Exploring the evidence base for Tier 3 weight management interventions for adults: a systematic review.

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Abstract

Background: Specialist weight management services provide a treatment option for severe obesity.

Objective: To review the characteristics, impact and practice implications of specialist weight management services for adults in the UK.

Design: Systematic review. EMBASE, MEDLINE and PsycINFO were searched from January 2005 to March 2016 with supplementary searches.

Inclusion criteria: Adults with a body mass index of ≥40kg/m^2, or ≥35kg/m^2 with comorbidity or ≥30 kg/m^2 with type 2 diabetes. Any study of multicomponent interventions, in any UK or Ireland setting, delivered by a specialist multidisciplinary team.

Results: 14 studies in a variety of settings were included: 1 randomised controlled trial; 3 controlled and 10 observational studies. Mean baseline body mass index and age ranged from 40-54 kg/m^2 and 40-58 years. The studies were heterogeneous making comparisons of service characteristics difficult. Multidisciplinary team composition and eligibility criteria varied; dropout rates were high (43-62%). Statistically significant reduction in mean body mass index over time ranged from -1.4 kg/m^2 to -3.1 kg/m^2 and mean weight changes ranged from -2.2 kg to -12.4 kg. Completers achieving at least 5% reduction of initial body weight ranged from 32%-51%. There was evidence for improved outcomes in diabetics.

Conclusions: Specialist weight management services can demonstrate clinically significant weight loss and have an important role in supporting adults to manage severe and often complex forms of obesity. This review highlights important variations in provision and strongly indicates the need for further research into effective approaches to support severely obese adults.

Introduction

England, typical of many high income countries, is facing an obesity epidemic with around a quarter of adults currently classed as obese[1]. In the UK obesity is managed on a tiered pathway: Tier 1: universal prevention services; Tier 2: lifestyle weight management interventions; Tier 3: specialist multidisciplinary weight management service (WMS); Tier 4: bariatric surgery[2,3,4]. Tier 3 services are recommended for adults with a body mass index (BMI) of ≥40kg/m^2, or ≥35kg/m^2 with co-morbidities, or ≥30kg/m^2 with type 2 diabetes mellitus (T2DM); who have been unsuccessful in losing weight through standard multicomponent lifestyle interventions (Tier 2). Since this review was conducted the National Institute for Health and Care Excellence (NICE) have published further guidance[5] on referral criteria for Tier 3 services: adults with a BMI of 30 or more for whom Tier 2 interventions have been unsuccessful.

An NHS England and Public Health England Working Group provided a working example of a Tier 3 service. A Tier 3 service is comprised of a multidisciplinary team (MDT) of specialists, led by a clinician and typically including: a physician (consultant or GP with a special interest); specialist nurse; specialist dietitian; psychologist or psychiatrist; and physiotherapist/physical activity specialist/physiology[3]. Clinical and commissioning guidance exist to support the delivery of Tier 3 services[6,7] and provide an evaluation framework[8].

Clinical commissioning groups and local authorities commission Tier 3 services in England, but there is no universal provision, with a number of areas not offering any or little in the way of specialist services[3,7,9,10]. A recent publication on the rewards and challenges of setting up a Tier 3 adult WMS in primary care called for more robust evaluation of Tier 3 services to demonstrate cost-effectiveness to the NHS[11].

Hassan et al[12] recently published a review examining the effectiveness of lifestyle interventions for adults with severe obesity. The review included 17 RCTs of at least 12-weeks duration; participants receiving the lifestyle intervention had a greater decrease in weight than participants in the control group for all studies (1.0–11.5 kg). The review was the first

systematic review to focus on lifestyle interventions for the severely obese and identified one RCT that exclusively targeted adults with a mean BMI >40 kg/m^2 (the other study participants had a comorbidity associated with excess weight and a mean baseline BMI between 35 kg/m^2 and 38 kg/m^2). In addition, quality of life was only reported in two RCTs. None of the RCTs were set in the UK.

Currently there is no review of Tier 3 services in the UK. This review aims to establish the evidence base for Tier 3 WMS for adults, both in hospital and the community, by exploring service characteristics, effectiveness and implications for practice. This paper is published as a summary of a report commissioned by Public Health England (PHE). Importantly, part of the translational work associated with this review involves the development of resources to support commissioners and providers of WMS as outlined in the Department of Health's letter detailing PHE's Strategic Remit and Priorities[13].

Methods

A protocol (a priori, unpublished) was developed in collaboration with the steering group members. The methods are underpinned by the Joanna Briggs Institute (JBI) methodology for scoping reviews [14]. The template for intervention description and replication (TIDieR) checklist and guide were used to extract data on delivery and context[15]. The review is reported following the Preferred Reporting Items for Systematic Reviews guidelines (PRISMA)[16].

Inclusion criteria

Our background research for this review revealed that there were very few published RCTs of Tier 3 WMS for adults in the UK. As such, we took an overarching approach that is used by NICE to identify the best available evidence[17]. Studies of any design that reported outcomes at least once pre and once post-intervention were included (RCTs, non-RCTs, and uncontrolled before and after studies). Studies with and without comparator groups were included without restriction on the type of comparator.

Adults with a mean baseline BMI of ≥40kg/m^2 or ≥35kg/m^2 with co-morbidities or ≥30 kg/m^2 with T2DM were included. We applied a mean baseline BMI rather than a cut-off because we

were aware of variability and inconsistency in eligibility. Many of the studies identified would pre-date the concept and definition of a Tier 3 service. A pragmatic decision was taken to include WMS that, although not 'Tier 3,' were multicomponent specialist multidisciplinary services, where some but not the entire sample had a mean baseline BMI of ≥40 kg/m^2. In addition, if a study reported outcomes for a subgroup that met our mean baseline BMI criteria, although the whole study did not, then the data for the relevant subgroup were extracted.

Multicomponent interventions comprising diet, physical activity and behaviour change were included. The intervention could also include anti-obesity drugs, low-energy liquid diets (LELD) or pre/post-bariatric surgery care. Interventions delivered by a MDT including specialists or clinicians were included. All study designs of any duration and setting were included. Interventions based in the UK or Ireland and published from 2005 onwards were included. There was no restriction on the type of outcome data.

Embase, MEDLINE and PsycINFO were searched from January 2005 to March 2016 and articles were retained within a Reference Manager database and further limited to UK-based studies using keywords and text words in the abstracts containing 'England', 'Ireland', 'Scotland', 'United Kingdom' or 'Wales'. Database searches were supplemented by hand searches and resources provided by the steering group and study author contacts. Reference lists of full-text articles were searched for additional studies. The titles and abstracts were screened by one reviewer (TB) who then screened full-text articles. Articles that were unclear for inclusion were independently screened by a second reviewer (LE) and a steering group member (AA). Articles that remained unclear were referred to PHE for final decision (JB, VC, BH).

Data extraction tables were developed to record participant and study characteristics, intervention components and outcomes. Quality appraisals were carried out using the JBI appraisal tools[18]. The studies were subjectively ranked as low (<4/9), moderate (4-6/9) or high quality (≥7/9) depending on how many of the quality assessment criteria were met. All data were independently extracted by two reviewers (TB, COM); throughout the process a third

reviewer (LE) was consulted if any queries arose. Evidence was appraised taking account of study design, quality and setting.

Results

The searches identified 1913 articles of which 120 were obtained and screened as full-text articles. Figure 1 shows the study flow. Grey literature searching, reference list searching and contacting authors resulted in the identification of two additional articles. In total, 14 studies met the inclusion criteria and were included; 105 articles were excluded of which 11 were studies of children which are reported in a separate systematic review (TJ Brown, LJ Ells, C O'Malley, et al. – unpublished data). Table 1 shows study characteristics including participant baseline characteristics. Supporting information can be found in supplementary tables for: detailed characteristics of included studies (Table S1), descriptions of interventions (Table S2), quality assessment (Table S3) and additional outcomes (Table S4).

Characteristics of interventions

Due to the heterogeneity of the included studies, meta-analyses were not possible, therefore a narrative synthesis is provided.

Study design

One study was an RCT[19]. Three studies had a control group (a retrospective case-control study[20], a prospective nonrandomized trial with a contemporaneous observational control group[21], and a retrospective non-contemporaneous matched cohort study[22]). Ten studies were uncontrolled, mainly observational cohorts (WMS evaluations) and one was a repeated measures cross-sectional study of a WMS[23]. Two studies had a usual care comparison group.

Setting and service characteristics

Seven studies evaluated the impact of existing Tier 3 WMS and one evaluated quality of life using participant data from a Tier 3 service[23]. Four studies were of specialist WMS commissioned by Greater Glasgow and Clyde NHS Health Board (GCWMS). One of these studies[25] adapted the service for adults with intellectual disabilities (TAKE-5).

Six studies had similar characteristics to a Tier 3 service; three were hospital-based services for adults with T2DM published between 2005 and 2008[19,20,26]. Two evaluated a commercial weight management programme, set within primary care[27,28]. Another hospital-based study evaluated a specialist weight management study for patients with chronic kidney disease (CKD) who were required to lose weight prior to kidney transplantation[21].

Intervention content

All interventions were multicomponent including diet, exercise and behaviour change; seven studies reported including optional pharmacotherapy. Some studies reported a theoretical underpinning of the intervention and training of programme deliverers. There was no evidence to suggest user group involvement in the design of the services; one study reported that a patient run support group was set up to provide long term support and motivation for discharged patients. The studies were too heterogeneous to make further inferences about service content.

Delivery

The MDT composition varied across the studies; most interventions included a dietitian or dietetic assistant, and around half included a physician. The studies were heterogeneous making comparisons of delivery difficult, however the majority of studies had a multidisciplinary team delivering the services. Table S1 provides further detail of the delivery setup.

Size and duration

Studies samples ranged from 28 to 6505 participants. Twelve studies had samples of <850; one study had a sample of 3170 and another study had a sample of 6505. Duration of intervention including final follow-up, ranged from 8 weeks to 24 months; six studies followed-up participants at 12 months or longer. Table S2 provides detailed description of interventions.

Quality

Two studies were low quality (<4/9) mainly due to poor reporting of methods, nine studies were moderate quality (4-6/9) and three studies were high quality (≥7/9); however none of the studies scored more than 7/9. The quality domains that most studies failed to meet were

insufficient duration of follow-up and exclusion of dropouts from analyses. Table S3 provides detailed quality assessments.

Participants

Eligibility criteria for weight in each study varied greatly. Two of the six studies[31,32] published at the same time or subsequently to the guidelines for Tier 3 WMS[7] reported using the guideline criteria. Eligibility criteria across ten studies ranged from BMI ≥30 to BMI ≥40 with no comorbidities and BMI ≥28 kg/m^2 to BMI ≥35 kg/m^2 with comorbidities. In two studies (both retrospective), eligibility criteria for weight were not reported. Mean baseline BMI ranged from 34 kg/m^2 to 54 kg/m^2.

Most of the studies included adults with obesity-related comorbidities; two studies recruited adults with T2DM[26] (participants in one study were on insulin therapy)[19]. One study recruited adults with CKD[21]. Two studies recruited bariatric patients for specialist WMS prior to surgery[22,32]. One study recruited adults with intellectual disabilities[25].

Mean baseline age ranged from 40 to 58 years. One study included females only[20] and 13 studies included males and females; in eleven of these studies the majority were female (55% to 81%). Only four studies reported ethnicity; in three of the study samples the majority were 'white' (56% to 99%). In one study[21] of adults with CKD, 55% were male, 47% were white, 40% were black, and 13% were Asian or other ethnicity. Five studies reported area deprivation and reported that 34% to 62% of participants were from the most deprived areas.

Two studies compared the characteristics of adults not recruited with those recruited. Jennings et al.[30] reported there was no difference in participants who only attended for assessment and those who were recruited in terms of gender, baseline weight or BMI. However recruited participants were 7.5 years older and reported a better quality of life than participants who only attended for assessment. Morrison et al.[24] reported that females were more likely than males to opt in (73.6% v. 69.4%, respectively; p=0.02) but among those who opted in there was no significant difference between the sexes in the proportion who completed the programme.

Effects of interventions

Table 2 provides anthropometric outcome data and Table S4 provides detailed information for all reported outcomes.

Attendance/compliance

Ten studies reported dropout rates which varied from 13% to 89% by the end of each study which ranged from two to 24 months; the majority of the studies had a dropout which ranged from 43% to 62% over six to 24 months. The 89% dropout relates to an established Tier 3 study, which lasted up to 24 months and included three phases of intervention[29]. Three studies[19,25,32] had relatively low dropout of between 13% and 20%, and were in carefully selected or volunteer samples.

Two studies compared the characteristics of dropouts with completers. Brown et al.[31] reported that completers were significantly older (49.2 compared with 46.9 years, p=0.005), had a greater prevalence of obstructive sleep apnoea (p=0.0001) and had a greater referral BMI (p=0.02). Crowe et al.[32] reported that compared to non-completers, completers were older (47.9 ± 11.2 versus 40.7 ± 12.9 years, p=0.003), were more likely to be men (34.7 versus 10.3 %, p=0.008) and were more likely to have diabetes (35.8 versus 13.8 %, p=0.03).

Two studies reported the effect of attendance on weight loss; Ross et al.[28] reported that the most favourable weight loss results were seen in adults with high attendance. MacLaughlin et al.[21] also reported that adults with higher attendance were associated with significantly greater weight loss, reduction in BMI and systolic blood pressure (BP) compared to adults with lower attendance.

Anthropometric

There were no RCTs included in adults without comorbidities. Six studies reported change in BMI; with statistically significant change in mean BMI over time ranging from -1.4 kg/m^2 to -3.1 kg/m^2.

Twelve studies (including 1 RCT) reported change in weight; mean change in weight over time ranged from -2.2 kg to -12.4 kg. The majority of studies reported a weight loss in the range of 2 kg to 6 kg. In seven studies the reduction in weight over time was statistically significant.

Seven studies reported percentage (%) weight change; change in % weight over time ranged from -3.9% to -9.6% for completers, with follow-up ranging from 6 to 24 months.

Six studies reported clinically significant weight losses of ≥5% initial body weight (IBW) and/or ≥10% IBW. These six studies included four medium quality and two high quality studies, one of which also had the largest sample size assessed (1838 participants). Four of these six studies were established Tier 3 services.

The percentages of adults that completed the weight management programmes and achieved ≥5% IBW ranged from 32% to 51%. The percentages of adults that completed the weight management programmes and achieved ≥10% IBW was approximately 10% at 6 months for one lifestyle weight management study[31], and 21-22% at 24 months in two other studies that included pharmacotherapy[29,30].

Sociodemographic factors as potential effect modifiers

The evidence was inconsistent for age, baseline BMI, deprivation and sex. Some evidence suggested that men, certain age groups, and higher baseline BMI was associated with improved weight loss deprivation and diabetes were associated with poorer outcomes.

Co-morbidities

One RCT[19] in adults with T2DM taking insulin reported statistically significant improvement from baseline to 4 months (-2.2 kg for the intervention group and -0.3 kg for control), but this was not sustained at 6-month and 12-month follow-ups. The baseline weight varied between the groups with the intervention group being nearly 6.5 kg higher than control. The mean change in weight was not directly compared between the intervention and control group. In one retrospective case-control study[20] of lifestyle plus sibutramine versus lifestyle only in adults with T2DM, the difference in total weight loss between the two groups was not statistically significant at 6 months (-2.32 kg, n=9 vs -1.9 kg, n=9 respectively).

For adults with T2DM, there is relatively good evidence for significant reductions in HbA1c and improvement in glycaemic control, which might be occurring independent of weight loss via improvements in diet, physical activity or medication use; this improvement occurred in a

variety of settings. Most of the evidence is derived from observational studies; 5 observational studies demonstrated significant reductions in HbA1c levels (either in absolute or % values) over time in adults with T2DM ranging from -0.6% to -7.6% over various durations (one of these studies only showed significant reductions when both the intervention groups with T2DM were combined). One observational study showed non-significant reduction in HbA1c levels over time and one RCT showed significant decreases in HbA1c levels over time by an average of 0.9±1% ($p<0.01$) in the intervention group, while the control group showed a mean decrease of 0.3±0.6% ($p<0.05$); reductions were not sustained at 6-month and 12-month follow-ups.

The only study[21] to report on longer-term clinical outcomes was specific to adults with CKD; patients in the weight management programme had a significantly longer event-free period for the combined outcome (all-cause mortality, myocardial infarction, stroke, and hospitalization for congestive heart failure), than those in the control group.

Quality of Life

There is limited evidence in that only four studies reported on quality of life (1 low, 2 moderate and 1 high quality), three of which reported that Tier 3 services significantly improved quality of life outcomes, in both community and primary care settings, in both bariatric patients and adults with/without comorbidities.

Behaviour change

Very few studies reported behaviour change outcomes; it was not possible to ascertain which components of the programmes (for example diet and/or physical activity or behaviour change techniques) were associated with weight loss.

Costs

None of the studies included a cost-effectiveness analysis. Two studies reported costs per participant in primary care based services. Lean et al.[27] reported costs of £861 per patient entered, or £2611 per documented 15 kg loss achieved. Jennings et al.[30] reported that a primary care based Tier 3 WMS cost between £900 and £1250 per year for each patient.

Discussion

The evidence in this review indicates that specialist MDT services can deliver clinically significant weight loss for adults. Due to the majority of evidence being derived from observational studies we focus on impact, rather than effectiveness, when describing change in outcomes and on the whole this is change from baseline to post intervention. Of note, where we report impact, we do so alongside the methodological quality of the study. We appreciate that impact results from uncontrolled studies should be treated with caution. The absence of a comparison group for the majority of studies makes it impossible to know what would have happened without the intervention. Some of the particular problems with interpreting data from uncontrolled studies include susceptibility to problems with confounding and regression to the mean[33].

All anthropometric outcomes demonstrated significant improvements and support a clinically significant weight loss. However, the majority of the studies had a dropout which ranged from 43% to 62% and most of the evidence derived from observational studies. The one included RCT reported a short-term weight reduction over time for the intervention group which was at the lower end of the range observed across the other studies (-2.2 kg); however, this study was in adults with T2DM on insulin therapy. Impact did not appear to vary by study quality, with the high quality studies reporting improvements in anthropometric outcomes across the range reported for all studies.

For adults with T2DM, there is evidence for significant reductions in HbA1c and improvement in glycaemic control. Medications for T2DM, particularly insulin, can promote weight gain; however the evidence suggests that adults with severe obesity and T2DM can reduce their BMI and have a clinically meaningful weight loss. Adults with T2DM have about half the odds of significant weight loss and sustainability of weight loss might be harder to achieve for adults with T2DM.

Very few studies reported on Quality of Life or behaviour change outcomes; better reporting of these types of outcomes is important to understand other potential beneficial outcomes related to WMS and the mechanisms of change underlying anthropometric outcomes.

As there were no studies that compared lifestyle intervention with a usual care control for severely obese adults, we cannot directly compare the effectiveness of Tier 3 WMS with usual care for adults with severe obesity. These types of lifestyle interventions are by their very nature, complex interventions; Medical Research Council guidance states that experimental designs are preferred to observational designs in most circumstances, but are not always practicable and that it is important to also understand processes[34]. In addition, it is difficult to define what 'usual care' means given the substantial variation in England's service provision[9]. It is apparent that NICE have not provided specific guidance on Tier 3 services, perhaps due to a lack of evidence evaluating the effectiveness and cost-effectiveness of Tier 3 services and a lack of information on the optimum composition of the specialist team. This review highlights variation in the composition of the MDT even in established Tier 3 services and it was not always clear if providers were specialists in obesity management. The evidence suggests there was more likelihood of secondary care or primary care –based studies to have physician involvement as part of the MDT compared to community based interventions. None of the established services met all the definitions of a Tier 3 service, in terms of BMI eligibility criteria, pharmacotherapy for obesity and the composition of a MDT. Even within established Tier 3 services only a minority are meeting the suggested composition in the working example of what constitutes an MDT[3]. This may reflect incomplete or limited reporting within the papers or it may reflect actual practice.

It was not possible to discern which intervention components improved which outcomes as most studies lacked a comparator; adding a Tier 3 WMS to Roux-en-Y gastric bypass (RYGB) significantly improved %weight loss. Thus supporting the working groups[3] patient journey of engagement with tier 3 pre and post entry to tier 4. It was difficult to make further inferences about the impact of intervention characteristics on intervention outcomes, given the heterogeneity of the interventions and the study designs. Weight loss did not appear to be modified by study quality or design or duration of the intervention. The intensity of the intervention may affect the amount of weight loss and this requires further exploration. The evidence regarding specific sociodemographic factors as potential effect modifiers of weight

change was inconsistent. The evidence was also inconsistent regarding the role of gender in entering and completing the services; however, the participants in the studies were predominantly female. More research is required regarding potential age and gender inequality in service access.

Lower dropout was seen in carefully selected groups of highly motivated adults. There was no clear pattern in dropout according to setting. Limited evidence demonstrated the most favourable weight loss results in adults with high attendance. When the percentage of participants achieving reductions of ≥5% IBW and ≥10% IBW was reported for larger samples (not limited to completers only) and the follow-up was at least 12 months, the percentage of participants achieving reductions of ≥5% IBW and ≥10% was reduced by about a half.

Hassan et al.[12] recently published a review examining the effectiveness of lifestyle interventions for adults with severe obesity. The review included 17 RCTs (none of which were based in the UK); participants receiving the lifestyle intervention had a greater decrease in weight than participants in the control group for all studies (1.0–11.5 kg). This is similar to the range of weight loss found in this review of UK studies of adults with severe obesity; our review provides UK evidence albeit derived from less robust study designs. Important issues highlighted by Hassan et al.[12] included a lack of RCT evidence exclusively targeted at adults with a mean BMI >40 kg/m^2; by including non-RCT evidence we were able to capture studies exclusively targeted at adults with a mean BMI >40 kg/m^2.

Strengths and limitations

This is the first systematic review of specialist multidisciplinary interventions (Tier 3 WMS) in the UK. Review authors believed there would be limited published evidence for Tier 3 services and so the scope was kept wide. Hence the review included existing Tier 3 services and other specialist multidisciplinary interventions that reflected a Tier 3 service (i.e. a multicomponent intervention provided by a multidisciplinary team for severely obese adults). Evidence from these types of studies strengthens the evidence base and the applicability of specialist multidisciplinary interventions for a wider population of adults with severe obesity. It is

important to note therefore that the review identified the best available evidence, and included interventions that were not established Tier 3 services and would not meet the NICE CG189 guidance for Tier 3 services[6]. Including these studies enabled comparison of services across hospital, community and primary care sites; it also enabled evaluation of such services within select population groups.

This review includes evidence from a broad range of study designs and most of the data derives from observational studies which limits the inferences that can be made in terms of effectiveness. The studies were too heterogeneous to enable meta-analyses; the studies varied in terms of design, duration, setting and types of outcomes reported. The main areas of concern in terms of study quality were insufficient duration of follow-up and exclusion of dropouts from the analyses.

Although some studies reported on sustainability of weight loss, for example, reporting longer-term follow-up data, there were no data that reported immediately after an active intervention phase and then reported data again following a period of no action or a maintenance phase. Therefore we do not know if weight reductions are sustained in the longer-term after completion of treatment.

It was often difficult to ascertain on screening of references for inclusion, which of the community based studies were specialist multidisciplinary interventions (Tier 3) and which were lifestyle interventions (Tier 2). This was mainly due to insufficient information being provided about who was delivering the service.

Implications for practice

Tier 2 and 3 service user populations cannot be directly compared, as tier 3 users are likely to be complex patients with multiple medical and psychological problems. Tier 3 services are likely to have higher staff costs but deliver a service that includes medical assessment and more specialist care given the more severe and/or complex nature of obesity, and/or co-morbidities in these patients. There is a need to clarify composition of MDTs to ensure the complex needs of patients entering a Tier 3 service are met. Services should meet defined

eligibility criteria to ensure equitable provision across the country, and alignment with NICE recommendations and Tier 2 and Tier 4 provision. Comparison across services could be improved by applying a clinical scoring system such as the Edmonton Obesity Scoring System (EOSS)[35,36].

There is a need for standardised key performance indicators for all Tier 3 services. Services should be encouraged to use the standard evaluation framework[8], to improve consistency in reporting and ensure important data such as sociodemographics, dropout rates and longer term outcomes are collected. Stipulating set time points and success criteria would help facilitate comparisons between services. Services should report findings for all patients as well as for completers. Services should record reduction in comorbidities and metabolic parameters to examine wider possible health benefits. It is important services undertake appropriate process and impact evaluations to help understand which elements work and don't work, for whom and why. This should include clear details of how different components are delivered. Cost-effectiveness data must be collected and reported, particularly when there is evidence of effectiveness.

Future services must consider consulting with end users to ensure services are equitable: meeting the needs of all users e.g. men, younger patients, and working patients. Assessing motivation to change is recommended, as evidence suggests attrition rates are lower in carefully selected groups of highly motivated adults.

Implications for research

Future research of specialist multidisciplinary interventions needs to ensure important mediators and moderators such as sociodemographic factors are measured and analysed. Research studies should consider aligning with the standard evaluation framework, to enable comparison of outcomes across studies. More research is required to examine the effectiveness of specialist multidisciplinary intervention provision for minority ethnic groups, younger adults and adults referred to the service from bariatric surgery (Tier 4). More research is required to examine the impact of intensity and different programme components in

specialist multidisciplinary interventions. Future studies should consider using RCT designs where possible and all studies should clearly report the service content and delivery.

Conclusions

Evidence demonstrates that multicomponent weight management interventions provided by multidisciplinary teams can have a positive clinically significant impact for adults with severe and often complex forms of obesity. The review provides evidence to support the provision of Tier 3 services for adults and highlights important variations in Tier 3 provision across the UK, and the need for services that are accessible to and used by all populations in need.

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Author contributions: Tamara J Brown developed the protocol, devised and carried out the searches, screening of references, data extraction and analysis; and wrote the paper. Louisa J Ells developed the protocol, carried out screening of references, data extraction and analysis. Claire O'Malley helped with data collection and carried out data extraction. Bethan Hamilton, Jamie Blackshaw and Vicki Coulton developed the protocol and assisted with screening of references. Carolyn Summerbell helped to develop the protocol. All authors were involved in writing the paper and had final approval of the submitted and published versions.

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Table 1 Summary of included study characteristics

Author, year	Study design	Setting	Interventions	Mean age, years (sd)	Mean baseline BMI kg/m^2 (sd)	Female (%)
Barratt 2008[21]	Retrospective case control	H	Dietitian-led lifestyle (diabetic)	48.89 (8.72)	43.78 (13.56)	100
			Dietitian-led sibutramine + lifestyle (diabetic)	43.67 (11.84)	41.11 (6.93)	100
			Dietitian-led sibutramine + lifestyle (nondiabetic)	40.40 (8.88)	40.04 (7.50)	100
*Brown 2015[32]	BA no control	H	Specialist Lifestyle Management	48.2 (11.6)	49.8 (9.3)	74
Cheyette 2007[20]	RCT	H	Dietitian led weight management for T2DM taking insulin	56.7 (9.7)	34.1 (4.7)	52
			Usual care for diabetics	58.0 (10.7)	31.7 (5.3)	40
*Crowe 2015[33]	Retrospective cohort	COM	Lifestyle programme for bariatric patients	47.9 (11.3)	46.3 (8.3)	65
*Jennings 2014[31]	BA no control	GP	Tier 3 weight management including orlistat	52.7 (13.6)	44.1 (7.8)	70
Lean 2013[28]	Feasibility BA no control	GP	LELD (reintroduction/maintenance/optional Orlistat)	46	48.0 (7.6)	81
*Logue 2014[30]	BA no control	COM	Specialist weight management including orlistat	M: 51.9 (11.96) F: 48.1 (13.86)	43.26 (NR)	73
MacLaughlin 2015[22]	CCT	H	Renal weight management including Orlistat	52.3 (12.9)	36.6 (5.3)	49
			Usual care control	53.3 (12.7)	34.5 (5.1)	42
*Melville 2011[26]	BA no control	HO	Specialist intellectual disability dietetic service	48·3 (12·01	40·0 (8·03)	59
*Morrison 2012[25]	BA no control	H + COM	Specialist weight management	M: 47.5 F: 44.6	41**	
*Patel 2015[23]	Retrospective matched cohort	H	Tier 3 + RYGB	46.5	54.1 (9.4)	76
			RYGB	44	53.2 (11.2)	68
Ross 2008[29]	BA no control	GP	Counterweight	49.4 (13.5	25% = BMI ≥40	77
Rowe 2005[27]	BA no control	H	Diabetic weight management with Orlistat	M: 54.5 (10.8) F: 54.8 (11.6)	39.5 (6.5)	55
*Wright 2013[24]	Cross-sectional	COM	Specialist weight management	49.7 (12.6)	42.32**	76

Legend, Table 1: *established Tier 3 service; ** reviewer calculated; BA: observational before-after study; BMI: body mass index; C: control group (usual care); CCT: controlled clinical trial; C/I: CKD: chronic kidney disease; COM: community; F: female; GP: general practice; H: hospital; HO: home; I: intervention group; LD: Lifestyle diabetic group; LELD: low-energy liquid diet; M: male; NR: not reported; RCT: randomised controlled trial; RYGB: Roux-en-Y gastric bypass; sd: standard deviation; SID: Sibutramine + lifestyle diabetic group; SIO: Sibutramine + lifestyle nondiabetic group; T2DM: type 2 diabetes mellitus

Table 2 Anthropometric outcomes

Intervention				Body Mass Index (kg/m^2)	Weight (kg)			
Study Summary	**Group**	**No.**	**Duration (months)**	**Mean change from baseline (sd/95% CI)**	**Mean change from baseline (sd/95% CI)**	**Mean % change from baseline (sd/95% CI)**	**% pts ≥5% IBW**	**% pts ≥10% IBW**
Barratt 2008[21] SID vs LD = NS, did not directly compare nondiabetic group (SIO) with diabetics groups (SID/LD), statistical significance from baseline to follow-up not clear	Sibutramine + lifestyle nondiabetic (SIO)	Assessed: n=10	6	-4.07 (2.98)	-10.74 (7.49)	-9.66% (1.74)	80%, 8/10	NR
	Sibutramine + lifestyle diabetic (SID)	Assessed: n=9		-2.32 (1.12)	-6.36 (3.10)	-5.81% (0.91)	66%, 6/9	
	Lifestyle diabetic (LD)	Assessed: n=9		-1.9 (1.20)	-5.26 (3.53)	-4.54% (0.94)	44.4%, 4/9	
Brown 2015[32] Statistically significant improvement from baseline to follow-up	Specialist Lifestyle Management Programme (SLiM)	Enrolled: 828 Assessed: 424	6	3 months: -1.3 (2.1), n=404 6 months: -2.0 (2.8), n=464; 6 months: -1.48 (-1.3 to -1.7), n=828;	3 months: -3.7 (5.4), n=404 6 months: -5.5 (7.4), n=464; 6 months: -4.1 (-3.1 to -4.0), n = 828;	6 months: 3.9% (5%), n=464 6 months: 2.9% (4.9%), n=828	6 months: 32.3%, n=464, 24.9%, n=828	6 months: 7.7%, n=828 6 months:10 %,approx. from figure, n=464
		Subset diabetics enrolled/assessed: 266/142		6 months: -1.2 (8.9),	-5.7 (6.9)	-4.0 % (4.57%)	30%	11%
Cheyette 2007[20] Mean difference between groups not reported (intervention group 6.5 kg heavier at baseline than control), Statistically significant improvement from	Dietitian led, weight management programme for T2DM taking insulin	Randomised: 29 Assessed: 21	12	NR	4 months:-2.2 (2.7), n=29 12 months: 0.0 (NR), n=21, NS from baseline	NR	NR	NR
	Usual care	Randomised: 20		NR	4 months: -0.3 (NR)	NR	NR	NR

Intervention				Body Mass Index (kg/m^2)	Weight (kg)			
Study Summary	**Group**	**No.**	**Duration (months)**	**Mean change from baseline (sd/95% CI)**	**Mean change from baseline (sd/95% CI)**	**Mean % change from baseline (sd/95% CI)**	**% pts ≥5% IBW**	**% pts ≥10% IBW**
baseline to 4 months not sustained at 6-month and 12-month follow-ups		Assessed: 18			6 months: +1.1 (NR), n=18, NS from baseline			
Crowe 2015[33] Statistically significant improvement from baseline to 2 month follow-up	Lifestyle programme for bariatric patients	Enrolled: 183 Assessed: 150	2	-1.4 (-2.1 to -0.7)	-2.7 (-3.4 to -2.0)	NR	NR	NR
Jennings 2014[31] Statistically significant improvements in weight from baseline to each follow-up for completers, those with recorded weight and BOCF except BOCF at final 24-mnth follow-up	Tier 3 weight management including orlistat	Recruited: 230 Assessed: 230	24	NR	3 months: -3.4 (3.9), n=230 6 months: -4.0 (5.6), n=230 9 months: -5.5 (6.8), n=230 12 months: -5.9 (7.8), n=230 18 months: -4.7 (9.7), n=157 24 months: -2.6 (7.4), n=84	24 months: -2.3% (6.3%), n=84 24 months: -5.1% (9.1%), n=29	24 months: 23.9% (20/84) 24 months: 44.8% (13/29)	24 months: 10.7% (9/84) 24 months: 20.7% (6/29)
		BMI≥40 subgroup, n=155		-3.1 (NR)	3 months: -4.3 (4.2), n=152 6 months: -6.9 (5.9), n=134 9 months: -9.0 (7.4), n=102 12 months: -9.3 (8.7), n=116			
Lean 2013[28] Statistically significance from baseline to follow-up	LELD (reintroduction/maintenanc	Entered: 91 Assessed: 91	12	NR	-12.4 (11.4)	-9.1% (8.2%)	NR	NR

Intervention				Body Mass Index (kg/m^2)	Weight (kg)			
Study Summary	**Group**	**No.**	**Duration (months)**	**Mean change from baseline (sd/95% CI)**	**Mean change from baseline (sd/95% CI)**	**Mean % change from baseline (sd/95% CI)**	**% pts ≥5% IBW**	**% pts ≥10% IBW**
not reported as not powered	e/optional Orlistat)							
Logue 2014[30] Statistically significant improvement from baseline to follow-up	Specialist weight management including orlistat	Referred: 6505 Eligible: 5637 Assessed: 1838 (LOCF)	Up to 24 months (end of phase 3 = 19 months)	NR	3 months: -2.7 (-2.9 to -2.5) 6 months: -3.4 (-3.6 to -3.2) 12 months: -3.6 (-3.9 to -3.3) 18-24 months: -3.56 (-3.8 to -3.3)	NR	12 months: 24%, n=447/1838 12 months: 51%, n=203/399	NR
		Subgroup Baseline BMI 40-49:	7 months (end of phase 2)	NR	-4.32 (-5.1 to -3.5) n=242 males; -3.49 (-3.9 to -3.1) n=630 female;	NR	NR	NR
		Subgroup BMI ≥50:	7 months (end of phase 2)	NR	-5.97 (-8.1 to -3.9) n=80 male; -3.93 (-4.8 to -3.1) n=209 female	NR	NR	NR
MacLaughlin 2015[22] statistically significant difference between groups for weight at 12 months, statistically significant improvement from baseline to 24-months for BMI and % weight for intervention group	Renal weight management programme including Orlistat	Referred: 369 Recruited: 185 Assessed: 169	24	24 months: I: -1.5 (0.2), n=135	12 months: -4.3 (5.5), n=169	24 months: -4.0% (0.5), n=135	24 months:42.7 %, n=135	24 months: 22.1%, n=135
	usual-care control	Declined and became C:175 Assessed: 169		NR	12 months: -1.9 (6.6)	NR	NR	NR

Intervention				Body Mass Index (kg/m^2)	Weight (kg)			
Study Summary	**Group**	**No.**	**Duration (months)**	**Mean change from baseline (sd/95% CI)**	**Mean change from baseline (sd/95% CI)**	**Mean % change from baseline (sd/95% CI)**	**% pts ≥5% IBW**	**% pts ≥10% IBW**
Melville 2011[26] Statistically significant improvement from baseline to follow-up	TAKE 5 specialist intellectual disability dietetic service	Invited: 101 Participated: 54 Assessed: 47	6	-1·82 (-2·36 to -1·29)	-4·47 (-5·91 to -3·03)	NR	36·2%, n=47	NR
Morrison 2012[25] Statistical significance not reported	Specialist weight management	Referred: 3170 Assessed: 2976	4	NR	NR	NR	NR	NR
Patel 2015[23] Statistically significant difference between groups for % weight change at 6 and 12 months	Tier 3+RYGB	I1: 44 I2: 66	12	NR	NR	6 months: -31% (0.10) 12 months: -34% (0.09)	NR	NR
	RYGB			NR	NR	6 months:-23% (0.12) 12 months: -27% (0.87)	NR	NR
Ross 2008[29] Statistically significant improvement in weight from baseline to follow-up	Counterweight	Subgroup (25%) with BMI ≥40 n=160	12	NR	–4.60 (8.86/–5.98 to –3.22)	NR	NR	NR
Rowe 2005[27] Statistically significant improvement from baseline to 6-month follow-up	Diabetic weight management with Orlistat	Recruited: 100 Assessed: 82	24	NR	6 months: -7.1 (NR)	6 months: -6.2% (4.0%)	6 months: 51.2%	NR
Wright 2012[24]	Specialist weight management	Attended ≥4 closed group	4.5	NR	-5.1 (4.3)	NR	NR	NR

Intervention				Body Mass Index (kg/m^2)	Weight (kg)			
Study Summary	**Group**	**No.**	**Duration (months)**	**Mean change from baseline (sd/95% CI)**	**Mean change from baseline (sd/95% CI)**	**Mean % change from baseline (sd/95% CI)**	**% pts ≥5% IBW**	**% pts ≥10% IBW**
Statistically significant improvement from baseline to follow-up		sessions: n=199						

Legend, Table 2: BOCF: baseline observation carried forward; CI: confidence interval; IBW: initial body weight; LD: Lifestyle diabetic group; LELD: low energy liquid diet; LOCF: last observation carried forward; NR: not reported; NS: not significant; RYGB: Roux-en-Y gastric bypass; SIO: sibutramine + lifestyle nondiabetic group; SID: sibutramine + lifestyle diabetic group; SD: standard deviation; T2DM: type 2 diabetes mellitus

Tables and figure legends

Table 1: *established Tier 3 service; ** reviewer calculated; BA: observational before-after study; BMI: body mass index; C: control group (usual care); CCT: controlled clinical trial; C/I: CKD: chronic kidney disease; COM: community; F: female; GP: general practice; H: hospital; HO: home; I: intervention group; LD: Lifestyle diabetic group; LELD: low-energy liquid diet; M: male; NR: not reported; RCT: randomised controlled trial; RYGB: Roux-en-Y gastric bypass; sd: standard deviation; SID: Sibutramine + lifestyle diabetic group; SIO: Sibutramine + lifestyle nondiabetic group; T2DM: type 2 diabetes mellitus

Table 2: BOCF: baseline observation carried forward; CI: confidence interval; IBW: initial body weight; LD: Lifestyle diabetic group; LELD: low energy liquid diet; LOCF: last observation carried forward; NR: not reported; NS: not significant; RYGB: Roux-en-Y gastric bypass; SIO: sibutramine + lifestyle nondiabetic group; SID: sibutramine + lifestyle diabetic group; SD: standard deviation; T2DM: type 2 diabetes mellitus