

**EFFECTIVENESS OF INTERVENTIONS TO PROMOTE PHYSICAL
ACTIVITY IN OVERWEIGHT ADULTS IN THE HEALTH CARE SETTING: A
SYSTEMATIC REVIEW**

Sohvi Katariina Nuojua

Master's Thesis in Sport and
Exercise Psychology
Autumn 2017
Department of Sport Sciences
University of Jyväskylä

ACKNOWLEDGEMENTS

I would like to thank my supervisor Dr. Mary Chasandra for her guidance and support throughout this thesis project.

Secondly, I am grateful to Dr. Taru Lintunen and Dr. Montse Ruiz, as well as my fellow students, for their guidance and advice.

Finally, thanks to the Chasandra et al. research team for providing me with the valuable data that made it possible for me to conduct this review.

ABSTRACT

Nuojua Sohvi Katariina, 2017. Effectiveness of Interventions to Promote Physical Activity in Overweight Adults in the Health Care Setting: A Systematic Review. Department of Sport Sciences. University of Jyväskylä. 74 p.

Overweight and obese individuals are at a significant risk for developing cardiovascular disease and other health concerns. Increasing physical activity (PA) in this population is associated with weight loss and positive health outcomes. One way of promoting PA is through interventions in the health care setting. Research is needed to identify the most effective ways of motivating overweight individuals to increase their PA behaviour and to maintain these changes. This systematic review seeks to synthesise current evidence on the effectiveness of behavioural interventions aimed at increasing PA in the overweight and obese population in the health care setting.

Literature searches were performed to locate RCT behavioural interventions with follow-up data, targeting PA in healthy overweight and obese adults (BMI>25) in health care settings. Two rounds of literature search were done in electronic databases for MEDLINE, EMBASE, CINAHL, CCRCT, and PsycINFO in spring 2015 and 2017. 11 primary studies were identified. The included studies were evaluated for risk of bias. Data extracted included participant characteristics, results on PA, behaviour change techniques (BCTs) and theoretical frameworks used, and properties of intervention delivery. The BCTs used were coded by two independent assessors using the Behaviour Change Taxonomy version 1. Qualitative synthesis was determined as the most suitable method for reporting the summative data.

Most studies were rated as being at low risk of bias. Majority of the studies reported significant time-effects that were rarely maintained at follow-up. Significant increases in PA that favoured the experimental condition were identified in three studies. No superiority of individual BCTs was identified, although self-monitoring was frequently used by successful studies. There was no indication of any intervention delivery properties being associated with intervention success.

The limitations of the review include heterogeneity and risk of bias within the study pool, as well as lack of interrater communication. The qualitative synthesis cannot provide enough information for a conclusion to be made yet on the effectiveness of specific BCTs in motivating the overweight and obese population to increase their PA behaviour. The only recommendation for guiding practice is that self-monitoring may be an effective technique for increasing PA in the health care environment, albeit this recommendation is based on weak evidence. Future RCTs should ensure high methodological quality and adequate reporting of BCTs used so that they can contribute to prospective systematic reviews and provide stronger evidence for guiding practice in the health care setting.

Keywords: PA, obesity, intervention, behaviour change

TABLE OF CONTENTS

ABSTRACT

1 INTRODUCTION	6
1.1 Background	6
1.2 Scope of the current review.....	7
1.3 Behaviour change.....	9
1.3.1 Social Cognitive Theory	10
1.3.2 Transtheoretical Model of Behaviour Change.....	12
1.3.3 Theory of Planned Behaviour	13
1.3.4 Self-determination Theory.....	14
1.3.5 Behaviour change techniques	16
1.4 Other properties of intervention delivery	17
1.4.1 Length of intervention and follow-up.....	18
1.4.2 Mode of intervention delivery	19
1.4.3 Intervention target behaviours	20
1.4.4 Type of PA measurement used	20
1.5 Objectives.....	21
2 METHOD.....	22
2.1 Inclusion and exclusion criteria	22
2.1.1 Population	22
2.1.2 Intervention and outcomes.....	23
2.1.3 Comparator	24
2.1.4 Setting	24
2.1.5 Study design	24
2.2 Literature search.....	24
2.3 Procedure.....	25
2.4 Data extraction	26
2.4.1 Study characteristics	26
2.4.2 PA outcomes.....	26
2.4.3 BCTs and theoretical framework.....	27
2.4.4 Intervention delivery properties.....	28
2.5 Quality assessment	28

2.6 Synthesis of results.....	29
3 RESULTS	30
3.1 Results of literature search	30
3.2 Results of quality assessment.....	30
3.3 Study and participant characteristics.....	31
3.4 PA outcome and intervention results	35
3.5 BCTs used	37
3.6 Intervention delivery properties	40
4 DISCUSSION	43
4.1 Summary of evidence.....	43
4.2 Strengths and limitations.....	47
4.3 Implications for future research	49
4.4 Conclusions	50
5 REFERENCES.....	52

APPENDICES

1 INTRODUCTION

1.1 Background

Excessive body weight is a global public health concern with more than 2.8 billion deaths annually resulting from overweight or obesity (WHO, 2017). According to the National Health and Nutrition Examination Survey (NHANES; Flegal, Carroll, Kit, & Ogden, 2012) two-thirds of the American adult population are *overweight* as defined by having body mass index (BMI) of 25 or more (WHO, 2000), while more than one in three adults have *obesity* (BMI \geq 30). This is particularly concerning given the association of excess weight with chronic health conditions such as cardiovascular disease (Lavie, Milani, & Ventura, 2009), type 2 diabetes mellitus (Kahn, Hull, & Utzschneider, 2006), cancer (Pischon, Nöthlings, & Boeing, 2008), and musculoskeletal disorders (Anandacoomarasamy, Caterson, Sambrook, Fransen, & March, 2008). Furthermore, the disease burden of excess body weight naturally encompasses economic consequences: It has been estimated that, in the United States alone, the annual national medical care costs of obesity and related illness is \$209.7 billion (Cawley & Meyerhoefer, 2012). Therefore, attempts to alleviate and prevent overweight and obesity are a crucial investment from the public health perspective.

In order to treat overweight effectively it is of paramount importance to consider the true behavioural patterns behind weight gain. A positive energy balance due to poor diet together with physical inactivity is considered the leading cause of overweight and obesity (Haslam & James, 2005). Thus, increasing *physical activity* (PA) behaviour has been a fundamental instrument in interventions designed to treat the overweight population (Foster, Makris, & Bailer, 2005; Wadden, Butryn, Hong, & Tsai, 2014; Wadden & Stunkard, 2002). As a guideline the American College of Sports Medicine has recommended at the minimum between 150 and 250 minutes per week of moderate-intensity PA to achieve modest weight loss (Donnelly et al., 2009). Indeed, PA interventions for the overweight adult population have traditionally mainly aimed at weight loss and used decrease in body weight as the indicator of intervention success (Shaw, O'Rourke, Del Mar, & Kenardy, 2005). Some studies have also used biological markers, such as body fat percentage, waist circumference, or blood triglyceride level to infer positive health outcomes and success of the PA intervention (Laatikainen et al., 2012; Meckling & Sherfey, 2007).

Although decrease in body weight and fatness inarguably yields multiple benefits for the obese population (Vidal, 2002), focusing merely on weight loss can be problematic. This is because short-term weight loss is difficult to maintain: A review of 15 dietary restriction weight-loss programs reported that participants lost an average of 9.0 kg of weight at post-intervention, but nearly half of it was gained back at the 40-week follow-up (Wing, 2002). On the other hand, one of the strongest and most consistent predictors of long-term weight loss and maintenance is regular PA (Pronk & Wing, 1994). Thus, it is reasonable to invest in efforts to motivate the overweight population to establish a habit of PA behaviour rather than to aim at maximal short-term weight loss. Moreover, it is now known that level of cardiovascular fitness is a better predictor of mortality due to cardiovascular disease than weight or BMI alone (Barry et al., 2014; Blair & Brodney, 1999). Similarly, Hamman et al. (2006) reported a 44 per cent lower incidence of diabetes among patients who did not achieve the designated weight-loss goal at 1 year follow-up but managed to reach the set PA goal. That is, increased PA alone can greatly alleviate the co-morbidities associated with excess weight (United States Department of Health & Human Services, 1996; Wolin, Carson, & Colditz, 2010). Thus, it may be worthwhile for interventionists designing programs for treating the overweight population to incorporate tools to both change and reliably measure PA behaviour. This ensures a holistic understanding of participant health and intervention success.

1.2 Scope of the current review

Numerous interventions have been designed and implemented for the overweight population that direct attention towards changing PA behaviour (Bélanger-Gravel, Godin, Vézina-Im, Amireault, & Poirier, 2011; Bravata et al., 2007). Some have yielded promising results for PA change in the short term (Nakade et al., 2012) as well as in the long run (Dallow & Anderson, 2003), yet some have been unsuccessful (Jakicic et al., 2015; Nakata et al., 2014). What we do not know yet is why some interventions induce PA behaviour change and some do not. That is, what are the properties of an intervention that make it effective? This is the main question that this systematic review seeks to answer. Although systematic reviews and meta-analyses have been conducted before on the efficacy of interventions promoting PA in the overweight population (Dombrowski et al., 2015; Ruotsalainen, Kyngäs, Tammelin, & Kääriäinen, 2015), there are some fundamental points that make the scope of the current

review unique. Firstly, this review considers *randomised controlled trial* (RCT) interventions that have been conducted in the *health care setting*. This covers trials implemented in all levels of rehabilitation, namely primary, secondary and tertiary care, in any hospital or institutional environment. This focus on the health care setting differs greatly from the scope of the numerous reviews that have been carried out on interventions within school, worksite, or community environments (Anderson et al., 2009; Brown & Summerbell, 2009). Professionals in the care setting frequently encounter individuals who suffer from overweight and related health problems. They often favour cost-effective lifestyle PA intervention approaches above, for example, pharmacological treatments (Greaves et al., 2011). The professionals are thus in particular need for guidelines on how to motivate these individuals to engage in PA. It is crucial that these guidelines be based on empirical findings because the public currently holds multiple conflicting views on how to make people active (Franz et al., 2007). This review can provide the specialists with this information as it seeks to uncover which ways of motivating patients to be more physically active work in the health care or rehabilitation setting. Yet, the current review does not include those overweight clinical patients who suffer from specific health conditions, such as diabetes or cardiovascular disease. These populations are beyond the scope of this review because it may be that individuals within these populations experience condition-specific barriers to exercise or differential levels of pressure to engage in PA (French, Olander, Chisholm, & Mc Sharry, 2014). Thus it is possible that these individuals respond to different motivational methods than the seemingly healthy overweight and obese populations, which could in turn create more heterogeneity within the study pool. Moreover, such clinical populations have indeed been assessed in previous systematic reviews (Chasandra et al., 2015; Greaves et al., 2011).

Secondly, this review is interested in *sustained behaviour change*. It is paramount for interventionists to consider and measure long-term effects, especially when the intervention targets lifestyle changes such as PA and diet. As only few reviews have previously reported and synthesised PA results from prolonged follow-up measurements (Greaves et al., 2011), more knowledge of sustained PA change is needed. Thus, the current review limits its focus on lengthy interventions and adequate follow-up periods. Despite several reports of increased PA immediately after an intervention period (e.g. Nakade et al., 2012), it is more than common that only half of those having initiated PA will continue their habit in the long term, especially when no follow-up booster sessions

are provided post-intervention (Marcus et al., 2006). It is not unlikely that this outcome is partly due to the decaying of intervention or follow-up measurement adherence over time (Marcus et al., 2000; Williams, Hendry, France, Lewis, & Wilkinson, 2007). Despite this and other issues that are inherent to long-term interventions, it is of great importance to examine how effective such interventions are in developing sustained behaviour change.

Finally, the current review explores the features and components of the interventions and aims to draw associations between them and intervention outcomes. Interventions in the health care setting can incorporate multiple techniques to bring about PA behaviour change: Giving advice, prescribing bouts of exercise, and providing social support in a group setting are all ways of promoting PA. Although some reviews have indeed examined the link between intervention properties and effectiveness (Abraham & Graham-Rowe, 2009; Ellis et al., 2004), they have mainly been interested in whether properties of intervention delivery, such as the intensity, duration and format, make a difference to outcomes. As denoted by Dombrowski et al. (2012), this focus may lead to omission of the features within the intervention programme that have a potential effect on outcomes. Thus, a more elaborate scope is being applied in this review: In addition to intervention delivery information, this review considers the specific motivational properties of the interventions. They are the components that can be thought of as the agents or ‘active ingredients’ that bring about behaviour change (Michie et al., 2013). Since these motivational methods are a focal subject of inquiry in this review, provided next are an introduction to behaviour change and related theoretical frameworks, together with an overview of behaviour change techniques.

1.3 Behaviour change

Development of interventions designed to promote PA ideally involves consideration of human behaviour change. Interventionists need to find ways to motivate sustainable change in the participants’ behaviour, and this can be a challenging task. Ideally these motivational methods are built on theoretical models of behaviour change: Utilisation of a theoretical framework may provide understanding as to why specific methods change behaviour, that is, what the mechanisms of change are (Michie, Rothman, & Sheeran, 2007). Furthermore, interventionists can use a theoretical basis to inform the participant selection criteria of the trial (Prestwich et al., 2014). That is, theory can also aid in the process of deciding who might and who might not benefit from the intervention. There

has been support for the notion that more extensive reported use of a theoretical framework in health behaviour interventions is associated with increased intervention effectiveness (Taylor, Conner, & Lawton, 2011; Webb, Joseph, Yardley, & Michie, 2010), yet not consistently (Gardner, Wardle, Poston, & Croker, 2011; Greaves et al., 2011; Michie & Prestwich, 2010). Knowledge of the association between reported theory use and intervention outcomes is essential since it can aid interventionist and health care professionals in deciding the most influential strategies for promoting health behaviour change and PA. Hence, the current review aims to clarify these associations by identifying the theoretical models used in successful and unsuccessful PA interventions, if used at all.

Multiple theories have been developed to explain or predict human behaviour and its determinants. Theories applied to PA and general health behaviour stem from research in the field of social, educational and health psychology (Biddle, Hagger, Chatzisarantis, & Lippke, 2007). The health care setting commonly utilises those theories that emphasise individual or interpersonal psychological factors as determinants of behaviour rather than factors in the environmental or organisational level (Glanz & Bishop, 2010). Thus, those theoretical models that incorporate individual-level factors to explain behaviour are considered in this review. Four theoretical frameworks that are most commonly used to explain or promote PA behaviour amongst other health behaviours have been identified (Biddle et al., 2007; Davis, Campbell, Hildon, Hobbs, & Michie, 2015). These are the Social Cognitive Theory, Transtheoretical Model of Behaviour Change, Theory of Planned Behaviour, and Self-determination Theory. An introduction to each model is presented next in order to provide a comprehensive overview of behaviour change along with evidence of theory use in the context of PA promotion.

1.3.1 Social Cognitive Theory

Social Cognitive Theory (SCT) posits that human action is a dynamic process that is determined by a constant reciprocal interaction between one's personal attributes, environmental factors and behaviour (Bandura, 1986). One of the basic tenets of the theory is that learning occurs through observations of others' behaviour and consequences of that behaviour. However, one's own sense of agency and personal experiences are also a major determinant of behaviour: One of the main concepts in the SCT that is thought to directly influence behaviour is that of *self-efficacy*. Self-efficacy

can be defined as the situation-specific belief in one's ability to succeed in the task at hand (Bandura, 1997), such as one's belief that he or she is able to successfully engage in a specific PA behaviour. Higher self-efficacy is associated with increased behaviour: Self-efficacy beliefs determine one's mobilisation of efforts to take action as well as one's perseverance in the task despite setbacks. There are four sources of self-efficacy that contribute to these beliefs: mastery experiences, vicarious learning, verbal persuasion and emotional arousal. In the context of PA, mastery experiences can refer to one's previous occurrences of successful attempts to go for a 20-minute walk despite tiredness. Similarly, vicarious learning occurs when a relatable model successfully practices PA, and a social comparison process takes place. For example, an individual's PA self-efficacy can be enhanced by him or her observing an obese person in their exercise class persevering through an intense or challenging series of movements. Additionally, verbal persuasion by others, such as a consultant's reassurance of one's ability to adhere to taking a 30-minute walk daily, functions as a source of PA self-efficacy. Finally, emotional arousal refers to attending to the emotional state that one is in whilst performing a behaviour or directly after having performed it. For example, monitoring the positive feelings that one experiences after having successfully walked 2 miles can bring about enhanced PA self-efficacy.

Another important construct in the SCT is *outcome expectancies* (OEs; Bandura, 1997) which refer to perceived potential consequences of changing one's behaviour. In general, perceiving more positive than negative consequences of change makes that change more likely to occur. The SCT posits that there are three areas of OE that can directly influence behaviour: the physical, social, and self-evaluative outcome expectancies. For an individual who takes on PA behaviour, the physical OEs can be anticipated consequences of increased exercise on the body, such as immediate feelings of being energised or experiences of muscle tension. Social expectancies refer to the anticipated social reactions, such as expected approval from the physically active relatives, or the anticipated disapproval from family members due to reduced sedentary time spent together. Finally, the self-evaluative OEs are the anticipated experiences in reference to personal standards. For example, one's self-evaluative OEs for increased PA can be feelings of pride or feelings of embarrassment whilst exercising in public due to negative body image.

Self-efficacy is considered the strongest psychosocial determinant of PA behaviour (Rovniak, Anderson, Winett, & Stephens, 2002). More specifically, a

correlation of $r = 0.69$ between change in self-efficacy and change in PA behaviour has been previously reported (Bauman et al., 2012). Thus, self-efficacy is often the only SCT construct targeted or measured in PA interventions that are claimed to be based on the SCT (Greaves et al., 2011; Luszczynska & Schwarzer, 2005). However, for the overweight population, the predictive ability of self-efficacy on PA is somewhat weak: A review by Olander et al. (2013) found no significant relationship between change in self-efficacy and PA in the obese population. Authors of the review emphasised that the effect of self-efficacy on behaviour change is moderated by OEs, and thus self-efficacy alone might not be a good predictor of PA, at least for the overweight population. Thus, it may be worthwhile to study the extent to which the social cognitive theoretical framework as a whole predicts PA change in this population. The current review examines if SCT has been employed in PA interventions for the healthy overweight population.

1.3.2 Transtheoretical Model of Behaviour Change

Transtheoretical Model of Behaviour Change (TTM; Prochaska & DiClemente, 1983) is a stage theory of behaviour change. Stage theories suppose that individuals can move along stages of readiness for behaviour change, and that different factors are important in each stage for transition to the next (Sutton, 2005). The TTM posits five stages of change: precontemplation, contemplation, preparation, action, and maintenance. In the context of PA behaviour, precontemplation is characterised by no intention to become physically active, while contemplation and preparation involve deliberate intention to start PA. Correspondingly, people in the action and maintenance stage have already been physically active for some time. Individuals are thought to proceed from one stage to the next in a circular manner, but relapse to an earlier stage can occur at any point. The TTM also introduces processes of change which are the presumed actions that individuals can undertake in order to progress from one stage to another. According to Prochaska and DiClemente (1983) there are five experiential processes (consciousness raising, dramatic relief, self-liberation, self-reevaluation, and environmental reevaluation) and five behavioural processes of change (social support, counterconditioning, reinforcement management, stimulus control, and social liberation). And additional important construct within the TTM is decisional balance. This encompasses the perceived advantages and disadvantages of behaviour change, such as pros and cons of becoming physically active. Perceiving more advantages than

disadvantages is generally linked to decision-making that favours change (Sutton, 2005). Finally, like the SCT, TTM also contains the concept of self-efficacy as a determinant of behaviour change.

The TTM stages of change concept has been used as a theoretical foundation in the development of PA intervention protocols (Hutchison, Breckon, & Johnston, 2009). That is, interventionists have used the TTM to tailor the PA intervention according to the stage of change that the individual is in. However, comparisons between such stage-matched PA interventions and non-matched or usual care control conditions have not favoured the TTM-based interventions (Bridle et al., 2005; Van Sluijs, Van Poppel, & Van Mechelen, 2004). Similarly, interventions based on the TTM have not been effective in increasing PA in the clinical obese population unless developed using SCT constructs along with TTM (Bélanger-Gravel et al., 2011). It has been suggested that the apparent ineffectiveness of the TTM may be due to the failure of interventionists to incorporate other parts of the model, such as the processes of change, in addition to the stages of change concept (Hutchison et al., 2009). Consideration of these additional constructs within the TTM is especially important for PA interventions because adoption of PA behaviour is more complex than smoking cessation upon which the TTM was originally generated (Marcus, Rossi, Selby, Niaura, & Abrams, 1992). Furthermore, a positive decisional balance for weight loss (more advantages than disadvantages to losing weight) seems to be a particularly important predictor of weight control actions, including PA readiness, in the overweight (O'Connell & Velicer, 1988). Thus, including the construct of decisional balance in a PA intervention for the overweight might further enhance adoption of PA behaviour. All in all, it is difficult to infer effectiveness of TTM-based PA interventions based on previous work because of the inconsistent consideration of the theoretical constructs. More research is needed that synthesises current knowledge of the use and applicability of the TTM model in promoting PA. One of the aims of the current review is to add to this knowledge.

1.3.3 Theory of Planned Behaviour

Theory of Planned Behaviour (TPB; Ajzen, 1991) suggests that the main determinant of human behaviour is intention to engage in the behaviour. This intention is in turn determined by three predicting variables: attitude, subjective norm, and perceived control. Attitude is one's evaluation of the relevant behaviour, whether favourable or unfavourable. In the context of PA, a positive attitude towards exercise makes engaging

in PA more likely. Subjective norms refer to the extent of one's belief that there is social pressure to engage in the behaviour. For example, if one thinks that their spouse or family members expect him or her to engage in PA regularly, one is more likely to do so. Finally, perceived behavioural control reflects one's perception that they have control over and required skill to perform the behaviour. For instance, one may think that he or she does not have the knowledge of how to exercise safely and thus feel out of control over his or her PA habit. This may then hinder taking on regular PA. The extent to which each of these variables determines behaviour can be dependent on individual differences as well as the situation at hand (Conner & Sparks, 2005). In addition, the TPB also stipulates actual behavioural control as determinant of behaviour (Hagger, Chatzisarantis, & Biddle, 2002). That is, behaviour can be outside one's volitional control, for example when one lives in an unsafe environment that does not permit PA. In such case this true barrier can be the sole determinant of behaviour.

Studies that apply TPB in a PA setting usually target and measure the beliefs antecedent to PA-related attitudes, subjective norms and perceived behavioural control (Ajzen & Fishbein, 1980). Similarly, TPB-based PA intervention designs aim to directly modify these beliefs, with the aim of inducing behaviour change (Hagger & Chatzisarantis, 2005). Indeed, TPB constructs have been found to consistently predict exercise and sports behaviour. For example, a review by Hagger et al. (2002) found that attitudes, subjective norms and perceived behavioural control accounted for 45 per cent of the variance in behavioural intentions across 72 studies. Correspondingly, behavioural intention together with perceived control explained 27 per cent of variance in actual behaviour. It is of interest in the current review whether TPB has been used in interventions designed for the overweight population.

1.3.4 Self-determination Theory

Self-determination Theory (SDT; Ryan & Deci, 2000) is a social cognition model of motivated behaviour. According to SDT, there are different types of motivation to perform a behaviour, and these types are placed on a continuum from least self-determined to most self-determined. On the least self-determined end is amotivation (i.e. no intention or willingness to perform), and on the opposite end of the continuum is intrinsic motivation (i.e. autonomous performing of the behaviour because it is inherently enjoyable). The type of motivation closest to amotivation is external motivation where behaviour is being determined by external reward or punishment.

Towards the other end, approaching intrinsic motivation, behaviour is being performed because of its personal value or utility. This kind of identified or integrated type of motivation is more self-determined than external motivation but does not presume behaviour is inherently fun or satisfying. Where the individual is placed on this continuum is determined by satisfaction of three main psychological needs: competence, autonomy, and relatedness. Competence refers to feelings of being capable and experience of personal mastery, while autonomy refers to a sense of independence and volition. Relatedness is a sense of belonging and being part of a social entity. Fulfilment of these basic needs drives the individual towards intrinsic, autonomous motivation to engage in, enjoy and persist in the behaviour. Such autonomous motivation is known to predict long-term adherence to different types of behaviour, including PA (Chatzisarantis, Biddle, & Meek, 1997; Teixeira, Carraça, Markland, Silva, & Ryan, 2012). There are multiple ways to support fulfilment of competence, autonomy and relatedness in a PA setting: Respectively, setting and achieving small exercise goals, having the opportunity to decide on one's exercise routine, and exercising in a group setting are examples of ways to support the basic needs.

SDT-based PA interventions in the health care setting commonly attempt to bring about behaviour change by creating an autonomy-supporting counselling atmosphere (Fortier, Sweet, O'Sullivan, & Williams, 2007; Ryan, Patrick, Deci, & Williams, 2008). Although not many such experimental interventions have been implemented thus far, a review by Teixeira et al. (2012) reported that they have been mostly successful in changing PA behaviour, some even in the long term (Silva et al., 2011). In order to achieve sustainable lifestyle change, some interventions grounded on SDT have utilised the *motivational interviewing* (MI) counselling style. It is a contemporary approach to augmenting treatment motivation (Miller & Rollnick, 2012). Although not based on the SDT, MI is thought to share commonalities with the SDT. More specifically, it has been suggested that SDT provides the theoretical conceptualisation of motivation that has been lacking in the MI approach, and that these two approaches can be used to complement each other (Vansteenkiste & Sheldon, 2006). MI and its practical principles, such as expressing empathy, rolling with resistance and cultivating discrepancy, have been used successfully to promote weight management (Armstrong et al., 2011) as well as exercise (Burke, Arkowitz, & Menchola, 2003) with medium effects. Thus, it is a framework worth including in discussion of autonomous

motivation in the overweight and obese population. The present review explores the use of the SDT and MI approaches in PA interventions.

1.3.5 Behaviour change techniques

Although report of theory use can provide indications with respect to intervention design and outcomes measured, theories and models are rarely used or reported consistently across complex interventions. Thus, identifying the theoretical framework alone does not render detailed information about what was done and which properties in the intervention ultimately produced behaviour change. In order to obtain this information, the specific motivational methods, also called *behaviour change techniques* (BCTs), need to be identified. In interventions aiming at behaviour change, BCTs are those intervention components, or ‘active ingredients’, that can be observed and replicated (Abraham & Michie, 2008). They are considered to independently influence behaviour under favourable conditions, and the techniques can be implemented individually or in combinations. Unfortunately, not all interventions use the same terms to refer to specific techniques, and some studies fail to provide detailed descriptions of what was actually done. For example, some interventions report that ‘counselling’ was used as a behavioural technique, yet no description as to what this counselling involves is given. More specifically, counselling can refer to social support or general advice giving, or it can entail giving feedback, setting goals, or providing incentives for behaviour change. Such inconsistent reporting of technique use makes it difficult for reviewers and meta-analysts to reliably synthesise effectiveness of intervention components (Hankonen, Nuojua, & Ahokas, 2017). To tackle this issue, Michie et al. (2013) developed the Behaviour Change Technique Taxonomy v1 (BCTTv1) which establishes a ‘common language’ for defining and reporting intervention BCTs. Their taxonomy enables easy identification of BCTs and thus makes it possible for researchers to accurately replicate study designs. Moreover, when adequately applied in different stages of research, it provides a framework for drawing associations between intervention techniques and effectiveness across study designs. The BCTTv1 consists of 93 individual BCTs clustered into 16 categories. These categories are 1. Goals and planning, 2. Feedback and monitoring, 3. Social support, 4. Shaping knowledge, 5. Natural consequences, 6. Comparison of behaviour, 7. Associations, 8. Repetition and substitution, 9. Comparison of outcomes, 10. Reward and threat, 11. Regulation, 12. Antecedents, 13. Identity, 14. Scheduled consequences,

15. Self-belief, and 16. Covert learning (see Appendix 1 for all 93 BCTs). Each BCT is provided with a definition and a real-life example (e.g. “Goal-setting [behaviour]: Set or agree on a goal defined in terms of the behaviour to be achieved. Example: Agree on a daily walking goal [e.g. 3 miles] with the person and reach agreement about the goal”). The BCTTv1 is the most comprehensive tool to date designed for assessing BCT use in behaviour change interventions.

The BCTTv1 and its preceding version (Abraham & Michie, 2008) have been used in several systematic reviews and meta-analyses to identify PA intervention components and to draw association between component use and intervention effectiveness (Bélanger-Gravel et al., 2011; Dombrowski et al., 2012; Olander et al., 2013; Williams & French, 2011). For example, Olander et al. (2013) found in their meta-analysis that two BCTs, ‘self-monitoring of outcomes of behaviour’ and ‘social support’, were positively associated with changes in PA in the obese population. They also found that interventions with the largest effects on PA used ‘teach to use prompts or cues’, ‘prompt practice’, or ‘prompt rewards contingent on effort or progress towards behaviour’. A limitation of this review is that study quality was not assessed, and thus these results should be considered with caution. However, a meta-analysis on PA interventions for obese adults with obesity-related co-morbidities identified no individual BCTs that had significant effects on PA behaviour (Dombrowski et al., 2012). In addition to the specific BCTs, reviews have also examined the effect of the number of BCTs implemented on PA behaviour. More specifically, Fjeldsoe, Neuhaus, Winkler and Eakin (2011) found that diet and PA interventions using more than six BCTs were more successful at achieving long-term behaviour change than those using less than six. Nevertheless, Dombrowski et al. (2012) found no association between number of BCTs used and magnitude of outcomes. To add to the previous work, the current review uses the BCTTv1 to identify the BCTs used in PA interventions designed for overweight and obese individuals. The BCTs used and the number of BCTs employed, as well as potential associations between these and intervention success are explored.

1.4 Other properties of intervention delivery

In addition to BCTs, properties of intervention delivery that may affect intervention effectiveness have been put forward and studied in previous reviews (Dombrowski et al., 2012; Foster et al., 2005). The properties considered in this interview are length of intervention and follow-up, mode of delivery, intervention target behaviours, and the

type of PA measurement used. This is not, however, an exhaustive list of intervention properties that may have an impact on outcomes, but these factors were included in this review because they have been used previously or because they are thought to play a role in promotion of PA in the overweight population (e.g. Dombrovski et al., 2012).

1.4.1 Length of intervention and follow-up

There are instances of PA interventions being successful in producing long-term increases in PA behaviour. In the primary care setting, Orrow, Kinmonth, Sanderson and Sutton (2012) reported in their systematic review small to medium significant intervention effects on self-reported physical activity as measured at 12 months in six out of 14 studies. Similarly, Greaves et al. (2011) maintained that self-reported levels of PA in populations at risk of developing type 2 diabetes can be maintained occasionally but only in follow-ups up to 6 months. As has been put forth by Marcus et al. (2006) lifestyle PA interventions can facilitate maintenance of PA for up to 5 years but only if the intervention is continued. That is, effects on behaviour tend to cease after the intervention has ended. Thus, intervention length has been studied in a few interventions as one of the factors possibly affecting intervention success in increasing PA. Yet, for obese participants with obesity-related co-morbidities intervention length played no part in weight-loss or in changing PA behaviour (Dombrovski et al., 2012). On the other hand, Fjeldsoe et al. (2011) found that the 21 out of 29 PA and dietary intervention trials that achieved maintenance were longer in duration (>24 weeks) than those with unsuccessful maintenance. Yet, the issues associated with intervention adherence may have been present within the study pool in this review as trials with more than 70 per cent retention less often achieved maintenance than trials with lower rates of retention. Other issues associated with long-term follow-ups are increased impact of confounding variables, such as concurrent interference, as well as poor descriptions of 'active' follow-up periods and subsequent uncertainty of effectiveness of specific maintenance strategies (Fjeldsoe et al., 2011; Marcus et al., 2000). Thus, results of PA maintenance should be considered with caution. Yet, knowledge of intervention length and its association with intervention success is important for future lifestyle PA intervention designs in the health care setting. This review looks at intervention length and its potential effect on PA outcomes, whilst taking into account study quality such as retention rate.

In addition to length of intervention, it is also of interest in this review whether intervention intensity makes a difference to PA behaviour. There is support for the notion that more overall contact time and higher contact frequency are associated with superior weight loss in obese individuals (Dombrowski et al., 2012) as well as in those at risk of developing type 2 diabetes (Greaves et al., 2011). In other words, higher contact intensity lifestyle interventions seem to be effective in producing at least some favourable outcomes in the overweight population. However, there is mixed evidence regarding whether intervention intensity has an effect on PA per se: Web-based PA interventions seem to be more effective when they employ more than five contacts with study participants (Vandelanotte, Spathonis, Eakin, & Owen, 2007), but no clear relationship with intensity and PA outcomes have been found in overweight populations specifically. The current review aims at clarifying the role of intervention intensity in induced PA behaviour change.

1.4.2 Mode of intervention delivery

The rapid advancement in technology has inspired several systematic reviews that have looked into the effectiveness of modern technological instruments and social network platforms in promoting PA (Connelly, Kirk, Masthoff, & MacRury, 2013; Maher et al., 2014; Stephens & Allen, 2013). Despite the apparent cost-effectiveness of such web-based or computerised delivery approaches (Roesch, Norman, Villodas, Sallis, & Patrick, 2010; Wylie-Rosett et al., 2001), PA interventions in the health care or rehabilitation milieu have generally employed more 'traditional' delivery formats, such as face-to-face sessions (Gillison et al., 2015) and telephone contact (Jakicic et al., 2015). There is evidence to show that face-to-face contact is particularly important for behaviour change maintenance in PA and dietary interventions (Fjeldsoe et al., 2011). However, delivery format has not been associated with increased weight loss or PA in interventions designed for the clinical obese population (Dombrowski et al., 2012; Greaves et al., 2011).

Intervention outcomes may also be dependent upon the setting in which the intervention sessions are implemented. That is, previous reviews have studied whether delivering intervention components, such as consultation or exercise classes, in individual sessions or to groups of people is more effective (Greaves et al., 2011). For example, Avenell et al. (2004) found that family therapy in the clinical setting is more effective in relieving obesity than individual therapy. However, other reviews have

reported no superiority of the group setting in promoting PA behaviour (Dombrowski et al., 2012; Ogilvie et al., 2007). Indeed, the review of reviews by Greaves et al. (2011) presented high-quality evidence that individual, group and mixed mode interventions are equally effective in changing PA behaviour. The current review illuminates the significance of delivery format and setting (individual or group-based) in intervention PA outcomes within the overweight population.

1.4.3 Intervention target behaviours

Interventions promoting PA in the overweight population can target PA behaviour alone, or they can be designed to alter multiple habitual behaviours. These interventions usually target PA and dietary intake, typically in order to achieve weight loss. It has been argued that interventions that target multiple behaviours can be particularly effective in promoting PA adherence, as well as weight loss, due to a motivational spill-over effect (Mata et al., 2009). However, the superiority of multiple behaviour interventions has been demonstrated for weight loss only (Greaves et al., 2011), and trials promoting PA alone have been as effective in increasing PA as those targeting both PA and diet (Vandelanotte et al., 2007). It is examined in this review whether there is any difference in effectiveness between interventions targeting one behaviour (PA) and those targeting multiple behaviours.

1.4.4 Type of PA measurement used

Interventions that are interested in participants' PA levels have used several different instruments to measure PA behaviour. These instruments can be subjective measures, such as a self-report PA questionnaire or a diary of daily PA. Alternatively, objective PA measurement can be used, such as a walking pedometer. Some have argued that objective measures of PA are more truthful than subjective measures because they eliminate reporting and social desirability bias (Troiano et al., 2008). This inaccuracy of self-report measures seems to be evident in the overweight population particularly (Buchowski, Townsend, Chen, Acra, & Sun, 1999; Irwin, Ainsworth, & Conway, 2001). Thus, objective measures may result in lower reported levels of PA than those measured by self-report instruments. Thus far there are no reports of measurement type having an impact on PA change following an intervention. However, this review takes type of PA measurement into account when reporting intervention effects in the overweight population.

1.5 Objectives

This systematic review takes into account all the presented variables, namely theoretical background, motivational methods and intervention delivery properties, in a qualitative synthesis of the existing reports of PA intervention effectiveness in the overweight and obese population. Therefore, the aims of this review are:

- to examine the short- and long-term effectiveness of RCT interventions in increasing PA among overweight and obese adults in the health care setting;
- to identify the most commonly used BCTs and theoretical models, and to explore which BCTs are most frequently associated with intervention effectiveness;
- to investigate if properties of intervention delivery (length, delivery mode, target behaviours, and measurement type) are associated with intervention effectiveness;
- to assess the methodological quality of the interventions designed to promote PA.

2 METHOD

The method of this review is partly identical with the methodological procedure employed in a previous review by Chasandra et al. (2015) that provided some of the core data used in the current review. The methodology of the previous review has been reported elsewhere (see Chasandra et al., 2015). The PRISMA statement for reporting systematic reviews and meta-analyses (Liberati et al., 2009) is being followed throughout this review. There is no review protocol available for this review.

2.1 Inclusion and exclusion criteria

The criteria for inclusion in the review are reported following the PICO guidelines (Higgins & Green, 2011). The PICO components are *population, intervention, comparator, outcome, setting, and study design*. It should be noted that the inclusion criteria of the current review are a restriction to the criteria used in Chasandra et al. (2015). In other words, the current review employs extended criteria for study exclusion, but otherwise the criteria for the two are identical. All studies included in the review had to be published in a peer-reviewed journal and written in English. The comprehensive eligibility criteria of the current review are described next.

2.1.1 Population

Included in this review are studies that consider adults aged 18 – 65 years old. Studies involving males, females or both were accepted for inclusion. Only studies with interventions primarily targeted for overweight (BMI > 25) or obese (BMI > 30) individuals were included in the current review. That is, studies that stated overweight or obesity as their main eligibility criterion for participants were included. Of the studies located and retrieved according to these criteria, the current review excluded any studies that reported interventions being targeted for a specific subpopulation suffering from or having survived from a physical or mental disease or condition. However, studies were included even if they did not specify exclusion of participants with a clinical illness, as long as they manifested overweight or obesity. Similarly, studies were included if they only accepted overweight participants with additional health risks, such as impaired glucose tolerance, hypertension, or other issues of health generally associated with overweight (WHO, 2017). Natural impermanent conditions were excluded, such as pregnancy and menopause.

Studies were not assessed for eligibility by their participants' baseline activity level. Thus, interventions were not excluded if they did not target sedentary behaviour per se or if the participants were not sedentary or inactive. This is because the definitions for sedentary or inactive vary among different studies. For the purpose of this review, referral to a PA intervention by a health care professional was sufficient as an argument for need for PA and thus for eligibility of the study.

2.1.2 Intervention and outcomes

The eligibility of interventions was assessed by the measured outcomes. Behavioural interventions that stated increase in or promotion of PA in their primary aims and outcomes were included in the previous review. However, since interventions targeted for the overweight population are likely to aim at weight loss, studies with weight loss as a primary aim and PA as a secondary outcome were accepted. Included studies were to promote PA in any form or type. Thus, studies presenting trials that specifically aimed at PA maintenance rather than promotion (i.e. active follow-up) were not included. Nevertheless, studies that employed physiotherapy interventions rather than PA promotion were excluded. That is, studies were not included if they focused on specific rehabilitative exercises unless they were done as a part of PA promotion and the study included a PA measure. Moreover, only interventions that provided quantitative continuous outcome measures of PA, including minutes, hours, steps, kilometres, calories, metabolic equivalents, or watts per a time period, were included. This was done to ensure variability in PA scores and to enable comparison between study outcomes. Thus, dichotomous or categorical measures of PA such as percentages of active/inactive individuals, or less commonly used PA measures such as scores or frequency of PA sessions per week, were not included. Furthermore, only studies that reported these data measured objectively (e.g. tracking devices) or subjectively (e.g. self-report) were eligible. Studies were not included if they lacked behavioural measures of PA and only reported results of physical fitness, such as cardiovascular fitness level.

Studies were accepted if they provided PA data for baseline, post-intervention, and follow-up time points. Follow-up measures taken at least one month from post-intervention assessment were included. Alternatively, studies with at least 3 time measurements along the intervention period were included. However, studies with only baseline and post-intervention measures were eligible if the intervention lasted for more

than one year: A post-intervention measure taken after an intervention period of this length is assumed to reflect sustainability of PA behaviour change (Marcus et al., 2000).

2.1.3 Comparator

Study designs were eligible if they had at least one control group that the intervention group was compared against. Included were usual care and wait-list comparators; and control groups with different type or intensity of PA promotion or general lifestyle advice.

2.1.4 Setting

Studies conducted in any level of health care or rehabilitation setting in primary, secondary or tertiary care were eligible for inclusion in the current review. This covers exercise-referral schemes in which patients are encouraged to increase their PA and are usually provided with tailored programmes and monitoring throughout the intervention. Studies were also eligible if participant recruitment was at least partly done through primary care databases or routine health checks. Excluded were studies with community interventions, such as those conducted for a church community or whole-population level campaigns. Furthermore, interventions implemented in the workplace or school were excluded.

2.1.5 Study design

Studies included had to be randomised controlled trials. Other study designs such as studies without a control group, or cross-sectional or qualitative studies, were excluded.

2.2 Literature search

A literature search was performed twice to identify studies published in journals of psychology, health psychology, physiotherapy, health education, exercise psychology, and medicine. The search was done across five electronic databases: MEDLINE, EMBASE, CINAHL, CCRCT, and PsycINFO. During the first search that took place in January 2015 MEDLINE was searched for publications until November 2014, EMBASE until January 2015, CINAHL until December 2014, CCRCT until October 2014, and PsycINFO until December 2014. Reference lists of relevant articles and previous systematic reviews were hand searched at this time. The second search was performed in February 2017 in the same databases for any material published after the

aforementioned cut-off times. This was followed again by hand searches of relevant references. No study authors were contacted in order to obtain additional studies.

All database searches were conducted by a professional librarian. Keywords used for the search were carefully selected and revised, and were grouped under categories such as “motivation”, “intervention”, “physical activity”, and “rehabilitation”. A complete list of search terms can be found in Appendix 2).

2.3 Procedure

Studies were first selected for inclusion according to the inclusion and exclusion criteria stated in Chasandra et al. (2015). All results from the first round of literature search were reviewed by two independent reviewers from the Chasandra et al. study group who had familiarised themselves with the criteria and review aims. In the occurrence of a disagreement the opinion of a third reviewer was sought, until an agreement was reached. In the initial screening phase studies were excluded based on title and abstract if sufficient information for exclusion was provided. All the studies remaining after this phase were obtained in full text and reviewed against the criteria.

Of the titles and abstracts identified in the second search the first 160 were screened by two independent trained reviewers, M.C. and the author of the current review. If any conflicts were present the author obtained and revised the full studies in question and made the final decision upon inclusion or exclusion. The remaining titles and abstracts from the second search were reviewed by the author alone, and full studies were obtained if essential information was lacking.

Studies from both searches identified as appropriate for inclusion in the review by Chasandra et al. were examined in full by the author alone for inclusion in the current review. This was seen an appropriate method because the current review simply has more items in its exclusion criteria than the review by Chasandra et al.. Hence no studies could have been left unconsidered for this review even though the initial screening of the original literature search results was not performed against the current review specific eligibility criteria. The studies included after the author’s final examination were checked against the current criteria by M.C., and no conflicting opinions occurred.

2.4 Data extraction

Data extraction was only performed on those studies that were identified as being eligible for inclusion in the review. All data was coded and abstracted on data sheets using Microsoft Excel (2010). This was done after piloting and refining the abstraction sheet with 3 studies initially. No authors of included studies were contacted in order to obtain additional or missing data. Detailed information about the data items abstracted and the procedure of abstraction are provided next.

2.4.1 Study characteristics

Trial characteristics extracted included study author(s) and year of publication; study inclusion criteria; and participant *N*, age and baseline BMI. When reported, study *N* at each point of measurement was extracted; otherwise the initial *N* was abstracted and used only. Data on study characteristics was extracted by the author.

2.4.2 PA outcomes

Outcome information extracted contained PA scores for all time points reported; the type of PA measurement used; and intervention effects on PA, such as between-group or time effects across measurement points. For studies that reported more than one score or measure of PA, for example those reporting both pedometer and self-report instrument scores, the objective PA scores were extracted over the subjective scores. This decision was made because objective scores are considered more truthful than subjective measures in this population (Troiano et al., 2008). Furthermore, in case of multiple reported measures those scores that better indicate compliance with general PA guidelines for the overweight population were chosen (e.g. Donnelly et al., 2009). Thus, when reported, moderate or more vigorous PA scores were chosen over light PA, such as walking. Similarly, scores of overall PA were chosen over scales of single PA form when both were reported. However, if scores for the preferred measures were lacking for significant time points (such as post-intervention or follow-up), the less preferred continuous scores were extracted. All PA data was extracted by the author alone and cross-checked by M.C.. There were no disagreements amongst the two reviewers.

2.4.3 BCTs and theoretical framework

The BCTs used in each study were identified from intervention descriptions and coded according to the instructions provided by Michie et al. (2013) in their report of the latest Behaviour Change Taxonomy, the BCTTv1. Only BCTs used in the intervention group, not in the control condition, were coded. Each one of the 93 BCTs (see Appendix 1 for full list of BCTs) were coded as present or absent in one study at a time. The number of BCTs coded as present was summed for each of the 16 higher order categories. Michie et al. (2013) also identified an additional 17th category containing the 94th BCT ‘Increase positive emotions’, and the studies were coded for this too. In order to obtain intervention descriptions as detailed as possible, study protocols and supplementary manuals were retrieved and consulted when available. Five additional reports were obtained and used for this purpose (Greaves, 2015; Greaves et al., 2015; Jebb et al., 2011; Nakata et al., 2011; Silva et al., 2008). Following author recommendations (Michie et al., 2013), only those intervention components were coded that were explicitly stated as relating to PA behaviour. Coding was done independently by the author and M.C. for studies obtained from the first round of the literature search. Interrater reliability was calculated for present/absent ratings of each BCT using Cohen’s (1960) Kappa statistic. Kappa can range from -1 to 1, with negative values indicating no agreement between assessors, and 1 reflecting perfect agreement. When it was not possible to compute a Kappa score for a BCT, it was deemed appropriate to use per cent agreement to assess interrater agreement, as suggested by McHugh (2012). This value indicates percentage of agreed upon items out of all rated items, but does not suggest cut-off values for ‘acceptable’ agreement. When disagreements emerged, the author revised the relevant material and made changes to the coding that she considered appropriate. For studies identified as eligible for inclusion from the second literature search the BCTs were coded by the author alone and cross-checked by M.C.. Disagreements were solved by discussion and appropriate changes were made.

Theoretical frameworks were extracted into the data sheet by the author.

Theoretical models utilised in each study were identified based on explicit mentions of theory use in the study article or supporting documents. Due to complexity of the interventions no evaluations of the extent of theory use or assessment of theory fidelity were made.

2.4.4 Intervention delivery properties

Data pertaining to properties of intervention delivery included length of intervention and follow-up (weeks), intensity (total contact time), number of intervention contacts, type and mode of delivery (present/absent ratings for intervention delivered face-to-face, by post, by telephone calls, or via Internet; intervention delivered to individuals or groups), and target behaviours (PA or multiple behaviours). Additionally, data on type of control group was extracted because a variety of comparison interventions or programs were reported across studies. These data were extracted by both the author and M.C., and no disagreements occurred.

2.5 Quality assessment

The final studies included were each assessed for internal validity and *risk of bias* according to the quality assessment evaluation form and instructions proposed by the Cochrane Back Review Group (CBRG; Furlan, Pennick, Bombardier, & van Tulder, 2009). This risk of bias assessment was chosen because it readily provides indications of study selection bias, performance bias, attrition bias, and detection bias. The assessment tool consists of 12 questions mapping the adequacy of study randomisation, blinding and outcome reporting along with other methodological issues potentially involving threats to validity (e.g. “Was the method of randomization adequate?”). Each question can be answered with “Yes”, “No”, or “Unsure”. A “Yes” answer to an item indicates the presence of that component in the study, for example in the case where randomisation is adequate and has been done by computer-generated random sequence. Correspondingly, a “No” answer is an indication of absence of the specific component, for example when randomisation has been done using an alphabetical order. “Unsure” indicates uncertainty of presence or absence of the component, for example when the method of randomisation is not described or cannot be inferred from the information provided in the study. The number of “Yes” answers is counted for each study, and thus total study quality score range is from 0 to 12. Furlan et al. (2009) recommend that studies which have met at least 6 of the 12 criteria are regarded as having a low risk of bias.

Assessment for risk of bias for the studies accepted for inclusion in the first search was done, after appropriate training, independently by the author and a member of the Chasandra et al. (2015) study group. All studies were assessed with each item, and the results were coded on a data sheet with “1” corresponding to a “Yes” and “0” indicating

“No” or “Unsure” for an item. In order to assess interrater reliability the Kappa statistic was calculated for the risk of bias assessment, as proposed by Furlan et al. (2009). Furthermore, means for the study-specific quality scores (number of “Yes” answers) as determined by the two assessors were calculated. The studies collected from the second round of literature search were assessed for risk of bias by the author alone, and these results were cross-checked by M.C. with no disagreement remarks. No studies were excluded from the review based on quality assessment scores.

2.6 Synthesis of results

The final study pool was analysed subjectively for applicability for a quantitative synthesis of results. The included trials were judged to be too heterogeneous for a statistical pooling of results after they were assessed for similarity of *patient characteristics, trial designs, and outcomes reported*, as suggested by Boland, Cherry and Dickson (2013). More specifically, the included trials differed in the type of participants they recruited; including age, manifested health risks and conditions, and baseline PA level. Similarly, included studies employed a variety of intervention designs and lengths, and there was substantial variability in the type of control group used. Finally, although all included trials reported continuous measures of PA, measurement instruments and timing differed considerably across trials. Therefore, a descriptive qualitative synthesis of the extracted data is presented in this review.

3 RESULTS

3.1 Results of literature search

The first literature search (January 2015) identified 3692 potentially relevant records; 1620 of which were from MEDLINE, 1680 from EMBASE, 85 from CINAHL, 130 from CCRCT, and 130 from PsycINFO. An additional 180 studies were identified through manual search. Out of these studies 3507 were excluded based on title or abstract, and therefore 365 records were reviewed in full text. 52 of these records were considered eligible for inclusion in the review by Chasandra et al. (2015). Out of these studies 7 were included in the current review (Bélanger-Gravel et al., 2013; Dallow et al., 2003; Fuller et al., 2014; Nakade et al., 2012; Roesch et al., 2010; Silva et al., 2010; Wylie-Rosett et al., 2001). A flow diagram presenting the search results along with reasons for record exclusion are presented in Figure 1. More details on reasons for exclusion can be found in Chasandra et al. (2015).

The second literature search (February 2017) resulted in 1093 records of potential relevance. Of these 738 were from MEDLINE, 34 from CINAHL, 282 from CCRCT, and 39 from PsycINFO. Of the identified records 961 were excluded by title or abstract, and thus 132 articles were obtained for full-text assessment. In addition, 5 studies were located by manual searches and reviewed in full-text. 4 of these articles were accepted for inclusion in the present review (Gillison et al., 2015; Jakicic et al., 2012; Jakicic et al., 2015; Nakata et al., 2014). Figure 2 presents the flow diagram for the second literature search. The final study pool consists of 11 studies ($k = 11$; see Table 1; references for the included studies are marked with an asterisk “*” in the reference list).

3.2 Results of quality assessment

The results of individual study risk of bias assessment can be seen in Table 2. Total quality scores of studies varied from 3 to 9, with the mean quality score of all studies being 6.4 out of 12. For studies that were assessed by two reviewers ($k = 7$; identified in the first literature search) the mean quality scores of the two assessors along with interrater reliability Kappa and/or per cent agreement scores can be found in Appendix 3. According to the guidelines provided by Furlan et al. (2009), 4 of the studies (Dallow et al., 2003; Nakade et al., 2012; Roesch et al., 2010; Wylie-Rosett et al., 2001)

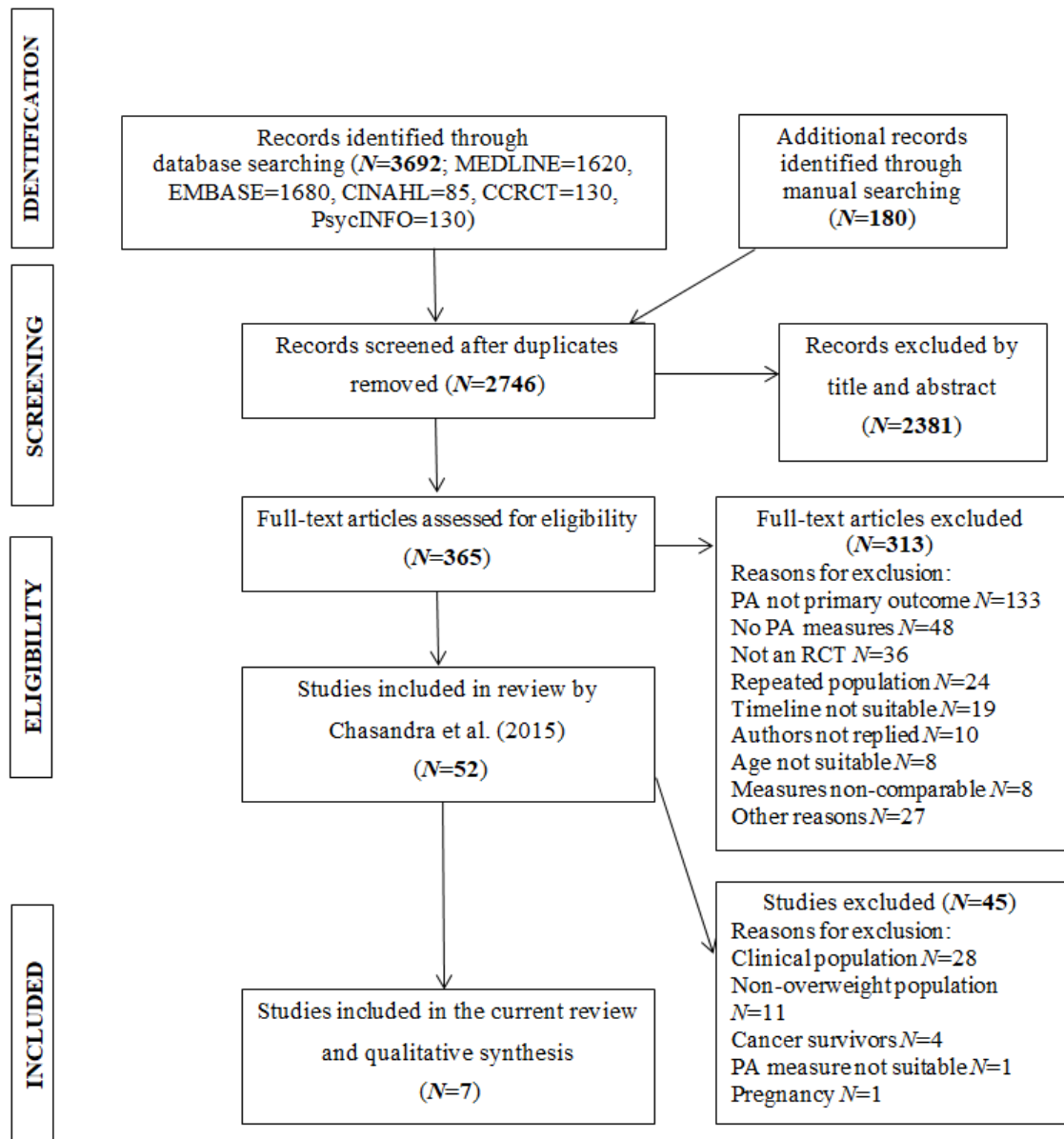


Figure 1. The flow diagram of the studies included after the first literature search.

can be rated as having high risk of bias (quality score lower than 6), whereas the remaining 7 studies are regarded as having low risk of bias (quality score 6 or above).

3.3 Study and participant characteristics

Basic study characteristics can be found in Table 1. The studies included were published between 2001 and 2015 and were most frequently conducted in the USA ($k = 5$). The rest of the studies were conducted in other countries including Japan ($k = 2$), Canada ($k = 1$), Portugal ($k = 1$) and the United Kingdom ($k = 1$), apart from one study

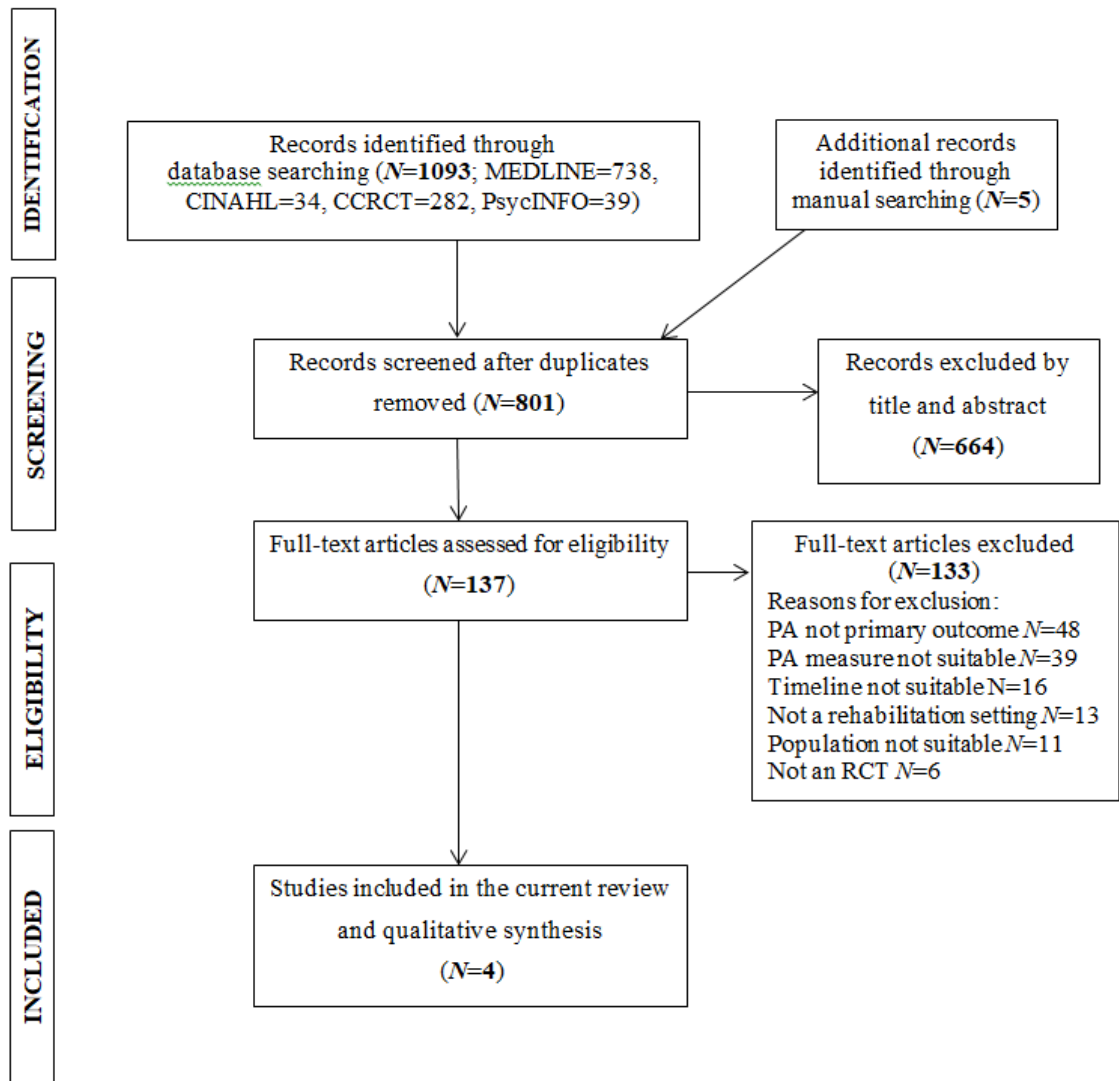


Figure 2. The flow diagram of the studies included after the second literature search.

that was conducted in three countries; Australia, Germany and the United Kingdom (Fuller et al., 2014). Five studies did not have a mention of a theoretical framework being used at any point of the study, while 3 studies explicitly stated having used the TTM. Two studies reported having used the SCT, and the rest of the theoretical frameworks including Self-efficacy Theory, the Process Model of Lifestyle Behaviour Change (PMLBC), and the MI counselling style, were used by one study only. Furthermore, majority of the studies ($k = 9$) employed a weight loss intervention whereas in the remaining two studies PA and related motivational aspects constituted the main intervention content.

Table 1
Study and Participant Characteristics (k = 11).

Study ID	Year	Country	N	Mean age (years)	Mean BMI (kg/m ²)	Theoretical framework	Intervention summary
Bélangier-Gravel	2013	Canada	101	59.4 ± 5.2	33.5 ± 3.2	No theory.	- Implementation intentions regarding to PA.
Dallow	2003	USA	58	46.7	36.1	TTM, Self-Efficacy Theory.	- Lifestyle intervention focused on PA barrier identification and elimination.
Fuller	2014	Australia, Germany, UK	772	46.5 ± 13.5 I 48.2 ± 12.2 C	31.5 ± 2.6 I 31.3 ± 2.6 C	No theory.	- Weight Watchers commercial programme: group support to balanced eating and increased PA.
Gillison	2015	UK	108	65.2 ± 7.0	32.7 ± 3.1	PMLBC.	- Waste the Waist intervention: sustainable healthy lifestyle and weight loss through self-regulatory activities.
Jakicic 1	2012	USA	363	42.20 ± 9.03	32.95 ± 3.63	No theory.	- Stepped-care intervention: group-facilitated weight loss.
Jakicic 2	2015	USA	195	43.2 ± 8.6	33.0 ± 3.4	SCT.	- Group-facilitated weight loss with additional exercise components provided at the start or at the end of intervention.
Nakade	2012	Japan	235	53.6 ± 6.7 ♂ 55.1 ± 6.4 ♀	29.8 ± 2.3 ♂ 30.9 ± 3.0 ♀	No theory.	- Saku Control Obesity Program: behavioural lifestyle weight loss intervention.
Nakata	2014	Japan	125	50.7 ± 6.7 I 51.7 ± 6.8 C	29.0 ± 3.0 I 29.2 ± 3.8 C	No theory.	- Group-facilitated educational materials on healthy diet, lifestyle and weight loss.
Roesch	2010	USA	842	42.61 ± 8.42	-	SCT, TTM.	- Website-delivered promotion of PA, healthy diet and weight loss.
Silva	2010	Portugal	239	38.1 ± 7.04 I 37.1 ± 6.99 C	31.7 ± 4.24 I 31.3 ± 4.00 C	SDT, MI.	- Intervention promoting autonomous exercise regulation and intrinsic motivation towards PA, diet, weight loss and body image.
Wylie-Rosett	2001	USA	352	51.6 ± 12.14 I 52.7 ± 11.27 C	35.16 ± 6.5 I 35.7 ± 6.7 C	TTM.	- 3 intensity levels of a weight loss intervention employing goal-setting.

Note. BMI = Body Mass Index; PA = physical activity; TTM = Transtheoretical Model of Behaviour Change; I = intervention group; C = control group; PMLBC = Process Model of Lifestyle Behaviour Change; SCT = Social Cognitive Theory; ♂ = males; ♀ = females; SDT = Self-determination Theory.

Table 2
Results of Individual Study Risk of Bias Assessment (k = 11).

Study	Total Q score	Risk of bias item										
		Adequate random- isation sequence	Treatment allocation concealed	Patient blinding	Care provider blinding	Outcome assessor blinding	Drop-out rate described and acceptable	Participants analysed in the group of allocation	Free of selective outcome reporting	Groups similar at baseline	Co- interventions avoided or similar	Compliance acceptable
Bélanger -Gravel	9	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Dallow	5						✓	✓	✓	✓	✓	✓
Fuller	7	✓	✓				✓	✓	✓	✓	✓	✓
Gillison	9	✓	✓		✓		✓	✓	✓	✓	✓	✓
Jakicic 1	6	✓	✓				✓	✓	✓	✓		✓
Jakicic 2	7	✓	✓				✓	✓	✓	✓		✓
Nakade	5						✓	✓	✓	✓		✓
Nakata	8	✓	✓		✓		✓	✓	✓	✓		✓
Roesch	3						✓	✓	✓	✓		✓
Silva	6	✓					✓	✓	✓	✓		✓
Wylie- Rosett	5						✓	✓	✓	✓		✓

Note. Q = quality. Tick indicating “Yes”, no tick indicating “No” or “Unsure”. Total quality score = sum of “Yes” answers.

As can be seen in Table 1, the mean age of study participants varied from 37 years in Silva et al. (2010) to 65 years in Gillison et al. (2015). One study (Nakade et al., 2012) reported mean participant age and BMI for males and females separately. Mean participant BMIs in all studies apart from those reported in Nakata et al. (2014) and in Nakade et al. (2012) for females were over 30 kg/m². The highest participant BMI mean of over 35 kg/m² was reported by Wylie-Rosett et al. (2001). The study by Roesch et al. (2010) did not report mean BMI of the study sample.

Table 3 presents the inclusion criteria employed in each study. 2 studies (Dallow et al., 2003; Silva et al., 2010) only recruited women, while for the remaining 9 studies no sex requirements were given. Almost all studies ($k = 10$) required a BMI of more than 25 kg/m², with the exception being study by Wylie-Rosett (2001) which also accepted participants with a BMI of more than 24 kg/m² if an additional cardiovascular risk factor was present. 3 studies (Fuller et al., 2014; Gillison et al., 2015; Nakata et al., 2014) required the participants to manifest an additional health risk, mainly cardiovascular, in order to be eligible for study participation. Only one study (Roesch et al., 2010) did not state exclusion of participants with health conditions. Furthermore, altogether 4 studies (Bélanger-Gravel et al., 2013; Dallow et al., 2003; Jakicic et al., 2012; Jakicic et al., 2015) excluded participants who were physically active at time of recruitment.

3.4 PA outcome and intervention results

PA outcome measure characteristics and summary results of intervention effects are listed in Table 4. Objective measures, either steps or moderate-to-vigorous PA (MVPA) minutes per a time period, were used by six studies. The rest of the studies ($k = 5$) employed subjective measures of PA. Altogether 8 out of the 11 studies demonstrated successful intervention outcomes: Three of these studies reported significant between-group effects on PA at post-intervention (Dallow et al., 2003; Roesch et al., 2010; Silva et al., 2010). In Dallow et al. (2003) these effects were sustained in follow-up. The remaining 5 studies reported positive overall time effects (Fuller et al., 2014; Jakicic et al., 2014; Wylie-Rosett et al., 2001) or positive time effects in intervention group only (Bélanger-Gravel et al., 2013; Nakade et al., 2012). Of these studies, two sustained time effects in follow-up (Bélanger-Gravel et al., 2013; Fuller et al., 2014). Of the overall study pool, five studies did not incorporate follow-up measurements (Jakicic et al., 2012; Jakicic et al., 2015; Roesch et al., 2010; Silva et al.,

Table 3

Study-specific Inclusion Criteria (k = 11).

Study	Inclusion criteria	Exclusion criteria
Bélanger-Gravel	Age 50-69; BMI 30-39.9 kg/m ² ; physically inactive	- CD or pulmonary disease
Dallow	Women age 25-60; BMI > kg/m ²	- History of HD, stroke or diabetes; physically active; currently on a WL plan; pregnancy; medication that may affect PA or metabolism; smoking
Fuller	Age ≥18; BMI 27-35 kg/m ² ; one additional health risk	- Recent WL; eating disorder; CV, metabolic or physical disease; pregnancy
Gillison	Age 40-74; BMI 28-45 kg/m ² ; one additional CV health risk	- CV, metabolic or terminal disease; pregnancy; WL drugs
Jakicic 1	Age 18-55; BMI 25-40 kg/m ²	- CV or metabolic disease; medication that may alter body weight; recent WL; physically active; pregnancy
Jakicic 2	Age 18-55; BMI 25-40 kg/m ²	- CV or metabolic disease; medication that may alter body weight; recent WL; physically active; pregnancy
Nakade	Age 40-64; top 5% of BMI (≥28.4 kg/m ²)	- Psychiatric or physical condition including CV; current treatment for obesity; current treatment that may alter weight
Nakata	Age 40-65; BMI 25-40 kg/m ² ; one additional CV risk	- Pregnancy; history of CD or stroke; drug treatment for diabetes; being a family member of a participant
Roesch	Age 18-55; BMI 25-40 kg/m ² ; able to engage in moderate PA	- Pregnancy
Silva	Women age 25-50; pre- menopausal; BMI 25-40 kg/m ²	- Pregnancy; major disease; medication that may alter body weight
Wylie-Rosett	BMI ≥25 OR BMI ≥24 + one CV risk factor	- Medical condition that may interfere with study adherence

Note. BMI = Body Mass Index; CD = cardiac disease; HD = heart disease; WL = weight loss; PA = physical activity; CV = cardiovascular.

2010; Wylie-Rosett et al., 2001). When it comes to measurement type, two out of the three studies with significant between-group effects utilised subjective measures of PA (Dallow et al., 2003; Roesch et al., 2010). Similarly, both objective (k = 3) and subjective measures (k = 2) were used by the other 5 studies that were successful in increasing PA over time.

Table 4

Study-specific Physical Activity Measures and Intervention Results (k = 11).

Study	PA measure and unit	Post-intervention timing and results	Follow-up timing and results
Bélanger-Gravel	Objective: steps / day	At 8 weeks: × --	At 34 weeks: + ¹ × --
Dallow	Subjective: kcal / kg of body weight per day	At 24 weeks: ++	At 48 weeks: ++
Fuller	Subjective: MET-mins / week	At 52 weeks: + --	At 104 weeks: + ¹ --
Gillison	Objective: mins / week MVPA	At 34 weeks: --	At 52 weeks: --
Jakicic 1	Objective: mins / week at ≥ 3 METs	At 78 weeks: + --	-
Jakicic 2	Subjective: kcal / week	At 78 weeks: --	-
Nakade	Objective: steps / day	At 52 weeks: ♂ + ¹ × ♀ + ¹ × --	At 104 weeks (<i>intervention group only</i>): No time effects.
Nakata	Objective: mins / day MVPA	At 22 weeks: --	At 108 weeks: --
Roesch	Subjective: leisure-time MET-mins / week	At 52 weeks: ++	-
Silva	Objective: steps / day	At 52 weeks: ++	-
Wylie-Rosett	Subjective: mins walked continuously / day	At 52 weeks: + --	-

Note. ++ = significant between-group effect favouring intervention group; -- = no between-group effects; + = significant positive time effect; × = significant group-time interaction effect; ¹ = in treatment group only; - = no data; PA = physical activity; MET = metabolic equivalent of task; MVPA = moderate-to-vigorous physical activity.

3.5 BCTs used

Altogether 37 different BCTs were used within the study pool. BCTs used in each study intervention, along with interrater reliability scores for the study BCTs rated by two assessors, are presented in Table 5. The number of BCTs used in a study varied from 5 (Fuller et al., 2014) to 21 (Silva et al., 2010), with the median being 14 BCTs used in a study. The range of BCT higher-order categories used by study was from 3 to 12 (Fuller et al., 2014; Silva et al., 2010, respectively). The most used BCTs were “Goal setting behaviour” in “Goals and planning” ($k = 10$), “Social support (unspecified)” in “Social support” ($k = 10$), “Self-monitoring of behaviour” in “Feedback and monitoring” ($k = 9$), “Problem-solving” in “Goals and planning” ($k = 8$), and “Instruction on how to perform the behaviour” in “Shaping knowledge” ($k = 8$). The BCTs used by only one study included “Discrepancy between current behaviour

Table 5

*Behaviour Change Techniques Used in Studies and Their Interrater Reliability Scores**(k = 11).*

Behaviour Change Technique (BCT)	Bélangier-Gravel ^{1,+}	Dallow ^{1,*}	Fuller ^{1,+}	Gillison	Jakicic 1 ⁺	Jakicic 2	Nakade ^{1,+}	Nakata	Roesch ^{1,*}	Silva ^{1,*}	Wylie-Rosett ^{1,+}	κ / per cent agreement
1.1 Goal-setting behaviour	•	•		•	•	•	•	•	•	•	•	1
1.2 Problem-solving	•	•		•	•	•			•	•	•	.50
1.3 Goal-setting (outcome)			•	•	•	•	•			•		62.5 %
1.4 Action planning	•	•		•		•	•			•		.75
1.5 Review behavioural goal(s)	•			•			•		•		•	.75
1.6 Discrepancy between current behaviour and goal										•		1
1.7 Review outcome goal(s)					•		•					87.5 %
<i>1. Goals and planning Total</i>	4	3	1	5	4	4	5	1	3	5	3	
2.1 Monitoring of behaviour by others without feedback							•	•	•			87.5 %
2.2 Feedback on behaviour	•				•	•	•			•		1
2.3 Self-monitoring of behaviour	•		•	•	•	•	•	•	•		•	.158
2.4 Self-monitoring of outcomes of behaviour			•				•	•		•		-.429
2.5 Monitoring of outcome(s) of behaviour without feedback			•					•	•			75%
2.7 Feedback on outcomes of behaviour					•		•					-.143
<i>2. Feedback and monitoring Total</i>	2	0	3	1	3	3	4	4	3	2	1	
3.1 Social support (unspecified)	•	•	•	•	•	•	•	•	•	•		.143
3.3 Social support (emotional)				•								NA
<i>3. Social support Total</i>	1	1	1	2	1	1	1	1	1	1	0	
4.1 Instruction on how to perform the behaviour		•		•		•	•	•	•	•	•	25%
4.2 Information about antecedents										•		87.5 %
<i>4. Shaping knowledge Total</i>	0	1	0	1	0	1	1	1	1	2	1	
5.1 Information about health consequences	•	•		•						•		.385
5.3 Information about social and environmental consequences				•					•			-.143
<i>5. Natural consequences Total</i>	1	1	0	2	0	0	0	0	1	1	0	
6.1 Demonstration of the behaviour		•				•	•			•		62.5 %
6.2 Social comparison		•		•						•		75%
<i>6. Comparison of behaviour Total</i>	0	2	0	1	0	1	1	0	0	2	0	
7.1 Prompts / cues							•		•			-.20
<i>7. Associations Total</i>	0	0	0	0	0	1	0	0	1	0	0	
8.1 Behavioural practice / rehearsal		•				•	•		•	•		.75
8.6 Generalisation of target behaviour						•				•		87.5 %
8.7 Graded tasks		•		•			•				•	.50
<i>8. Repetition and substitution</i>	0	2	0	1	0	2	2	0	1	2	1	

<i>Total</i>												
9.2 Pros and cons									•	•	.60	
<i>9. Comparison of outcomes Total</i>	0	0	0	0	0	0	0	0	1	1	0	
10.3 Non-specific reward			•						•	•	.385	
10.9 Self-reward			•						•	•	.385	
<i>10. Reward and threat Total</i>	0	2	0	0	0	0	0	0	2	2	0	
11.2 Reduce negative emotions				•							NA	
<i>11. Regulation Total</i>	0	0	0		0	0	0	0	0	0	0	
12.2 Restructuring the social environment				•							62.5 %	
12.5 Adding objects to the environment						•		•		•	87.5 %	
<i>12. Antecedents Total</i>	0	0	0	1	0	1	0	1	0	1	0	
13.2 Framing / reframing			•			•				•	75%	
<i>13. Identity Total</i>	0	1	0	0	0	1	0	0	0	1	0	
14.7 Reward incompatible behaviour			•								1	
<i>14. Scheduled consequences Total</i>	0	1	0	0	0	0	0	0	0	0	0	
15.1 Verbal persuasion about capability						•					NA	
15.3 Focus on past success				•	•						NA	
15.4 Self-talk				•					•	•	.60	
<i>15. Self-belief Total</i>	0	0	0	2	1	1	0	0	1	1	0	
17. Increase positive emotions (Total)	0	0	0	0	0	0	0	0	1	0	0	
<i>Total number of BCTs used</i>	8	14	5	16	9	16	14	8	16	21	6	
<i>Total number of BCT higher order categories used</i>	4	7	3	9	4	10	6	5	11	12	4	
	Bélangier-Gravel ^{1,+}	Dallow ^{1,*}	Fuller ^{1,+}	Gillison	Jakicic 1 ⁺	Jakicic 2	Nakade ^{1,+}	Nakata	Roesch ^{1,*}	Silva ^{1,*}	Wylie-Rosett ^{1,+}	κ / per cent agreement

Note. κ = Cohen's Kappa; NA = not applicable (only one assessor); Studies with significant intervention effects are marked with an asterisk “*”; Studies with significant time effects at post-intervention or follow-up are marked with a plus “+”. Studies with BCTs rated by two assessors and thus included in the interrater reliability calculations are marked with a “1”; Higher-order BCT categories in italics; BCTs or higher-order categories not used by any study are not listed. *Kappa interpretation:* $\kappa \leq 0$ = no agreement; 0.01-0.20 = none to slight agreement; 0.21-0.40 = fair agreement; 0.41-0.60 = moderate agreement; 0.61-0.80 = substantial agreement; 0.81-1.00 = almost perfect or perfect agreement (McHugh, 2012). Study BCTs are coded using the BCTTv1 (Michie et al., 2013).

and goal”, “Social support (emotional)”, “Information about antecedents”, “Reduce negative emotions”, “Restructuring the social environment”, “Reward incompatible behaviour”, and “Verbal persuasion about capability”. The BCTs not listed in Table 5 were not used by any study (57 BCTs; see Appendix 1 for full list of BCTs). No two studies used the same combinations of BCTs or higher-order categories.

The three studies that reported significant intervention effects (Dallow et al., 2003; Roesch et al., 2010; Silva et al., 2010) used 14, 16 and 21 BCTs, respectively.

The BCTs that were used by all three studies are “Goal-setting behaviour”, “Problem solving”, “Social support (unspecified)”, “Instruction on how to perform a behaviour”, “Behavioural practice/rehearsal”, “Non-specific reward”, and “Self-reward”.

Furthermore, studies that demonstrated significant time-effects at some measurement point (Bélanger-Gravel et al., 2013; Fuller et al., 2014; Jakicic et al., 2012; Nakade et al., 2012; Wylie-Rosett et al., 2001) were all identified as using “Self-monitoring of behaviour”. In addition, “Goal-setting behaviour” and “Social support (unspecified)” were used by 4 (80 %) of these studies.

For studies with BCTs identified by two independent assessors (Bélanger-Gravel et al., 2013; Dallow et al., 2003; Fuller et al., 2014; Nakade et al., 2012; Roesch et al., 2010; Silva et al., 2010; Wylie-Rosett et al., 2001) those BCTs that were assessed using Kappa scores showed mostly moderate or higher agreement (12 out of 21 BCTs). The BCTs that were not reliably identified by the two assessors, or which showed only slight or fair agreement, were “Self-monitoring of behaviour”, “Self-monitoring of outcomes of behaviour”, “Feedback on outcomes of behaviour”, “Social support (unspecified)”, “Information about health consequences”, “Information about social and environmental consequences”, “Prompts / cues”, “Non-specific reward” and “Self-reward”.

3.6 Intervention delivery properties

Properties of intervention delivery for all studies can be seen in Table 6. The length of interventions varied from 8 weeks (Bélanger-Gravel et al., 2013) to 78 weeks (Jakicic et al., 2012; Jakicic et al., 2015), with the most common intervention length being 52 weeks (Fuller et al., 2014; Nakade et al., 2012; Roesch et al., 2010; Silva et al., 2010; Wylie-Rosett et al., 2001). Of the studies that measured follow-up PA effects ($k = 6$), the shortest follow-up length of 12 weeks from post-intervention was in the study by Gillison et al. (2015). At the latest these measures were taken at 108 weeks (Nakata et al., 2014). There was substantial variability across studies in intervention intensity and number of contacts, with intensity range of 3515 minutes and number of contacts range of 53. All but one study (Roesch et al., 2010) utilised face-to-face sessions in intervention delivery, and telephone contact was used by four studies (Jakicic et al., 2012; Jakicic et al., 2015; Roesch et al., 2010; Wylie-Rosett et al., 2001). Interventions facilitated with computerised delivery were those by Fuller et al. (2014) and Wylie-Rosett et al. (2001). Furthermore, almost all studies ($k = 9$) delivered the intervention to a group, and some of them used both group and individualised modes of delivery

Table 6

Intervention Delivery Properties (k = 11).

Study	Int. length (weeks)	FU length (weeks)	Intensity (total contact time in min)	No. of contacts	Delivery type	Delivery mode	Target behaviours	Control group type
Bélanger-Gravel ⁺	8	26	90	3	Face-to-face	Individual	PA	AC: strategies to healthy eating and PA
Dallow [*]	24	24	1800	20	Face-to-face	Group	PA	UC: PA advice and free pass to a health club
Fuller ⁺	52	52	(1560) ^a	(52) ^a	Face-to-face; computer	Group	Multiple	SC: general lifestyle material
Gillison	40	12	810	9	Face-to-face	Group	Multiple	UC: general lifestyle material
Jakicic 1 ⁺	78	-	810-1420 ^b	18-54 ^b	Face-to-face; telephone; by post	Individual + group	Multiple	SBWT ^b
Jakicic 2	78	-	2355	56	Face-to-face; telephone	Individual + group	Multiple	SBWI
Nakade ⁺	52	52	250	10	Face-to-face; by post	Individual + group	Multiple	WL
Nakata	22	108	1080	9	Face-to-face	Group	Multiple	Educational lifestyle materials
Roesch [*]	52	-	85	5	Telephone	Individual	Multiple	WL
Silva [*]	52	-	3600	30	Face-to-face	Group	Multiple	General health education
Wylie-Rosett ⁺	52	-	440 (-890) ^c	22 (-46) ^c	(Face-to-face; telephone;) computer ^c	(Group); individual ^c	Multiple	Workbook only OR workbook + computer ^c

Note. Int. = intervention; FU = follow-up; PA = physical activity; AC = active control; UC = usual care; SC = standard care; SBWI = standard behavioural weight-loss intervention; WL = wait-list. Follow-up length reported as time from post-intervention. ^a participants only provided with free access to a commercial weight loss program. ^b participants provided with a stepped-care modification of the SBWI in which intensity and no. of contacts are dependent upon participant's individual progress. ^c three intensity levels of a weight-loss program: workbook only, workbook + computer; workbook + computer + staff consultation; Intensity, no. of contacts, delivery type and delivery mode are dependent upon group. Studies with significant intervention effects are marked with an asterisk “*”. Studies with significant time effects at post-intervention or follow-up are marked with a plus “+”.

(Jakicic et al., 2012; Jakicic et al., 2015; Nakade et al., 2012; Wylie-Rosett et al., 2001). Similarly, the majority of studies ($k = 9$) targeted multiple behaviours, whereas the other two (Bélanger-Gravel et al., 2013; Dallow et al., 2003) only targeted PA behaviour. When it comes to control group type, only two studies (Nakade et al., 2012; Roesch et al., 2010) employed a passive wait-list comparison group. Other studies ($k = 9$) provided the control group participants with some health or lifestyle material. In the studies by Jakicic et al. (2012) and Wylie-Rosett et al. (2001) the control group activities were highly similar to those in the intervention group.

Of the studies that reported significant between-group effects (Dallow et al., 2003; Roesch et al., 2010; Silva et al., 2010) only Dallow et al. measured PA at follow-up, whereas the other two studies did not employ a follow-up. There was considerable variability in intervention length, intensity, delivery features and control group characteristics across the studies that reported any group- or time effects ($k = 8$).

4 DISCUSSION

4.1 Summary of evidence

This systematic review aimed to provide a unique synthesis of PA intervention effects for overweight individuals in the health care setting. More specifically, this review attempted to assess and report effectiveness of PA interventions whilst taking into account study quality. Also, the BCTs employed in the interventions were explored using the taxonomy of Michie et al. (2013), along with a variety of intervention delivery properties. The evidence located and assessed comprised of 11 RCT studies with mostly low risk of bias, reporting short- and long-term PA outcomes. Generally, the trials included most frequently reported significant increases in PA levels over time (in 8 out of 11 studies). This effect was mainly observed in measurements immediately after the intervention, as only three studies showed significant time effects in the follow-up measurement. Thus, there is limited evidence in the data extracted to support effectiveness of PA interventions in sustained behaviour change. Furthermore, the study results brought together suggested sporadic superiority of the experimental PA group: Only three trials in the study pool reported significant effects favouring the experimental group over the comparison condition, and two out of these three studies were rated as having high risk of bias.

The current review also found that successful interventions most frequently used the BCTs “Goal-setting behaviour”, “Problem solving”, and “Social support (unspecified)”, “Instruction on how to perform a behaviour”, “Behavioural practice/rehearsal”, “Non-specific reward”, and “Self-reward”. Furthermore, “Self-monitoring of behaviour” was employed by all studies that reported significant time-effects on PA. However, the first three BCTs as well as “Self-monitoring of behaviour” were also the ones used most often across the whole study pool. When it comes to properties of intervention delivery, it was found that delivery features varied considerably in the study pool and among the studies reporting successful increase in PA. Moreover, control group characteristics were very different between studies. Thus, evidence synthesis of intervention delivery properties did not indicate any commonalities or patterns across the pool of studies.

The present findings are largely in line with those reported in previous systematic reviews. Regarding intervention results, a descriptive review by Bélanger-Gravel et al. (2011) on theory-based PA interventions in the overweight population found significant

time effects in most of the included studies. Similarly, only a few of the studies located by Bélanger-Gravel et al. (2011) demonstrated significant effects favouring the participant group that received the experimental PA intervention. However, said review did not limit its inclusion criteria to interventions conducted in the health care setting, neither did it assess study-specific risk of bias. There are a variety of potential reasons as to why PA interventions carefully designed in this setting for the overweight population do not seem to produce better results than general lifestyle advice. Firstly, as proposed by Williams, Block and Fitzsimons (2006), mere inquiry about health behaviours may have a positive effect on subsequent said behaviours. The study group demonstrated improvement in exercise levels by students that were simply asked questions about their intentions to exercise in the near future. Considering these encouraging findings, it is possible that participants increased their PA levels in the majority of the studies included in the present review because exercise behaviour was made salient to them by inquiry. Furthermore, Williams et al. (2013) proposed that this effect is observed for socially normative behaviours. There may be particular social pressure to engage in PA by the population studied in the present review because of the social stigmatisation of the overweight or obese (e.g. Shaw et al., 2005). Moreover, in addition to making PA salient, researchers have also demonstrated a mere-measurement effect on PA. To illustrate, measuring PA alone has been shown to cause PA levels to increase in an RCT study (van Sluijs, van Poppel, Twisk, & van Mechelen, 2006). Mere measurement by a self-report instrument has also resulted in improved PA levels in the overweight and obese population in particular (Godin, Bélanger-Gravel, Amireault, Vohl, & Pérusse, 2011).

The reasons stated are presented mainly in order to explain the lack of significant intervention effects in the current study pool, not to suggest that carefully designed PA interventions are redundant. After all, most interventions assessed in the current review resulted in improved PA levels. However, there have been suggestions that exercise-referral schemes may not be feasible when compared to usual-care lifestyle or PA advice that is fairly cost-effective (Williams et al., 2007). Furthermore, such PA interventions have generally manifested poor adherence, at least in those studies that have reported drop-out rates in the first place (Gidlow, Johnston, Crone, & James, 2005). Although studies included in the present review generally reported acceptable adherence (8 out of 11 studies), interestingly, out of the three studies with significant between-group effects two (Dallow et al., 2003; Roesch et al., 2010) did not report

drop-out rates or the rates were not within the acceptable limits as defined by Furlan et al. (2009). However, it is not rational to draw conclusions on the adherence-success association based on these few studies. Furthermore, in addition to intervention or measurement adherence, it is important to consider the overall compliance of participants to the intervention or control program. The general impression from the risk of bias assessment of the included studies is that compliance was poorly reported and rarely adequate (in 3 out of 11 studies). This indicates that it is nearly impossible to infer that it was indeed the intervention that caused PA to increase and not some other factor, such as mere-measurement effect.

The current review also found weak support for the PA interventions' effectiveness in inducing maintained behaviour change. This finding was not particularly surprising, as it has been suggested in previous work that PA changes are often poorly maintained (Marcus et al., 2006; Vandelanotte et al., 2007). More specifically, two out of the three studies that reported significant intervention effects did not employ a follow-up (Roesch et al., 2010; Silva et al., 2010), but were included in the review because they employed a year-long intervention. This finding supports the notion that PA interventions may only be effective up to the point to which they are 'active' (Marcus et al., 2006). However, the encouraging time-effects demonstrated in two of the included studies with long follow-up periods, one of which employed a follow-up period as long as one year (Fuller et al., 2014), should not go unnoticed.

The present findings regarding the BCTs used showed no superiority of any specific BCT. However, some patterns were observed across the study pool which are, at least partly, in keeping with those identified in previous systematic reviews. A meta-analysis on PA interventions designed for obese individuals by Olander et al. (2013) found that "plan social support / social change" and "prompt self-monitoring of behavioural outcome" were significantly associated with positive changes in PA. Although this review utilised a different tool for identifying BCTs (the CALO-RE taxonomy; Michie et al., 2011), BCTs that contain "self-monitoring" are very much identical between the CALO-RE and the BCTTv1. In the current study pool, self-monitoring was used by successful studies, but this self-monitoring was done on the PA behaviour itself. In turn, "Self-monitoring of outcomes of behaviour", which refers to monitoring of behavioural outcomes, such as weight (Michie et al., 2013), was used by four studies only. However, three out of these four studies (Fuller et al., 2014; Nakade et al., 2012; Silva et al., 2010) showed positive time effects at post-intervention or

follow-up. Exploration of the use of the BCT “Self-monitoring of outcomes of behaviour” may provide an indication of whether or not self-monitoring of one’s weight whilst undergoing a PA intervention is associated with success in increasing PA behaviour. Although several studies have demonstrated effectiveness of consistent self-monitoring of weight on ultimate weight loss (Akers, Cornett, Savla, Davy, & Davy, 2012; Butryn, Phelan, Hill, & Wing, 2007), there are no reports showing that monitoring of weight has a ‘spill-over’ effect on PA behaviour. Yet, self-monitoring of PA behaviour itself has been shown to be effective in increasing self-reported PA in primary health care, at least in short-term (Aittasalo, Miilunpalo, Kukkonen-Harjula, & Pasanen, 2006). However, it should be noted that in the current review most of the BCTs weakly associated with successful intervention outcomes, including “Self-monitoring of behaviour” and “Self-monitoring of outcomes of behaviour”, were not reliably identified by the two independent BCT coders. Overall, the current evidence synthesis only tentatively suggests that self-monitoring may be a useful tool in promoting PA.

The current review did not find any evidence on the role of the number of BCTs employed in intervention success. This comes as no surprise, as findings regarding this issue have been inconsistent (Dombrowski et al., 2010; Fjeldsoe et al., 2011). These authors have suggested that providing participants with a wide variety of BCTs ensures that at least some of them will be effective in facilitating behaviour change. However, this method might not enable investment of enough resources in and careful planning of all the employed BCTs. Furthermore, interventions incorporating a large number of BCTs are likely to further distance us from the goal of being able to pin-point the BCTs that are indeed effective (Michie et al., 2011).

The theoretical frameworks used in the included studies were not assessed beyond a descriptive summary. This decision was made because it was found that the studies included utilised intervention techniques and methods that were highly complex, and it was impossible to conclude whether a theoretical framework was truly used in some or all phases of the intervention. Moreover, 45 % of the included studies reported no theoretical framework whatsoever. As an earlier review of reviews has reported (Greaves et al., 2011), interventions with mentions of theory have not been associated with superior intervention effects on PA. However, such findings do not provide insight into the means of behaviour change. A more fruitful approach would be to assess the true mediators through which increases in PA are produced, as was done in a review by

Rhodes and Pfaeffli, (2010). Nevertheless, this review did not indicate any mediators to be particularly effective, but instead raised the concern of theory-based PA interventions being predominantly unsuccessful. After all, as noted by Bélanger-Gravel et al. (2011), interventions implemented in the health care setting or in the clinical population may not wish to focus on theory testing but instead in increasing PA as effectively as possible, due to ethical reasons. All in all, judgments of associations between theory use and intervention success were not attempted in this review.

Finally, there was a lack of observable patterns in the evidence synthesis of intervention delivery features. It is possible that delivery properties do not play a role in determining intervention success, at least in the long term, simply because any potential effects of such practical aspects may have dispersed over time. That is, it is likely that the intervention content, such as the BCTs used, make the intervention more or less effective, not the means by which it was delivered. However, as previous literature has often demonstrated, intervention intensity is commonly positively associated with PA behaviour change (Foster, Hillsdon, Thorogood, Kaur, & Wedatilake, 2005; Vandelanotte et al., 2007). This finding is intuitively appealing, yet there was remarkable heterogeneity within the current study pool regarding the total time of contact with participants. Thus, the data extracted does not make it possible to speculate potential effects that intervention delivery features may have on the effectiveness of PA interventions designed for the overweight population.

4.2 Strengths and limitations

There are several strengths in how this review was carried out. Most of these have been pointed out in the review by Chasandra et al. (2015) but will be presented here as well. Firstly, the search strategy employed was extensive with search terms and strategy being developed in collaboration with a professional librarian. Furthermore, comprehensive manual searches of relevant literature were done. This ensured inclusion of as many potentially relevant records as possible. Secondly, only RCTs were accepted for inclusion in this review, which made it possible to assess and compare only those interventions that have utilised a comparison group. More importantly, inclusion of only those studies that looked into overweight or obese participants allowed intervention effects to be assessed for a population that is at a notable health risk and urgently needs effective tools for PA promotion. Also, the reviewed study pool consisted of reports from various countries, not only from the

Western societies. Furthermore, only those studies were included that reported continuous PA outcomes over an adequately long period of time, in order to enable meaningful inter-study comparison of intervention success for both short-term PA and maintenance effects.

The included studies were assessed for quality using the risk of bias assessment tool presented by Furlan et al. (2009). The quality assessment was used in order to critically review the collected evidence. Strength of the data extraction process is that data was abstracted for a variety of variables. This allowed a comprehensive comparison and synthesis on both intervention content and means of delivery. Another strength pertaining to data abstraction was that majority of the data (data for 7 out of 11 studies) was abstracted by two independent reviewers. The remaining studies were only assessed and reviewed by the author, but the content retrieved was cross-checked by a second reviewer.

Nevertheless, it is important to recognise the limitations to this study. Firstly, some of the studies ($k = 4$) were rated as manifesting a high risk of bias. The remaining studies scored above the determined cut-off point for low risk of bias. Nevertheless, sources of potential bias were present in all studies, and consequently the findings presented in this study should be regarded cautiously. It could be gathered from the risk of bias table that blinding was implemented poorly or not described at all in virtually all of the studies. Additionally, no study reported absence of co-occurring interventions or attempts to control for such co-interventions. Finally, only a few studies ($k = 3$) included reports of compliance or the compliance rate was determined as acceptable.

When it comes to the limitations in the methodology implemented, only studies written in English language were searched for. More importantly, a rather small number of studies met the set eligibility criteria. Broader criteria for study inclusion, for example by qualifying studies employing other PA outcomes (e.g. percentage of participants meeting a set PA goal) may have resulted in a higher number of studies reviewed. However, inclusion of only those studies that used continuous PA measures allowed the gathered data to be compared in an informative yet concise way. In addition, this review used a qualitative evidence synthesis method, which does not allow for conclusions to be made based on between-study magnitude of effect comparisons or statistical pooling of data. It should be noted, however, that the study pool considered was subjectively judged to be very heterogeneous, and that due to the small number of included studies formal moderator analyses may not have yielded

much information regarding study effectiveness. Another limitation of the current review is that due to time restraints there was no communication between independent assessors regarding rules for BCT or risk of bias data extraction. This may have been a major cause of the poor interrater agreement observed. For example, different rules of thumb for coding of the BCTs may have been followed by the two reviewers: It has been recommended that comprehensive BCT coding training is undertaken before identification of the BCTs from intervention descriptions occurs (see <http://www.bct-taxonomy.com/>), and that any specific instructions provided in Michie et al. (2013) are complied with. It would have also been good practice to set some ground rules for the risk of bias assessment. At the minimum, discussion amongst the reviewers and adoption of a consensus method regarding any emerging disagreements in data extraction would have increased the confidence with which the current results can be approached. It should be noted as well that there may have been even more occurrences of ‘statistical disagreement’ in the study pool than seemingly reported. That is, ratings for some BCTs or quality assessment items did not allow the use of Kappa statistic because one assessor rated all occasions for said objects as constant (all “0” or all “1”). Subsequently, the percent agreement calculation was used for those objects, which does not readily indicate agreement or disagreement. Thus, the seemingly “agreed” values as shown by the percent agreement score (e.g. 75% agreement) may, when the possibility of chance is taken into account, prove disagreed upon. Nevertheless, all data collected by the two reviewers and all studies were carefully revised by the author, and she made modifications to the data abstracted at her own discretion. Given these limitations, it is advisable that readers approach the findings presented in the qualitative synthesis with caution.

4.3 Implications for future research

Based on the provided evidence synthesis some recommendations for future research can be made. Most importantly, more evaluative research is needed that maps the efficacy of PA interventions in the studied population. Such research is especially needed in order to infer effectiveness of those interventions that aim at inducing long-term PA behaviour change or maintenance. Exploration of intervention effects that uses statistical data pooling methods would provide valuable information about the overall magnitude of effect, as well as about the possible intervention variables that may contribute to intervention effects. These variables include BCTs and various

intervention delivery properties, such as intervention length and intensity, type of PA measurement used, and delivery mode. Additionally, more research is needed to discover any impact that intervention target behaviours may have on PA outcomes. Furthermore, as the current review did not explore behaviour maintenance strategies per se, examining which such strategies are most likely to result in sustained behaviour change is a task worth embarking on in the future. Furthermore, given that complex behavioural interventions in the health care setting can be expensive and time consuming to implement, future research may be needed to evaluate the cost-effectiveness of such interventions.

Other than recommendations for future summative research, there may be need for future RCT studies to pay careful attention to ensuring high methodological quality. One suggestion is that RCTs should carefully plan and report use of tools to monitor intervention compliance. Similarly, it may be good practice to engage in attempts to control for the effect of co-interventions on PA, and to communicate these attempts carefully. Furthermore, interventionists in the health care setting should pay attention to ensuring adequate patient, care provider, and outcome assessor blinding in order to avoid any performance bias associated. Finally, although the current results synthesis does not suggest that interventions are plagued with attrition, powerful tools for ensuring patient adherence are needed, especially when long follow-ups are being employed. One way to relieve the biases associated with poor methodological quality is to develop and register a review protocol prior to commencement of the review process.

RCTs should also make sure that theoretical and motivational techniques used in the interventions are reported in a way that makes replication and meaningful evidence summary possible. To ensure this a reliable BCT taxonomy, more specifically the BCTTv1 by Michie et al. (2013), should be used throughout the intervention process and reporting. Although the studies included in the current review do not imply superiority of specific BCTs, it is possible that employing various forms of self-monitoring may result in increasingly positive intervention effects in the overweight and/or obese population.

4.4 Conclusions

While the overall findings of the current review are informative, the information presented in the qualitative synthesis are insufficient to enable conclusions to be made regarding the effectiveness of single BCTs or intervention delivery properties in

motivating increase in PA behaviour in the overweight and obese population. There may be, however, reason to recommend the use of self-monitoring as a technique to induce PA behaviour change in interventions implemented in the health care setting. Although this recommendation is based on weak evidence, it may be used to inform policy, decision-making and training of staff in the health care environment. Furthermore, it is apparent that the included moderate-quality interventions rarely manage to increase PA to a larger extent than general lifestyle advice provided by health care professionals. To conclude, more high-quality RCTs and summative research are needed to map PA intervention effects on behaviour change of the overweight population. This future research can perhaps provide stronger evidence to guide practice in the health care setting.

5 REFERENCES

- Abraham, C., & Graham-Rowe, E. (2009). Are worksite interventions effective in increasing physical activity? A systematic review and meta-analysis. *Health Psychology Review*, 3(1), 108-144.
- Abraham, C. & Michie, S. (2008). A taxonomy of behaviour change techniques used in interventions. *Health Psychology*, 27(3), 379–387.
- Aittasalo, M., Miilunpalo, S., Kukkonen-Harjula, K., & Pasanen, M. (2006). A randomized intervention of physical activity promotion and patient self-monitoring in primary health care. *Preventive Medicine*, 42(1), 40-46.
- Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes*, 50(2), 179-211.
- Ajzen, I., & Fishbein, M. (1980). *Understanding attitudes and predicting social behavior*. Englewood Cliffs, NJ: Prentice Hall
- Akers, J. D., Cornett, R. A., Savla, J. S., Davy, K. P., & Davy, B. M. (2012). Daily self-monitoring of body weight, step count, fruit/vegetable intake, and water consumption: A feasible and effective long-term weight loss maintenance approach. *Journal of the Academy of Nutrition and Dietetics*, 112(5), 685-692.
- Anandacoomarasamy, A., Caterson, I., Sambrook, P., Fransen, M., & March, L. (2008). The impact of obesity on the musculoskeletal system. *International Journal of Obesity*, 32(2), 211.
- Anderson, L. M., Quinn, T. A., Glanz, K., Ramirez, G., Kahwati, L. C., Johnson, D. B., ... & Katz, D. L. (2009). The effectiveness of worksite nutrition and physical activity interventions for controlling employee overweight and obesity: A systematic review. *American Journal of Preventive Medicine*, 37(4), 340-357.
- Armstrong, M. J., Mottershead, T. A., Ronksley, P. E., Sigal, R. J., Campbell, T. S., & Hemmelgarn, B. R. (2011). Motivational interviewing to improve weight loss in overweight and/or obese patients: A systematic review and meta-analysis of randomized controlled trials. *Obesity Reviews*, 12(9), 709-723.
- Avenell, A., Broom, J., Brown, T. J., Poobalan, A., Aucott, L., Stearns, S. C., ... & Grant, A. M. (2004). Systematic review of the long-term effects and economic consequences of treatments for obesity and implications for health improvement. *Health Technology Assessment*, 8(21), 1-194.

- Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory*. Englewood Cliffs, NJ: Prentice-Hall.
- Bandura, A. (1997). *Self-efficacy: The exercise of control*. New York: WH Freeman
- Barry, V. W., Baruth, M., Beets, M. W., Durstine, J. L., Liu, J., & Blair, S. N. (2014). Fitness vs. fatness on all-cause mortality: A meta-analysis. *Progress in Cardiovascular Diseases, 56*(4), 382-390.
- Bauman, A. E., Reis, R. S., Sallis, J. F., Wells, J. C., Loos, R. J., Martin, B. W., & Lancet Physical Activity Series Working Group. (2012). Correlates of physical activity: Why are some people physically active and others not?. *The Lancet, 380*(9838), 258-271.
- *Bélanger-Gravel, A., Godin, G., Bilodeau, A., & Poirier, P. (2013). The effect of implementation intentions on physical activity among obese older adults: A randomised control study. *Psychology & Health, 28*(2), 217-233.
- Bélanger-Gravel, A., Godin, G., Vézina-Im, L. A., Amireault, S., & Poirier, P. (2011). The effect of theory-based interventions on physical activity participation among overweight/obese individuals: A systematic review. *Obesity Reviews, 12*(6), 430–439.
- Biddle, S. J., Hagger, M. S., Chatzisarantis, N. L., & Lippke, S. (2007). Theoretical frameworks in exercise psychology. *Handbook of Sport Psychology, 3*, 537-559.
- Blair, S. N., & Brodney, S. (1999). Effects of physical inactivity and obesity on morbidity and mortality: Current evidence and research issues. *Medicine and Science in Sports and Exercise, 31*, S646-S662.
- Boland, A., Cherry, M. G., & Dickson, R. (Eds.). (2013). *Doing a systematic review: A student's guide*. Sage
- Bravata, D. M., Smith-Spangler, C., Sundaram, V., Gienger, A. L., Lin, N., Lewis, R., ... & Sirard, J. R. (2007). Using pedometers to increase physical activity and improve health: A systematic review. *Journal of the American Medical Association, 298*(19), 2296-2304.
- Bridle, C., Riemsma, R. P., Pattenden, J., Sowden, A. J., Mather, L., Watt, I. S., & Walker, A. (2005). Systematic review of the effectiveness of health behavior interventions based on the transtheoretical model. *Psychology & Health, 20*(3), 283-301.
- Brown, T., & Summerbell, C. (2009). Systematic review of school-based interventions that focus on changing dietary intake and physical activity levels to prevent

- childhood obesity: An update to the obesity guidance produced by the National Institute for Health and Clinical Excellence. *Obesity Reviews*, 10(1), 110-141.
- Buchowski, M. S., Townsend, K. M., Chen, K. Y., Acra, S. A., & Sun, M. (1999). Energy expenditure determined by self-reported physical activity is related to body fatness. *Obesity*, 7(1), 23-33.
- Burke, B. L., Arkowitz, H., & Menchola, M. (2003). The efficacy of motivational interviewing: A meta-analysis of controlled clinical trials. *Journal of Consulting and Clinical Psychology*, 71(5), 843-861.
- Butryn, M. L., Phelan, S., Hill, J. O., & Wing, R. R. (2007). Consistent self-monitoring of weight: A key component of successful weight loss maintenance. *Obesity*, 15(12), 3091-3096.
- Cawley, J., & Meyerhoefer, C. (2012). The medical care costs of obesity: An instrumental variables approach. *Journal of Health Economics*, 31(1), 219-230.
- Chasandra, M., Novoradovskaya, E., Sjögren, T., Lintunen, T., Karvanen J., Immonen, J., & Ruiz, M. (2015). *Effectiveness of motivational methods to change physical activity behaviour of sedentary adults in rehabilitation settings: A systematic review and meta-analyses*. Manuscript in preparation.
- Chatzisarantis, N. L., Biddle, S. J., & Meek, G. A. (1997). A self-determination theory approach to the study of intentions and the intention-behaviour relationship in children's physical activity. *British Journal of Health Psychology*, 2(4), 343-360.
- Cohen, J. (1960). A coefficient of agreement for nominal scales. *Educational and Psychological Measurement*, 20, 37-46.
- Connelly, J., Kirk, A., Masthoff, J., & MacRury, S. (2013). The use of technology to promote physical activity in Type 2 diabetes management: A systematic review. *Diabetic Medicine*, 30(12), 1420-1432.
- Conner, M., & Sparks, P. (2005). Theory of planned behaviour and health behaviour. In M. Conner & P. Norman (Eds.), *Predicting health behaviour*, (2nd ed., pp. 170-222). Buckingham: Open University Press.
- *Dallow, C. B., & Anderson, J. (2003). Using self-efficacy and a transtheoretical model to develop a physical activity intervention for obese women. *American Journal of Health Promotion*, 17(6), 373-381.
- Davis, R., Campbell, R., Hildon, Z., Hobbs, L., & Michie, S. (2015). Theories of behaviour and behaviour change across the social and behavioural sciences: A scoping review. *Health Psychology Review*, 9(3), 323-344.

- Dombrowski, S. U., Sniehotta, F. F., Avenell, A., Johnston, M., MacLennan, G., & Araújo-Soares, V. (2012). Identifying active ingredients in complex behavioural interventions for obese adults with obesity-related co-morbidities or additional risk factors for co-morbidities: A systematic review. *Health Psychology Review*, 6(1), 7-32.
- Donnelly, J. E., Blair, S. N., Jakicic, J. M., Manore, M. M., Rankin, J. W., & Smith, B. K. (2009). American College of Sports Medicine Position Stand. Appropriate physical activity intervention strategies for weight loss and prevention of weight regain for adults. *Medicine and Science in Sports and Exercise*, 41(2), 459-471.
- Ellis, S. E., Speroff, T., Dittus, R. S., Brown, A., Pichert, J. W., & Elasy, T. A. (2004). Diabetes patient education: A meta-analysis and meta-regression. *Patient Education and Counseling*, 52(1), 97-105.
- Fjeldsoe, B., Neuhaus, M., Winkler, E., & Eakin, E. (2011). Systematic review of maintenance of behavior change following physical activity and dietary interventions. *Health Psychology*, 30(1), 99.
- Flegal, K. M., Carroll, M. D., Kit, B. K., & Ogden, C. L. (2012). Prevalence of obesity and trends in the distribution of body mass index among US adults, 1999-2010. *Journal of the American Medical Association*, 307(5), 491-497.
- Fortier, M. S., Sweet, S. N., O'Sullivan, T. L., & Williams, G. C. (2007). A self-determination process model of physical activity adoption in the context of a randomized controlled trial. *Psychology of Sport and Exercise*, 8(5), 741-757.
- Foster, C., Hillsdon, M., Thorogood, M., Kaur, A., & Wedatilake, T. (2005). Interventions for promoting physical activity. *The Cochrane Library*.
- Foster, G. D., Makris, A. P., & Bailer, B. A. (2005). Behavioral treatment of obesity. *The American Journal of Clinical Nutrition*, 82(1), 230S-235S.
- Franz, M. J., VanWormer, J. J., Crain, A. L., Boucher, J. L., Histon, T., Caplan, W., ... & Pronk, N. P. (2007). Weight-loss outcomes: A systematic review and meta-analysis of weight-loss clinical trials with a minimum 1-year follow-up. *Journal of the American Dietetic Association*, 107(10), 1755-1767.
- French, D. P., Olander, E. K., Chisholm, A., & Mc Sharry, J. (2014). Which behaviour change techniques are most effective at increasing older adults' self-efficacy and physical activity behaviour? A systematic review. *Annals of Behavioral Medicine*, 48(2), 225-234.

- *Fuller, N. R., Williams, K., Shrestha, R., Ahern, A. L., Holzapfel, C., Hauner, H., ... & Caterson, I. D. (2014). Changes in physical activity during a weight loss intervention and follow-up: A randomized controlled trial. *Clinical Obesity*, 4(3), 127-135.
- Furlan, A. D., Pennick, V., Bombardier, C., & van Tulder, M. (2009). 2009 updated method guidelines for systematic reviews in the Cochrane Back Review Group. *Spine*, 34(18), 1929-1941.
- Gardner, B., Wardle, J., Poston, L., & Croker, H. (2011). Changing diet and physical activity to reduce gestational weight gain: A meta-analysis. *Obesity Reviews*, 12, e602–e620.
- Gidlow, C., Johnston, L. H., Crone, D., & James, D. (2005). Attendance of exercise referral schemes in the UK: A systematic review. *Health Education Journal*, 64(2), 168-186.
- *Gillison, F., Stathi, A., Reddy, P., Perry, R., Taylor, G., Bennett, P., ... & Greaves, C. (2015). Processes of behavior change and weight loss in a theory-based weight loss intervention program: A test of the process model for lifestyle behavior change. *International Journal of Behavioral Nutrition and Physical Activity*, 12(1), 2.
- Glanz, K., & Bishop, D. B. (2010). The role of behavioral science theory in development and implementation of public health interventions. *Annual Review of Public Health*, 31, 399-418.
- Godin, G., Bélanger-Gravel, A., Amireault, S., Vohl, M. C., & Pérusse, L. (2011). The effect of mere-measurement of cognitions on physical activity behavior: A randomized controlled trial among overweight and obese individuals. *International Journal of Behavioral Nutrition and Physical Activity*, 8(1), 2.
- Greaves, C.J. (2015). The Waste the Waist Intervention. *Open Research Exeter*. Retrieved from https://ore.exeter.ac.uk/repository/bitstream/handle/10871/16379/R_5132%20Additional%20File%202.pdf?sequence=6
- Greaves, C., Gillison, F., Stathi, A., Bennett, P., Reddy, P., Dunbar, J., ... & Davis, M. (2015). Waste the waist: a pilot randomised controlled trial of a primary care based intervention to support lifestyle change in people with high cardiovascular risk. *International Journal of Behavioral Nutrition and Physical Activity*, 12(1), 1.

- Greaves, C. J., Sheppard, K. E., Abraham, C., Hardeman, W., Roden, M., Evans, P. H., & Schwarz, P. (2011). Systematic review of reviews of intervention components associated with increased effectiveness in dietary and physical activity interventions. *BMC Public Health, 11*(1), 119.
- Hagger, M., & Chatzisarantis, N.L.D. (2005). *The social psychology of exercise and sport*. Buckingham, U.K.: Open University.
- Hagger, M. S., Chatzisarantis, N. L., & Biddle, S. J. (2002). A meta-analytic review of the theories of reasoned action and planned behavior in physical activity: Predictive validity and the contribution of additional variables. *Journal of Sport and Exercise Psychology, 24*(1), 3-32.
- Hagstromer, M., Ainsworth, B. E., Oja, P., & Sjostrom, M. (2010). Comparison of a subjective and an objective measure of physical activity in a population sample. *Journal of Physical Activity and Health, 7*(4), 541-550.
- Hamman, R. F., Wing, R. R., Edelstein, S. L., Lachin, J. M., Bray, G. A., Delahanty, L., ... & Regensteiner, J. (2006). Effect of weight loss with lifestyle intervention on risk of diabetes. *Diabetes Care, 29*(9), 2102-2107.
- Hankonen, N., Nuojua, S., & Ahokas, M. (2017). Käyttäytymisen muuttamisen tekniikoiden luokitusjärjestelmä: Askel kohti systemaattisempaa käyttäytymismuutostiedettä [Behaviour Change Technique Taxonomy: A step towards more systematic science of behaviour change]. *Psykologia, 52*(1). 61-65.
- Haslam, D. W., & James, W. P. T. (2005). Obesity. *The Lancet, 366*(9492), 1197-1209.
- Higgins, J. P., & Green, S. (Eds.). (2011). *Cochrane handbook for systematic reviews of interventions* (Vol. 4). John Wiley & Sons.
- Hutchison, A. J., Breckon, J. D., & Johnston, L. H. (2009). Physical activity behavior change interventions based on the transtheoretical model: A systematic review. *Health Education & Behavior, 36*(5), 829-845.
- Irwin, M. L., Ainsworth, B. E., & Conway, J. M. (2001). Estimation of energy expenditure from physical activity measures: Determinants of accuracy. *Obesity, 9*(9), 517-525.
- *Jakicic, J. M., Rickman, A. D., Lang, W., Davis, K. K., Gibbs, B. B., Neiberg, R., & Marcus, M. D. (2015). Time-based physical activity interventions for weight loss: A randomized trial. *Medicine and Science in Sports and Exercise, 47*(5), 1061.
- *Jakicic, J. M., Tate, D. F., Lang, W., Davis, K. K., Polzien, K., Rickman, A. D., ... & Finkelstein, E. A. (2012). Effect of a stepped-care intervention approach on

- weight loss in adults: A randomized clinical trial. *Journal of the American Medical Association*, 307(24), 2617-2626.
- Jebb, S. A., Ahern, A. L., Olson, A. D., Aston, L. M., Holzapfel, C., Stoll, J., ... & Lau, N. S. (2011). Primary care referral to a commercial provider for weight loss treatment versus standard care: A randomised controlled trial. *The Lancet*, 378(9801), 1485-1492.
- Kahn, S. E., Hull, R. L., & Utzschneider, K. M. (2006). Mechanisms linking obesity to insulin resistance and type 2 diabetes. *Nature*, 444(7121), 840.
- Laatikainen, T., Philpot, B., Hankonen, N., Sippola, R., Dunbar, J. A., Absetz, P., ... & Vartiainen, E. (2012). Predicting changes in lifestyle and clinical outcomes in preventing diabetes: The Greater Green Triangle Diabetes Prevention Project. *Preventive Medicine*, 54(2), 157-161.
- Lavie, C. J., Milani, R. V., & Ventura, H. O. (2009). Obesity and cardiovascular disease. *Journal of the American College of Cardiology*, 53(21), 1925-1932.
- Liberati, A., Altman, D. G., Tetzlaff, J., Mulrow, C., Gøtzsche, P. C., Ioannidis, J. P., ... & Moher, D. (2009). The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: Explanation and elaboration. *PLoS medicine*, 6(7), e1000100.
- Luszczynska, A., & Schwarzer, R. (2005). Social cognitive theory. In M. Conner & P. Norman (Eds.), *Predicting health behaviour*, (2nd ed., pp. 127-169). Buckingham: Open University Press.
- Maher, C. A., Lewis, L. K., Ferrar, K., Marshall, S., De Bourdeaudhuij, I., & Vandelanotte, C. (2014). Are health behavior change interventions that use online social networks effective? A systematic review. *Journal of Medical Internet Research*, 16(2).
- Marcus, B. H., Forsyth, L. H., Stone, E. J., Dubbert, P. M., McKenzie, T. L., Dunn, A. L., & Blair, S. N. (2000). Physical activity behavior change: Issues in adoption and maintenance. *Health Psychology*, 19(1S), 32.
- Marcus, B. H., Rossi, J. S., Selby, V. C., Niaura, R. S., & Abrams, D. B. (1992). The stages and processes of exercise adoption and maintenance in a worksite sample. *Health Psychology*, 11, 386-395.
- Marcus, B. H., Williams, D. M., Dubbert, P. M., Sallis, J. F., King, A. C., Yancey, A. K., ... & Claytor, R. P. (2006). Physical activity intervention studies. *Circulation*, 114(24), 2739-2752.

- Mata, J., Silva, M. N., Vieira, P. N., Carraça, E. V., Andrade, A. M., Coutinho, S. R., ... & Teixeira, P. J. (2009). Motivational “spill-over” during weight control: Increased self-determination and exercise intrinsic motivation predict eating self-regulation. *Health Psychology, 28*(6), 709-716.
- McHugh, M. L. (2012). Interrater reliability: The kappa statistic. *Biochemia Medica, 22*(3), 276-282.
- Meckling, K. A., & Sherfey, R. (2007). A randomized trial of a hypocaloric high-protein diet, with and without exercise, on weight loss, fitness, and markers of the Metabolic Syndrome in overweight and obese women. *Applied Physiology, Nutrition, and Metabolism, 32*(4), 743-752.
- Michie, S., Ashford, S., Sniehotta, F. F., Dombrowski, S. U., Bishop, A., & French, D. P. (2011). A refined taxonomy of behaviour change techniques to help people change their physical activity and healthy eating behaviours: The CALO-RE taxonomy. *Psychology & Health, 26*(11), 1479-1498.
- Michie, S., & Prestwich, A. (2010). Are interventions theory-based? Development of a theory coding scheme. *Health Psychology, 29*(1), 1.
- Michie, S., Richardson, M., Johnston, M., Abraham, C., Francis, J., Hardeman, W., ... & Wood, C. (2013). The Behaviour Change Technique Taxonomy (v1) of 93 hierarchically-clustered techniques: Building an international consensus for the reporting of behaviour change interventions. *Annals of Behavioral Medicine, 46*(1), 81–95.
- Michie, S., Rothman, A., & Sheeran, P. 2007. Current issues and new directions in psychology and health: Advancing the science of behavior change. *Psychology and Health, 22*, 249–253.
- Miller, W. R., & Rollnick, S. (2012). *Motivational interviewing: Helping people change* (5th ed.). New York, NY: Guilford press.
- *Nakade, M., Aiba, N., Suda, N., Morita, A., Miyachi, M., Sasaki, S., & Watanabe, S. (2012). Behavioral change during weight loss program and one year follow-up: Saku Control Obesity Program (SCOP) in Japan. *Asia Pacific Journal of Clinical Nutrition, 21*(1), 22-34.
- Nakata, Y., Okada, M., Hashimoto, K., Harada, Y., Sone, H., & Tanaka, K. (2011). Comparison of education-only versus group-based intervention in promoting weight loss: A randomised controlled trial. *Obesity Facts, 4*(3), 222-228.

- *Nakata, Y., Okada, M., Hashimoto, K., Harada, Y., Sone, H., & Tanaka, K. (2014). Weight loss maintenance for 2 years after a 6-month randomised controlled trial comparing education-only and group-based support in Japanese adults. *Obesity Facts*, 7(6), 376-387.
- National Institute for Health and Care Excellence. (2007). *Behaviour change at population, community and individual levels* [NICE public health guidance 6]. London: Author.
- O'Connell, D., & Velicer, W. F. (1988). A decisional balance measure and the stages of change model for weight loss. *International Journal of the Addictions*, 23(7), 729-750.
- Ogilvie, D., Foster, C. E., Rothnie, H., Cavill, N., Hamilton, V., Fitzsimons, C. F., & Mutrie, N. (2007). Interventions to promote walking: Systematic review. *BMJ*, 334(7605), 1204.
- Olander, E. K., Fletcher, H., Williams, S., Atkinson, L., Turner, A., & French, D. P. (2013). What are the most effective techniques in changing obese individuals' physical activity self-efficacy and behaviour?: A systematic review and meta-analysis. *International Journal of Behavioral Nutrition and Physical Activity*, 10(1), 29.
- Orrow, G., Kinmonth, A. L., Sanderson, S., & Sutton, S. (2012). Effectiveness of physical activity promotion based in primary care: Systematic review and meta-analysis of randomised controlled trials. *Journal of Behavioral Medicine*, 34, e1389.
- Pischon, T., Nöthlings, U., & Boeing, H. (2008). Obesity and cancer. *Proceedings of the Nutrition Society*, 67(02), 128-145.
- Prestwich, A., Sniehotta, F. F., Whittington, C., Dombrowski, S. U., Rogers, L., & Michie, S. (2014). Does theory influence the effectiveness of health behavior interventions? Meta-analysis. *Health Psychology*, 33(5), 465-474.
- Prochaska, J. O. & DiClemente, C. C. (1983). Stages and processes of self-change of smoking: Toward an integrative model of change. *Journal of Consulting and Clinical Psychology*, 51, 390-5.
- Pronk, N. P., & Wing, R. R. (1994). Physical activity and long-term maintenance of weight loss. *Obesity*, 2(6), 587-599.

- Rhodes, R. E., & Pfaeffli, L. A. (2010). Mediators of physical activity behaviour change among adult non-clinical populations: A review update. *International Journal of Behavioral Nutrition and Physical Activity*, 7(1), 37.
- *Roesch, S. C., Norman, G. J., Villodas, F., Sallis, J. F., & Patrick, K. (2010). Intervention-mediated effects for adult physical activity: A latent growth curve analysis. *Social Science & Medicine*, 71(3), 494-501.
- Rovniak, L. S., Anderson, E. S., Winett, R. A., & Stephens, R. S. (2002). Social cognitive determinants of physical activity in young adults: A prospective structural equation analysis. *Annals of Behavioral Medicine*, 24(2), 149-156.
- Ruotsalainen, H., Kyngäs, H., Tammelin, T., & Kääriäinen, M. (2015). Systematic review of physical activity and exercise interventions on body mass indices, subsequent physical activity and psychological symptoms in overweight and obese adolescents. *Journal of Advanced Nursing*, 71(11), 2461-2477.
- Ryan, R. M., & Deci, E. L. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *American Psychologist*, 55(1), 68.
- Ryan, R. M., Patrick, H., Deci, E. L., & Williams, G. C. (2008). Facilitating health behaviour change and its maintenance: Interventions based on self-determination theory. *European Health Psychologist*, 10(1), 2-5.
- Shaw, K., O'Rourke, P., Del Mar, C., & Kenardy, J. (2005). Psychological interventions for overweight or obesity. *Cochrane Database Systematic Reviews*, 2(2).
- Silva, M. N., Markland, D., Carraça, E. V., Vieira, P. N., Coutinho, S. R., Minderico, C. S., ... & Teixeira, P. J. (2011). Exercise autonomous motivation predicts 3-yr weight loss in women. *Medicine & Science in Sports & Exercise*, 43(4), 728-737.
- Silva, M. N., Markland, D., Minderico, C. S., Vieira, P. N., Castro, M. M., Coutinho, S. R., ... & Teixeira, P. J. (2008). A randomized controlled trial to evaluate self-determination theory for exercise adherence and weight control: Rationale and intervention description. *BMC Public Health*, 8(1), 234.
- *Silva, M. N., Vieira, P. N., Coutinho, S. R., Minderico, C. S., Matos, M. G., Sardinha, L. B., & Teixeira, P. J. (2010). Using self-determination theory to promote physical activity and weight control: A randomized controlled trial in women. *Journal of Behavioral Medicine*, 33(2), 110-122.

- Stephens, J., & Allen, J. (2013). Mobile phone interventions to increase physical activity and reduce weight: A systematic review. *The Journal of Cardiovascular Nursing, 28*(4), 320.
- Sutton, S. (2005). Stage theories of health behaviour. In M. Conner & P. Norman (Eds.), *Predicting health behaviour*, (2nd ed., pp. 223-275). Buckingham: Open University Press.
- Taylor, N., Conner, M., & Lawton, R. (2011). The impact of theory on the effectiveness of worksite physical activity interventions: A meta-analysis and meta-regression. *Health Psychology Review, 6*, 33–73.
- Teixeira, P. J., Carraça, E. V., Markland, D., Silva, M. N., & Ryan, R. M. (2012). Exercise, physical activity, and self-determination theory: A systematic review. *International Journal of Behavioral Nutrition and Physical Activity, 9*(1), 78.
- Troiano, R. P., Berrigan, D., Dodd, K. W., Mâsse, L. C., Tilert, T., & McDowell, M. (2008). Physical activity in the United States measured by accelerometer. *Medicine and Science in Sports and Exercise, 40*(1), 181.
- Unick, J. L., Jakicic, J. M., & Marcus, B. H. (2010). Contribution of behavior intervention components to 24-month weight loss. *Medicine and Science in Sports and Exercise, 42*(4), 745.
- United States Department of Health and Human Services. (1996). *Physical activity and health: A report of the Surgeon General*. US Dept of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion.
- Vandelanotte, C., Spathonis, K. M., Eakin, E. G., & Owen, N. (2007). Website-delivered physical activity interventions: A review of the literature. *American Journal of Preventive Medicine, 33*(1), 54-64.
- van Sluijs, E. M., van Poppel, M. N., Twisk, J. W., & van Mechelen, W. (2006). Physical activity measurements affected participants' behavior in a randomized controlled trial. *Journal of Clinical Epidemiology, 59*(4), 404-411.
- Van Sluijs, E. M. F., Van Poppel, M. N. M., & Van Mechelen, W. (2004) Stage-based lifestyle interventions in primary care: Are they effective? *American Journal of Preventive Medicine, 26*, 330–43.
- Vansteenkiste, M., & Sheldon, K. M. (2006). There's nothing more practical than a good theory: Integrating motivational interviewing and self-determination theory. *British Journal of Clinical Psychology, 45*(1), 63-82.

- Vidal, J. (2002). Updated review on the benefits of weight loss. *International Journal of Obesity*, 26(S4), S25.
- Vuori, I. M., Lavie, C. J., & Blair, S. N. (2013). Physical activity promotion in the health care system. *Mayo Clinic Proceedings*, 88(12), 1446-1461.
- Wadden, T. A., Butryn, M. L., Hong, P. S., & Tsai, A. G. (2014). Behavioral treatment of obesity in patients encountered in primary care settings: A systematic review. *Journal of the American Medical Association*, 312(17), 1779-1791.
- Wadden, T. A., & Stunkard, A. J. (Eds.). (2002). *Handbook of obesity treatment*. New York: Guilford Press
- Webb, T. L., Joseph, J., Yardley, L., & Michie, S. (2010). Using the internet to promote health behavior change: A systematic review and meta-analysis of the impact of theoretical basis, use of behavior change techniques, and mode of delivery on efficacy. *Journal of Medical Internet Research*, 12(1).
- Williams, P., Block, L. G., & Fitzsimons, G. J. (2006). Simply asking questions about health behaviors increases both healthy and unhealthy behaviors. *Social Influence*, 1(2), 117-127.
- Williams, S. L., & French, D. P. (2011). What are the most effective intervention techniques for changing physical activity self-efficacy and physical activity behaviour—and are they the same?. *Health Education Research*, 26(2), 308-322.
- Williams, N. H., Hendry, M., France, B., Lewis, R., & Wilkinson, C. (2007). Effectiveness of exercise-referral schemes to promote physical activity in adults: Systematic review. *British Journal of General Practice*, 57(545), 979-986.
- Wing, R. R. (2002). *Behavioral weight control*. *Handbook of obesity treatment*, 2, 301-317.
- Wolin, K. Y., Carson, K., & Colditz, G. A. (2010). Obesity and cancer. *The oncologist*, 15(6), 556-565.
- WHO. (2000). Obesity: Preventing and managing the global epidemic. Report of a WHO consultation. *World Health Organization - Technical Report Series*, 894.
- World Health Organisation (2017). *Obesity and overweight*.
<http://www.who.int/features/factfiles/obesity/en/>
- *Wylie-Rosett, J., Swencionis, C., Ginsberg, M., Cimino, C., Wassertheil-Smoller, S., Caban, A., ... & Lewis, J. (2001). Computerized weight loss intervention optimizes staff time: The clinical and cost results of a controlled clinical trial

conducted in a managed care setting. *Journal of the American Dietetic Association*, 101(10), 1155-1162.

Studies included in the systematic review are marked with an asterisk (*)

APPENDIX 1: 93 Behaviour Change Techniques (BCTTv1)

Grouping and BCTs		
<p>1. Goals and planning</p> <p>1.1 Goal-setting (behaviour)</p> <p>1.2 Problem solving</p> <p>1.3 Goal setting (outcome)</p> <p>1.4 Action planning</p> <p>1.5 Review behaviour goals(s)</p> <p>1.6 Discrepancy between current behaviour and goal</p> <p>1.7 Review outcome goal(s)</p> <p>1.8 Behavioural contract</p> <p>1.9 Commitment</p> <p>2. Feedback and monitoring</p> <p>2.1 Monitoring of behaviour by others without feedback</p> <p>2.2 Feedback on behaviour</p> <p>2.3 Self-monitoring of behaviour</p> <p>2.4 Self-monitoring of outcome(s) of behaviour</p> <p>2.5 Monitoring of outcome(s) of behaviour without feedback</p> <p>2.6 Biofeedback</p> <p>2.7 Feedback on outcome(s) of behaviour</p> <p>3. Social support</p> <p>3.1 Social support (unspecified)</p> <p>3.2 Social support (practical)</p> <p>3.3 Social support (emotional)</p> <p>4. Shaping knowledge</p> <p>4.1 Instruction on how to perform the behaviour</p> <p>4.2 Information about antecedents</p> <p>4.3 Re-attribution</p> <p>4.4 Behavioural experiments</p> <p>5. Natural consequences</p> <p>5.1 Information about health consequences</p> <p>5.2 Salience of consequences</p> <p>5.3 Information about social and environmental consequences</p> <p>5.4 Monitoring of emotional consequences</p> <p>5.5 Anticipated regret</p> <p>5.6 Information about emotional consequences</p>	<p>6. Comparison of behaviour</p> <p>6.1 Demonstration of the behaviour</p> <p>6.2 Social comparison</p> <p>6.3 Information about others' approval</p> <p>7. Associations</p> <p>7.1 Prompts/cues</p> <p>7.2 Cue signalling reward</p> <p>7.3 Reduce prompts/cues</p> <p>7.4 Remove access to the reward</p> <p>7.5 Remove aversive stimulus</p> <p>7.6 Satiation</p> <p>7.7 Exposure</p> <p>7.8 Associative learning</p> <p>8. Repetition and substitution</p> <p>8.1 Behavioural practice/rehearsal</p> <p>8.2 Behavioural substitution</p> <p>8.3 Habit formation</p> <p>8.4 Habit reversal</p> <p>8.5 Overcorrection</p> <p>8.6 Generalisation of target behaviour</p> <p>8.7 Graded tasks</p> <p>9. Comparison of outcomes</p> <p>9.1 Credible source</p> <p>9.2 Pros and cons</p> <p>9.3 Comparative imagining of future outcomes</p> <p>10. Reward and threat</p> <p>10.1 Material incentive (behaviour)</p> <p>10.2 Material reward (behaviour)</p> <p>10.3 Non-specific reward</p> <p>10.4 Social reward</p> <p>10.5 Social incentive</p> <p>10.6 Non-specific incentive</p> <p>10.7 Self-incentive</p> <p>10.8 Incentive (outcome)</p> <p>10.9 Self-reward</p> <p>10.10 Reward (outcome)</p> <p>10.11 Future punishment</p> <p>11. Regulation</p> <p>11.1 Pharmacological support</p> <p>11.2 Reduce negative emotions</p>	<p>11.3 Conserving mental resources</p> <p>11.4 Paradoxical instructions</p> <p>12. Antecedents</p> <p>12.1 Restructuring the physical environment</p> <p>12.2 Restructuring the social environment</p> <p>12.3 Avoidance/reducing exposure to cues for the behaviour</p> <p>12.4 Distraction</p> <p>12.5 Adding objects to the environment</p> <p>12.6 Body changes</p> <p>13. Identity</p> <p>13.1 Identification of self as role model</p> <p>13.2 Framing/reframing</p> <p>13.3 Incompatible beliefs</p> <p>13.4 Valued self-identity</p> <p>13.5 Identity associated with changed behaviour</p> <p>14. Scheduled consequences</p> <p>14.1 Behaviour cost</p> <p>14.2 Punishment</p> <p>14.3 Remove reward</p> <p>14.4 Reward approximation</p> <p>14.5 Rewarding completion</p> <p>14.6 Situation-specific reward</p> <p>14.7 Reward incompatible behaviour</p> <p>14.8 Reward alternative behaviour</p> <p>14.9 Reduce reward frequency</p> <p>14.10 Remove punishment</p> <p>15. Self-belief</p> <p>15.1 Verbal persuasion about capability</p> <p>15.2 Mental rehearsal of successful performance</p> <p>15.3 Focus on past success</p> <p>15.4 Self-talk</p> <p>16. Covert learning</p> <p>16.1 Imaginary punishment</p> <p>16.2 Imaginary reward</p> <p>16.3 Vicarious consequences</p>

From Michie et al. (2013)

APPENDIX 2: Search terms

MEDLINE:

- 1 Sedentary Lifestyle/ (2896)
- 2 sedentary.tw. (13106)
- 3 physical\$ inactiv\$.tw. (3849)
- 4 physical\$ activ\$.tw. (48378)
- 5 Exercise/ (56151)
- 6 Physical Fitness/ (13855)
- 7 Walking/ (18795)
- 8 Leisure Activities/ (4771)
- 9 exercis\$.tw. (120920)
- 10 physical\$ fit\$.tw. (3592)
- 11 walking.tw. (31445)
- 12 leisure.tw. (7204)
- 13 Recreation/ (3114)
- 14 recreation\$.tw. (11080)
- 15 or/1-14 (221805)
- 16 Motivation/ (31157)
- 17 behavio?r change\$.tw. (6196)
- 18 Maintenance/ (917)
- 19 enjoyment.tw. (2075)
- 20 transtheoretical model.tw. (935)
- 21 health belief model.tw. (892)
- 22 stages of change theory.tw. (16)
- 23 theory of planned behavio?r.tw. (1426)
- 24 motivational interviewing.tw. (1544)
- 25 social cognitive theory.tw. (737)
- 26 cognitive behavio?ral therapy.tw. (4954)
- 27 Mindfulness/ (265)
- 28 mindfulness.tw. (1547)
- 29 "acceptance and commitment therapy".tw. (195)
- 30 theory of reasoned action.tw. (256)
- 31 social learning theory.tw. (217)
- 32 Self Report/ (9098)
- 33 self report.tw. (24640)
- 34 self monitoring.tw. (2840)
- 35 Social Support/ (41890)
- 36 social support.tw. (16763)
- 37 psychosocial support.tw. (1408)
- 38 Self-Help Groups/ (4758)
- 39 support group\$.tw. (3392)
- 40 motivation\$.tw. (35989)
- 41 maintenance\$.tw. (129168)
- 42 well?being.tw. (4635)
- 43 self-help group\$.tw. (752)
- 44 goal\$.tw. (158029)
- 45 Goals/ (7680)
- 46 information.tw. (548821)
- 47 action planning.tw. (438)
- 48 barriers.tw. (51246)
- 49 facilitator\$.tw. (9176)
- 50 Problem Solving/ (12374)
- 51 problem solving.tw. (7620)
- 52 Reward/ (9370)
- 53 reward\$.tw. (23256)
- 54 past success\$.tw. (141)
- 55 Feedback/ (13049)
- 56 feedback.tw. (56158)

- 57 modelling.tw. (31682)
- 58 demonstration\$.tw. (34946)
- 59 Environment/ (32176)
- 60 environment.tw. (209092)
- 61 Contracts/ (2004)
- 62 contract\$.tw. (114846)
- 63 social comparison\$.tw. (553)
- 64 role model\$.tw. (2464)
- 65 anticipated regret\$.tw. (108)
- 66 fear arousal.tw. (34)
- 67 self-talk.tw. (114)
- 68 imagery.tw. (5818)
- 69 coping.tw. (23827)
- 70 stress management.tw. (1934)
- 71 emotional control.tw. (350)
- 72 Communication skill\$.tw. (4610)
- 73 relapse prevention.tw. (1605)
- 74 Self Efficacy/ (12199)
- 75 self-efficacy.tw. (11009)
- 76 or/16-75 (1430780)
- 77 Exercise Therapy/ (17001)
- 78 physical therapy.tw. (6443)
- 79 physiotherapy.tw. (7415)
- 80 functional therapy.tw. (106)
- 81 Occupational Therapy/ (4799)
- 82 dietician.tw. (449)
- 83 dietitian.tw. (1063)
- 84 Dietetics/ (2519)
- 85 Occupational Health Services/ (3510)
- 86 multidisciplinary therapy.tw. (206)
- 87 Exercise Movement Techniques/ (398)
- 88 energy expenditure.tw. (11995)
- 89 "Delivery of Health Care"/ (39662)
- 90 public health service\$.tw. (2684)
- 91 Nursing/ (9122)
- 92 medical treatment\$.tw. (23465)
- 93 Rehabilitation/ (4506)
- 94 Health Promotion/ (42806)
- 95 health counse?ling.tw. (370)
- 96 directive counse?ling.tw. (96)
- 97 coaching.tw. (1962)
- 98 health guidance.tw. (173)
- 99 Primary Prevention/ (11326)
- 100 Secondary Prevention/ (2041)
- 101 Tertiary Prevention/ (83)
- 102 Health Education/ (24986)
- 103 Patient Education as Topic/ (50398)
- 104 Behavior Therapy/ (10268)
- 105 Cognitive Therapy/ (14781)
- 106 rehabilitation setting\$.tw. (849)
- 107 exercise-based rehabilitation.tw. (52)
- 108 Hospitals/ (18113)
- 109 Primary Health Care/ (40300)
- 110 primary care.tw. (55320)
- 111 exercise referral.tw. (50)
- 112 exercise prescription\$.tw. (843)
- 113 (physical activity adj2 prescription\$.tw. (84)
- 114 "Delivery of Health Care"/ (39662)
- 115 or/77-114 (348024)
- 116 Intervention Studies/ (6288)

- 117 intervention\$.tw. (437656)
 118 Randomized Controlled Trial/ (281040)
 119 Randomized Controlled Trials as Topic/ (85261)
 120 randomi#ed controlled trial\$.tw. (70362)
 121 Controlled Clinical Trial/ (42768)
 122 controlled clinical trial\$.tw. (12857)
 123 clinical trial\$.tw. (165521)
 124 116 or 117 (438706)
 125 or/118-123 (539308)
 126 15 and 76 and 115 and 124 and 125 (2612)
 127 ("20141103" or "20141104" or "20141105" or "20141106" or "20141107" or "20141110" or
 "20141111" or "20141112" or "20141113" or "20141114" or "20141117" or "20141118" or
 "20141119").up. (42377)
 128 limit 126 to (("adult (19 to 44 years)" or "middle age (45 to 64 years)") and (english or finnish))
 (1594)
 129 127 and 128 (13)
 130 128 not 127 (1581)

EMBASE:

- 1 'kinesiotherapy':de (23543)
 2 'kinesiotherapy':ab,ti (275)
 3 'exercise therapy':ab,ti (2685)
 4 'physiotherapy':de (57797)
 5 'physical therapy':ab,ti (15981)
 6 'physiotherapy':ab,ti (19174)
 7 'functional therapy':ab,ti (368)
 8 'occupational therapy':de (18159)
 9 'neuropsychology':de (15523)
 10 'dietitian':de (5309)
 11 'dietician':ab,ti (1459)
 12 'dietitian':ab,ti (3052)
 13 'dietetics':de (6172)
 14 'occupational health service':de (9234)
 15 'multidisciplinary therapy':ab,ti (375)
 16 'physical activity':de(85808)
 17 'physical activity':ab,ti (76087)
 18 'exercise':de (264356)
 19 'motor activity':de (38037)
 20 'energy expenditure':de (21961)
 21 'energy expenditure':ab,ti (20960)
 22 'health care delivery':de (129311)
 23 'public health service':ab,ti (3992)
 24 'public health services':ab,ti (2066)
 25 'nursing diagnosis':de (3661)
 26 'nursing informatics':de (3661)
 27 'community health nursing':de (25667)
 28 'nursing':de (462214)
 29 (medical NEXT/1 treatment*):ab,ti (50804)
 30 'psychiatry':de (87085)
 31 'rehabilitation':de (107118)
 32 'health promotion':de (70237)
 33 'health counselling' (197)
 34 'health counseling' (589)
 35 'directive counseling':de (531)
 36 'directive counselling' (87)
 37 'directive counseling' (603)
 38 coaching:ab,ti(3489)
 39 'health guidance':ab,ti (354)
 40 'daily life activity':de (57045)

41 adl:ab,ti (9504)
 42 participation:ab,ti (118286)
 43 'cultural activities':ab,ti (201)
 44 'leisure':de (21307)
 45 'physical education':de (10302)
 46 'primary prevention':de (28223)
 47 'secondary prevention':de (17249)
 48 'sport':de (61365)
 49 'active lifestyle':ab,ti (1206)
 50 'physical lifestyle':ab,ti (36)
 51 'fitness':de (31012)
 52 'health education':de(86333)
 53 'patient education':de (86597)
 54 'behavior therapy':de (37385)
 55 'cognitive therapy':de (34627)
 56 OR/1-55 (1 752201)
 57 (mobile NEXT/1 system*):ab,ti (223)
 58 'telemedicine'/exp (19847)
 59 'telehealth':de (1418)
 60 ehealth:ti,ab (831)
 61 'mobile health':ab,ti (569)
 62 mhealth:ab,ti (291)
 63 phealth:ab,ti (30)
 64 'mobile multimedia':ab,ti (13)
 65 (mobile NEXT/1 communication*):ab,ti (481)
 66 (mobile NEXT/1 technolog*):ab,ti (583)
 67 'mobile phone'/exp (8396)
 68 (cellular NEXT/1 phone*):ab,ti (739)
 69 (cell NEXT/1 phone*):ab,ti (1723)
 70 (cellular NEXT/1 telephone*):ab,ti (407)
 71 (mobile NEXT/1 phone*):ab,ti (4111)
 72 (mobile NEXT/1 telephone*):ab,ti (466)
 73 'preventive health service'/exp (21208)
 74 'microcomputer'/exp(13673)
 75 (communication NEXT/1 technolog*):ab,ti (2145)
 76 'technology integration':ab,ti (85)
 77 'web based communication':ab,ti (83)
 78 'web based communications':ab,ti (7)
 79 'web based organisation':ab,ti (0)
 80 'web based organization':ab,ti (1)
 81 'web based organisations':ab,ti (0)
 82 'web based organizations':ab,ti (0)
 83 (virtual NEXT/1 communit*):ab,ti (209)
 84 (e+learning NEXT/1 environment*):ab,ti (45)
 85 'computer interface'/exp (20841)
 86 'virtual learning environment':ab,ti(132)
 87 'virtual learning environments':ab,ti (55)
 88 'accelerometer':de (4643)
 89 acceleromet*:ab,ti (8553)
 90 'mobile application':de (548)
 91 (mobile NEXT/1 application*):ab,ti (548)
 92 'web based interaction':ab,ti (8)
 93 'web based interactive':ab,ti (173)
 94 'web based interactively':ab,ti (0)
 95 (mobile NEXT/3 game*):ab,ti (19)
 96 'mobile gaming':ab,ti (2)
 97 (pervasive NEXT/1 game*):ab,ti (0)
 98 'geographic information system'/exp (5871)
 99 'global positioning system':de (1078)
 100 'global positioning system':ab,ti (807)

- 101 'global positioning systems':ab,ti (146)
 102 telerehabilitation:ab,ti (300)
 103 'tele rehabilitation':ab,ti (53)
 104 'web 2.0 intervention':ab,ti (0)
 105 'web 2.0 interventions':ab,ti(2)
 106 'web 2.0 application':ab,ti (7)
 107 'web 2.0 applications':ab,ti (28)
 108 (smart NEXT/1 phone*):ab,ti (524)
 109 'teleconsultation'/exp (6249)
 110 sms:ab,ti (3995)
 111 'text messaging'/exp (1109)
 112 (text NEXT/1 messag*):ab,ti (1499)
 113 'digital learning':ab,ti (34)
 114 OR/57–113 (107146)
 115 'clinical trial'/exp (989045)
 116 'randomized controlled trial'/exp (353121)
 117 'randomization'/exp (63829)
 118 'single blind procedure'/exp (18834)
 119 'double blind procedure'/exp (117862)
 120 'crossover procedure'/exp (40566)
 121 'placebo'/exp (261122)
 122 'randomised controlled trial':ab,ti (14470)
 123 'randomised controlled trials':ab,ti (13794)
 124 'randomized controlled trial':ab,ti (44690)
 125 'randomized controlled trials':ab,ti (36122)
 126 'rct':ab,ti (15545)
 127 'random allocation':ab,ti (1387)
 128 'randomly allocated':ab,ti (21444)
 129 'allocated randomly':ab,ti (1979)
 130 (allocated NEAR/2 random):ab,ti (799)
 131 (single NEXT/1 blind*):ab,ti (15206)
 132 (double NEXT/1 blind*):ab,ti (151565)
 133 ((treble OR triple) NEAR/1 blind*):ab,ti (487)
 134 placebo*:ab,ti(210009)
 135 'prospective study'/exp (264310)
 136 OR/115–135 (1 464966)
 137 'case study'/exp (30520)
 138 'case report':ab,ti (279045)
 139 'abstract report'/exp OR 'letter'/exp (920637)
 140 OR/137–139 (1 224308)
 141 136 NOT 140(1 425640)
 142 56 AND 114 AND 141 (2884)
 143 limits 142: (Publication Years: from 2000 to 2014) and (Humans) and (Article languages: English or Finnish or German or Swedish) and (Age groups: Adult: 18 to 64 years) (1194)
 144 'intervention study'/exp (21612)
 145 intervention*:ab,ti (749336)
 146 144 OR 145 (753020)
 147 143 AND 146(669)
 148 147 AND [embase]/lim NOT [medline]/lim (148)

CCRCT:

- 1 Sedentary Lifestyle/ (286)
 2 sedentary.tw. (2276)
 3 physical\$ inactiv\$.tw. (299)
 4 physical\$ activ\$.tw. (7086)
 5 Exercise/ (9006)
 6 Physical Fitness/ (1992)
 7 Walking/ (2402)
 8 Leisure Activities/ (172)

- 9 exercis\$.tw. (34012)
- 10 physical\$ fit\$.tw. (767)
- 11 walking.tw. (6245)
- 12 leisure.tw. (543)
- 13 Recreation/ (84)
- 14 recreation\$.tw. (952)
- 15 or/1-14 (44605)
- 16 Motivation/ (2939)
- 17 behavio?r change\$.tw. (1473)
- 18 Maintenance/ (8)
- 19 enjoyment.tw. (359)
- 20 transtheoretical model.tw. (206)
- 21 health belief model.tw. (107)
- 22 stages of change theory.tw. (2)
- 23 theory of planned behavio?r.tw. (157)
- 24 motivational interviewing.tw. (868)
- 25 social cognitive theory.tw. (234)
- 26 cognitive behavio?ral therapy.tw. (2505)
- 27 Mindfulness/ (17)
- 28 mindfulness.tw. (719)
- 29 "acceptance and commitment therapy".tw. (121)
- 30 theory of reasoned action.tw. (17)
- 31 social learning theory.tw. (58)
- 32 Self Report/ (551)
- 33 self report.tw. (3352)
- 34 self monitoring.tw. (865)
- 35 Social Support/ (2124)
- 36 social support.tw. (1517)
- 37 psychosocial support.tw. (167)
- 38 Self-Help Groups/ (516)
- 39 support group\$.tw. (645)
- 40 motivation\$.tw. (4165)
- 41 maintenance\$.tw. (16452)
- 42 well?being.tw. (616)
- 43 self-help group\$.tw. (114)
- 44 goal\$.tw. (10184)
- 45 Goals/ (396)
- 46 information.tw. (21305)
- 47 action planning.tw. (65)
- 48 barriers.tw. (2140)
- 49 facilitator\$.tw. (573)
- 50 Problem Solving/ (1159)
- 51 problem solving.tw. (1437)
- 52 Reward/ (397)
- 53 reward\$.tw. (965)
- 54 past success\$.tw. (7)
- 55 Feedback/ (940)
- 56 feedback.tw. (4862)
- 57 modelling.tw. (953)
- 58 demonstration\$.tw. (1603)
- 59 Environment/ (278)
- 60 environment.tw. (4505)
- 61 Contracts/ (5)
- 62 contract\$.tw. (6425)
- 63 social comparison\$.tw. (66)
- 64 role model\$.tw. (103)
- 65 anticipated regret\$.tw. (22)
- 66 fear arousal.tw. (14)
- 67 self-talk.tw. (41)
- 68 imagery.tw. (995)

- 69 coping.tw. (2884)
- 70 stress management.tw. (736)
- 71 emotional control.tw. (38)
- 72 Communication skill\$.tw. (462)
- 73 relapse prevention.tw. (866)
- 74 Self Efficacy/ (1543)
- 75 self-efficacy.tw. (2959)
- 76 or/16-75 (84563)
- 77 Exercise Therapy/ (4911)
- 78 physical therapy.tw. (1628)
- 79 physiotherapy.tw. (2580)
- 80 functional therapy.tw. (22)
- 81 Occupational Therapy/ (446)
- 82 dietician.tw. (114)
- 83 dietitian.tw. (288)
- 84 Dietetics/ (73)
- 85 Occupational Health Services/ (273)
- 86 multidisciplinary therapy.tw. (10)
- 87 Exercise Movement Techniques/ (97)
- 88 energy expenditure.tw. (1863)
- 89 "Delivery of Health Care"/ (384)
- 90 public health service\$.tw. (164)
- 91 Nursing/ (36)
- 92 medical treatment\$.tw. (2244)
- 93 Rehabilitation/ (209)
- 94 Health Promotion/ (3059)
- 95 health counse?ling.tw. (61)
- 96 directive counse?ling.tw. (24)
- 97 coaching.tw. (499)
- 98 health guidance.tw. (6)
- 99 Primary Prevention/ (497)
- 100 Secondary Prevention/ (156)
- 101 Tertiary Prevention/ (0)
- 102 Health Education/ (2649)
- 103 Patient Education as Topic/ (5781)
- 104 Behavior Therapy/ (3157)
- 105 Cognitive Therapy/ (4299)
- 106 rehabilitation setting\$.tw. (90)
- 107 exercise-based rehabilitation.tw. (26)
- 108 Hospitals/ (170)
- 109 Primary Health Care/ (2294)
- 110 primary care.tw. (6921)
- 111 exercise referral.tw. (15)
- 112 exercise prescription\$.tw. (232)
- 113 (physical activity adj2 prescription\$.tw. (36)
- 114 "Delivery of Health Care"/ (384)
- 115 or/77-114 (37538)
- 116 Intervention Studies/ (1977)
- 117 intervention\$.tw. (86066)
- 118 Randomized Controlled Trial/ (103)
- 119 Randomized Controlled Trials as Topic/ (5553)
- 120 randomi#ed controlled trial\$.tw. (55289)
- 121 Controlled Clinical Trial/ (10)
- 122 controlled clinical trial\$.tw. (10676)
- 123 clinical trial\$.tw. (58945)
- 124 116 or 117 (86273)
- 125 or/118-123 (113588)
- 126 15 and 76 and 115 and 124 and 125 (1105)
- 127 limit 126 to yr="1990 -Current" (1100)
- 128 ("201411" or "201412").up. (27048)

129 127 not 128 (1065)
130 limit 129 to medline records (935)
131 129 not 130 (130)

APPENDIX 3: Risk of bias assessment and interrater agreement

Results of Individual Study Risk of Bias Assessment by Two Independent Reviewers S and L ($k = 7$).

Study	Total Q mean score	Risk of bias item														Timing of outcome assessment similar	
		Adequate random- isation sequence	Treatment allocation concealed	Patient blinding	Care provider blinding	Outcome assessor blinding	Drop-out rate described and acceptable	Participants analysed in the group of allocation	Free of selective outcome reporting	Groups similar at baseline	Co- interventions avoided or similar	Compliance acceptable	Timing of outcome assessment similar				
Bélanger -Gravel	8.5	Y	Y	Y		Y	Y	Y	Y	Y	Y	Y				Y	Y
Dallow	3							Y		Y					Y		Y
Fuller	7.5	Y	Y				Y	Y	Y	Y	Y	Y			Y	Y	Y
Nakade	4.5						Y			Y	Y	Y			Y	Y	Y
Roesch	2.5							Y		Y		Y					Y
Silva	6.5	Y	Y				Y	Y	Y	Y	Y	Y			Y	Y	Y
Wylie- Rosett	4						Y	Y	Y	Y	Y	Y				Y	Y
IRA (κ or % agree- ment)		1	1	1	85.7 %	85.7 %	71.4 %	57.1 %	71.4 %	57.1 %	1	-40	85.7 %				

Note. Q = quality. IRA = interrater agreement. κ = Kappa score. "Y" indicating "Yes", no mark indicating "No" or "Unsure". Total quality mean score = between-assessor mean for sum of "Yes" answers.