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Systematic review of mental health outcomes following community-based obesity prevention interventions among adolescents

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Abstract

Objectives

Due to co-morbidity and common risk factors between overweight/obesity and mental illness among adolescents, it is plausible that interventions aiming to prevent obesity may influence mental health and well-being outcomes. This paper aimed to systematically evaluate the mental health and well- being outcomes observed in previous community-based obesity prevention interventions in adolescent populations.

Setting

Systematic review of literature from database inception to July 2014. PRISMA guidelines were followed and search terms and search strategy ensured all possible eligible studies were identified for review.

Participants

Intervention studies were eligible for inclusion if they were: focused on overweight or obesity prevention, community-based, targeted adolescent population (aged 10-19 years), reported a mental health measure, and included a comparison or control group. Studies that focused on atypical adolescents or were treatment interventions were excluded from review. Quality of evidence was assessed using GRADE guidelines.

Primary and secondary outcome measures

Primary outcomes were measures of mental health and wellbeing, including diagnostic and symptomatic measures. Secondary outcomes included weight or weight-related measures.

Results

Seven studies met the inclusion criteria. Positive mental health outcomes demonstrated following obesity prevention interventions included a decrease in anxiety and improved health-related quality of life. Quality of evidence was graded as low.

Conclusions

Although positive outcomes for mental health do exist, rarely have obesity prevention interventions included mental health measures (n=7). Future interventions need to incorporate mental health and well-being measures to identify any potential mechanisms influencing adolescent health, and equally to ensure interventions are not causing harm to adolescent mental health.

Strengths and limitations of this study

- This study was the first to systematically review mental health outcomes following community-based obesity prevention interventions
- This study ensured rigorous methodology by following PRISMA guidelines and evaluated quality of evidence using GRADE guidelines to allow findings to be interpreted with respect to the quality of studies in which they are found
- A limitation of this review was that a meta-analysis was not possible due to study heterogeneity in differing components of the interventions and different measures of mental health outcomes at follow-up
- Study biases may be present due to interventions having the primary outcome of weight reduction, therefore mental health measures at outcome may have been underreported or not reported at all

Background

Adolescent obesity prevention remains a high priority given negative health consequences of overweight/obesity both during adolescence and later in life. It has been suggested that prevention efforts should be community-based to meet the complex and multi-dimensional nature of obesity [1 2]. Importantly, recent research also suggests that there is a high comorbidity between poor mental health and obesity and this may reflect some shared underlying mechanisms and common potentially modifiable risk factors [3 4]. Changes in physical activity and diet patterns have been linked to mental health outcomes and compelling evidence suggests that weight-related risk factors are bi-directionally associated with common mental health disorders [5]. There is potential then that interventions aiming to promote healthy weight among adolescents may also impact on mental health and well-being outcomes.

Weight treatment programs appear to have positive psychological impacts for children and adolescents; a systematic review examining the impact of weight management programs on self-esteem found that despite variance in methodology and treatment design, there were overall positive effects for self-esteem following weight treatment programs in pediatric overweight populations [6]. This review highlighted the importance of considering both physical and emotional health outcomes from weight based treatment for overweight adolescents.

Given weight-related stigma and particular sensitivity to body image concerns during adolescence, it is also important to ensure weight-based programs are not causing psychological harm to participants. O'Dea (2005) identified the importance of prevention versus treatment for obesity, emphasizing that prevention initiatives must encompass all the dimensions of a child's health and that other healthy behaviours should not be forfeited in place of weight control. Care must be taken to avoid further stigmatizing overweight and

obese young people, and to ensure the health messages delivered in obesity prevention interventions do not damage any other essential dimensions of health, such as normal eating behaviours, or self-esteem.

One systematic review [7] examined prevention of mental disorders in children, adolescents and adults, with studies included if they included interventions aimed at positively affecting mental health outcomes. Interventions were mostly based on Cognitive Behavioural Therapy/counselling sessions, drug therapy or pro-social behaviour management programs. This review did not examine obesity prevention interventions.

Three systematic reviews have examined community-based obesity prevention studies in children and adolescents, however none of these reviews investigated mental health and wellbeing outcomes either as intentional effects or side-effects of the interventions. Shaya *et al*. (2008) examined interventions conducted in schools finding no persistence of positive results in reducing obesity in school-age children [8]. Bleich *et al*. (2013) reviewed prevention interventions in United States and high-income countries, finding that a combined diet and physical activity intervention conducted in the community with a school component is more effective at preventing obesity or overweight [9]. Similar findings were observed by Ickes and Sharma (2013) who examined the efficacy of community-based interventions targeting childhood obesity, finding that obesity prevention is strengthened by use of multiple settings including schools, use of interactive strategies and environmental change approaches [10].

Currently, our understanding of mental health outcomes in obesity prevention interventions is limited because existing systematic reviews are limited to specific high-risk groups such as individuals classified as overweight or obese [6], those with diagnosed mental health disorders [11], or individuals undergoing weight management [6] or mental health treatment programs [7]. For community-based obesity prevention interventions, previous reviews have

focused solely on weight-related outcomes, and none have reported mental health and wellbeing outcomes [8-10]. It remains unknown whether positive mental health effects have been achieved following such interventions and whether obesity prevention interventions protect mental health and well-being to ensure no harm has been done.

Despite emerging empirical evidence highlighted above, there is not yet a clear synthesis of the literature relating to the effect of obesity prevention interventions on mental health outcomes. Without this understanding, efforts to target and protect mental health in such interventions are limited. The purpose of this systematic review is to evaluate the mental health outcomes following community-based obesity prevention interventions among adolescents, and develop a set of recommendations for future interventions. The aim of this systematic review was to examine the literature on community-based obesity prevention studies that included mental health outcomes among adolescents.

The specific questions addressed in this review were;

(1) What mental health and well-being outcomes have been examined in community- based obesity prevention interventions for adolescents and what do the findings reveal?

(2) What limitations exist in the research to date and what recommendations can be made for future interventions?

Methods

Search strategy

Articles for this review were sourced from CINAHL, Global Health, Health Source: Nursing and Academic Edition, Medline, PsycARTICLES and PsycINFO. The search was limited to peer-reviewed papers, published from database inception through July 2014. A range of search terms was used to maximise the yield of the search for studies that

conducted a community-based obesity prevention intervention among adolescents and included a mental health measure. Search terms were selected based on components of obesity prevention interventions, community settings, and mental health outcomes. Mental health outcomes are described in more detail in the following section. The full search strategy including search terms can be found in Figure 1. The reference lists of selected articles, and reference lists of other systematic reviews were screened to identify all relevant articles for potential study selection. The studies included in the previously mentioned systematic reviews [8-10] examining community-based obesity preventions were scanned to determine whether they included adolescent samples, and if so, the original article was sourced and the full text was assessed for eligibility.

Definitions of outcomes

Mental health outcomes included any diagnosed psychopathologies, or symptoms of psychopathologies (for example, depression or depressive symptoms). Given that weight-based interventions have rarely investigated psychological and cognitive mediators [12], studies that included health-related quality of life, self-efficacy and other psychosocial factors were eligible for inclusion. Due to outcome measures utilising different measurement tools, there were no principle summary measures set. The overall findings in relation to mental health were summarized individually and combined.

Inclusion/exclusion criteria

The search was designed to identify studies that were community-based obesity prevention interventions, targeting adolescent populations. Community-based interventions were defined as those that target a group of individuals or a geographic community but are not aimed at a single individual. This included cities, schools and community health care centers. It did not include clinical settings. Adolescence was defined as the period including and between 10-19 years as defined by the World Health Organisation. Studies that were

randomised control trials (RCTs), quasi-experimental, and natural experiments were eligible for selection. Inclusion criteria were (1) primary research; (2) overweight or obesity prevention interventions; (3) community-based; (4) targeted adolescent population; (5) mental health measure reported at baseline and follow-up; (6) included a comparison or control group; and (7) were published through January 2014. Exclusion criteria were (1) obesity treatment/management interventions; (2) targeted children or adult populations; and (3) focused on specific high risk (such as overweight or obese adolescents) or disadvantaged groups. This review was focused on weight interventions to prevent overweight and obesity and therefore studies examining eating disorders and underweight management were not eligible for review. Exclusion criteria were set to ensure studies examining typical adolescent populations were sourced.

Data extraction and data synthesis

One author (EH) screened titles, abstracts and reference lists for potential inclusion in this review. Forty-one articles were selected for full text review to assess eligibility for inclusion. A standardised form for data extraction was created for study aim, characteristics, participants, intervention type, outcome measures and main findings (Table 1). Data were synthesized by categorising the components of the obesity prevention intervention and by the mental health outcome the study examined (Table 2). Mental health outcomes at follow-up were extracted and used as the main findings for this review. The quality of evidence was assessed using the Grading of Recommendations, Assessment, Development and Evaluation (GRADE) system (Table 3) [13].

Table 2: Mental health outcomes and community-based obesity prevention components of reviewed studies

	n	Setting	Community capacity building	Increased opportunity for PA or HE	Educational/curriculum component	Environmental component	Counselling/psychology component	MH disorders/symptoms	HRQoL	Self-perception
Fotu *et al*., 2011 (51)	1712	S	✓	✓		✓			✓	
Huang *et al*., 2007 (47)	657	C			✓		✓			✓
Kremer *et al*., 2011(52)	2948	S	✓	✓	✓	✓			✓	
Melnyk *et al*., 2009 (48)	19	S		✓	✓		✓	✓		
Millar *et al*., 2011 (50)	2054	S	✓	✓	✓	✓			✓	
Simon *et al*., 2006 (49)	954	S		✓	✓	✓				✓
Utter *et al*., 2011 (53)	1612	S		✓		✓			✓	

S, school: C, community; PA, physical activity; HE, healthy eating; MH, mental health; HRQoL, health-related quality of life

Table 3: Assessment of quality of studies based on mental health and well-being outcome using the GRADE system

Outcome No. of studies (No. of participants)	Study limitations	Consistency	Directness	Precision	Publication bias	Quality
Mental health disorder/symptoms 1 (19)	Serious limitations -2	Important inconsistency -1	Indirectness -1	Imprecision -1	Unlikely	Very low
Health-related quality of life 4 (8,326)	Serious limitations -2	Important inconsistency -1	Indirectness -1	No important imprecision	Unlikely	Low
Self-perception 2 (1,611)	Serious limitations -2	Important inconsistency -1	Indirectness -1	No important imprecision	Unlikely	Low

Results

Summary of included studies

The search strategy yielded 580 abstracts, which were screened by authors for possible inclusion. After screening, 41 full-text articles were selected and examined in detail to determine eligibility. A further 34 articles were excluded at this stage; 14 studies did not include mental health outcome measures [14-27], 11 studies sampled atypical adolescents such as those at risk or already overweight/obese [28-33], disadvantaged or sedentary adolescents [34 35], or younger or older age groups [36-38], four studies did not include an intervention design with a comparison or control group [39-42], two studies failed to report mental health measures at follow-up [20 43], two studies sampled from specific communities such a rural [44] or low income schools [45], and one study focused on disordered eating behaviours [46] leaving seven eligible studies for review. See Figure 2 for flow chart process of article inclusion. A list of excluded studies with reasons for exclusion can be found in Supplementary Table 1.

Two interventions took place in the United States [47 48], and one each in France [49], Australia [50], Tonga [51], Fiji [52], and New Zealand [53]. The details pertaining to study aim, intervention, design and outcomes are outlined in Table 1. The mental health domains measured in each study are summarised in Table 2. Six of the seven reviewed studies had samples consisting of close to half (40-55%) male [47 49-53]. One study had higher proportions of females at 72% [48]. All reviewed studies did not limit the population group involved and examined typically developing adolescents.

Community-based obesity prevention interventions

Design methodology of the reviewed interventions included randomised control trials [47-49] and quasi-experimental studies [50-53]. Four of the reviewed studies had interventions that lasted 2-3 years [50-53], and the other studies lasted one year [47], six months [49] and

nine weeks [48]. The interventions took place in schools [48-53] and in the general community [47] and shared similar specific intervention components; increased opportunities for adolescents to engage in physical activities and healthy eating behaviours; included educational sessions in relation to physical activity, nutrition and behaviours promoting healthy weight; targeted environmental aspects such as increased water fountains in school or improved canteen quality, and incorporated counselling or psychology sessions in relation to healthy living (see Table 2). Community capacity building for obesity prevention was an explicit component in four of the reviewed studies. Four of the interventions [47 48 50 52] successfully reduced or prevented unhealthy weight in adolescents based on significant changes in weight from pre- to post- intervention. Two studies resulted in no significant effect in anthropometry post-intervention [51 53]. One study [49] did not report anthropometric outcomes at follow-up.

Each of the 7 interventions included a mental health measurement as an outcome, which fell into one or more of the following categories: mental health disorders (including depression and anxiety), health-related quality of life and self-perception referring to one's beliefs about oneself including self-concept, self-worth, self-esteem, body satisfaction, and physical self-worth. Findings for each mental health outcome are discussed in detail below. Due to heterogeneity in population characteristics, intervention components, outcome measures and duration of interventions, it was not possible to complete a meta-analysis.

Mental health outcomes measured in weight-based interventions

Mental health disorders/symptoms

Mental health disorders were examined as outcomes in one of the reviewed studies [48]. Melnyk *et al. [48]* reported a moderate decrease in anxiety symptoms, as indicated by the *Beck Youth Inventory* (*BYI*) [54] from pre- to post-intervention (d=-0.56, p<0.05) in adolescents following a nine week healthy lifestyles programme. The intervention

consisted of 15 fifty-minute sessions based on educational information on healthy lifestyles, strategies to build self-esteem, nutrition and physical activity. No significant mean difference was observed for depressive symptoms (Cohen's *d*=-0.32, *p*=0.11).

Health-related quality of life

All four of the Pacific Obesity Prevention in Communities (*OPIC*) studies [50-53] measured health-related quality of life by the Adolescent Quality of Life Inventory (AQoL) [55] and Pediatric Quality of Life Inventory (PedsQoL) [56]. Fotu *et al*. [51] found that health-related quality of life increased in the intervention group at follow-up according to one measure (PedsQoL), however, remained significantly lower in the intervention group compared with the comparison group ($p<0.001$). Similarly, Kremer *et al*. [52] found the intervention group had smaller increase in health related quality of life compared to comparison group ($p<0.05$) following a three-year comprehensive school-based obesity prevention project. The other two *OPIC* studies, set in Geelong, Australia [50] and Auckland, New Zealand [53] did not find significant changes in HRQoL from baseline to follow-up in either measure.

Self-perception

Two obesity prevention intervention studies among adolescents have included self-perception as an outcome measure [47 49]. Huang *et al*. [47] assessed self-esteem using the Rosenberg Self- Esteem Scale [57] and found no significant differences between intervention and control groups following a one-year intervention targeting physical activity, sedentary, and diet behaviours. Simon *et al*. [49] assessed self-efficacy with self-reported questions scored on a six point Likert-scale, and found no significant differences in self-efficacy between comparison and intervention groups following a six month program aimed at preventing excessive weight gain by promoting physical activity.

Quality of evidence

Study limitations

Six of the included studies were quasi-randomised [48-53]. One study was randomised [47]. Concealment of allocation and blinding were not clearly described in the studies however due to school-based randomisation procedures in the quasi-experimental designs, it is expected that data were not obtained blind to school intervention status. Loss to follow-up was 67% for intervention and 55% for control in one study [52], between 25% and 35% in four studies [47 50 51 53], 11% in one study [48], and one study did not report loss to follow-up [49]. None of the reviewed studies reported intention-to-treat analysis.

Consistency

Inconsistencies were found in the results obtained for male and female adolescents, and also overweight/obese compared to normal weight. Inconsistency in these results included lower levels of weight gain were observed in male adolescents compared to female [51], and body image satisfaction was found to improve in female adolescents who experienced weight reduction over twelve months [47], compared to female adolescents who did not experience weight reduction. In addition, the relationship between weight change in adolescents to mental health and well-being outcomes also demonstrated inconsistent results.

Directness

Eligibility criteria precluded studies that focused on particular groups of adolescents and therefore the results obtained are expected to be applicable to general adolescent populations. Interventions have however, taken place most commonly in western and high-income countries and this may limit the applicability of results.

Precision

Due to different intervention components and outcome measures, it was not possible to extract data to calculate a summary relative risk and a corresponding confidence interval.

Publication bias

Studies reviewed here reported positive and negative result, suggesting that there is no evidence of publication bias. It is acknowledged however, that publication bias cannot be completely ruled out.

GRADE system

Quality of evidence according to the GRADE rating system is summarized in Table 3. Due to significant limitations in study design, inconsistency and lack of directness, the overall quality of evidence was low for the outcomes of health-related quality of life and self-perception. In addition to these limitations, measurement of mental health symptoms/disorders was graded as very low quality due to the added limitation of imprecision due to low sample sizes.

Discussion

What mental health and well-being outcomes have been examined in community-based obesity prevention interventions for adolescents and what do findings reveal?

An examination of the literature on obesity prevention interventions targeting adolescents in community settings reveals that the following mental health outcomes have been reported: anxiety and depressive symptoms, health-related quality of life, body image, self-worth, and self-esteem. Obesity prevention interventions that have included mental health measures as outcomes have taken place most commonly in school settings (n=7) and have had the primary focus on anthropometry at follow-up. The GRADE quality of evidence assessment revealed very low quality of evidence for mental health disorders or symptoms, and low quality of evidence for health related quality of life and self-perception.

Findings of mental health outcomes following community based obesity prevention interventions were mixed. A significant decrease in anxiety symptoms was found in the

intervention group compared to controls following a nine week healthy lifestyle intervention, however no significant differences were found in depressive symptoms [48]. Of the four studies that examined health-related quality of life, two [51 52] found significant increases post-intervention, however these increases were smaller than increases observed in the control groups. The other two studies [50 53] that examined health related quality of life did not find any significant changes in health related quality of life following three-year obesity prevention interventions in school settings. Two studies found no significant differences in self-esteem or self-efficacy following a one-year [47] and 6-month [49] intervention. Common characteristics across the interventions that demonstrated positive mental health outcomes were; inclusion of a physical exercise component, education components targeting healthy living behaviours (specifically healthy eating and physical activity), group-based sessions aimed at both healthy living and provision of opportunities for adolescents to engage in meaningful activities that promote personal development (such as mastery, friendships, leadership). Mechanisms contributing to significant findings are difficult to identify due to heterogeneity in interventions delivered to adolescents.

Interventions that included a cognitive behavioural component, or that were theoretically based on cognitive behavioural theory [49 58], showed positive findings in promotion of mental health and well-being. Cognitive behavioural approach refers to the thoughts and beliefs in relation to behaviour, and this approach is widely accepted as a beneficial therapy for mental health disorders [59-61]. Research suggests that adolescents who have stronger beliefs/confidence about their ability to engage in healthy lifestyle behaviours and perceive them as less difficult to perform are more likely to engage in more healthy choices [48]. Similarly, opportunities for adolescents to participate in physical activity or diet related activities provide mastery experience. Bandura (1978) outlined mastery experience

as key in the theory of Self-Efficacy as this experience builds beliefs about capabilities to produce behaviours that exercise influence over events that affect their lives [62]. Adolescents withgreater perceived self-efficacy may be better equipped to maintain healthy lifestyles and deal with adversity such as mental health problems.

Importantly, there were some findings that suggested that intervention groups experienced poorer mental health following obesity prevention interventions compared to control groups [51 52]. Authors in one study acknowledged a potential explanation being that the schools that made up the intervention sample were located in a more urbanised main island in Tonga [51]. These students may have been exposed to more pressure in terms of achieving high examination results and obtaining employment or overseas tertiary education, compared to the less-urbanised outer island that made up the comparison sample. This may have been a result of biases in sampling technique, however exposes the need for targeted interventions to suit the specific needs of communities, as previously identified as a priority in obesity prevention [63]. Additionally, these findings may reflect negative consequences of the obesity prevention interventions. Potential psychological harm due to weight-related interventions has been raised in previous research [64]. These results demonstrate the need to assess mental health to ensure no harm is being done to adolescents, and also highlights the importance of incorporating explicit aims to protect mental health of participants involved in such interventions.

What limitations exist in the research to date and what recommendations can be made for future interventions?

As identified in this review, there is evidence for positive mental health outcomes following community-based obesity prevention interventions, however the number of interventions incorporating mental health measures is few (*n*=7). The findings of this systematic review demonstrate the dearth of evidence: there were 14 studies excluded

from this review for not including a mental health measure, and two studies that included a measure but failed to report the mental health outcomes at follow-up. Given the co-morbidity between overweight/obesity and obesogenic behaviours with mental and emotional health [4 5 65], and the increased vulnerability to both unhealthy weight and mental health problems during adolescence [66 67], future interventions should aim to include mental health measures to assess the impact such interventions are having on participant's mental health and well-being. In addition, the issue of directionality still remains in relation to changes in obesogenic behaviours and mental health, and risk factors that may be common to both conditions. Sample biases exist in the reviewed studies with majority of interventions taking place at school [48-53] and consequently overlooking those adolescents who do not attend school and may represent a population in need of mental health support. Additionally, two [51 53] of the seven reviewed studies did not find significant improvements in weight post- intervention, and therefore were not successful in meeting their primary weight-related aims. The implications of these null findings are outside the scope of this review however may limit the extent to which mental health can be evaluated as an outcome of the reviewed weight-related interventions, given that the effectiveness of interventions' obesity prevention was varied.

Finally, the current review categorized mental health outcomes by disorders, health-related quality of life or self-perception. The extent to which results can be compared is limited by use of different mental health instruments. Mental disorders, for example, have been measured by diagnostic tools indicating presence of a disorder and also symptomatic measures that indicate suspected presence of disorder symptoms. Such differences affect findings as outcomes vary greatly depending on mental health measures being used.

This review has some limitations. As discussed in the GRADE quality of evidence

assessment, many studies published have included less than optimal study designs and this may have biased the findings presented here. As the primary aim of obesity prevention interventions is to reduce or prevent weight gain, this may have led to mental health outcomes being under reported or not reported at all. Eligible interventions may therefore have not been included in the analysis because of a lack of published data. A further limitation of this review was that a meta-analysis could not be performed due to heterogeneity in the reviewed studies.

Despite limitations this study has a number of strengths. There was a range of obesity prevention interventions included in this review including differences in duration, components and country where the intervention took place. The review process was systematic and all studies included were assessed based on strict eligibility and exclusion criteria and robust review methods were used including the searching of multiple databases to ensure all relevant articles were included in this review. The inclusion of the GRADE quality of evidence assessment ensured that the findings presented here could be considered in relation to the quality of research in which they are found.

Future research needs to build on what is already known about the effect of weight-based interventions on mental health outcomes in adolescents, as the mechanisms affecting these outcomes are yet to be clearly defined. Mental health needs to become a primary outcome of weight-based interventions, as potential benefits do exist, however rarely have mental health measures been evaluated (or reported) in community-based interventions. Additionally, two of the reviewed interventions were not successful in reducing or preventing unhealthy weight gain and future research should aim to resolve the impact this has on mental health outcomes so that interventions can be designed to suit the unique needs of adolescents.

Conclusions

Co-morbidity between poor mental health and poor physical health is well-established [68] and evidence for successful community-based obesity prevention strategies among adolescents is growing. A focus now needs to be placed on mental health of adolescents in these interventions. There is a need to incorporate mental health measures in community- based obesity prevention interventions to monitor the mental health and well-being of adolescents. Mental health needs to shift from a secondary outcome of these interventions to a primary outcome, alongside weight, to ensure that the mechanisms leading to co-morbidity can be identified and outcomes can be improved through these interventions. In addition, continued care needs to be taken to ensure that community-based obesity prevention initiatives do not have adverse effects on adolescents' mental health.

Competing interests

The authors have no conflict of interest to declare.

Authors' contributions

EH contributed to the conception and design of the study, performed the literature search, extracted and analysed data, and drafted and revised the manuscript. MFT and HS contributed to the conception and design of the study, analysed data, critically revised the manuscript and approved the final draft. LM and MN were involved in drafting the manuscript, critically revising the piece and approved the final draft. SA critically revised the manuscript and approved the final draft for publication.

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Figure 1. Search terms and strategy

Mental health OR mental disorder* OR depress* OR anxiety OR psychiat* OR well-being OR quality of life OR self-esteem OR self perception Weight OR BMI OR body mass index OR overweight OR obes* OR waist circumference OR skin fold* OR central adiposity

Adolescen* OR teen* OR youth

And: interven* OR intervention study OR randomised controlled trial OR RCT OR prevent*

Limiters: all in abstract, peer reviewed, - April 2014

712 articles found

Figure 2: Flow Diagram of Included Studies

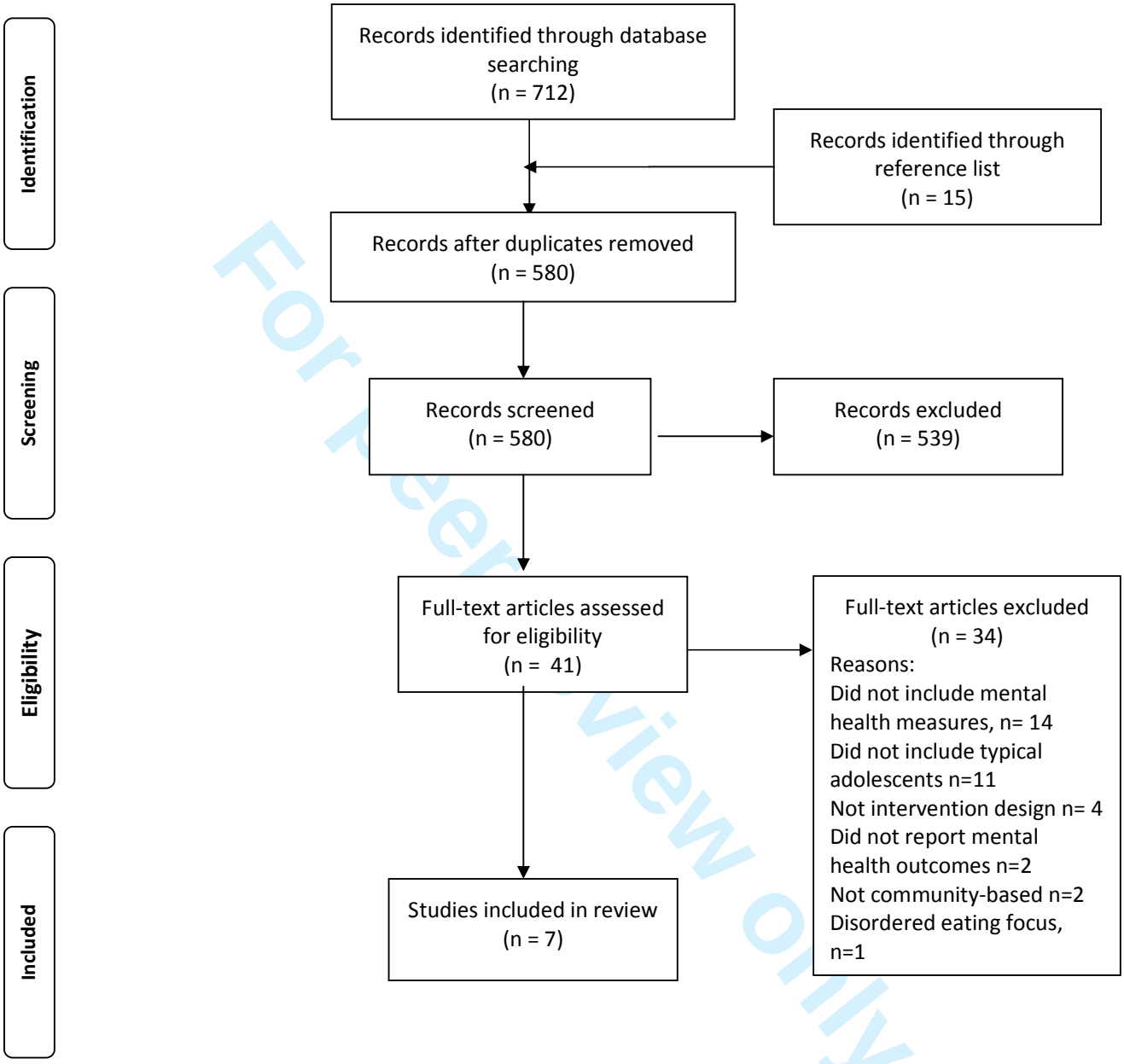

Table 1: Interventions designed to prevent overweight/obesity that include mental health outcomes in adolescents

Study	Sample and setting	Design and intervention	Measures	Findings
Fotu *et al*., 2011 Tonga (51) Aim: To evaluate the outcomes of a three year, quasi-experimental study of community-based obesity interventions among Tongan adolescents in three districts. Ma'alahi Youth Project (MYP). Study length: 3 years	*Sample:* Tongan secondary students, baseline overweight/obesity 46%, Tongan 100% Intervention group: *n*= 815, mean age (baseline) 14.4 ± 2.0 years, Male 46% Control group: *n*=897, mean age (baseline) 15.2 ± 1.8, Male= 41%. Follow-up rate: 75%	Formed part of the Pacific Obesity Prevention in Communities study (*OPIC)*. Quasi-experimental design, longitudinal cohort follow-up, baseline (2006) and follow-up (2008). Intervention group: The intervention group were exposed to social marketing approaches, community capacity building and grass roots activities to promote healthy behaviours Control group: Did not receive the MYP project, but anthropometry measures and QoL were taken at baseline and follow-up.	*Mental Health:* Two instruments measured health-related quality of life, Assessment of Quality of Life instrument (AQoL-6D) (55), Pediatric Quality of Life Inventory 4.0 (PedsQL) (56) *Anthropometry:* Objectively measured height and weight. The 2007 WHO Reference standards for age/gender specific body mass index centiles and cut-offs were used to determine weight status (69).	One of the measures of quality of life (PedsQL) showed a smaller increase in the adolescents from the intervention group, compared to the less urbanized comparison group (p<0.001). Lower levels of weight gain were observed in male adolescents compared to female, indicating the importance that gender plays in values behaviours, and lifestyle.
Huang et al., 2007 United States [47] Aim: To examine the effect of a one year intervention targeting physical activity, sedentary, and diet behaviours among adolescents on self-reported body image and self-esteem. PACE+ intervention Study length: 1 year	*Sample:* 657 adolescents, age range 11-15 years, baseline 26% overweight/obesity, 53% female Intervention group: female n= 175, boys n= 166 Control group: female = 174, boys n=142	Randomised control trial, 1 year longitudinal follow-up, data collections occurred at baseline, 6 months and 12 months. Intervention group: The Patient-Centred Assessment and Counseling for Exercise Plus Nutrition Project (PACE+) included a tailored interactive computer program for assessment and goal setting, and counselling in relation to physical activity and sedentary behaviours. Control group: received computer assessment and counselling in relation to sun protection.	*Mental Health:* Body image was measured via self-report Body Dissatisfaction subscales of the Eating Disorders Inventory Self-esteem was measured with Rosenberg Self-Esteem Scale. *Anthropometry:* Height and weight were objectively measured. BMI was determined by the Centers for Disease Control and Prevention national norms.	There were no intervention effects on body image or self-esteem for either boys or girls. Self-esteem and body dissatisfaction did not worsen as a result of participating in the intervention. Girls in the intervention group who experienced weight reduction of maintenance at 6 and 12 months reported improvements in body image satisfaction (p=0.02) over time compared with subjects who experienced weight gain.
Kremer *et al*., 2011 Fiji [52] Aim: To evaluate a community-based obesity intervention (Health Youth Healthy Communities, HYHC) in Fijian adolescents, designed to strengthen	*Sample:* Fijian secondary school students aged 13-18 years. Baseline overweight/obesity 21% Intervention group: secondary school students from 7 schools, mean age 15.4 ± 0.9 (baseline), 17.6 ± 0.9 (follow-up); *n*=879 (follow-up), Male= 46%	Formed part of the *OPIC* study. Quasi-experimental design, with the intervention being applied over three school years (2006-2008). Intervention group: The HYHC intervention was delivered over three school years, via school events, canteen, awareness programmes, healthy lunches, promotion of activities such as walking to school, and	*Mental Health:* Two instruments measured health-related quality of life: AQoL-6D (55) and PedsQoL (56) *Anthropometry:* Height, weight and body fat percentage, were objectively measured by trained researchers. The 2007 WHO Reference	At follow-up the intervention group had lower percentage body fat (p<0.001) and smaller increase in quality of life (PedsQL: p<0.001, AQoL: p<0.05) than the comparison group (controlled for age, gender and ethnicity).

community capacity to promote healthy eating and regular physical activity to reduce overweight and obesity in Fijian adolescents. Study length: 2 years	Control group: Secondary school students from 11 comparison schools, mean age 15.2 ± 1.1 (baseline), 17.3± 0.9 (follow-up); *n*=2,069 (follow-up), Male= 43% Follow-up rate: 33% for intervention group, 45% for control group	training of physical education teachers. Control group: did not receive the HYHC programme, but completed questionnaires and anthropometric measuring at base line and follow-up.	standards for age/gender specific body mass index centiles and cut-offs were used (69).	
Melnyk *et al*., 2009 United States [48] Aim: To evaluate the preliminary efficacy of a manualized educational and cognitive behavioural skills-building program, on Hispanic adolescents' healthy lifestyle choices as well as mental and physical health outcomes. Study length: 9 weeks	*Sample*: 19 Hispanic adolescents enrolled in health classes in a South-western US high school, Mean BMI baseline 27.1 (8.88), Hispanic 100% Intervention group: mean age 15.67 ± 0.65; *n*=12, male= 42% Control group: mean age 15.28 ± 0.53; *n*=7, male= 14% Follow-up rate: 89%	RCT Intervention group: Received the COPE Healthy Lifestyles TEEN program; based on educational information on healthy lifestyles, strategies to build self-esteem, stress management, goal setting, communication, nutrition and physical activity, delivered over 9 weeks. Students wore pedometer everyday over 9-week period. Control: Control group received instruction in health topics that were not contained in the intervention group, such as acne, first aid. No physical activity component, but students did wear pedometers.	*Mental Health:* Beck Youth Inventory (54). Measures; depressive symptoms, anxiety symptoms, anger, disruptive behaviour, and self-concept. *Anthropometric Measures:* Height and weight measured at baseline and follow-up. BMI reported however criteria for percentile cut-off were not reported.	Adolescents in the intervention group reported a significant decrease in anxiety symptoms (d=-0.56, p<0.05) from baseline to post-intervention follow-up. The was a decrease in depressive symptoms (d=0.27) in overweight adolescents (BMI≥85th percentile) in the intervention group, however this decrease was not significant (p=0.35). No gender differences were reported.
Millar *et al*., 2011 Australia [50] Aim: To evaluate the outcome results of a 3-year obesity prevention intervention (*It's Your Move; IYM*) study implemented in secondary schools in Australia. Study length: 3 years	*Sample:* 2054 secondary school students, percentage overweight/obese baseline 29%, ethnicity not reported Intervention group: 5 secondary schools, mean age=14.5±1.40 at baseline, *n*=1276, male= 60% Control group: 7 secondary schools (4 government, 1 catholic, 2 christian), mean age 14.7±1.45 at baseline, *n*=778, male= 46% Follow-up rate: 69% (intervention), 66% (comparison)	Formed part of the *OPIC* study. Quasi-experimental, longitudinal cohort design, baseline measurements were collected from 2005 to 2006 and follow-up in 2008. Intervention group: Received *IYM* 3-year programme targeting secondary school students aged 12-18 years. Programme focused on building capacity of families, schools and communities to promote healthy eating and physical activity. Control group: Completed questionnaires at baseline and follow-up but did not receive *IYM* programme.	*Mental Health:* Two instruments measured health-related quality of life: AQoL-6D [55] and PedsQoL [56] *Anthropometric Measures*: Height and weight objectively measured to determine BMI based on WHO Reference 2007 (69).	Adolescents in the intervention group had a relative reduction in body weight (p<0.05) compared to comparison group. No significant difference in quality of life was found between comparison group and intervention group. This intervention demonstrated success in reducing unhealthy weight gain in adolescents through a community-based intervention.
Simon et al., 2006 France (49) Aim: to evaluate the	*Sample:* 954 secondary school students from France. Age range 11.7 years ± 0.6, 24% overweight prevalence at	RCT Intervention group: Received the ICAPS program, a multilevel program aimed at modifying the personal, social and	*Mental health:* Stanford Adolescent Heart Health Program assessed self-efficacy, social influence and intention	No significant intervention effects were found between intervention and control for self-efficacy, intention and social

outcomes of the Intervention Centres on Aolescents' Physical activity and Sedentary behaviour (ICAPS), aimed at preventing excessive weight gain and cardiovascular risk in adolescents by promoting physical activity Study length: 4 years	baseline Intervention group: N= 255 females (mean age 11.51± 0.03) 220 males (mean age 11.58 years±0.04) Control group: N= 231 females (mean age 11.68 years± 0.04) 248 males (mean age 11.77±0.04)	environmental determinants of physical activity. ICAPS included school setting, and numerous partnerships at different levels (teachers, parents, community agencies). Control group: students in control schools follow their usual school curriculum and physical education classes	toward PA. *Anthropometric measures:* Objectively measured height and weight by trained researchers. International Obesity Task Force age and sex-based cut offs. Waist and hip circumference were objectively measured.	support. Six-month results showed increased physical activity and decreased sedentary behaviour.
Utter *et al*., 2011 New Zealand [53] Aim: To evaluate the effectiveness of the *Living 4 Life* study, a youth-led, school-based intervention to reduce obesity in New Zealand, by improving nutrition and increasing physical activity. Study length: 3 years	*Sample:* Secondary school students aged 9-13 years at baseline, New Zealand. 1634 students at baseline, 1612 at follow-up. Mean BMI baseline 25.36 Intervention group: 4 schools, mean age not reported, n=953, male=50% (baseline), n=1023, male=43% (follow-up) Control group: Two comparison schools, mean age not reported, n=681, male=46% (baseline), n=589, male=47% (follow-up) Follow-up rate: Cross-sectional comparison, participation rate 66%	Formed part of the *OPIC* study. Quasi-experimental, comparisons made by two cross-sectional samples within schools. Baseline data including anthropometry and questionnaires were completed at baseline (2005) and follow-up (2008). Intervention group: The intervention aimed to create opportunities for meaningful participation, quality relationships, and to create opportunities for student training and development. Control group: Did not participate in the Living 4 Life intervention however did complete questionnaires and anthropometric measurements at baseline and follow-up.	*Mental health:* Two instruments measured health-related quality of life: AQoL-6D (55) and PedsQoL (56). *Anthropometric measures:* Height, weight and body fat percentage, were collected by trained researchers. The 2007 WHO Reference standards for age/gender specific body mass index centiles and cut-offs were used (69).	There were no significant differences in findings of weight or quality of life in intervention or comparison from base line to follow-up. Results adjusted for gender and no gender differences in outcomes were reported.

Supplementary Table1: Excluded studies with reasons

#	**Author**	**Reason for Exclusion**
1	Berkey *et al*., 2003, Pediatrics, 111	Not an intervention design
2	Blissmer *et al*., 2006, Health Qual Life Outcomes, 4(43)	Aged >18 years
3	Bonsergent *et al*., 2013, Am J Prev Med, 44(1)	Did not report MH outcomes at follow-up
4	Carrel *et al*., 2005, Arch Pediatr Adolesc Med, 159(10)	Overweight adolescents
5	Coleman *et al*., 2005, Arch Pediatr Adolesc Med, 159(3)	Low income schools
6	Ebbeling *et al*., 2006, Pediatrics, 117(3)	Did not include MH outcomes
7	Foster *et al*., 2012, Pediatr, 130(4)	Overweight/obese adolescents
8	Gortmaker *et al*., 1999, Arch Pediatr Adolesc Med, 153(9)	Did not include MH outcomes
9	Haerens *et al*., 2006, Health Educ Res, 21(6)	Did not include MH outcomes
10	Hawley *et al*., 2006, J Community Health Nurs, 23(2)	Rural setting
11	Heinicke *et al*., 2007, J Abnorm Child Psychol, 35(3)	Focus on eating disorders
12	Jamner *et al*., 2004, J Adolesc Health, 73(8)	Sedentary female adolescents
13	Jelalian *et al*., 2010, Journal of Pediatrics, 157 (6)	Overweight adolescents
14	Killen *et al*., 1988, JAMA, 260(12)	Did not include MH outcomes
15	Kimm *et al*., 2005, Lancet, 366(9482)	Not an intervention design
16	Loth *et al*., 2011, J Pediatr Psychol, 36(2)	Not an intervention design
17	McKenzie *et al*., 2001, Am J Prev Med, 21(2)	Did not include MH outcomes
18	McMurray *et al*., 2002, J Adolesc Health, 31(2)	Did not include MH outcomes
19	Morgan *et al*., 2012, Pediatric Obesity, 7 (3)	Disadvantaged adolescents
	Neumark-Sztainer *et al.,* 2003, Prev Med, 37(1)	Overweight or at risk for overweight female adolesecents
20	Nguyen *et al*., 2012, Archives of Pediatric & Adolescent Medicine, 166(2)	Overweight and obese adolescents
21	Pate *et al*., 2005, Am J Pub Health, 95(9)	Did not include MH outcomes
22	Patrick *et al*., 2006, Arch Pediatr Adolesc Med	Did not include MH outcomes
23	Peralta *et al*., 2009, Prev Med, 48(6)	Did not include MH outcomes
24	Pott *et al*., 2009, Int J Eating Disorders, 42(3).	Did not report MH outcomes at follow-up
25	Prosper *et al*., 2009, Californian Journal of Health Promotion, 7.	No comparison/control group
26	Robertson *et al*., 2011, Child: care, health and development, 38(2)	Aged <13 years
27	Singh *et al*., 2007, Arch Pediatr Adolesc Med, 161(6)	Did not include MH outcomes
28	Singh *et al*., 2009, Arch Pediatr Adolesc Med,	Did not include MH outcomes

	163(4)	
29	Spiegel *et al*., 2006, Obesity, 14(1)	Did not include MH outcomes
30	Stice *et al*., 2013, Journal of Consulting and Clinical Psychology, 81 (1)	At risk for overweight/obesity
31	Verhaeghe *et al*., 2012, BMC Pub Health, 12(431)	Aged >18 years
32	Webber *et al*., 2008, Am J Prev Med, 34(3)	Did not include MH outcomes
33	Zahner *et al*., 2006, BMC Pub Health, 6(147)	Did not include MH outcomes

PRISMA 2009 Checklist

Section/topic	#	Checklist item	Reported on page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	1
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	2
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	4-6
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	4-6
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	NA
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	7-8
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	7-8
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	6-7 (figure 1)
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	7-8
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	8
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	7-8
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	9
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	8-9
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.	7-9

PRISMA 2009 Checklist

Section/topic	#	Checklist item	Reported on page #
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	10
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	NA
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	11 (figure 2)
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	11-12 (Table 1)
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	14-15
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	11-13
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	NA
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	14-15
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	NA
DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	15-17
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	17-19
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	20
FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	20-21

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Systematic review of mental health and well-being outcomes following community-based obesity prevention interventions among adolescents

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Systematic review of mental health and well-being outcomes following community-based obesity prevention interventions among adolescents

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Abstract

Objectives

This paper aimed to systematically evaluate the mental health and well- being outcomes observed in previous community-based obesity prevention interventions in adolescent populations.

Setting

Systematic review of literature from database inception to October 2014. Articles were sourced from CINAHL, Global Health, Health Source: Nursing and Academic Edition, MEDLINE, PsycARTICLES and PsycINFO, all of which were accessed through EBSCOhost. The Cochrane Database was also searched to identify all eligible articles. PRISMA guidelines were followed and search terms and search strategy ensured all possible studies were identified for review.

Participants

Intervention studies were eligible for inclusion if they were: focused on overweight or obesity prevention, community-based, targeted adolescents (aged 10-19 years), reported a mental health or well-being measure, and included a comparison or control group. Studies that focused on specific adolescent groups or were treatment interventions were excluded from review. Quality of evidence was assessed using GRADE guidelines.

Primary and secondary outcome measures

Primary outcomes were measures of mental health and well-being, including diagnostic and symptomatic measures. Secondary outcomes included adiposity or weight-related measures.

Results

Seven studies met the inclusion criteria; one reported anxiety/depressive outcomes, two reported on self-perception well-being measures such as self-esteem and self-efficacy, and four studies reported outcomes of quality of life. Positive mental health outcomes demonstrated following obesity prevention interventions included a decrease in anxiety and improved health-related quality of life. Quality of evidence was graded as very low.

Conclusions

Although positive outcomes for mental health and well-being do exist, controlled evaluations of community-based obesity prevention interventions have not often included mental health measures (n=7). It is recommended that future intervention's incorporate mental health and well-being measures to identify any potential mechanisms influencing adolescent weight related outcomes, and equally to ensure interventions are not causing harm to adolescent

mental health.

Strengths and limitations of this study

- This study was the first to systematically review mental health outcomes following community-based obesity prevention interventions among adolescents
- This study ensured rigorous methodology by following PRISMA guidelines and evaluated quality of evidence using GRADE guidelines to allow findings to be interpreted with respect to the quality of studies in which they are found
- A limitation of this review was that a meta-analysis was not possible due to study heterogeneity in differing components of the interventions and different measures of mental health outcomes at follow-up
- Study biases may be present due to interventions having the primary outcome of weight reduction, therefore mental health measures at outcome may have been underreported or not reported at all

Background

Adolescent obesity prevention remains a high priority given negative health consequences of overweight/obesity both during adolescence and later in life. It has been suggested that prevention efforts should be community-based to meet the complex and multi-dimensional nature of obesity [1 2]. Importantly, recent research also suggests that there is a high comorbidity between poor mental health and obesity and this may reflect some shared underlying mechanisms and common potentially modifiable risk factors [3 4]. Changes in physical activity and diet patterns have been linked to mental health outcomes and compelling evidence suggests that unhealthy weight-related risk factors are bi-directionally associated with common mental health disorders [5]. There is potential then that interventions aiming to promote healthy weight among adolescents may also impact on mental health and well-being outcomes.

Overweight and obesity treatment programs appear to have positive psychological impacts for children and adolescents; a systematic review examining the impact of weight management programs on self-esteem found that despite variance in methodology and treatment design, there were overall positive effects for self-esteem following weight treatment programs in paediatric overweight populations [6]. This review highlighted the importance of considering both physical and emotional health outcomes from weight based treatment for overweight adolescents. A second review examined the psychological outcomes of weight loss following behavioural and diet interventions in overweight/obese populations [7] finding that improvements in body image and health-related quality of life were consistently associated with weight loss.

Given weight-related stigma and particular sensitivity to body image concerns during adolescence, it is also important to ensure overweight/obesity focused programs are not causing psychological harm to participants. O'Dea (2000) identified the importance of

prevention versus treatment for obesity, emphasizing that prevention initiatives must encompass all the dimensions of a child's health and that other healthy behaviours should not be forfeited in place overweight and obesity prevention [8]. Care must be taken to avoid further stigmatizing overweight and obese young people, and to ensure the health messages delivered in obesity prevention interventions do not damage any other domains of health, such as normal eating behaviours, or self-esteem.

One systematic review [9] examined prevention of mental disorders in children, adolescents and adults, with studies included if they included interventions aimed at positively affecting mental health outcomes. Interventions were mostly based on Cognitive Behavioural Therapy/counselling sessions, drug therapy or pro-social behaviour management programs. This review did not examine obesity prevention interventions. One other review [10] examined mental health and wellness in relation to the prevention of childhood obesity in studies from January 2000 to January 2011. This review identified that psychosocial emotional health is one of the most neglected areas of study in childhood overweight/obesity and that many recommendations focus on physical outcomes such as body mass index, ignoring the impact on psychological or social well-being. Three systematic reviews have examined community-based obesity prevention studies in children and adolescents, however none of these reviews investigated mental health and well-being outcomes either as intentional effects or side-effects of the interventions [11-13].

Currently, our understanding of mental health outcomes in obesity prevention interventions is limited because existing systematic reviews are limited to specific high-risk groups such as individuals classified as overweight or obese [7 10], individuals undergoing weight management [6] or mental health treatment programs [9]. For community-based obesity prevention interventions, previous reviews have focused solely on weight status outcomes, and none have reported mental health and well-being outcomes [11-13]. It remains unknown

whether positive mental health effects have been achieved following such interventions and whether obesity prevention interventions protect mental health and well-being to ensure no harm has been done.

Despite emerging empirical evidence highlighted above, there is not yet a clear synthesis of the literature relating to the effect of obesity prevention interventions on mental health outcomes. Without this understanding, efforts to target and protect mental health in such interventions are limited. The purpose of this systematic review is to evaluate the mental health outcomes following community-based obesity prevention interventions among adolescents, and develop a set of recommendations for future interventions. This review is limited to controlled studies.

The specific questions addressed in this review were;

(1) What mental health and well-being outcomes have been examined in community- based obesity prevention interventions for adolescents and what do the findings reveal?

(2) What limitations exist in the research to date and what recommendations can be made for future interventions?

Methods

Inclusion/exclusion criteria

The search was designed to identify studies that were community-based obesity prevention interventions, targeting adolescent populations. Community-based interventions were defined as those that target a group of individuals or a geographic community but are not aimed at a single individual. This included cities, schools and community health care centres. It did not include clinical settings. Adolescence was defined as the period including and between 10-19 years as defined by the World Health Organization. Studies that were

randomised control trials (RCTs), quasi-experimental, and natural experiments were eligible for selection. Inclusion criteria were (1) primary research; (2) overweight or obesity prevention interventions; (3) community-based; (4) targeted adolescent population; (5) mental health measure reported at baseline and follow-up; (6) included a comparison or control group; and (7) were published through October 2014. Exclusion criteria were (1) obesity treatment/management interventions; (2) targeted children or adult populations; and (3) focused on specific high risk (such as overweight/obese adolescents), or that were designed to suit specific demographics such those living in rural areas. Studies were not excluded based on ethnicity. This review was focused on interventions to prevent overweight and obesity and therefore studies examining eating disorders and underweight management were not eligible for review. Exclusion criteria were set to ensure studies examining adolescents who were representative of the broader population were sourced.

Definitions of outcomes

Mental health and well-being outcomes included any diagnosed psychopathologies, or symptoms of psychopathologies (for example, depression or depressive symptoms). Given that obesity prevention interventions have rarely investigated psychological and cognitive mediators [14], studies that included health-related quality of life, self-efficacy and other psychosocial factors were eligible for inclusion. Due to outcome measures utilising different measurement tools, there were no principle summary measures set. The overall findings in relation to mental health and well-being were summarized individually and combined.

Search strategy

Articles for this review were sourced from CINAHL, Global Health, Health Source: Nursing and Academic Edition, Medline, PsycARTICLES and PsycINFO, all of which were accessed through EBSCOhost. In addition, the same search was also performed on the

Cochrane Database to ensure all relevant articles were screened for eligibility. The search was limited to peer-reviewed paper published from database inception through October 2014. A range of search terms was used to maximize the yield of the search for studies that conducted a community-based obesity prevention intervention among adolescents and included a mental health or well-being measure. Search terms were selected based on components of obesity prevention interventions, community settings, and mental health/well-being outcomes. Mental health and well-being outcomes are described in more detail in the following section. The full search strategy including search terms can be found in Figure 1. The reference lists of selected articles, and reference lists of other systematic reviews were screened by two independent authors to identify all relevant articles for potential study selection. Disagreements in study selection were resolved by a third reviewer. The studies included in the previously mentioned systematic reviews [10-13] examining community-based obesity preventions were scanned to determine whether they included adolescent samples, and if so, the original article was sourced and the full text was assessed for eligibility.

Data extraction and data synthesis

Two authors (EH, LM) screened titles, abstracts and reference lists for potential inclusion in this review. Forty-one articles were selected for full text review to assess eligibility for inclusion. A standardised form for data extraction was created for study aim, characteristics, participants, intervention type, outcome measures and main findings (Table 1). Data were synthesized by categorising the components of the obesity prevention intervention and by the mental health outcome the study examined (Table 2). Mental health outcomes at follow-up were extracted and used as the main findings for this review. The quality of evidence was assessed using the Grading of Recommendations, Assessment, Development and Evaluation (GRADE) system (Table 3)[15].

Table 1: Interventions designed to prevent overweight/obesity that include mental health outcomes in adolescents

Study	Sample and setting	Design and intervention	Measures	Findings
Fotu *et al*., 2011 Tonga [16] Aim: To evaluate the outcomes of a three year, quasi-experimental study of community-based obesity interventions among Tongan adolescents in three districts. Ma'alahi Youth Project (MYP). Study length: 3 years	*Sample:* Tongan secondary students, baseline overweight/obesity 46%, Tongan 100% Intervention group: *n*= 815, mean age (baseline) 14.4 ± 2.0 years, Male 46% Control group: *n*=897, mean age (baseline) 15.2 ± 1.8, Male= 41%. Follow-up rate: 75%	Formed part of the Pacific Obesity Prevention in Communities study (*OPIC).* Quasi-experimental design, longitudinal cohort follow-up, baseline (2006) and follow-up (2008). Intervention group: The intervention group were exposed to social marketing approaches, community capacity building and grass roots activities to promote healthy behaviours Control group: Did not receive the MYP project, but anthropometry measures and QoL were taken at baseline and follow-up.	*Mental Health:* Two instruments measured health-related quality of life, Assessment of Quality of Life instrument (AQoL-6D), Pediatric Quality of Life Inventory 4.0 (PedsQL) *Anthropometry:* Objectively measured height and weight. The 2007 WHO Reference standards for age/gender specific body mass index centiles and cut-offs were used to determine weight status.	One of the measures of quality of life (PedsQL) showed a smaller increase in the adolescents from the intervention group, compared to the less urbanized comparison group (p<0.001). Lower levels of weight gain were observed in male adolescents compared to female, indicating the importance that gender plays in values behaviours, and lifestyle.
Huang et al., 2007 United States [17] Aim: To examine the effect of a one year intervention targeting physical activity, sedentary, and diet behaviours among adolescents on self-reported body image and self-esteem. PACE+ intervention Study length: 1 year	*Sample:* 657 adolescents, age range 11-15 years, baseline 26% overweight/obesity, 53% female Intervention group: female n= 175, boys n= 166 Control group: female = 174, boys n=142	Randomised control trial, 1 year longitudinal follow-up, data collections occurred at baseline, 6 months and 12 months. Intervention group: The Patient-Centred Assessment and Counseling for Exercise Plus Nutrition Project (PACE+) included a tailored interactive computer program for assessment and goal setting, and counselling in relation to physical activity and sedentary behaviours. Control group: received computer assessment and counselling in relation to sun protection.	*Mental Health:* Body image was measured via self-report Body Dissatisfaction subscales of the Eating Disorders Inventory Self-esteem was measured with Rosenberg Self-Esteem Scale. *Anthropometry:* Height and weight were objectively measured. BMI was determined by the Centers for Disease Control and Prevention national norms.	There were no intervention effects on body image or self-esteem for either boys or girls. Self-esteem and body dissatisfaction did not worsen as a result of participating in the intervention. Girls in the intervention group who experienced weight reduction of maintenance at 6 and 12 months reported improvements in body image satisfaction (p=0.02) over time compared with subjects who experienced weight gain.
Kremer *et al*., 2011 Fiji [18] Aim: To evaluate a	*Sample:* Fijian secondary school students aged 13-18 years. Baseline overweight/obesity 21%	Formed part of the *OPIC* study. Quasi-experimental design, with the intervention being applied over three school years (2006-2008).	*Mental Health:* Two instruments measured health-related quality of life: AQoL-6D and PedsQoL.	At follow-up the intervention group had lower percentage body fat (p<0.001) and smaller increase in quality of life

community-based obesity intervention (Health Youth Healthy Communities, HYHC) in Fijian adolescents, designed to strengthen community capacity to promote healthy eating and regular physical activity to reduce overweight and obesity in Fijian adolescents. Study length: 2 years	Intervention group: secondary school students from 7 schools, mean age 15.4 ± 0.9 (baseline), 17.6 ± 0.9 (follow-up); *n*=879 (follow-up), Male= 46% Control group: Secondary school students from 11 comparison schools, mean age 15.2 ± 1.1 (baseline), 17.3± 0.9 (follow-up); *n*=2,069 (follow-up), Male= 43% Follow-up rate: 33% for intervention group, 45% for control group	Intervention group: The HYHC intervention was delivered over three school years, via school events, canteen, awareness programmes, healthy lunches, promotion of activities such as walking to school, and training of physical education teachers. Control group: did not receive the HYHC programme, but completed questionnaires and anthropometric measuring at base line and follow-up.	*Anthropometry:* Height, weight and body fat percentage, were objectively measured by trained researchers. The 2007 WHO Reference standards for age/gender specific body mass index centiles and cut-offs were used.	(PedsQL: $p<0.001$, AQoL: $p<0.05$) than the comparison group (controlled for age, gender and ethnicity).
Melnyk *et al*., 2009 United States [19] Aim: To evaluate the preliminary efficacy of a manualized educational and cognitive behavioural skills-building program, on Hispanic adolescents' healthy lifestyle choices as well as mental and physical health outcomes. Study length: 9 weeks	*Sample*: 19 Hispanic adolescents enrolled in health classes in a South-western US high school, Mean BMI baseline 27.1 (8.88), Hispanic 100% Intervention group: mean age 15.67 ± 0.65; *n*=12, male= 42% Control group: mean age 15.28 ± 0.53; *n*=7, male= 14% Follow-up rate: 89%	RCT Intervention group: Received the COPE Healthy Lifestyles TEEN program; based on educational information on healthy lifestyles, strategies to build self-esteem, stress management, goal setting, communication, nutrition and physical activity, delivered over 9 weeks. Students wore pedometer everyday over 9-week period. Control: Control group received instruction in health topics that were not contained in the intervention group, such as acne, first aid. No physical activity component, but students did wear pedometers.	*Mental Health:* Beck Youth Inventory. Measures; depressive symptoms, anxiety symptoms, anger, disruptive behaviour, and self-concept. *Anthropometric Measures:* Height and weight measured at baseline and follow-up. BMI reported however criteria for percentile cut-off were not reported.	Adolescents in the intervention group reported a significant decrease in anxiety symptoms (d=-0.56, $p<0.05$) from baseline to post-intervention follow-up. The was a decrease in depressive symptoms (d=0.27) in overweight adolescents (BMI≥85th percentile) in the intervention group, however this decrease was not significant (p=0.35). No gender differences were reported.
Millar *et al*., 2011 Australia [20] Aim: To evaluate the outcome results of a 3-	*Sample:* 2054 secondary school students, percentage overweight/obese baseline 29%, ethnicity not reported	Formed part of the *OPIC* study. Quasi-experimental, longitudinal cohort design, baseline measurements were collected from 2005 to 2006 and follow-up in 2008.	*Mental Health:* Two instruments measured health-related quality of life: AQoL-6D and PedsQoL.	Adolescents in the intervention group had a relative reduction in body weight ($p<0.05$) compared to comparison group.

year obesity prevention intervention (*It's Your Move; IYM*) study implemented in secondary schools in Australia. Study length: 3 years	Intervention group: 5 secondary schools, mean age=14.5±1.40 at baseline, *n*=1276, male= 60% Control group: 7 secondary schools (4 government, 1 catholic, 2 christian), mean age 14.7±1.45 at baseline, *n*=778, male= 46% Follow-up rate: 69% (intervention), 66% (comparison)	Intervention group: Received *IYM* 3-year programme targeting secondary school students aged 12-18 years. Programme focused on building capacity of families, schools and communities to promote healthy eating and physical activity. Control group: Completed questionnaires at baseline and follow-up but did not receive *IYM* programme.	*Anthropometric Measures*: Height and weight objectively measured to determine BMI based on WHO Reference 2007.	No significant difference in quality of life was found between comparison group and intervention group. This intervention demonstrated success in reducing unhealthy weight gain in adolescents through a community-based intervention.
Simon et al., 2006 France [21] Aim: to evaluate the outcomes of the Intervention Centres on Aolescents' Physical activity and Sedentary behaviour (ICAPS), aimed at preventing excessive weight gain and cardiovascular risk in adolescents by promoting physical activity Study length: 4 years	*Sample:* 954 secondary school students from France. Age range 11.7 years ± 0.6, 24% overweight prevalence at baseline Intervention group: N= 255 females (mean age 11.51± 0.03) 220 males (mean age 11.58 years±0.04) Control group: N= 231 females (mean age 11.68 years± 0.04) 248 males (mean age 11.77±0.04)	RCT Intervention group: Received the ICAPS program, a multilevel program aimed at modifying the personal, social and environmental determinants of physical activity. ICAPS included school setting, and numerous partnerships at different levels (teachers, parents, community agencies). Control group: students in control schools follow their usual school curriculum and physical education classes	*Mental health:* Stanford Adolescent Heart Health Program assessed self-efficacy, social influence and intention toward PA. *Anthropometric measures:* Objectively measured height and weight by trained researchers. International Obesity Task Force age and sex-based cut offs. Waist and hip circumference were objectively measured.	No significant intervention effects were found between intervention and control for self-efficacy, intention and social support. Six-month results showed increased physical activity and decreased sedentary behaviour.
Utter *et al*., 2011 New Zealand [22] Aim: To evaluate the effectiveness of the *Living 4 Life* study, a youth-led, school-based	*Sample:* Secondary school students aged 9-13 years at baseline, New Zealand. 1634 students at baseline, 1612 at follow-up. Mean BMI baseline 25.36	Formed part of the *OPIC* study. Quasi-experimental, comparisons made by two cross-sectional samples within schools. Baseline data including anthropometry and questionnaires were completed at baseline (2005) and follow-up (2008).	*Mental health:* Two instruments measured health-related quality of life: AQoL-6D and PedsQoL. *Anthropometric measures:* Height, weight and body fat	There were no significant differences in findings of weight or quality of life in intervention or comparison from base line to follow-up. Results adjusted for gender

intervention to reduce obesity in New Zealand, by improving nutrition and increasing physical activity. Study length: 3 years	Intervention group: 4 schools, mean age not reported, n=953, male=50% (baseline), n=1023, male=43% (follow-up) Control group: Two comparison schools, mean age not reported, n=681, male=46% (baseline), n=589, male=47% (follow-up) Follow-up rate: Cross-sectional comparison, participation rate 66%	Intervention group: The intervention aimed to create opportunities for meaningful participation, quality relationships, and to create opportunities for student training and development. Control group: Did not participate in the Living 4 Life intervention however did complete questionnaires and anthropometric measurements at baseline and follow-up.	percentage, were collected by trained researchers. The 2007 WHO Reference standards for age/gender specific body mass index centiles and cut-offs were used.	and no gender differences in outcomes were reported.

Table 2: Mental health outcomes (shaded) and community-based obesity prevention components of reviewed studies

	n	Setting	Community capacity building	Increased opportunity for PA or HE	Educational/curriculum component	Environmental component	Counselling/psychology component	MH disorders/symptoms	HRQoL	Self-perception
Fotu *et al*., 2011	1712	S	✓	✓		✓			✓	
Huang *et al*., 2007	657	C			✓		✓			✓
Kremer *et al*., 2011	2948	S	✓	✓	✓	✓			✓	
Melnyk *et al*., 2009	19	S		✓	✓		✓	✓		
Millar *et al*., 2011	2054	S	✓	✓	✓	✓			✓	
Simon *et al*., 2006	954	S		✓	✓	✓				✓
Utter *et al*., 2011	1612	S		✓		✓			✓	

S, school: C, community; PA, physical activity; HE, healthy eating; MH, mental health; HRQoL, health-related quality of life

Table 3: Assessment of quality of studies based on mental health and well-being outcome using the GRADE system

Outcome No. of studies (No. of participants)	Study limitations	Consistency	Directness	Precision	Publication bias	Quality
Mental health disorder/symptoms 1 (19)	Serious limitations (-1) Quasi-randomised design. Concealment of allocation and blinding not described [19]. Loss to follow-up: 11% Did not report intention to treat analysis. Sparse data (<200).	Important inconsistency (-1) Decrease in depressive symptoms in obese adolescents only [19].	Indirectness (-1) Sample of Hispanic adolescents enrolled in a South-Western US High School	No important imprecision	Unlikely Study reported both positive and negative results.	Very Low
Health-related quality of life 4 (8,326)	Serious limitations (-1) Quasi-randomised design. Concealment of allocation and blinding not described. Loss to follow-up: 25-35% [16 20 22], 55-67% [18]. Did not report intention to treat analysis.	Important inconsistency (-1) Important gender differences in mental health and weight-related measures, although not consistent [20].	Indirectness (-1) Interventions taken place in western/high income countries.	No important imprecision	Unlikely Studies reported both positive and negative results.	Very Low
Self-perception 2 (1,611)	Serious limitations (-1) One study was randomised [17], one study was quasi-randomised [21]. Concealment of allocation and blinding not	Important inconsistency (-1) Mental health changes linked to	Indirectness (-1) Interventions taken place in western/high	No important imprecision	Unlikely Studies reported both positive and negative	Very Low

	described. Loss to follow-up: Between 25-35% [17], one study did not report loss to follow-up [21]. Did not report intention to treat analysis.	weight change inconsistently [17].	income countries.	results.

Results

Summary of included studies

The search strategy yielded 621 abstracts through EBSCOhost and 140 studies through Cochrane Database which were screened by authors for possible inclusion. After screening, 46 full-text articles were selected and examined in detail to determine eligibility. A further 39 articles were excluded at this stage; 14 studies did not include mental health outcome measures [23-36], 14 studies sampled specific adolescent groups such as those at risk or already overweight/obese [37-45], disadvantaged or sedentary adolescents [46 47], or younger or older age groups [48-50], six studies did not include an intervention design with a comparison or control group [51-56], two studies failed to report mental health measures at follow-up [29 57], two studies sampled from specific communities such a rural [58] or low income schools [59], and one study focused on disordered eating behaviours [60] leaving seven eligible studies for review. See Figure 2 for flow chart process of article inclusion. A list of excluded studies with reasons for exclusion can be found in Supplementary Table 1. Quality of evidence according to the GRADE rating system is summarized in Table 3. Due to significant limitations in study design, inconsistency, lack of directness, and sparse data for outcome of mental health disorders/symptoms the overall quality of evidence was very low. A full description of the GRADE rating system is described in Balshem et al. [15]. Two interventions took place in the United States [17 19], and one each in France [21], Australia [20], Tonga [16], Fiji [18], and New Zealand [22]. The details pertaining to study aim, intervention, design and outcomes are outlined in Table 1. The mental health domains measured in each study are summarised in Table 2. Six of the seven reviewed studies had samples consisting of close to half (40-55%) male [16-18 20-22]. One study had higher proportions of females at 72% [19].

Community-based obesity prevention interventions

Design methodology of the reviewed interventions included randomised control trials [17 19 21] and quasi-experimental studies [16 18 20 22]. Four of the reviewed studies had interventions that lasted 2-3 years [16 18 20 22], and the other studies lasted one year [17], six months [21] and nine weeks [19]. The interventions took place in schools [16 18-22] and in the general community [17] and shared similar specific intervention components; increased opportunities for adolescents to engage in physical activities and healthy eating behaviours; included educational sessions in relation to physical activity, nutrition and behaviours promoting healthy weight; targeted environmental aspects such as increased water fountains in school or improved canteen quality, and incorporated counselling or psychology sessions in relation to healthy living (see Table 2). Community capacity building for obesity prevention was an explicit component in four of the reviewed studies. Four of the interventions [17-20] successfully reduced or prevented unhealthy weight in adolescents based on significant changes in weight from pre- to post- intervention. Two studies resulted in no significant effect in anthropometry post-intervention [16 22]. One study [21] did not report anthropometric outcomes at follow-up.

Each of the 7 interventions included a mental health measurement as an outcome, which fell into one or more of the following categories: mental health disorders (including depression and anxiety), health-related quality of life and self-perception referring to one's beliefs about oneself including self-concept, self-worth, self-esteem, body satisfaction, and physical self-worth. Findings for each mental health outcome are discussed in detail below. Due to heterogeneity in population characteristics, intervention components, outcome measures and duration of interventions, it was not possible to complete a meta-analysis.

Mental health outcomes measured in community based obesity prevention interventions

Mental health disorders/symptoms

Mental health disorders were examined as outcomes in one of the reviewed studies [19]. Melnyk *et al.* [19] reported a moderate decrease in anxiety symptoms, as indicated by the *Beck Youth Inventory* (*BYI*) [61] from pre- to post-intervention (d=-0.56, p<0.05) in adolescents following a nine week healthy lifestyles programme. The intervention consisted of 15 fifty-minute sessions based on educational information on healthy lifestyles, strategies to build self-esteem, nutrition and physical activity. No significant mean difference was observed for depressive symptoms (Cohen's d=-0.32, p=0.11).

Health-related quality of life

All four of the Pacific Obesity Prevention in Communities (*OPIC*) studies [16 18 20 22] measured health-related quality of life by the Adolescent Quality of Life Inventory (AQoL) [62] and Pediatric Quality of Life Inventory (PedsQoL) [63]. Fotu *et al*. [16] found that health-related quality of life increased in the intervention group at follow-up according to one measure (PedsQoL), however, remained significantly lower in the intervention group compared with the comparison group (p<0.001). Similarly, Kremer *et al*. [18] found the intervention group had smaller increase in health related quality of life compared to comparison group (p<0.05) following a three-year comprehensive school-based obesity prevention project. The other two *OPIC* studies, set in Geelong, Australia [20] and Auckland, New Zealand [22] did not find significant changes in HRQoL from baseline to follow-up in either measure.

Self-perception

Two obesity prevention intervention studies among adolescents have included self-perception as an outcome measure [17 21]. Huang *et al*. [17] assessed self-esteem using the Rosenberg Self- Esteem Scale [64] and found no significant differences between intervention and control groups following a one-year intervention targeting physical activity, sedentary, and diet behaviours. Simon *et al*. [21] assessed self-efficacy with self-

reported questions scored on a six point Likert-scale, and found no significant differences in self-efficacy between comparison and intervention groups following a six month program aimed at preventing excessive weight gain by promoting physical activity.

Discussion

What mental health and well-being outcomes have been examined in community-based obesity prevention interventions for adolescents and what do findings reveal?

An examination of the literature on obesity prevention interventions targeting adolescents in community settings reveals that the following mental health outcomes have been reported: anxiety and depressive symptoms, health-related quality of life, body image, self-worth, and self-esteem. Obesity prevention interventions that have included mental health measures as outcomes have taken place most commonly in school settings (*n*=7) and have had the primary focus on anthropometry at follow-up. The GRADE quality of evidence assessment revealed very low quality of evidence for mental health disorders or symptoms, and low quality of evidence for health related quality of life and self-perception.

Findings of mental health outcomes following community-based obesity prevention interventions were mixed. A significant decrease in anxiety symptoms was found in the intervention group compared to controls following a nine week healthy lifestyle intervention, however no significant differences were found in depressive symptoms [19]. Of the four studies that examined health-related quality of life, two [16 18] found significant increases post-intervention, however these increases were smaller than increases observed in the control groups. The other two studies [20 22] that examined health related quality of life did not find any significant changes in health related quality of life following three-year obesity prevention interventions in school settings. Two studies found no significant differences in self-esteem or self-efficacy following a one-year [17] and 6-

month [21] intervention. Common characteristics across the interventions that demonstrated positive mental health outcomes were; inclusion of a physical exercise component, education components targeting healthy living behaviours (specifically healthy eating and physical activity), group-based sessions aimed at both healthy living and provision of opportunities for adolescents to engage in meaningful activities that promote personal development (such as mastery, friendships, leadership). Mechanisms contributing to significant findings are difficult to identify due to heterogeneity in interventions delivered to adolescents.

Interventions that included a cognitive behavioural component, or that were theoretically based on cognitive behavioural theory [21 65], showed positive findings in promotion of mental health and well-being. Cognitive behavioural approach refers to the thoughts and beliefs in relation to behaviour, and this approach is widely accepted as a beneficial therapy for mental health disorders [66-68]. Research suggests that adolescents who have stronger beliefs/confidence about their ability to engage in healthy lifestyle behaviours and perceive them as less difficult to perform are more likely to engage in more healthy choices [19]. Similarly, opportunities for adolescents to participate in physical activity or diet related activities provide mastery experience. Bandura (1978) outlined mastery experience as key in the theory of Self-Efficacy as this experience builds beliefs about capabilities to produce behaviours that exercise influence over events that affect their lives [69]. Adolescents with greater perceived self-efficacy may be better equipped to maintain healthy lifestyles and deal with adversity such as mental health problems.

Importantly, there were some findings that suggested that intervention groups experienced poorer mental health following obesity prevention interventions compared to control groups [16 18]. Authors in one study acknowledged a potential explanation being that the schools that made up the intervention sample were located in a more urbanised main island

in Tonga [16]. These students may have been exposed to more pressure in terms of achieving high examination results and obtaining employment or overseas tertiary education, compared to the less-urbanised outer island that made up the comparison sample. This may have been a result of biases in sampling technique, however exposes the need for targeted interventions to suit the specific needs of communities, as previously identified as a priority in obesity prevention [70]. Additionally, these findings may reflect negative consequences of the obesity prevention interventions. Potential psychological harm due to obesity interventions has been raised in previous research [8]. These results demonstrate the need to assess mental health to ensure no harm is being done to adolescents, and also highlights the importance of incorporating explicit aims to protect mental health of participants involved in such interventions.

What limitations exist in the research to date and what recommendations can be made for future interventions?

As identified in this review, there is evidence for positive mental health outcomes following community-based obesity prevention interventions, however the number of interventions incorporating mental health measures is few (*n*=7). The findings of this systematic review demonstrate the dearth of evidence: there were 14 studies excluded from this review for not including a mental health measure, and two studies that included a measure but failed to report the mental health outcomes at follow-up. Given the co-morbidity between overweight/obesity and obesogenic behaviours with mental and emotional health [4 5 71], and the increased vulnerability to both unhealthy weight and mental health problems during adolescence [72 73], future interventions should aim to include mental health measures to assess the impact such interventions are having on participant's mental health and well-being. In addition, the issue of directionality still remains in relation to changes in obesogenic behaviours and mental health, and risk

factors that may be common to both conditions. Sample biases exist in the reviewed studies with majority of interventions taking place at school [16 18-22] and consequently overlooking those adolescents who do not attend school and may represent a population in need of mental health support. Additionally, two [16 22] of the seven reviewed studies did not find significant improvements in weight status post- intervention, and therefore were not successful in meeting their primary obesity-related aims. The implications of these null findings are outside the scope of this review however may limit the extent to which mental health can be evaluated as an outcome of the reviewed interventions, given that the effectiveness of interventions' obesity prevention was varied.

Finally, the current review categorized mental health outcomes by disorders, health-related quality of life or self-perception. The extent to which results can be compared is limited by use of different mental health instruments. Mental disorders, for example, have been measured by diagnostic tools indicating presence of a disorder and also symptomatic measures that indicate suspected presence of disorder symptoms. Such differences affect findings as outcomes vary greatly depending on mental health measures being used.

This review has some limitations. As discussed in the GRADE quality of evidence assessment, many studies published have included less than optimal study designs and this may have biased the findings presented here. As the primary aim of obesity prevention interventions is to reduce or prevent weight gain, this may have led to mental health outcomes being under reported or not reported at all. Eligible interventions may therefore have not been included in the analysis because of a lack of published data. A further limitation of this review was that a meta-analysis could not be performed due to heterogeneity in the reviewed studies.

This systematic review was also limited in focusing solely on obesity prevention

interventions that were community-based. Studies conducted in clinical settings were excluded from this review and these studies may have provided important insight into the mental health and well-being. Previous research examining mental health in clinical settings have discussed psycho-social issues such as weight stigmatisation, and the negative impact this has on client's emotional health [74]. Within clinical settings, there also appears to be psychological benefits such as improved body image and health related quality of life, however these issues have been underreported due to being considered secondary to the primary aim of obesity prevention [75], which reflects the findings found in the current review.

Despite limitations this study has a number of strengths. There was a range of obesity prevention interventions included in this review including differences in duration, components and country where the intervention took place. The review process was systematic and all studies included were assessed based on strict eligibility and exclusion criteria and robust review methods were used including the searching of multiple databases to ensure all relevant articles were included in this review. The inclusion of the GRADE quality of evidence assessment ensured that the findings presented here could be considered in relation to the quality of research in which they are found.

Future research needs to build on what is already known about the effect of community based obesity prevention interventions on mental health outcomes in adolescents, as the mechanisms affecting these outcomes are yet to be clearly defined. Mental health is strongly recommended to become a primary outcome of obesity prevention interventions, as potential benefits do exist, however rarely have mental health measures been evaluated (or reported) in community-based interventions. Additionally, two of the reviewed interventions were not successful in reducing or preventing unhealthy weight gain and

future research should evaluate the mental health and well-being of adolescents alongside the efficaciousness of obesity prevention initiatives, to highlight potential shared underlying mechanisms.

Conclusions

Co-morbidity between poor mental health and poor physical health is well-established [76] and evidence for successful community-based obesity prevention strategies among adolescents is growing. A focus now needs to be placed on mental health of adolescents in these interventions. It is recommended that obesity prevention interventions incorporate mental health measures to monitor the mental health and well-being of adolescents. This review supports a shift in thinking around mental health, from a secondary outcome of these interventions to a primary outcome alongside overweight and obesity, to ensure that the mechanisms leading to co-morbidity can be identified and outcomes can be improved through these interventions. In addition, including such measures can allow care to be taken to ensure that community-based obesity prevention initiatives do not have adverse effects on adolescents' mental health.

Competing interests

The authors have no conflict of interest to declare.

Authors' contributions

EH contributed to the conception and design of the study, performed the literature search, extracted and analysed data, and drafted and revised the manuscript. MFT and HS contributed to the conception and design of the study, analysed data, critically revised the manuscript and approved the final draft. LM screened articles for eligibility for review. LM and MN were involved in drafting the manuscript, critically revising the

piece and approved the final draft. SA critically revised the manuscript and approved the final draft for publication.

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DATA SHARING

No additional data available.

Figure 1. Search terms and strategy used in CINAHL, Global Health, Health Source: Nursing and Academic Edition, Medline, PsycARTICLES and PsycINFO, all of which were accessed through EBSCOhost. In addition, the same search was also performed on the Cochrane Database to ensure all relevant articles were screened for eligibility.

Figure 2. Flow diagram of studies that were identified using the search terms and strategy, articles screened for eligibility, included/excluded with reasons, following PRISMA guidelines

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Systematic review of mental health and well-being outcomes following community-based obesity prevention interventions among adolescents

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Abstract

Objectives

This paper aimed to systematically evaluate the mental health and well- being outcomes observed in previous community-based obesity prevention interventions in adolescent populations.

Setting

Systematic review of literature from database inception to October 2014. Articles were sourced from CINAHL, Global Health, Health Source: Nursing and Academic Edition, MEDLINE, PsycARTICLES and PsycINFO, all of which were accessed through EBSCOhost. The Cochrane Database was also searched to identify all eligible articles. PRISMA guidelines were followed and search terms and search strategy ensured all possible studies were identified for review.

Participants

Intervention studies were eligible for inclusion if they were: focused on overweight or obesity prevention, community-based, targeted adolescents (aged 10-19 years), reported a mental health or well-being measure, and included a comparison or control group. Studies that focused on specific adolescent groups or were treatment interventions were excluded from review. Quality of evidence was assessed using GRADE guidelines.

Primary and secondary outcome measures

Primary outcomes were measures of mental health and well-being, including diagnostic and symptomatic measures. Secondary outcomes included adiposity or weight-related measures.

Results

Seven studies met the inclusion criteria; one reported anxiety/depressive outcomes, two reported on self-perception well-being measures such as self-esteem and self-efficacy, and four studies reported outcomes of quality of life. Positive mental health outcomes demonstrated following obesity prevention interventions included a decrease in anxiety and improved health-related quality of life. Quality of evidence was graded as very low.

Conclusions

Although positive outcomes for mental health and well-being do exist, controlled evaluations of community-based obesity prevention interventions have not often included mental health measures (n=7). It is recommended that future intervention's incorporate mental health and well-being measures to identify any potential mechanisms influencing adolescent weight related outcomes, and equally to ensure interventions are not causing harm to adolescent

mental health.

Strengths and limitations of this study

- This study was the first to systematically review mental health outcomes following community-based obesity prevention interventions among adolescents
- This study ensured rigorous methodology by following PRISMA guidelines and evaluated quality of evidence using GRADE guidelines to allow findings to be interpreted with respect to the quality of studies in which they are found
- A limitation of this review was that a meta-analysis was not possible due to study heterogeneity in differing components of the interventions and different measures of mental health outcomes at follow-up
- Study biases may be present due to interventions having the primary outcome of weight reduction, therefore mental health measures at outcome may have been underreported or not reported at all

Background

Adolescent obesity prevention remains a high priority given negative health consequences of overweight/obesity both during adolescence and later in life. It has been suggested that prevention efforts should be community-based to meet the complex and multi-dimensional nature of obesity [1 2]. Importantly, recent research also suggests that there is a high comorbidity between poor mental health and obesity and this may reflect some shared underlying mechanisms and common potentially modifiable risk factors [3 4]. Changes in physical activity and diet patterns have been linked to mental health outcomes and compelling evidence suggests that unhealthy weight-related risk factors are bi-directionally associated with common mental health disorders [5]. There is potential then that interventions aiming to promote healthy weight among adolescents may also impact on mental health and well-being outcomes.

Overweight and obesity treatment programs appear to have positive psychological impacts for children and adolescents; a systematic review examining the impact of weight management programs on self-esteem found that despite variance in methodology and treatment design, there were overall positive effects for self-esteem following weight treatment programs in paediatric overweight populations [6]. This review highlighted the importance of considering both physical and emotional health outcomes from weight based treatment for overweight adolescents. A second review examined the psychological outcomes of weight loss following behavioural and diet interventions in overweight/obese populations [7] finding that improvements in body image and health-related quality of life were consistently associated with weight loss.

Given weight-related stigma and particular sensitivity to body image concerns during adolescence, it is also important to ensure overweight/obesity focused programs are not causing psychological harm to participants. O'Dea (2000~~5~~) identified the importance of

prevention versus treatment for obesity, emphasizing that prevention initiatives must encompass all the dimensions of a child's health and that other healthy behaviours should not be forfeited in place ~~of weight control~~ overweight and obesity prevention [8]. Care must be taken to avoid further stigmatizing overweight and obese young people, and to ensure the health messages delivered in obesity prevention interventions do not damage any other ~~essential dimensions~~domains of health, such as normal eating behaviours, or self-esteem.

One systematic review [9] examined prevention of mental disorders in children, adolescents and adults, with studies included if they included interventions aimed at positively affecting mental health outcomes. Interventions were mostly based on Cognitive Behavioural Therapy/counselling sessions, drug therapy or pro-social behaviour management programs. This review did not examine obesity prevention interventions. One other review [10] examined mental health and wellness in relation to the prevention of childhood obesity in studies from January 2000 to January 2011. This review identified that psychosocial emotional health is one of the most neglected areas of study in childhood overweight/obesity and that many recommendations focus on physical outcomes such as body mass index, ignoring the impact on psychological or social well-being. T

~~T~~hree systematic reviews have examined community-based obesity prevention studies in children and adolescents, however none of these reviews investigated mental health and well-being outcomes either as intentional effects or side-effects of the interventions [11-13].

Currently, our understanding of mental health outcomes in obesity prevention interventions is limited because existing systematic reviews are limited to specific high-risk groups such as individuals classified as overweight or obese [7 10], individuals undergoing weight management [6] or mental health treatment programs [9]. For community-based obesity prevention interventions, previous reviews have focused solely on ~~weight-related~~weight

status outcomes, and none have reported mental health and well-being outcomes [11-13]. It remains unknown whether positive mental health effects have been achieved following such interventions and whether obesity prevention interventions protect mental health and well-being to ensure no harm has been done.

Despite emerging empirical evidence highlighted above, there is not yet a clear synthesis of the literature relating to the effect of obesity prevention interventions on mental health outcomes. Without this understanding, efforts to target and protect mental health in such interventions are limited. The purpose of this systematic review is to evaluate the mental health outcomes following community-based obesity prevention interventions among adolescents, and develop a set of recommendations for future interventions. This review is limited to controlled studies. ~~The aim of this systematic review was to examine the literature on community-based obesity prevention studies that included mental health outcomes among adolescents.~~

The specific questions addressed in this review were;

(1) What mental health and well-being outcomes have been examined in community- based obesity prevention interventions for adolescents and what do the findings reveal?

(2) What limitations exist in the research to date and what recommendations can be made for future interventions?

Methods

Inclusion/exclusion criteria

The search was designed to identify studies that were community-based obesity prevention interventions, targeting adolescent populations. Community-based interventions were defined as those that target a group of individuals or a geographic community but are not

aimed at a single individual. This included cities, schools and community health care centres. It did not include clinical settings. Adolescence was defined as the period including and between 10-19 years as defined by the World Health Organization. Studies that were randomised control trials (RCTs), quasi-experimental, and natural experiments were eligible for selection. Inclusion criteria were (1) primary research; (2) overweight or obesity prevention interventions; (3) community-based; (4) targeted adolescent population; (5) mental health measure reported at baseline and follow-up; (6) included a comparison or control group; and (7) were published through October 2014. Exclusion criteria were (1) obesity treatment/management interventions; (2) targeted children or adult populations; and (3) focused on specific high risk groups within the community (such as overweight/obese adolescents or low active adolescents). Studies were not excluded based on ethnicity. This review was focused on ~~weight~~ interventions to prevent overweight and obesity and therefore studies examining eating disorders and underweight management were not eligible for review. Exclusion criteria were set to ensure studies examining adolescents who were representative of the broader population were sourced.

Definitions of outcomes

Mental health and well-being outcomes included any diagnosed psychopathologies, or symptoms of psychopathologies (for example, depression or depressive symptoms). Given that ~~weight- based~~obesity prevention interventions have rarely investigated psychological and cognitive mediators [14], studies that included health-related quality of life, self-efficacy and other psychosocial factors were eligible for inclusion. Due to outcome measures utilising different measurement tools, there were no principle summary measures set. The overall findings in relation to mental health and well-being were summarized individually and combined.

Search strategy

Articles for this review were sourced from CINAHL, Global Health, Health Source: Nursing and Academic Edition, Medline, PsycARTICLES and PsycINFO, all of which were accessed through EBSCOhost. In addition, the same search was also performed on the Cochrane Database to ensure all relevant articles were screened for eligibility. ~~Cochrane Central Register of Controlled Trials was searched independently through the Cochrane Library.~~ The search was limited to peer-reviewed paper~~s,~~ published from database inception through October~~July~~ 2014. A range of search terms was used to maximize the yield of the search for studies that conducted a community-based obesity prevention intervention among adolescents and included a mental health or well-being measure. Search terms were selected based on components of obesity prevention interventions, community settings, and mental health/well-being outcomes. The full search strategy including search terms can be found in Figure 1. The reference lists of selected articles, and reference lists of other systematic reviews were screened by two independent authors to identify all relevant articles for potential study selection. Disagreements in study selection were resolved by a third reviewer. The studies included in the previously mentioned systematic reviews [10-13] examining community-based obesity preventions were scanned to determine whether they included adolescent samples, and if so, the original article was sourced and the full text was assessed for eligibility.

Data extraction and data synthesis

Two author~~s~~ (EH, LM) screened titles, abstracts and reference lists for potential inclusion in this review. Forty-six articles were selected for full text review to assess eligibility for inclusion. A standardised form for data extraction was created for study aim, characteristics, participants, intervention type, outcome measures and main findings (Table 1). Data were synthesized by categorising the components of the obesity prevention intervention and by the mental health outcome the study examined (Table 2). Mental health outcomes at follow-

up were extracted and used as the main findings for this review. The quality of evidence was assessed using the Grading of Recommendations, Assessment, Development and Evaluation (GRADE) system (Table 3)[15].

Table 1: Interventions designed to prevent overweight/obesity that include mental health outcomes in adolescents

Study	Sample and setting	Design and intervention	Measures	Findings
Fotu *et al*., 2011 Tonga [16] Aim: To evaluate the outcomes of a three year, quasi-experimental study of community-based obesity interventions among Tongan adolescents in three districts. Ma'alahi Youth Project (MYP). Study length: 3 years	*Sample:* Tongan secondary students, baseline overweight/obesity 46%, Tongan 100% Intervention group: *n*= 815, mean age (baseline) 14.4 ± 2.0 years, Male 46% Control group: *n*=897, mean age (baseline) 15.2 ± 1.8, Male= 41%. Follow-up rate: 75%	Formed part of the Pacific Obesity Prevention in Communities study (*OPIC).* Quasi-experimental design, longitudinal cohort follow-up, baseline (2006) and follow-up (2008). Intervention group: The intervention group were exposed to social marketing approaches, community capacity building and grass roots activities to promote healthy behaviours Control group: Did not receive the MYP project, but anthropometry measures and QoL were taken at baseline and follow-up.	*Mental Health:* Two instruments measured health-related quality of life, Assessment of Quality of Life instrument (AQoL-6D), Pediatric Quality of Life Inventory 4.0 (PedsQL) *Anthropometry:* Objectively measured height and weight. The 2007 WHO Reference standards for age/gender specific body mass index centiles and cut-offs were used to determine weight status.	One of the measures of quality of life (PedsQL) showed a smaller increase in the adolescents from the intervention group, compared to the less urbanized comparison group ($p<0.001$). Lower levels of weight gain were observed in male adolescents compared to female, indicating the importance that gender plays in values behaviours, and lifestyle.
Huang et al., 2007 United States [17] Aim: To examine the effect of a one year intervention targeting physical activity, sedentary, and diet behaviours among adolescents on self-reported body image and self-esteem. PACE+ intervention Study length: 1 year	*Sample:* 657 adolescents, age range 11-15 years, baseline 26% overweight/obesity, 53% female Intervention group: female n= 175, boys n= 166 Control group: female = 174, boys n=142	Randomised control trial, 1 year longitudinal follow-up, data collections occurred at baseline, 6 months and 12 months. Intervention group: The Patient-Centred Assessment and Counseling for Exercise Plus Nutrition Project (PACE+) included a tailored interactive computer program for assessment and goal setting, and counselling in relation to physical activity and sedentary behaviours. Control group: received computer assessment and counselling in relation to sun protection.	*Mental Health:* Body image was measured via self-report Body Dissatisfaction subscales of the Eating Disorders Inventory Self-esteem was measured with Rosenberg Self-Esteem Scale. *Anthropometry:* Height and weight were objectively measured. BMI was determined by the Centers for Disease Control and Prevention national norms.	There were no intervention effects on body image or self-esteem for either boys or girls. Self-esteem and body dissatisfaction did not worsen as a result of participating in the intervention. Girls in the intervention group who experienced weight reduction of maintenance at 6 and 12 months reported improvements in body image satisfaction (p=0.02) over time compared with subjects who experienced weight gain.
Kremer *et al*., 2011 Fiji [18] Aim: To evaluate a	*Sample:* Fijian secondary school students aged 13-18 years. Baseline overweight/obesity 21%	Formed part of the *OPIC* study. Quasi-experimental design, with the intervention being applied over three school years (2006-2008).	*Mental Health:* Two instruments measured health-related quality of life: AQoL-6D and PedsQoL.	At follow-up the intervention group had lower percentage body fat ($p<0.001$) and smaller increase in quality of life

community-based obesity intervention (Health Youth Healthy Communities, HYHC) in Fijian adolescents, designed to strengthen community capacity to promote healthy eating and regular physical activity to reduce overweight and obesity in Fijian adolescents. Study length: 2 years	Intervention group: secondary school students from 7 schools, mean age 15.4 ± 0.9 (baseline), 17.6 ± 0.9 (follow-up); *n*=879 (follow-up), Male= 46% Control group: Secondary school students from 11 comparison schools, mean age 15.2 ± 1.1 (baseline), 17.3± 0.9 (follow-up); *n*=2,069 (follow-up), Male= 43% Follow-up rate: 33% for intervention group, 45% for control group	Intervention group: The HYHC intervention was delivered over three school years, via school events, canteen, awareness programmes, healthy lunches, promotion of activities such as walking to school, and training of physical education teachers. Control group: did not receive the HYHC programme, but completed questionnaires and anthropometric measuring at base line and follow-up.	*Anthropometry:* Height, weight and body fat percentage, were objectively measured by trained researchers. The 2007 WHO Reference standards for age/gender specific body mass index centiles and cut-offs were used.	(PedsQL: $p<0.001$, AQoL: $p<0.05$) than the comparison group (controlled for age, gender and ethnicity).
Melnyk *et al*., 2009 United States [19] Aim: To evaluate the preliminary efficacy of a manualized educational and cognitive behavioural skills-building program, on Hispanic adolescents' healthy lifestyle choices as well as mental and physical health outcomes. Study length: 9 weeks	*Sample:* 19 Hispanic adolescents enrolled in health classes in a South-western US high school, Mean BMI baseline 27.1 (8.88), Hispanic 100% Intervention group: mean age 15.67 ± 0.65; *n*=12, male= 42% Control group: mean age 15.28 ± 0.53; *n*=7, male= 14% Follow-up rate: 89%	RCT Intervention group: Received the COPE Healthy Lifestyles TEEN program; based on educational information on healthy lifestyles, strategies to build self-esteem, stress management, goal setting, communication, nutrition and physical activity, delivered over 9 weeks. Students wore pedometer everyday over 9-week period. Control: Control group received instruction in health topics that were not contained in the intervention group, such as acne, first aid. No physical activity component, but students did wear pedometers.	*Mental Health:* Beck Youth Inventory. Measures; depressive symptoms, anxiety symptoms, anger, disruptive behaviour, and self-concept. *Anthropometric Measures:* Height and weight measured at baseline and follow-up. BMI reported however criteria for percentile cut-off were not reported.	Adolescents in the intervention group reported a significant decrease in anxiety symptoms (d=-0.56, $p<0.05$) from baseline to post-intervention follow-up. The was a decrease in depressive symptoms (d=0.27) in overweight adolescents (BMI≥85th percentile) in the intervention group, however this decrease was not significant (p=0.35). No gender differences were reported.
Millar *et al*., 2011 Australia [20] Aim: To evaluate the outcome results of a 3-	*Sample:* 2054 secondary school students, percentage overweight/obese baseline 29%, ethnicity not reported	Formed part of the *OPIC* study. Quasi-experimental, longitudinal cohort design, baseline measurements were collected from 2005 to 2006 and follow-up in 2008.	*Mental Health:* Two instruments measured health-related quality of life: AQoL-6D and PedsQoL.	Adolescents in the intervention group had a relative reduction in body weight ($p<0.05$) compared to comparison group.

year obesity prevention intervention (*It's Your Move; IYM*) study implemented in secondary schools in Australia. Study length: 3 years	Intervention group: 5 secondary schools, mean age=14.5±1.40 at baseline, *n*=1276, male= 60% Control group: 7 secondary schools (4 government, 1 catholic, 2 christian), mean age 14.7±1.45 at baseline, *n*=778, male= 46% Follow-up rate: 69% (intervention), 66% (comparison)	Intervention group: Received *IYM* 3-year programme targeting secondary school students aged 12-18 years. Programme focused on building capacity of families, schools and communities to promote healthy eating and physical activity. Control group: Completed questionnaires at baseline and follow-up but did not receive *IYM* programme.	*Anthropometric Measures*: Height and weight objectively measured to determine BMI based on WHO Reference 2007.	No significant difference in quality of life was found between comparison group and intervention group. This intervention demonstrated success in reducing unhealthy weight gain in adolescents through a community-based intervention.
Simon et al., 2006 France [21] Aim: to evaluate the outcomes of the Intervention Centres on Aolescents' Physical activity and Sedentary behaviour (ICAPS), aimed at preventing excessive weight gain and cardiovascular risk in adolescents by promoting physical activity Study length: 4 years	*Sample:* 954 secondary school students from France. Age range 11.7 years ± 0.6, 24% overweight prevalence at baseline Intervention group: N= 255 females (mean age 11.51± 0.03) 220 males (mean age 11.58 years±0.04) Control group: N= 231 females (mean age 11.68 years± 0.04) 248 males (mean age 11.77±0.04)	RCT Intervention group: Received the ICAPS program, a multilevel program aimed at modifying the personal, social and environmental determinants of physical activity. ICAPS included school setting, and numerous partnerships at different levels (teachers, parents, community agencies). Control group: students in control schools follow their usual school curriculum and physical education classes	*Mental health:* Stanford Adolescent Heart Health Program assessed self-efficacy, social influence and intention toward PA. *Anthropometric measures:* Objectively measured height and weight by trained researchers. International Obesity Task Force age and sex-based cut offs. Waist and hip circumference were objectively measured.	No significant intervention effects were found between intervention and control for self-efficacy, intention and social support. Six-month results showed increased physical activity and decreased sedentary behaviour.
Utter *et al.*, 2011 New Zealand [22] Aim: To evaluate the effectiveness of the *Living 4 Life* study, a youth-led, school-based	*Sample:* Secondary school students aged 9-13 years at baseline, New Zealand. 1634 students at baseline, 1612 at follow-up. Mean BMI baseline 25.36	Formed part of the *OPIC* study. Quasi-experimental, comparisons made by two cross-sectional samples within schools. Baseline data including anthropometry and questionnaires were completed at baseline (2005) and follow-up (2008).	*Mental health:* Two instruments measured health-related quality of life: AQoL-6D and PedsQoL. *Anthropometric measures:* Height, weight and body fat	There were no significant differences in findings of weight or quality of life in intervention or comparison from base line to follow-up. Results adjusted for gender

intervention to reduce obesity in New Zealand, by improving nutrition and increasing physical activity. Study length: 3 years	Intervention group: 4 schools, mean age not reported, n=953, male=50% (baseline), n=1023, male=43% (follow-up) Control group: Two comparison schools, mean age not reported, n=681, male=46% (baseline), n=589, male=47% (follow-up) Follow-up rate: Cross-sectional comparison, participation rate 66%	Intervention group: The intervention aimed to create opportunities for meaningful participation, quality relationships, and to create opportunities for student training and development. Control group: Did not participate in the Living 4 Life intervention however did complete questionnaires and anthropometric measurements at baseline and follow-up.	percentage, were collected by trained researchers. The 2007 WHO Reference standards for age/gender specific body mass index centiles and cut-offs were used.	and no gender differences in outcomes were reported.

Table 2: Mental health outcomes (shaded) and community-based obesity prevention components of reviewed studies

	n	Setting	Community capacity building	Increased opportunity for PA or HE	Educational/curriculum component	Environmental component	Counselling/psychology component	MH disorders/symptoms	HRQoL	Self-perception
Fotu *et al.*, 2011	1712	S	✓	✓		✓			✓	
Huang *et al.*, 2007	657	C			✓		✓			✓
Kremer *et al.*, 2011	2948	S	✓	✓	✓	✓			✓	
Melnyk *et al.*, 2009	19	S		✓	✓		✓	✓		
Millar *et al.*, 2011	2054	S	✓	✓	✓	✓			✓	
Simon *et al.*, 2006	954	S		✓	✓	✓				✓
Utter *et al.*, 2011	1612	S		✓		✓			✓	

S, school: C, community; PA, physical activity; HE, healthy eating; MH, mental health; HRQoL, health-related quality of life

Table 3: Assessment of quality of studies based on mental health and well-being outcome using the GRADE system

Outcome No. of studies (No. of participants)	Study limitations	Consistency	Directness	Precision	Publication bias	Quality
Mental health disorder/symptoms 1 (19)	Serious limitations (-1) Quasi-randomised design. Concealment of allocation and blinding not described [19]. Loss to follow-up: 11% Did not report intention to treat analysis. Sparse data (<200).	Important inconsistency (-1) Decrease in depressive symptoms in obese adolescents only [19].	Indirectness (-1) Sample of Hispanic adolescents enrolled in a South-Western US High School	No important imprecision	Unlikely Study reported both positive and negative results.	Very Low
Health-related quality of life 4 (8,326)	Serious limitations (-1) Quasi-randomised design. Concealment of allocation and blinding not described. Loss to follow-up: 25-35% [16 20 22], 55-67% [18]. Did not report intention to treat analysis.	Important inconsistency (-1) Important gender differences in mental health and weight-related measures, although not consistent [20].	Indirectness (-1) Interventions taken place in western/high income countries.	No important imprecision	Unlikely Studies reported both positive and negative results.	Very Low
Self-perception 2 (1,611)	Serious limitations (-1) One study was randomised [17], one study was quasi-randomised [21]. Concealment of allocation and blinding not	Important inconsistency (-1) Mental health changes linked to	Indirectness (-1) Interventions taken place in western/high	No important imprecision	Unlikely Studies reported both positive and negative	Very Low

	described. Loss to follow-up: Between 25-35% [17], one study did not report loss to follow-up [21]. Did not report intention to treat analysis.	weight change inconsistently [17].	income countries.		results.

Results

Summary of included studies

The search strategy yielded 621 abstracts through EBSCOhost and 140 studies through Cochrane Database which were screened by authors for possible inclusion. After screening, 46 full-text articles were selected and examined in detail to determine eligibility. A further 39 articles were excluded at this stage; 14 studies did not include mental health outcome measures [23-36], 15 studies sampled specific adolescent groups such as those at risk or already overweight/obese [37-45], low active or sedentary adolescents [46 47], or younger or older age groups [48-50 59], six studies did not include an intervention design with a comparison or control group [51-56 58], two studies failed to report mental health measures at follow-up [29 57], two studies sampled from specific communities or low income schools [59], and one study focused on disordered eating behaviours [60] leaving seven eligible studies for review. See Figure 2 for flow chart process of article inclusion. A list of excluded studies with reasons for exclusion can be found in Supplementary Table 1.

Quality of evidence according to the GRADE rating system is summarized in Table 3. Due to significant limitations in study design, inconsistency, lack of directness, and sparse data for outcome of mental health disorders/symptoms the overall quality of evidence was very low. A full description of the GRADE rating system is described in Balshem et al. [15].

Comment [EH1]: GRADE quality of evidence moved to here, condensed and more information provided in Table 3

Two interventions took place in the United States [17 19], and one each in France [212], Australia [2017], Tonga [168], Fiji [1820], and New Zealand [2219]. The details pertaining to study aim, intervention, design and outcomes are outlined in Table 1. The mental health domains measured in each study are summarised in Table 2. Six of the seven reviewed studies had samples consisting of close to half (40-55%) male [16-18 20-22]. One study had higher proportions of females at 72% [19].

Community-based obesity prevention interventions

Design methodology of the reviewed interventions included randomised control trials [17 19 21] and quasi-experimental studies [16 18 20 22]. Four of the reviewed studies had interventions that lasted 2-3 years [16 18 20 22], and the other studies lasted one year [1721], six months [212] and nine weeks [1961]. The interventions took place in schools [116 18-227 20 22 61] and in the general community [1721] and shared similar specific intervention components; increased opportunities for adolescents to engage in physical activities and healthy eating behaviours; included educational sessions in relation to physical activity, nutrition and behaviours promoting healthy weight; targeted environmental aspects such as increased water fountains in school or improved canteen quality, and incorporated counselling or psychology sessions in relation to healthy living (see Table 2). Community capacity building for obesity prevention was an explicit component in four of the reviewed studies. Four of the interventions [17 20 21 6117-20] successfully reduced or prevented unhealthy weight in adolescents based on significant changes in weight from pre- to post- intervention. Two studies resulted in no significant effect in anthropometry post-intervention [18 1916 22]. One study [212] did not report anthropometric outcomes at follow-up.

Each of the 7 interventions included a mental health measurement as an outcome, which fell into one or more of the following categories: mental health disorders (including depression and anxiety), health-related quality of life and self-perception referring to one's beliefs about oneself including self-concept, self-worth, self-esteem, body satisfaction, and physical self-worth. Findings for each mental health outcome are discussed in detail below. Due to heterogeneity in population characteristics, intervention components, outcome measures and duration of interventions, it was not possible to complete a meta-analysis.

Mental health outcomes measured in community based weight-basedobesity prevention interventions

Mental health disorders/symptoms

Mental health disorders were examined as outcomes in one of the reviewed studies [19~~61~~]. Melnyk *et al.* [19~~61~~] reported a moderate decrease in anxiety symptoms, as indicated by the *Beck Youth Inventory* (*BYI*) [6~~12~~] from pre- to post-intervention (d=-0.56, p<0.05) in adolescents following a nine week healthy lifestyles programme. The intervention consisted of 15 fifty-minute sessions based on educational information on healthy lifestyles, strategies to build self-esteem, nutrition and physical activity. No significant mean difference was observed for depressive symptoms (Cohen's d=-0.32, p=0.11).

Health-related quality of life

All four of the Pacific Obesity Prevention in Communities (*OPIC*) studies [16 18 20 22] measured health-related quality of life by the Adolescent Quality of Life Inventory (AQoL) [6~~23~~] and Pediatric Quality of Life Inventory (PedsQoL) [63]. Fotu *et al.* [16~~8~~] found that health-related quality of life increased in the intervention group at follow-up according to one measure (PedsQoL), however, remained significantly lower in the intervention group compared with the comparison group (p<0.001). Similarly, Kremer *et al.* [18~~20~~] found the intervention group had smaller increase in health related quality of life compared to comparison group (p<0.05) following a three-year comprehensive school-based obesity prevention project. The other two *OPIC* studies, set in Geelong, Australia [20~~17~~] and Auckland, New Zealand [22~~19~~] did not find significant changes in HRQoL from baseline to follow-up in either measure.

Self-perception

Two obesity prevention intervention studies among adolescents have included self-perception as an outcome measure [17 21~~21 22~~]. Huang *et al.* [17~~21~~] assessed self-esteem using the Rosenberg Self- Esteem Scale [6~~45~~] and found no significant differences between intervention and control groups following a one-year intervention targeting physical activity, sedentary, and diet behaviours. Simon *et al.* [21~~2~~] assessed self-efficacy with self-

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reported questions scored on a six point Likert-scale, and found no significant differences in self-efficacy between comparison and intervention groups following a six month program aimed at preventing excessive weight gain by promoting physical activity.

Discussion

What mental health and well-being outcomes have been examined in community-based obesity prevention interventions for adolescents and what do findings reveal?

An examination of the literature on obesity prevention interventions targeting adolescents in community settings reveals that the following mental health outcomes have been reported: anxiety and depressive symptoms, health-related quality of life, body image, self-worth, and self-esteem. Obesity prevention interventions that have included mental health measures as outcomes have taken place most commonly in school settings (*n*=7) and have had the primary focus on anthropometry at follow-up. The GRADE quality of evidence assessment revealed very low quality of evidence for mental health disorders or symptoms, health related quality of life and self-perception.

Findings of mental health outcomes following community-based obesity prevention interventions were mixed. A significant decrease in anxiety symptoms was found in the intervention group compared to controls following a nine week healthy lifestyle intervention, however no significant differences were found in depressive symptoms [19~~61~~]. Of the four studies that examined health-related quality of life, two [16 18~~18 20~~] found significant increases post-intervention, however these increases were smaller than increases observed in the control groups. The other two studies [20 22~~17 19~~] that examined health related quality of life did not find any significant changes in health related quality of life following three-year obesity prevention interventions in school settings. Two studies found no significant differences in self-esteem or self-efficacy following a one-year [17~~21~~]

and 6-month [212] intervention. Common characteristics across the interventions that demonstrated positive mental health outcomes were; inclusion of a physical exercise component, education components targeting healthy living behaviours (specifically healthy eating and physical activity), group-based sessions aimed at both healthy living and provision of opportunities for adolescents to engage in meaningful activities that promote personal development (such as mastery, friendships, leadership). Mechanisms contributing to significant findings are difficult to identify due to heterogeneity in interventions delivered to adolescents.

Interventions that included a cognitive behavioural component, or that were theoretically based on cognitive behavioural theory [21 6516 22], showed positive findings in promotion of mental health and well-being. Cognitive behavioural approach refers to the thoughts and beliefs in relation to behaviour, and this approach is widely accepted as a beneficial therapy for mental health disorders [66-68]. Research suggests that adolescents who have stronger beliefs/confidence about their ability to engage in healthy lifestyle behaviours and perceive them as less difficult to perform are more likely to engage in more healthy choices [1961]. Similarly, opportunities for adolescents to participate in physical activity or diet related activities provide mastery experience. Bandura (1978) outlined mastery experience as key in the theory of Self-Efficacy as this experience builds beliefs about capabilities to produce behaviours that exercise influence over events that affect their lives [69]. Adolescents with greater perceived self-efficacy may be better equipped to maintain healthy lifestyles and deal with adversity such as mental health problems.

Importantly, there were some findings that suggested that intervention groups experienced poorer mental health following obesity prevention interventions compared to control groups [16 1818 20]. Authors in one study acknowledged a potential explanation being that the schools that made up the intervention sample were located in a more urbanised

main island in Tonga [168]. These students may have been exposed to more pressure in terms of achieving high examination results and obtaining employment or overseas tertiary education, compared to the less-urbanised outer island that made up the comparison sample. This may have been a result of biases in sampling technique, however exposes the need for targeted interventions to suit the specific needs of communities, as previously identified as a priority in obesity prevention [70]. Additionally, these findings may reflect negative consequences of the obesity prevention interventions. Potential psychological harm due to ~~weight related~~obesity interventions has been raised in previous research [8]. These results demonstrate the need to assess mental health to ensure no harm is being done to adolescents, and also highlights the importance of incorporating explicit aims to protect mental health of participants involved in such interventions.

What limitations exist in the research to date and what recommendations can be made for future interventions?

As identified in this review, there is evidence for positive mental health outcomes following community-based obesity prevention interventions, however the number of interventions incorporating mental health measures is few (*n*=7). The findings of this systematic review demonstrate the dearth of evidence: there were 14 studies excluded from this review for not including a mental health measure, and two studies that included a measure but failed to report the mental health outcomes at follow-up. Given the co-morbidity between overweight/obesity and obesogenic behaviours with mental and emotional health [4 5 71], and the increased vulnerability to both unhealthy weight and mental health problems during adolescence [72 73], future interventions should aim to include mental health measures to assess the impact such interventions are having on participant's mental health and well-being. In addition, the issue of directionality still remains in relation to changes in obesogenic behaviours and mental health, and risk

factors that may be common to both conditions. Sample biases exist in the reviewed studies with majority of interventions taking place at school [~~17 20 22 61~~16 18-22] and consequently overlooking those adolescents who do not attend school and may represent a population in need of mental health support. Additionally, two [~~18 19~~16 22] of the seven reviewed studies did not find significant improvements in weight status post- intervention, and therefore were not successful in meeting their primary ~~weight~~obesity-related aims. The implications of these null findings are outside the scope of this review however may limit the extent to which mental health can be evaluated as an outcome of the reviewed ~~weight related~~ interventions, given that the effectiveness of interventions' obesity prevention was varied.

Finally, the current review categorized mental health outcomes by disorders, health-related quality of life or self-perception. The extent to which results can be compared is limited by use of different mental health instruments. Mental disorders, for example, have been measured by diagnostic tools indicating presence of a disorder and also symptomatic measures that indicate suspected presence of disorder symptoms. Such differences affect findings as outcomes vary greatly depending on mental health measures being used.

This review has some limitations. As discussed in the GRADE quality of evidence assessment, many studies published have included less than optimal study designs and this may have biased the findings presented here. As the primary aim of obesity prevention interventions is to reduce or prevent weight gain, this may have led to mental health outcomes being under reported or not reported at all. Eligible interventions may therefore have not been included in the analysis because of a lack of published data. A further limitation of this review was that a meta-analysis could not be performed due to heterogeneity in the reviewed studies.

This systematic review was also limited in focusing solely on obesity prevention interventions that were community-based. Studies conducted in clinical settings were excluded from this review and these studies may have provided important insight into the mental health and well-being. Previous research examining mental health in clinical settings have discussed psycho-social issues such as weight stigmatisation, and the negative impact this has on client's emotional health [74]. Within clinical settings, there also appears to be psychological benefits such as improved body image and health related quality of life, however these issues have been underreported due to being considered secondary to the primary aim of ~~weight~~ obesity prevention [75~~-7~~], which reflects the findings found in the current review.

Comment [EH2]: Discussion of findings in clinical settings

Despite limitations this study has a number of strengths. There was a range of obesity prevention interventions included in this review including differences in duration, components and country where the intervention took place. The review process was systematic and all studies included were assessed based on strict eligibility and exclusion criteria and robust review methods were used including the searching of multiple databases to ensure all relevant articles were included in this review. The inclusion of the GRADE quality of evidence assessment ensured that the findings presented here could be considered in relation to the quality of research in which they are found.

Future research needs to build on what is already known about the effect of ~~weight-based~~community based obesity prevention interventions on mental health outcomes in adolescents, as the mechanisms affecting these outcomes are yet to be clearly defined. Mental health ~~needs to become~~is strongly recommended to become a primary outcome of ~~weight based~~obesity prevention interventions, as potential benefits do exist, however rarely have mental health measures been evaluated (or reported) in community-based

interventions. Additionally, two of the reviewed interventions were not successful in reducing or preventing unhealthy weight gain and future research should evaluate the mental health and well-being of adolescents alongside the efficaciousness of obesity prevention initiatives, to highlight potential shared underlying mechanisms.

Comment [EH3]: Improved for clarity

Conclusions

Co-morbidity between poor mental health and poor physical health is well-established [76] and evidence for successful community-based obesity prevention strategies among adolescents is growing. A focus now needs to be placed on mental health of adolescents in these interventions. It is recommended that obesity prevention interventions incorporate mental health measures to monitor the mental health and well-being of adolescents. This review supports a shift in thinking around mental health, from a secondary outcome of these interventions to a primary outcome alongside overweight and obesity~~weight~~, to ensure that the mechanisms leading to co-morbidity can be identified and outcomes can be improved through these interventions. In addition, including such measures can allow care to be taken to ensure that community-based obesity prevention initiatives do not have adverse effects on adolescents' mental health.

Comment [EH4]: Improved wording so not as strong, removed the word 'needs' from most sentences.

Competing interests

The authors have no conflict of interest to declare.

Authors' contributions

EH contributed to the conception and design of the study, performed the literature search, extracted and analysed data, and drafted and revised the manuscript. MFT and HS contributed to the conception and design of the study, analysed data, critically revised the manuscript and approved the final draft. LM screened articles for eligibility

for review. LM and MN were involved in drafting the manuscript, critically revising the piece and approved the final draft. SA critically revised the manuscript and approved the final draft for publication.

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Figure 1. Search terms and strategy used in CINAHL, Global Health, Health Source: Nursing and Academic Edition, Medline, PsycARTICLES and PsycINFO, all of which were accessed through EBSCOhost. In addition, the same search was also performed on the Cochrane Database to ensure all relevant articles were screened for eligibility.

Figure 2. Flow diagram of studies that were identified using the search terms and strategy, articles screened for eligibility, included/excluded with reasons, following PRISMA guidelines

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Figure 1. Search terms and strategy

Mental health OR mental disorder* OR depress* OR anxiety OR psychiat* OR well-being OR quality of life OR self-esteem OR self perception

And: Weight OR BMI OR body mass index OR overweight OR obes* OR waist circumference OR skin fold* OR central adiposity

And: Adolescen* OR teen* OR youth

And: interven* OR intervention study OR randomised controlled trial OR RCT OR prevent*

Limiters: all in abstract, peer reviewed, - October 2014

761 articles found

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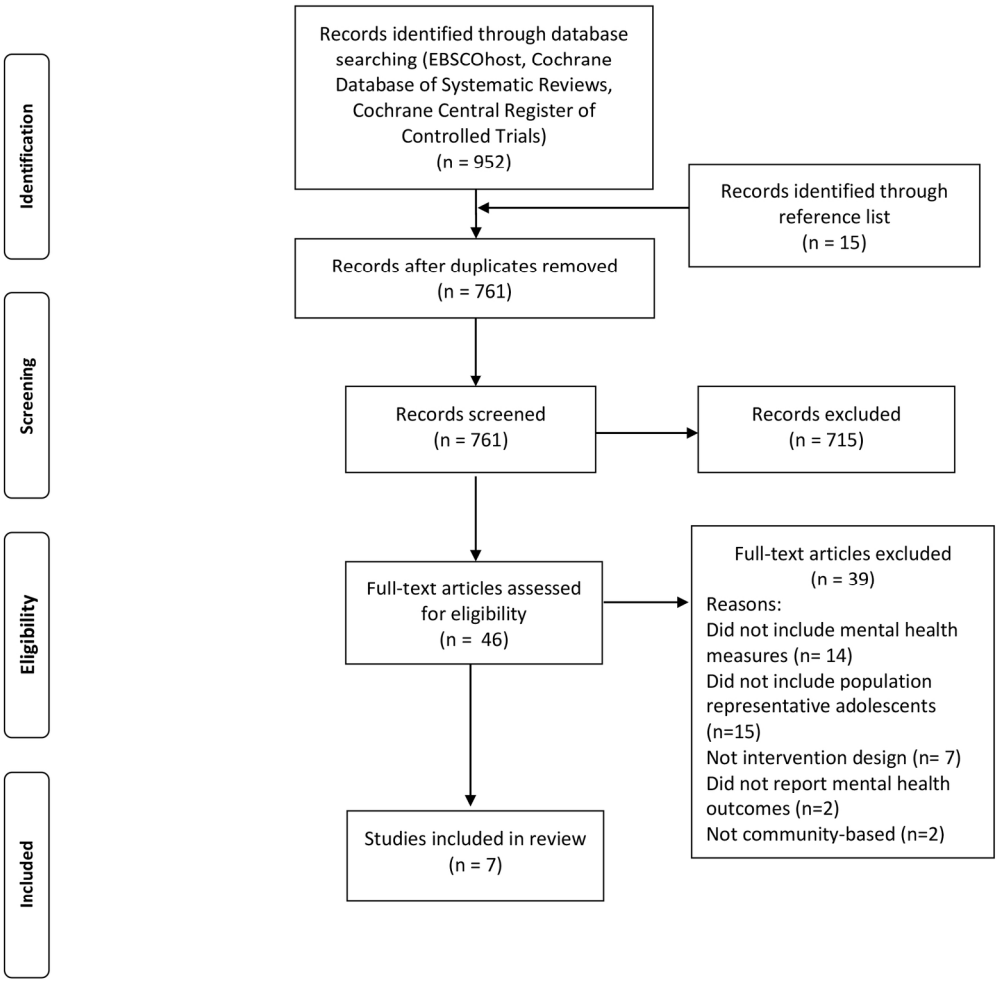
Figure 2: Flow Diagram of Included Studies



181x188mm (300 x 300 DPI)

Supplementary Table1: Excluded studies with reasons

#	**Author**	**Reason for Exclusion**
1	Berkey *et al*., 2003, Pediatrics, 111	Not an intervention design
2	Blissmer *et al*., 2006, Health Qual Life Outcomes, 4(43)	Aged >18 years
3	Bonsergent *et al*., 2013, Am J Prev Med, 44(1)	Did not report MH outcomes at follow-up
4	Carrel *et al*., 2005, Arch Pediatr Adolesc Med, 159(10)	Overweight adolescents
5	Chen et al., 2014, Pediatrics, 133(4)	Not an intervention design
6	Coleman *et al*., 2005, Arch Pediatr Adolesc Med, 159(3)	Did not sample adolescents
7	Ebbeling *et al*., 2006, Pediatrics, 117(3)	Did not include MH outcomes
8	Foster *et al*., 2012, Pediatr, 130(4)	Overweight/obese adolescents
9	Gortmaker *et al*., 1999, Arch Pediatr Adolesc Med, 153(9)	Did not include MH outcomes
10	Haerens *et al*., 2006, Health Educ Res, 21(6)	Did not include MH outcomes
11	Hawley *et al*., 2006, J Community Health Nurs, 23(2)	Did not include comparison group
12	Heinicke *et al*., 2007, J Abnorm Child Psychol, 35(3)	Focus on eating disorders
13	Jamner *et al*., 2004, J Adolesc Health, 73(8)	Sedentary female adolescents
14	Jelalian *et al*., 2010, Journal of Pediatrics, 157 (6)	Overweight adolescents
15	Killen *et al*., 1988, JAMA, 260(12)	Did not include MH outcomes
16	Kimm *et al*., 2005, Lancet, 366(9482)	Not an intervention design
17	Kotte et al., 2014, Physical Therapy, 94(9)	Adolescents with disability
18	Loth *et al*., 2011, J Pediatr Psychol, 36(2)	Not an intervention design
19	McKenzie *et al*., 2001, Am J Prev Med, 21(2)	Did not include MH outcomes
20	McMurray *et al*., 2002, J Adolesc Health, 31(2)	Did not include MH outcomes
21	Mellin et al., 1987, J Am Diet Assoc, 87(3)	Overweight and obese adolescents
22	Morgan *et al*., 2012, Pediatric Obesity, 7 (3)	Sampled low active males
23	Neumark-Sztainer *et al*., 2003, Prev Med, 37(1)	Overweight or at risk for overweight female adolesecents
24	Nguyen *et al*., 2012, Archives of Pediatric & Adolescent Medicine, 166(2)	Overweight and obese adolescents
25	Pate *et al*., 2005, Am J Pub Health, 95(9)	Did not include MH outcomes
26	Patrick *et al*., 2006, Arch Pediatr Adolesc Med, 160(2)	Did not include MH outcomes
27	Peralta *et al*., 2009, Prev Med, 48(6)	Did not include MH outcomes
28	Pott *et al*., 2009, Int J Eating Disorders, 42(3).	Did not report MH outcomes at follow-up
29	Prosper *et al*., 2009, Californian Journal of Health Promotion, 7.	No comparison/control group

30	Robertson *et al*., 2011, Child: care, health and development, 38(2)	Aged <13 years
31	Singh *et al*., 2007, Arch Pediatr Adolesc Med, 161(6)	Did not include MH outcomes
32	Singh *et al*., 2009, Arch Pediatr Adolesc Med, 163(4)	Did not include MH outcomes
33	Staiano et al., 2013, Obesity, 21(3)	Overweight and obese adolescents
34	Spiegel *et al*., 2006, Obesity, 14(1)	Did not include MH outcomes
35	Stice *et al*., 2013, Journal of Consulting and Clinical Psychology, 81 (1)	At risk for overweight/obesity
36	Toumbourou *et al*., 2014, Australian Psychologist, 49(2)	Not an intervention design
37	Verhaeghe *et al*., 2012, BMC Pub Health, 12(431)	Aged >18 years
38	Webber *et al*., 2008, Am J Prev Med, 34(3)	Did not include MH outcomes
39	Zahner *et al*., 2006, BMC Pub Health, 6(147)	Did not include MH outcomes

PRISMA 2009 Checklist

Section/topic	#	Checklist item	Reported on page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	1
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	2
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	4-6
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	4-6
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	NA
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	7-8
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	7-8
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	6-7 (figure 1)
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	7-8
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	8
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	7-8
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	9
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	8-9
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.	7-9

PRISMA 2009 Checklist

Section/topic	#	Checklist item	Reported on page #
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	10
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	NA
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	11 (figure 2)
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	11-12 (Table 1)
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	14-15
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	11-13
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	NA
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	14-15
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	NA
DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	15-17
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	17-19
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	20
FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	20-21

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