.

Eight (88.9%) studies delivered a component of their intervention on at least a weekly basis (Balk-Møller et al., 2017; Christensen et al., 2011, 2012; Nepper et al., 2020; Racette et al., 2009; Ribeiro et al., 2014; Thorndike et al., 2011, 2012). Two out of three interventions included in Ribeiro et al.'s (2014) study had at least weekly contact and the third intervention had at least monthly contact. The final study (LaCaille et al., 2016) introduced gradual changes over the 12-month intervention period with no clear indication of timings.

Diet and physical activity intervention content

One study (Ribeiro et al., 2014) employed a physical activity only intervention. All studies employing a dietary intervention (n = 8) focused on reducing calorie intake in some form, either through feedback on energy balance (Balk-Møller et al., 2017), reducing portions, implementing nutritional labelling (LaCaille et al., 2016), creating personalised calorie "prescriptions" (Christensen et al., 2011, 2012), onsite weight management meetings (Racette et al., 2009) healthy eating advice, cooking classes (Nepper et al., 2020) or encouraging participants to maintain food logs (Thorndike et al., 2011, 2012). As part of the physical activity component, the majority of studies focused on either aerobic (Racette et al., 2009; Ribeiro et al., 2014) or strength training, or a combination of both (Balk-Møller et al., 2017; Christensen et al., 2011, 2012; Nepper et al., 2020; Thorndike et al., 2012). Four

studies (LaCaille et al., 2016; Ribeiro et al., 2014; Thorndike et al., 2011, 2012) employed a pedometer-based intervention.

Weight loss

To maintain consistency across interventions, the review presents weight loss data based on the changes from baseline to post-treatment assessment. Five studies reported significant differences in weight loss in at least one condition of their intervention relative to control groups (Balk-Møller et al., 2017; Christensen et al., 2011, 2012; Racette et al., 2009; Ribeiro et al., 2014). Two of the quasi-experimental studies reported a significant difference in weight loss between baseline and post-treatment assessment (Nepper et al., 2020; Thorndike et al., 2011). Two studies, one RCT (Thorndike et al., 2012), and one quasi-experimental (LaCaille et al., 2016), reported no significant weight loss between intervention and control groups or from baseline to post-treatment assessment Table 6: Mean changes attributed to the intervention(Table 6).

Table 6: Mean changes attributed to the intervention

Authors / Year	N	Intervention duration	Follow-up	Change (mean)	p value (* denotes significant change)	CI (95%)	Effect size
Balk-Møller et al. (2017)	566	38 weeks	N/A	-1.01 (kg)	p=.03*	(-1.94, -0.08)	N/A
LaCaille et al. (2016)	500	12 months	N/A	-0.32% (kg)	p=.66	(-1.80, 1.17)	N/A
Christensen et al. (2012)	98	12 months	N/A	-5.8 (kg)	p<.001*	N/A	N/A
Christensen et al. (2011)	98	3 months	N/A	-3.59 (kg)	p<.001*	N/A	N/A
Racette et al. (2009)	151	12 months	N/A	N/A (kg)	p=.02*	(-3.90, -0.31)	N/A
Ribeiro et al. (2014)**	195	3 months	3 months	-0.70 (kg)	p<.05**	(-1.193, 0.986)	0.88
Thorndike et al. (2011)***	774	10 weeks	12 months	-1.90 (kg)	<.001*	N/A	N/A
Nepper et al. (2020)	41	16 weeks	6 months	-13 (lbs)	p<.001*	N/A	N/A
Thorndike et al. (2012)	330	9 months	6 month	-3 (lb)	p=.39	N/A	N/A

** AT intervention associated with significant decrease in weight after 3 and 6 months

*** Weight loss was still significant at 12 month follow up (p=0.002)

Abbreviations: N/A = not available, AT = aerobic training intervention

Other outcomes

In addition to weight loss, studies measured other weight and cardiovascular related variables. Most commonly, they included physical activity, eating related or physiological outcomes. Of those that reported physical activity outcomes (n = 7), 6 reported significant improvements following interventions or compared with usual care (Christensen et al., 2011, 2012; LaCaille et al., 2016; Nepper et al., 2020; Racette et al., 2009; Ribeiro et al., 2014) and one reported improvements in both the intervention and usual care groups with no significant difference between groups (Thorndike et al., 2012). Two studies (Balk-Møller et al., 2017; Thorndike et al., 2011) appeared to implement a physical activity component in their intervention yet failed to report any physical activity related outcomes.

Fewer than half the studies (n = 4) reported changes in eating related behaviours (LaCaille et al., 2016; Nepper et al., 2020; Racette et al., 2009; Thorndike et al., 2012). One study (Racette et al., 2009) found a significant improvement and difference between intervention and usual care groups in fruit and vegetable intake and decrease in fatty food intake. One study (Thorndike et al., 2012) found a significant improvement in fruit and sugar intake in both the intervention and usual care group without a significance difference. Nepper et al. (2020) reported a significant increase in fruit and vegetable intake. One (LaCaille et al., 2016) reported a decline in fruit and vegetable intake in both the intervention and control groups.

The most common physiological measures were blood pressure (n = 7) (Balk-Møller et al., 2017; Christensen et al., 2011, 2012; Nepper et al., 2020; Racette et al., 2009; Thorndike et al., 2011, 2012) and waist circumference (n = 7) (Balk-Møller et al., 2017; Christensen et al., 2011, 2012; LaCaille et al., 2016; Ribeiro et al., 2014; Thorndike et al., 2011, 2012). Of the 7

studies measuring blood pressure, 3 found a reduction in blood pressure but with no significant difference between intervention and usual care (Christensen et al., 2012; Racette et al., 2009; Thorndike et al., 2012), one study found a significant difference in blood pressure in the intervention group compared to usual care (Christensen et al., 2011), two found a significant difference in blood pressure but had no control group (Nepper et al., 2020; Thorndike et al., 2011) and one study found no change (Balk-Møller et al., 2017). In terms of waist circumference, four studies found a significant difference between intervention and usual care groups (Balk-Møller et al., 2017; Christensen et al., 2011, 2012; Ribeiro et al., 2014), one study found a difference which was not significant between groups (Thorndike et al., 2012), one found a significant difference in waist circumference but had no control group (Thorndike et al., 2011) and one study found no difference in waist circumference (LaCaille et al., 2016).

BCTs

Frequency of BCTs across studies

Twenty-eight of 93 possible BCTs were identified as present in the intervention group and not the control group. A total of 130 BCTs were used across the studies, with an average of 14.44 BCTs per study, ranging from 10 (LaCaille et al., 2016) to 21 (Balk-Møller et al., 2017). Self-monitoring of behaviour (n=11), instruction on how to perform the behaviour (n=10), monitoring of outcome(s) of behaviour without feedback (n=9) and behaviour practice/rehearsal (n=9) were the most frequently occurring BCTs. There were more BCTs within the physical activity interventions (n=83) compared to the dietary interventions (n=47). Individual BCTs and their frequency are reported in Table 8.

Promising BCTs

Twenty-five BCTs were identified as "promising". Instruction on how to perform the behaviour (n=9), behaviour practice/rehearsal (n=8) and self-monitoring of behaviour (n=6) were the most frequently occurring BCTs in studies reporting significant weight loss. They were most commonly found in interventions offering regular group exercise sessions with qualified instructors (Christensen et al., 2011, 2012; Racette et al., 2009; Ribeiro et al., 2014). Promising BCTs and their frequency are reported in Table 7.

Table 7: frequency of BCTs

BCT no.	BCT label	BCT in all studies; n	"Promising" BCTs; n
2.3	Self-monitoring of behaviour	11	6
4.1	Instruction on how to perform the behavior	10	9
8.1	Behavioral practice/rehearsal	9	8
2.5	Monitoring of outcome(s) of behavior without feedback	9	5
6.1	Demonstration of the behavior	8	7
1.1	Goal setting (behavior)	8	4
1.3	Goal setting (outcome)	6	4
9.1	Credible source	6	4
3.1	Social support (unspecified)	6	2
2.6	Biofeedback	5	5
1.2	Problem solving	5	4
1.4	Action planning	5	4
2.2	Feedback on behaviour	5	3
2.4	Self-monitoring of outcome(s) of behaviour	5	3
2.7	Feedback on outcome(s) of behavior	4	4
10.2	Material reward (behavior)	4	4
3.3	Social support (emotional)	3	2
8.3	Habit formation	2	2
8.7	Graded tasks	2	2
1.5	Review behavior goal(s)	2	2
1.9	Commitment	2	2
5.1	Information about health consequences	2	2
6.2	Social comparison	2	2
10.1	Material incentive (behavior)	2	2
12.5	Adding objects to the environment	2	1
7.1	Prompts/cues	2	
2.1	Monitoring of behavior by others without feedback	2	
12.1	Restructuring the physical environment	1	
	Total	**130**	**93**

Discussion

The primary aim of the review was to synthesise the active ingredients, in line with TIDieR guidelines, of physical activity and dietary interventions to achieve weight loss in overweight and obese healthcare staff. The majority of studies reported a significant reduction in weight loss post-intervention and a combined physical activity and dietary intervention was the most common type of workplace-based intervention implemented, with all but 1 of the studies undertaking this approach.

The primary goal of interventions varied significantly between studies, however those reporting a primary goal of preventing weight gain (LaCaille et al., 2016; Thorndike et al., 2012) also reported longer intervention length of between 9 (Thorndike et al., 2012) and 12 (LaCaille et al., 2016) months. This aligns with evidence surrounding long-term weight loss and maintenance; with previous research indicating that although initial weight loss can be successful, it usually plateaus at around 6 months and follows a period of weight regain (Franz et al., 2007).

Intervention content within studies also varied significantly. The two studies that did not achieve significant weight loss employed a combined physical activity and dietary intervention, which contradicts the evidence suggesting a combined approach leads to greater weight loss compared to interventions that focus on diet or physical activity in isolation (Johns et al., 2014; Power et al., 2014; Racette et al., 2009). A component of intervention content which appeared to be associated with insignificant reduction in weight was “reducing portions and implementing nutritional labelling” (LaCaille et al., 2016), however we are hesitant in making inferences about this as it was a small element of a large intervention with many components.

The review fails to highlight any observable relationship between the mode of intervention delivery and significant weight loss, as the two studies reporting no significant weight loss implemented both online (Thorndike et al., 2012) and face-to-face (LaCaille et al., 2016) interventions. Evidence suggests that a combined online and face-to-face approach is most successful at supporting overweight and obese adults with weight loss (Hurkmans et al., 2018), however this observation aligns with previous reviews which have reported mixed results regarding the effectiveness of online vs. face-to-face interventions (Neve et al., 2010). This review does not allow the opportunity to effectively compare mode of delivery due to the diverse nature of interventions.

Studies overwhelmingly lacked, or at least failed to report, any theoretical basis. Glanz and Bishop (2010) propose that using theory or theoretical constructs to guide the development of interventions may be more effective in changing health behaviours than studies not using theory, however the evidence is inconsistent (Davis et al., 2015; Greaves et al., 2011; Prestwich et al., 2014) and reflects our own narrative synthesis of finding no association between significant weight loss and reference to theoretical constructs.

The secondary aim of the review was to identify a list of promising BCTs likely to be present within physical activity and / or dietary interventions in achieving weight loss in overweight and obese healthcare staff. The three most promising BCTs identified within the review were “self-monitoring of behaviour”, “instruction on how to perform the behaviour” and “behaviour practice/rehearsal”, and were most commonly found in interventions offering regular group exercise sessions with qualified instructors (Christensen et al., 2011, 2012; Racette et al., 2009; Ribeiro et al., 2014). The review supports the evidence of previous reviews that physical activity related BCTs, such as “instruction on how to perform the

behaviour", "behavioural practice/rehearsal" (Hankonen et al., 2015) and "self-monitoring of behaviour" (Acharya et al., 2009; Michie et al., 2009), are effective in achieving weight loss. Our results were comparable to Samdal et al.'s (2017) study which reported the BCTs "self-monitoring of behaviour" and "goal setting" were associated with successfully improving physical activity and healthy eating in overweight and obese adults. Although not directly measuring weight loss, improved diet and physical activity is often a behavioural precursor for weight loss which allows comparisons to be made. Similar to previous studies (Hankonen et al., 2015) the review found that the number of BCTs used within interventions may be linked to their effectiveness. LaCaille et al.'s (2016) study reported the fewest BCTs and did not achieve significant weight loss or success in other outcomes, such as increasing fruit and vegetable intake and decreasing waist circumference.

The evidence suggests that the same BCTs, particularly "self-monitoring of behaviour", are effective at achieving both weight loss and behavioural change. This should be considered when designing future interventions as evidence suggests that "weight neutral" approaches, such as Health at Every Size, compared to traditional weight loss focused interventions, are just as effective when it comes to biochemical markers of health, such as cholesterol and blood glucose, and may lead to greater improvements in self-esteem, disordered eating and depression (Clifford et al., 2015) even in the absence of weight change. This reflects what was evident in LaCaille et al.'s (2016) intervention, which failed to achieve significant weight loss but reported significantly increased walking activity. Moving the focus away from weight loss as the ultimate indicator of health may encourage the take up of more positive health behaviours by removing the damaging stigma associated with focusing on weight. Although it is important to understand components of interventions that lead to weight

change, we must also consider the wider behavioural and physiological changes associated to weight related issues, such as cardiovascular disease and diabetes.

It was initially assumed that the nuances involved in healthcare work may result in the identification of unique intervention content and BCTs associated with weight change, however the review does not highlight any observable difference between overweight and obese healthcare workers vs. non-healthcare workers. Despite this, lack of research in the area, and the poor quality of research that does exist, warrants more investigation.

Limitations of the literature

The risk of bias and quality of the studies included within the review were poor which limits the reliability of the conclusions drawn. An important measure of interventions is the extent to which they were delivered as intended. Despite this, only two papers (Balk-Møller et al., 2017; LaCaille et al., 2016) reported any assessment of fidelity, both of which identified that the interventions were implemented as planned. The remaining papers failed to report any measure of fidelity. Although the majority of studies were significant, the reporting of post-hoc power analysis was poor, with only two studies reporting post-hoc power analysis (Balk-Møller et al., 2017; Nepper et al., 2020). The remaining papers either failed to report any power (LaCaille et al., 2016; Thorndike et al., 2011), estimated a power of 0.8 with minimal drop out but reported no post hoc power analysis (Christensen et al., 2011, 2012; Ribeiro et al., 2014; Thorndike et al., 2012) or estimated a power of 0.8 with significant drop out and no post hoc power analysis (Racette et al., 2009). Additionally, Thorndike et al. (2011, 2012) used a combination of parametric and non-parametric analysis without justification as to whether the non-parametric analysis was restricted to categorical data. As non-parametric and parametric tests make different assumptions about the data, this has to be taken into

consideration when evaluating significance and effect. Additionally, non-parametric tests have less statistical power than parametric tests and are thus more likely to detect a type II error.

Limitations of the review

The most significant limitation of the review was that, due to the heterogeneity of interventions, a meta-analysis was not performed. Additionally, the authors were unable to directly compare interventions and their components due to their disparate nature. This was further hindered by the generally poor descriptions of interventions and BCTs, which were more often than not very limited and lacked any concrete information. Although this is not uncommon, it likely led to BCTs being omitted from the coding which were in fact included within an intervention. This reiterates previous studies calls for thorough reporting of BCTs and interventions to allow better reporting and analysis, and replicability of successful interventions.

Whilst the focus of the review was to determine the active ingredients of interventions with overweight or obese healthcare workers, only three studies (Christensen et al., 2011, 2012; Nepper et al., 2020) limited recruitment to this population. The authors believe that the inclusion of healthy weight participants in the interventions included in this review is not appropriate; however inclusion of such studies is a result of limited research within the area. Although the majority of participants in the remaining studies were overweight or obese, it would be beneficial for future studies to focus exclusively on this group to determine whether there are unique differences compared to healthy weight healthcare workers and to avoid any floor effects occurring from the inclusion of healthy weight participants.

Finally, discrepancies in reviewer selections were not formally assessed or reported. The authors appreciate that this is a limitation of the review.

Strengths of the review

The current review employed two recognised and validated reporting tools; TIDieR guidelines (Hoffmann et al., 2014) and BCTTv1 (Michie et al., 2013). Additionally, the systematic review adhered to the criteria of the PRISMA statement and followed a protocol which was developed before undertaking the review. Additionally, the review is one of few in the field to extract and report intervention content to such a detailed level.

Recommendations for practice

The review identified a list of "promising" BCTs which should be considered when designing interventions for overweight and obese healthcare staff with an intended outcome of weight loss, although the inferences that can be made are minimal due to the articles' risk of bias and quality. The most effective mode of delivery of interventions to achieve weight loss in overweight and obese healthcare workers is debatable. Interventions should implement the APEASE criteria (Michie, Atkins & West, 2014) to ascertain which mode of delivery is most appropriate for the situation. Intervention components should be reported appropriately in published articles, preferably following TIDieR guidelines to allow for replicability and transparency. Behaviour Change Techniques (BCTs) should be reported appropriately in published articles, following BCTTv1 recommendations, to allow for replicability and transparency.

Conclusions

In summary, the review has confirmed that the contents of behaviour change interventions are complex and nuanced and rely on accurate reporting of intervention components and behaviour change techniques to allow concrete and robust assumptions to be made regarding which factors are most effective at achieving a desired outcome. This is of paramount importance to ensure that research is replicable and can be translated into real life practice in order to be implemented at scale to help address the obesity pandemic.

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Appendix A: Search Strategy per Database

Database	Search	Number of results
PsychINFO (1806-2021)	obes* OR weight gain OR overweight OR body weight OR healthcare OR health-care OR prediabet* AND physical activity OR exercise OR walking OR movement OR physical activity OR diet or health* eating OR dietary OR dietary prog* OR nutrition OR dietary regime OR intervention* OR behav* change AND weight loss OR weight manage* OR weight change OR hba1c OR fasting plasma glucose AND workplace OR work-place OR workbased OR work-based OR worksite OR work site OR work-site	83
CINAHL (1989-2021)	obes* OR weight gain OR overweight OR body weight OR healthcare OR health-care OR prediabet* AND physical activity OR exercise OR walking OR movement OR physical activity OR diet or health* eating OR dietary OR dietary prog* OR nutrition OR dietary regime OR intervention* OR behav* change AND weight loss OR weight manage* OR weight change OR hba1c OR fasting plasma glucose AND workplace OR work-place OR workbased OR work-based OR worksite OR work site OR work-site	157

MEDLINE (1946-2021)	obes* OR weight gain OR overweight OR body weight OR healthcare OR health-care OR prediabet* AND physical activity OR exercise OR walking OR movement OR physical activity OR diet or health* eating OR dietary OR dietary prog* OR nutrition OR dietary regime OR intervention* OR behav* change AND weight loss OR weight manage* OR weight change OR hba1c OR fasting plasma glucose AND workplace OR work-place OR workbased OR work-based OR worksite OR work site OR work-site	447
PubMed (1976-2021)	obes* OR weight gain OR overweight OR body weight OR healthcare OR health-care OR prediabet* AND physical activity OR exercise OR walking OR movement OR physical activity OR diet or health* eating OR dietary OR dietary prog* OR nutrition OR dietary regime OR intervention* OR behav* change AND weight loss OR weight manage* OR weight change OR hba1c OR fasting plasma glucose AND workplace OR work-place OR workbased OR work-based OR worksite OR work site OR work-site	915