New debate: is it time for infertility weight loss programmes to be couple-based?

Running title: Should weight loss programmes be couple based?

Damian Best[1,*], Alison Avenell[2], Siladitya Bhattacharya[1], Gertraud Stadler[3]

[1]Aberdeen Fertility Centre, University of Aberdeen, Foresterhill, Aberdeen, AB25 2ZL, United Kingdom. [2]Health Services Research Unit, University of Aberdeen Foresterhill, Aberdeen, AB25 2ZD, United Kingdom. [3]Health Psychology Group, Department of Applied Health Sciences, University of Aberdeen Foresterhill, Aberdeen, AB25 2ZD, Scotland, United Kingdom.

*Correspondence address: Damian Best, Obstetrics & Gynaecology, Faculty of Medical Sciences, University of the West Indies Queen Elizabeth Hospital, St. Michael, BB11155, Barbados. Email dajbest1@gmail.com

Abstract

With obesity on the rise in the general population, it has also become more prevalent among people of reproductive age. Weight loss has shown benefits in overweight women and men experiencing fertility problems. However, the existing weight loss interventions for individuals with infertility are associated with high drop-out rates and limited success. In this article, we argue for the development of weight loss programmes targeting couples, as couples are routinely seen in fertility clinics, rather than individuals. Couples may have correlated weights, and similar eating and activity patterns. Involving both partners may facilitate mutual support, behaviour change, weight loss, and programme continuation, at very little additional cost. A successful couple-based intervention could improve the chances of achieving pregnancy and delivering a healthy baby, with a reduction in pregnancy complications. In the longer run, both partners and their baby could benefit from maintained behaviour change with better health across the lifespan. We conclude that there is a need for research to systematically develop a couple-based weight loss intervention with state-of-the-art design that is tailored to both partners' needs.

Keywords: body mass index / BMI / fertility / weight loss / couple-based intervention / couples / obesity / overweight / pregnancy

Introduction

With obesity on the rise in the general population (World Health Organization, 2016), it has also become more prevalent among people experiencing fertility problems (Vahratian and Smith, 2009). It is widely recognised that being overweight in the face of central adiposity may contribute to delayed conception. Much of the prevailing literature uses weight and body mass index (BMI) as surrogates for adiposity, and while muscle mass may increase these measures, persons with BMI of 30 kg/m^2 or more mostly have excess body fat, as do as many as 50% of those below (Romero-Corral *et al.*, 2008).

In women, insulin resistance secondary to overweight and obesity can disrupt ovulation through its effect on the sex hormone pathway, as well as through leptin and other adipokines (Klenov and Jungheim, 2014; Zain and Norman, 2008; Pantasri and Norman, 2014). Oocyte quality may also be compromised (Klenov and Jungheim, 2014), as embryos derived from the oocytes of obese women have been noted to be of poorer quality (Carrell *et al.*, 2001; Metwally *et al.*, 2007; Metwally *et al.*, 2007). High body mass index may also affect endometrial quality and implantation, as obese recipients of oocytes from normal weight donors are less likely to conceive following in-vitro fertilisation (IVF) than normal weight recipients (Bellver *et al.*, 2007).

In men, increased body weight may also compromise fertility. Excessive lower abdominal fat can increase testicular temperature during episodes of prolonged sitting, which may have implications for spermatogenesis (Hammoud *et al.*, 2012). Obese men have been shown to have increased oestrogen levels, with disruption of the hypothalamo-pituitary-gonadal axis (Shukla *et al.*, 2014; Schneider *et al.*, 1979; Schneider *et al.*, 1979). Such high circulating oestrogen levels have also been shown to have a deleterious effect on spermatogenesis in animal studies (Goyal O *et al.*, 2003). In humans, higher BMI and more central adiposity are associated with reduced sperm concentration, lower total motile sperm count (Eisenberg *et al.*, 2014; Hammiche *et al.*, 2012; Hakonsen *et al.*, 2011; Hammiche *et al.*, 2012; Hakonsen *et al.*, 2011) and abnormal sperm morphology (Hammiche *et al.*, 2012; Hakonsen *et al.*, 2011; Hakonsen *et al.*, 2011). In a systematic review investigating the impact of BMI on sperm parameters (Sermondade *et al.*, 2013) across 21 studies and 13,007 men attending fertility clinics, oligozoospermia and azoospermia were more common among overweight (OR 1.11, 95% confidence interval(CI) 1.01-1.21), obese (OR 1.28, 95% CI 1.06, 1.55), and morbidly obese men (OR 2.04, 95% CI 1.59-2.62) (Sermondade *et al.*, 2013).

Few researchers have studied the association between weight and fertility in both partners. One study of 47,835 couples sought to explore the effect of obesity on couple infertility, over and above the effects on each individual (Ramlau-Hansen *et al.*, 2007). Among couples where both partners were either overweight or obese, the adjusted odds of a delay of over one year in achieving pregnancy were 1.41 (95% CI

1.28, 1.56) for overweight and 2.74 (95% CI 2.27, 3.30) for obese couples, compared to normal weight couples, with a dose-response relationship with increasing BMI. Obesity in both partners was associated with greater difficulty achieving pregnancy (Ramlau-Hansen *et al.*, 2007). Another study found that couples where both partners' BMI exceeded 35.0 kg/m^2 experienced a delay in time to pregnancy, or reduced fecundity, when compared to couples with a BMI below 25 kg/m^2 (adjusted fecundity odds ratio aFOR 0.41; 95% CI: 0.17, 0.98) (Sundaram *et al.*, 2017).

For assisted conception, it would appear that IVF live birth rates (Petersen *et al.*, 2013), but not those with intracytoplasmic sperm injection (ICSI) (Petersen *et al.*, 2013; Wang *et al.*, 2016), might be reduced by couple obesity, though further research seems warranted to confirm whether this is truly the case (Schliep *et al.*, 2015).

Potential benefits of weight loss

Weight loss has shown benefits in overweight women and men experiencing fertility problems (Best, 2016). In overweight women, a weight loss of 10% or more has been shown to improve insulin resistance (Zain and Norman, 2008), spontaneous pregnancy (Lan *et al.*, 2017; Mutsaerts *et al.*, 2016; Duval *et al.*, 2015) and live birth rates (Kort *et al.*, 2014). A reduction of body weight by 2-5% has been associated with restoration of ovulation and a 71% increase in insulin sensitivity (Huber-Buchholz *et al.*, 1999). Weight loss exceeding 3 kg has been associated with an improvement in the numbers of mature oocytes retrieved in IVF cycles (Chavarro *et*

al., 2012). However, it is uncertain whether this translates into improved pregnancy or live birth rates in these cycles, as some studies suggest no added benefit (Einarsson *et al.*, 2017; Moran *et al.*, 2011; Chavarro *et al.*, 2012; Moran *et al.*, 2011), while others do (Clark *et al.*, 1998; Sim *et al.*, 2014a). In obese men, a weight loss programme was associated with improvement in semen quality (Hakonsen *et al.*, 2011), while a dietary programme resulted in reduced abdominal fat, decreased sperm DNA fragmentation, and improvement in metabolic and hormone profiles, with all spouses in the latter case series becoming pregnant (Faure *et al.*, 2014). In a prospective uncontrolled pilot study (Homan *et al.*, 2012), 23 infertile couples received motivational face-to-face interviews on an on-going basis with one to two weekly phone calls over four months. The weight loss achieved was not precisely described, but 47% were reported to having "a modest loss of between 1 and 5 kg". Eight of the twenty-three couples conceived by the end of the follow-up period (Homan *et al.*, 2012).

Individual-based weight-loss interventions

Weight loss requires dietary modification, with or without a change in physical activity, to induce a caloric deficit resulting in the body metabolising fat. Individual-based programmes described in the literature to improve fertility have utilized such strategies as low calorie diets, usually low in fat and saturated fat and added sugars, (Turner-McGrievy *et al.*, 2014; Qublan *et al.*, 2007; Mavropoulos *et al.*, 2005; Thomson *et al.*, 2009; Qublan *et al.*, 2007; Mavropoulos *et al.*, 2005; Thomson *et al.*, 2009), low glycaemic index diets (Becker *et al.*, 2015), very low calorie diets (Kiddy

et al., 1992; Tsagareli *et al.*, 2006; van Dam *et al.*, 2004; Tsagareli *et al.*, 2006; van Dam *et al.*, 2004), and a variety of different diets with exercise (Karimzadeh and Javedani, 2010; Moran *et al.*, 2011; Moran *et al.*, 2003; Thomson *et al.*, 2008; Salama *et al.*, 2015; Khaskheli *et al.*, 2013; Hollman *et al.*, 1996; Mahoney, 2014; Mutsaerts *et al.*, 2016; Sim *et al.*, 2014b; De Frene *et al.*, 2015; Miller *et al.*, 2008; Moran *et al.*, 2011; Moran *et al.*, 2003; Thomson *et al.*, 2008; Salama *et al.*, 2015; Khaskheli *et al.*, 2013; Hollman *et al.*, 1996; Mahoney, 2014; Mutsaerts *et al.*, 2016; Sim *et al.*, 2014b; De Frene *et al.*, 2015; Miller *et al.*, 2008). Motivational interviewing has also been described as a useful tool (Koning, 2015; Karlsen *et al.*, 2013; Karlsen *et al.*, 2013).

Poor programme compliance has been a problem in many weight loss programmes. In a systematic review of discontinuation rates in such interventions among obese infertile women (Mutsaerts *et al.*, 2013), 10 of 15 studies reported discontinuation, with the median discontinuation rate at 24% (range 0-31%). The programmes ranged from 6-32 weeks in duration, with a median of 24 weeks. Given the small number of studies, it was difficult to identify correlates of discontinuation, but the authors noted that weight loss and pregnancy rates were lower in non-compliant persons (Mutsaerts *et al.*, 2013). Two studies suggest that very stringent diets (e.g., vegan or low-carbohydrate ketogenic) may be particularly hard to follow with even higher discontinuation rates than less restricted diets (Turner-McGrievy *et al.*, 2014; Mavropoulos *et al.*, 2005; Mavropoulos *et al.*, 2005). Studies aiming to improve motivation seem to achieve greater success. Two programmes integrated motivational interviewing and had relatively low discontinuation rates of 10.6% at 6

months (Mutsaerts *et al.*, 2016), and 10.9%, respectively (Koning, 2015). An exercise programme for obese infertile women to improve psychological well-being (Galletly *et al.*, 1996) showed a discontinuation rate of 33.3%, with women who dropped out having higher anxiety and depression scores and lower self-esteem at baseline. In summary, weight loss interventions which are mainly focussed on the individual, have high discontinuations rates, even for patients thought to be motivated in order to improve their fertility, and this results in less weight loss associated with lower pregnancy rates.

The rationale for a couple-based intervention

Partner support in everyday life may facilitate behaviour change and continuation in programmes. Infertility clinics are relatively unique in medicine, as they accommodate the needs of couples rather than individuals. Partners support each other during treatment and the emotional upheavals engendered by it. Where weight loss is required as part of their management, it is reasonable to expect that this support would be useful, particularly in facilitating programme continuation. Perhaps it is time to consider the development of weight loss programmes targeting couples, rather than individuals.

Couples may have similar weight and eating and activity patterns

Couples tend to have similar body mass indices, and weight change in one partner can go hand in hand with weight change in the other. A systematic review (Di Castelnuovo *et al.*, 2009) found correlations between partners with regards to BMI

175 (r = 0.15 across 34,582 couples in 19 studies) and weight (r = 0.11 across 6,765
176 couples in 9 studies). A representative study of 11,979 Dutch couples replicated
177 correlations for BMI between partners (r = 0.23) (Monden, 2007). A study including
178 3356 expectant couples attending antenatal clinics (Edvardsson *et al.*, 2013) found
179 a positive partner correlation for BMI (r = 0.21). A woman's odds of being obese
180 were more than six times higher if their partner was also obese, in comparison with
181 women whose partner was of normal weight (OR 6.2, 95% CI 4.2-9.3). More than
182 one third (37.8%, p<0.001) of couples in a study investigating semen parameters
183 were concordant for obesity (Polotsky *et al.*, 2015). A Danish population cohort
184 study reported that couples presenting for IVF resembled each other in BMI, though
185 they did not supply supportive data (Petersen *et al.*, 2013). In a study of weight
186 change in 3722 older couples, the probability of weight loss in women was 36%
187 when the partner also lost weight compared to 15% if the partner's weight was
188 static (Jackson *et al.*, 2015).
189
190 Weight correlations between partners may be attributed to similar eating and
191 activity patterns. For example, an 18-month home-based weight loss trial with 132
192 couples found concordance in daily caloric intake, food intake, including that outside
193 the home, physical activity and sedentary behaviours between partners (Scherr and
194 Gorin, 2011). Prior epidemiological studies have found concordance in many health
195 behaviours in couples, including physical activity and diet (Brummett *et al.*, 2008;
196 Meyler *et al.*, 2007; Homish and Leonard, 2008; Pachucki *et al.*, 2011; Simonen *et al.*,
197 2002; Wilson, 2002) The main barriers to exercise reported by women in another

198 study (Banting *et al.*, 2014) were lack of time and fatigue, and their main physical
199 activity supports were their partners (Banting *et al.*, 2014). This compels us to
200 consider whether couple-based interventions might in fact be more useful than
201 individual interventions.
202
203 **Partner involvement may facilitate behaviour change, programme**
204 **continuation, and prove cost-effective**
205 Social support from close others has been a long-standing treatment
206 recommendation for weight loss interventions (Brownell, 1984; Kalodner and Lucia,
207 1990; Look AHEAD Research Group *et al.*, 2006; Perri *et al.*, 2008; Kalodner and
208 Lucia, 1990; Look AHEAD Research Group *et al.*, 2006; Perri *et al.*, 2008). Existing
209 trials involving partners often show greater weight loss effects with interventions
210 involving persons participating with family members rather than individually
211 (Cousins *et al.*, 1992; Black and Lantz, 1984; Murphy *et al.*, 1982; Pearce *et al.*, 1981;
212 Rosenthal *et al.*, 1980; Wing *et al.*, 1991; Avenell *et al.*, 2004; McLean *et al.*, 2003;
213 Black and Lantz, 1984; Murphy *et al.*, 1982; Pearce *et al.*, 1981; Rosenthal *et al.*,
214 1980; Wing *et al.*, 1991; Avenell *et al.*, 2004; McLean *et al.*, 2003). Involving support
215 partners proved beneficial, particularly if the partners actively participated in the
216 programme (Kumanyika *et al.*, 2009) and if they also lost weight (Gorin *et al.*, 2005).
217 Couple-based interventions may be an effective and cost-effective public health
218 approach, as two individuals could lose weight as inexpensively as one (Black and
219 Threlfall, 1989).
220

Trial data illustrate the fact that partners may facilitate behaviour change and weight loss. A meta-analysis in 1990 compared behavioural weight-control programmes involving partners to individual programmes (Black *et al.*, 1990). The programmes contained couples with both concordant and discordant need for weight loss. The authors concluded that couple based programmes were superior to individual interventions immediately post treatment (estimated effect size = 0.331, 95% CI 0.13, 0.54; $p < 0.05$), and at 2- to 3-months' follow-up (estimated effect size = 0.279, 95% CI 0.008, 0.566; $p = 0.06$), though the latter did not reach statistical significance. Participants in a small weight loss trial (N = 23) lost more weight when their partners had normal weight than when their partners were overweight (at 12 months: 12.7 kg vs. 9.2 kg; at 15 months: 13.4 kg vs. 7.9 kg) (Black and Threlfall, 1989), supporting the argument for couple enrolment, even when one partner has no excess weight to lose.

Another small trial (N = 29) of overweight men and women found greater weight loss at 6 months when the partner was cooperative and participated in the programme (13.4 kg) than when the programme was delivered individually, either with a cooperative partner (8.8 kg) or a non-cooperative partner (6.9 kg) (Brownell *et al.*, 1978). Participants in this couple intervention reported that mutual monitoring was key in the early weeks of the programme, and subsequent support and encouragement from their partner enabled them to adhere (Brownell *et al.*, 1978). One further small trial (N = 49) found that overweight women, but not men, with diabetes lost more weight when enrolled with their spouses (Wing *et al.*, 1991). Lastly, 393 UK council employees were enrolled in a large trial to reduce the levels of saturated fat in their diets, either individually or with their partner (Prestwich *et al.*, 2014). Participants receiving the partner-based intervention increased the ratio of 'good' fats to 'bad' fats at 3 and 6 months, and also managed to decrease their waist circumference more than those receiving the individual intervention (effect size not given; p = 0.04).

Preparation for parenthood as a teachable moment for adopting a healthier lifestyle with long-term benefits for both partners and their baby

A successful weight loss intervention could improve the chances of achieving pregnancy and delivering a healthy baby (Best, 2016) via higher spontaneous pregnancy rates (Lan *et al.*, 2017; Mutsaerts *et al.*, 2016; Duval *et al.*, 2015) and possibly better IVF treatment outcomes (Clark *et al.*, 1998; Sim *et al.*, 2014a),

including fewer pregnancy complications (The Royal Australian and New Zealand College of Obstetricians and Gynaecologists, 2011) and more live births (Kort *et al.*, 2014). In the longer run, both partners in addition to their baby could benefit from maintained behaviour change with better health across the lifespan. A healthy weight is related to loer risk for cardiovascular disease, type 2 diabetes, and all-cause mortality (National Clinical Guideline Centre, 2014). Weight loss is related to reduced incidence of Type 2 diabetes in women and men (Avenell *et al.*, 2004; Robertson *et al.*, 2014) and erectile dysfunction in men (Robertson *et al.*, 2014). The point at which couples experience fertility problems could thus become a teachable moment for long-term changes towards a healthier lifestyle, with benefits to the couple and their family over their life course (Cohen *et al.*, 2011).

What is needed for a couple-based intervention?

Need for a systematic approach to intervention development

The existing studies have a number of weaknesses. First, most suffered from small sample sizes. Second, few studies have been conducted outside the United States. Strong cultural differences in eating, physical activity, and close relationships call for adequately powered studies in other countries to establish the generalizability of these findings. Third, most studies were not based on systematic intervention development such as an intervention mapping approach (Eldredge *et al.*, 2016). Studies based on systematic intervention development draw on theory and behaviour change methods; thus, they have the potential to focus interventions on the active ingredients of behaviour change, and systematically improve intervention

effect sizes and weight loss maintenance. In summary, the current evidence underlines the need for systematic intervention development in this field.

Need for a tailored intervention

A weight loss intervention for couples seeking fertility treatment would need to be tailored to the individual needs of both partners. If both partners are obese or overweight, the intervention would need to focus on weight loss in both partners. For non-obese partners, the intervention would focus on supporting weight loss in the obese partner and changing relevant health behaviours for the non-obese partner, for example, eating a healthier diet or becoming more active.

Need for measures to maximize retention

As stated above, a prior review of intervention studies for overweight and obese infertile women had a median discontinuation rate of 24% (Mutsaerts *et al.*, 2013), with lesser weight loss and fewer spontaneous pregnancies in dropouts compared to retained participants. Measures to maximize retention will therefore be critical in the design of future lifestyle interventions for infertile women and their partners. These could encompass tailored information and behavioural recommendations based on participants' prior knowledge and preferences (e.g., offering individualized sessions to develop behavioural recommendations).

Need to address a comprehensive set of behavioural outcomes for fertility

An intervention for overweight partners should include standard recommendations for a calorie-reduced diet, and could include meal replacements, dependent on participant preference. Prior trials have found that exercise alone has minimal effects on weight loss (Franz *et al.*, 2007). However, exercise may help to maintain weight loss, and may be important to include, particularly for its ability to appeal to the male partner (Robertson *et al.*, 2014). Thus, the intervention should include a behavioural goal to increase physical activity, such as gradually increasing walking towards a daily 10,000-step goal, or by taking at least 30 minutes of moderate-to-vigorous activity per day. Non-overweight partners could receive a standard recommendation to eat a healthy diet and increase physical activity, if necessary. Because general recommendations for infertile couples' treatment include advice regarding alcohol and smoking, the intervention should include elements to support either partner in quitting these habits as required. Last, but not least, a couples' intervention could also include a module to improve social processes to facilitate behaviour change.

Need for a better understanding of underlying social processes in weight loss

Few trials so far have assessed the underlying social processes in weight loss, even with inclusion of social network members in some studies. Therefore, there is ample room for improvement in delineating active ingredients and optimising these interventions. Behaviour change methods aimed at changing social support and social influence should boost effects when a behaviour is at least partly influenced

by the social environment (Eldredge *et al.*, 2016). Baseline data from a weight loss trial in women (Kiernan *et al.*, 2012) found low support from family and friends. Many women reported "never" or "rarely" receiving support for healthy eating (from family: 77.9%, from friends: 90.3%) or for physical activity (from family: 77.2%, from friends: 87.6%). Women also reported some sabotaging behaviour from close others, e.g., they "ate high-fat or unhealthy foods in front of me" or they "refused to eat healthy or low-fat foods with me".

The few available trials including partners have used a variety of intervention approaches. These have included partner training for social support to increase positive reinforcement (e.g. praise), role modelling healthier eating, setting goals, and focusing on problem solving; also reduction of negative social control including criticism, punishment, and nagging (McLean *et al.*, 2003). To identify the social processes most relevant to couples seeking fertility treatment, it will be necessary to study support, but also processes that have received less attentions such as social control, companionship, person-to-person contact, and access to resources and material goods (Berkman *et al.*, 2000). Skilled support and positive influence should facilitate behaviour change (Rafaeli and Gleason, 2009; Scholz *et al.*, 2013; Cutrona and Russell, 1990; Scholz *et al.*, 2013; Cutrona and Russell, 1990). Diminishing negative control and sabotaging behaviours (e.g., tempting the dieting partner with high-caloric food) should benefit weight loss additionally (Gorin *et al.*, 2014). Last but not least, the intervention should also promote relationship-strengthening behaviours such as companionship and emotional and physical intimacy (e.g. date

nights, joint fun activities) to counter the distress and irritability that accompanies attempts at behaviour change.

A weight-loss intervention will need state-of-the art methodology

It is feasible and acceptable to use real-time assessments via smartphone apps, passive sensors, and text messages in individuals and couples. Examples have been given for diet (Inauen *et al.*, 2016), physical activity (Berli *et al.*, 2016), alcohol intake (Muench *et al.*, 2017), and for smoking. These assessments could boost intervention effects and facilitate the maintenance of behaviour change. These methods should be tested in couples experiencing fertility problems, underscoring the need for careful pilot work during intervention development.

Conclusion

Overweight and obesity in both men and women attending infertility clinics is a growing challenge. Accumulating evidence demonstrates the effects of weight on reproductive function, and the benefits of weight loss in both sexes. Individual interventions for weight loss in women are often unsuccessful - mainly due to lack of compliance. A couple-based intervention may achieve more efficient weight loss at little additional cost and promises considerable public health benefits. Further clinical trials are warranted to develop and evaluate such an intervention in terms of efficacy, cost and compliance.

Author Roles

All authors contributed to the ideas in this paper. DB and GS wrote the first draft. All authors contributed to revision of drafts.

Funding

No specific funding was sought. All authors were employed by the University of Aberdeen in a research capacity. The Health Services Research Unit is core funded by the Chief Scientist Office of the Scottish Government Health and Social Care Directorate.

Conflicts of Interest

AA, DB, GS and SB have no conflicts of interest to declare.

References

Avenell A, Broom J, Brown TJ, Poobalan A, Aucott L, Stearns SC, Smith WC, Jung RT, Campbell MK, Grant AM. Systematic review of the long-term effects and economic consequences of treatments for obesity and implications for health improvement. *Health Technol Assess* 2004:**21**; iii-iv, 1-182.

Banting L, Gibson-Helm M, Polman R, Teede H, Stepto N. Physical activity and mental health in women with polycystic ovary syndrome. *BMC Womens Health* 2014:**1**; 51.

Becker GF, Passos EP, Moulin CC. Short-term effects of a hypocaloric diet with low glycemic index and low glycemic load on body adiposity, metabolic variables, ghrelin, leptin, and pregnancy rate in overweight and obese infertile women: a randomized controlled trial. *Am J Clin Nutr* 2015:**6**; 1365-1372.

Bellver J, Melo A M, Bosch E, Serra V, Remohi J, Pellicer A. Obesity and poor reproductive outcome: the potential role of the endometrium. *Fertil Steril* 2007:**2**; 446-451.

Berkman LF, Glass T, Brissette I, Seeman TE. From social integration to health: Durkheim in the new millennium. *Soc Sci Med* 2000:**6**; 843-857.

Berli C, Stadler G, Inauen J, Scholz U. Action control in dyads: A randomized controlled trial to promote physical activity in everyday life. *Soc Sci Med* 2016:**163**; 89-97.

Best D. A systematic review of non-surgical weight reduction strategies in the infertile. *Thesis* 2016.

Black DR, Threlfall WE. Partner weight status and subject weight loss: Implications for cost-effective programs and public health. *Addict Behav* 1989:**3**; 279-289.

Black DR, Lantz CE. Spouse involvement and a possible long-term follow-up trap in weight loss. *Behav Res Ther* 1984:**5**; 557-562.

Black DR, Gleser LJ, Kooyers KJ. A meta-analytic evaluation of couples weight-loss programs. *Health Psychol* 1990:**3**; 330-347.

Brownell KD, Heckerman CL, Westlake RJ, Hayes SC, Monti PM. The effect of couples training and partner co-operativeness in the behavioral treatment of obesity. *Behav Res Ther* 1978:**5**; 323-333.

Brownell KD. Behavioral, psychological, and environmental predictors of obesity and success at weight reduction. *Int J Obes* 1984:**5**; 543-550.

Brummett BH, Siegler IC, Day RS, Costa PT. Personality as a predictor of dietary quality in spouses during midlife. *Behav Med* 2008:**1**; 5-10.

Carrell DT, Jones KP, Peterson CM, Aoki V, Emery R B, Campbell R B. Body mass index is inversely related to intrafollicular hCG concentrations, embryo quality and IVF outcome. *Reprod Biomed Online* 2001:**2**; 109-111.

Chavarro J, Ehrlich S, Colaci D, Wright D, Toth T, Petrozza J, Hauser R. Body mass index and short term weight change in relation to treatment outcomes in women undergoing assisted reproduction. *Fertil Steril* 2012:**1**; 109-116.

Christakis NA, Fowler JH. The Spread of Obesity in a Large Social Network over 32 Years. *N Engl J Med* 2007:**4**; 370-379.

Clark AM, Thornley B, Tomlinson L, Galletley C, Norman RJ. Weight loss in obese infertile women results in improvement in reproductive outcome for all forms of fertility treatment. *Hum Reprod* 1998:**6**; 1502-1505.

Cohen DJ, Clark EC, Lawson PJ, Casucci BA, Flocke SA. Identifying teachable moments for health behavior counseling in primary care. *Patient Educ Couns* 2011:**2**; e8-e15.

Cousins JH, Rubovits DS, Dunn JK, Reeves RS, Ramirez AG, Foreyt JP. Family versus individually oriented intervention for weight loss in Mexican American women. *Public Health Rep* 1992:**5**; 549-555.

Cutrona CE, Russell DW. Type of social support and specific stress: Toward a theory of optimal matching. In Sarason BR, Sarason IG and Pierce GR (eds) Social support: An interactional view. 1990. John Wiley & Sons, Oxford, England, pp. 319-366.

De Frene V, Verhofstadt L, Lammertyn J, Stuyver I, Buysse A, De Sutter P. Quality of Life and Body Mass Index in Overweight Adult Women with Polycystic Ovary Syndrome During a Lifestyle Modification Program. *J Obstet Gynecol Neonatal Nurs* 2015:**5**; 587-599.

Di Castelnuovo A, Quacquaruccio G, Donati MB, de Gaetano G, Iacoviello L. Spousal Concordance for Major Coronary Risk Factors: A Systematic Review and Meta-Analysis. *Am J Epidemiol* 2009:**1**; 1-8.

Duval K, Belan M, JeanDenis F, Baillargeon J. An interdisciplinary lifestyle intervention improves clinically relevant fertility outcomes in obese infertile women-preliminary results. *Fertil Steril* 2015:**3 SUPPL. 1**; e97.

Edvardsson K, Lindkvist M, Eurenius E, Mogren I, Small R, Ivarsson A. A population-based study of overweight and obesity in expectant parents: socio-demographic patterns and within-couple associations. *BMC Public Health* 2013:**1**; 923.

Einarsson S, Bergh C, Friberg B, Pinborg A, Klajnbard A, KarlstrÃ¶m P, Kluge L, Larsson I, Loft A, Mikkelsen-Englund A et al. Weight reduction intervention for obese infertile women prior to IVF: a randomized controlled trial. 2017:**8**; 1621-1630.

Eisenberg ML, Kim S, Chen Z, Sundaram R, Schisterman EF, Buck Louis GM. The relationship between male BMI and waist circumference on semen quality: data from the LIFE study. *Hum Reprod* 2014:**2**; 193-200.

453 Eldredge LKB, Markham CM, Kok G, Ruiter RA, Parcel GS. Planning health promotion
454 programs: an intervention mapping approach. 2016. John Wiley & Sons, USA.

455 Faure C, Dupont C, Baraibar MA, Ladouce R, Cedrin-Durnerin I, Wolf JP, Levy R. In subfertile
456 couple, abdominal fat loss in men is associated with improvement of sperm quality and
457 pregnancy: A case-series. *PLoS ONE* 2014:**2**; e86300.

458 Franz MJ, VanWormer JJ, Crain AL, Boucher JL, Histon T, Caplan W, Bowman JD, Pronk NP.
459 Weight-loss outcomes: a systematic review and meta-analysis of weight-loss clinical trials with a
460 minimum 1-year follow-up. *J Am Diet Assoc* 2007:**10**; 1755-1767.

461 Galletly C, Clark A, Tomlinson L, Blaney F. A group program for obese, infertile women:
462 Weight loss and improved psychological health. *J Psychosom Obstet Gynaecol* 1996:**2**; 125-128.

463 Gorin AA, Powers TA, Koestner R, Wing RR, Raynor HA. Autonomy support, self-regulation,
464 and weight loss. *Health Psychol* 2014:**4**; 332.

465 Gorin A, Phelan S, Tate D, Sherwood N, Jeffery R, Wing R. Involving support partners in obesity
466 treatment. *J Consult Clin Psychol* 2005:**2**; 341.

467 Goyal O H, Robateau A, Braden D T, Williams S C, Srivastava K K, Ali K. Neonatal estrogen
468 exposure of male rats alters reproductive functions at adulthood. *Biol Reprod* 2003:**6**; 2081-2091.

469 Hakonsen L, Thulstrup A, Aggerholm A, Olsen J, Bonde J, Andersen C, Bungum M, Ernst E,
470 Hansen M, Ernst E et al. Does weight loss improve semen quality and reproductive hormones?
471 Results from a cohort of severely obese men. *Reprod Health* 2011:**1**; 24.

472 Hammiche F, Laven JSE, Twigt JM, Boellaard WPA, Steegers EAP, SteegersTheunissen RP.
473 Body mass index and central adiposity are associated with sperm quality in men of subfertile
474 couples. *Hum Reprod* 2012:**8**; 2365-2372.

475 Hammoud A, Meikle A, Reis L, Gibson M, Peterson C, Carrell D. Obesity and Male Infertility: A
476 Practical Approach. *Semin Reprod Med* 2012:**6**; 486-495.

477 Hollman M, Runnebaum B, Gerhard I. Effects of weight loss on the hormonal profile in obese,
478 infertile women. *Hum Reprod* 1996:**9**; 1884-1891.

479 Homan G, Litt J, Norman RJ. The FAST study: Fertility ASsessment and advice Targeting
480 lifestyle choices and behaviours: A pilot study. *Hum Reprod* 2012:**8**; 2396-2404.

481 Homish GG, Leonard KE. Spousal influence on general health behaviors in a community sample.
482 *Am J Health Behav* 2008:**6**; 754-763.

483 Huber-Buchholz M, Carey G, Norman J. Restoration of reproductive potential by lifestyle
484 modification in obese polycystic ovary syndrome: role of insulin sensitivity and luteinizing
485 hormone. *J Clin Endocrinol Metab* 1999:**4**; 1470-1474.

Inauen J, Shrout PE, Bolger N, Stadler G, Scholz U. Mind the Gap? An Intensive Longitudinal Study of Between-Person and Within-Person Intention-Behavior Relations. *Ann Behav Med* 2016:**4**; 516-522.

Jackson SE, Steptoe A, Wardle J. The influence of partner's behavior on health behavior change: the English Longitudinal Study of Ageing. *JAMA Intern Med* 2015:**3**; 385-392.

Kalodner CR, Lucia JL. Components of effective weight loss program: Theory, research, and practice. *J Couns Dev* 1990:**4**; 427-433.

Karimzadeh MA, Javedani M. An assessment of lifestyle modification versus medical treatment with clomiphene citrate, metformin, and clomiphene citrate-metformin in patients with polycystic ovary syndrome. *Fertil Steril* 2010:**1**; 216-220.

Karlsen K, Humaidan P, Sorensen LH, Alsbjerg B, Ravn P. Motivational interviewing: A part of the weight loss program for overweight and obese women prior to fertility treatment. *Gynecol Endocrinol* 2013:**9**; 839-842.

Khaskheli M, Baloch S, Baloch AS. Infertility and weight reduction: Influence and outcome. *J College Phys Surg Pak* 2013:**23**; 798-801.

Kiddy DS, Hamilton-Fairley D, Bush A, Short F, Anyaoku V, Reed MJ, Franks S. Improvement in endocrine and ovarian function during dietary treatment of obese women with polycystic ovary syndrome. *Clin Endocrinol (Oxf)* 1992:**1**; 105-111.

Kiernan M, Moore SD, Schoffman DE, Lee K, King AC, Taylor CB, Kiernan NE, Perri MG. Social support for healthy behaviors: scale psychometrics and prediction of weight loss among women in a behavioral program. *Obesity* 2012:**4**; 756-764.

Klenov V, Jungheim E. Obesity and reproductive function: a review of the evidence. *Curr Opin Obstet Gynecol* 2014:**26**; 455-460.

Koning AMH. Fertility treatment in obese women. *Thesis* 2015.

Kort J, Winget C, Kim S, Lathi R. A retrospective cohort study to evaluate the impact of meaningful weight loss on fertility outcomes in an overweight population with infertility. *Fertil Steril* 2014:**5**; 1400-1403.

Kumanyika SK, Wadden TA, Shults J, Fassbender JE, Brown SD, Bowman MA, Brake V, West W, Frazier J, Whitt-Glover MC et al. Trial of family and friend support for weight loss in African American adults. *Arch Intern Med* 2009:**19**; 1795-1804.

Lan L, Harrison C, Misso M, Hill B, Teede H, Mol B, Moran L. Systematic review and meta-analysis of the impact of preconception lifestyle interventions on fertility, obstetric, fetal, anthropometric and metabolic outcomes in men and women. 2017:**32**; 1-16.

Look AHEAD Research Group, Wadden TA, West DS, Delahanty L, Jakicic J, Rejeski J, Williamson D, Berkowitz RI, Kelley DE, Tomchee C et al. The Look AHEAD study: a

521 description of the lifestyle intervention and the evidence supporting it. *Obesity (Silver Spring)*
522 2006:**5**; 737-752.

523 Mahoney D. Lifestyle modification intervention among infertile overweight and obese women
524 with polycystic ovary syndrome. *J Am Assoc Nurse Pract* 2014:**6**; 301-308.

525 Mavropoulos JC, Yancy WS, Hepburn J, Westman EC. The effects of a low-carbohydrate,
526 ketogenic diet on the polycystic ovary syndrome: A pilot study. *Nutr Metab* 2005:**1**; 35.

527 McLean N, Griffin S, Toney K, Hardeman W. Family involvement in weight control, weight
528 maintenance and weight-loss interventions: a systematic review of randomised trials. *Int J Obes*
529 2003:**9**; 987-1005.

530 Metwally M, Cutting R, Tipton A, Skull J, Ledger L W, Li C T. Effect of increased body mass
531 index on oocyte and embryo quality in IVF patients. *Reprod Biomed Online* 2007:**5**; 532-538.

532 Meyler D, Stimpson JP, Peek MK. Health concordance within couples: a systematic review. *Soc*
533 *Sci Med* 2007:**11**; 2297-2310.

534 Miller PB, Forstein DA, Styles S. Effect of short-term diet and exercise on hormone levels and
535 menses in obese, infertile women. *J Reprod Med* 2008:**5**; 315-319.

536 Monden C. Partners in health? Exploring resemblance in health between partners in married and
537 cohabiting couples. *Sociol Health Illn* 2007:**3**; 391-411.

538 Moran L, Noakes M, Clifton P, Tomlinson L, Norman R. Dietary composition in restoring
539 reproductive and metabolic physiology in overweight women with polycystic ovary syndrome. *J*
540 *Clin Endocrinol Metab* 2003:**2**; 812-819.

541 Moran L, Tsagareli V, Norman R, Noakes M. Diet and IVF pilot study: Short-term weight loss
542 improves pregnancy rates in overweight/obese women undertaking IVF. *Aust N Z J Obstet*
543 *Gynaecol* 2011:**51**; 455-459.

544 Muench F, van Stolk-Cooke K, Kuerbis A, Stadler G, Baumel A, McKay J, Morgenstern J. A
545 randomized controlled pilot trial of different mobile messaging interventions for problem
546 drinking. *PLoS ONE* 2017:**2**; e0167900.

547 Murphy JK, Williamson DA, Buxton AE, Moody SC, Absher N, Warner M. The long-term
548 effects of spouse involvement upon weight loss and maintenance. *Behav Ther* 1982:**5**; 681-693.

549 Mutsaerts MAQ, Kuchenbecker WKH, Mol BW, Land JA, Hoek A. Dropout is a problem in
550 lifestyle intervention programs for overweight and obese infertile women: A systematic review.
551 *Hum Reprod* 2013:**4**; 979-986.

552 Mutsaerts MAQ, Van Oers AM, Groen H, Burggraaff JM, Kuchenbecker WKH, Perquin DAM,
553 Koks CAM, Van Golde R, Kaaijk EM, Schierbeek JM et al. Randomized trial of a lifestyle
554 program in obese infertile women. *N Engl J Med* 2016:**20**; 1942-1953.

National Clinical Guideline Centre. Obesity: Identification and management of overweight and obesity in children, young people and adults. Commissioned by the National Institute for Health and Care Excellence. 2014; 1.

Pachucki MA, Jacques PF, Christakis NA. Social network concordance in food choice among spouses, friends, and siblings. *Am J Public Health* 2011:**11**; 2170-2177.

Pantasri T, Norman J. The effects of being overweight and obese on female reproduction. *Gynecol Endocrinol* 2014:**2**; 90-94.

Pearce JW, LeBow MD, Orchard J. Role of spouse involvement in the behavioral treatment of overweight women. *J Consult Clin Psychol* 1981:**2**; 236.

Perri MG, Limacher MC, Durning PE, Janicke DM, Lutes LD, Bobroff LB, Dale MS, Daniels MJ, Radcliff TA, Martin AD. Extended-care programs for weight management in rural communities: the treatment of obesity in underserved rural settings (TOURS) randomized trial. *Arch Intern Med* 2008:**21**; 2347-2354.

Petersen GL, Schmidt L, Pinborg A, Kamper-JÃ¸rgensen M. The influence of female and male body mass index on live births after assisted reproductive technology treatment: a nationwide register-based cohort study. *Fertil Steril* 2013:**6**; 1654-1662.

Polotsky AJ, Allshouse AA, Casson PR, Coutifaris C, Diamond MP, Christman GM, Schlaff WD, Alvero R, Trussell JC, Krawetz SA et al. Impact of Male and Female Weight, Smoking, and Intercourse Frequency on Live Birth in Women With Polycystic Ovary Syndrome. 2015:**6**; 2405-2412.

Prestwich A, Conner MT, Lawton RJ, Ward JK, Ayres K, McEachan RRC. Partner- and planning-based interventions to reduce fat consumption: randomized controlled trial. *Br J Health Psychol* 2014:**1**; 132-148.

Qublan HS, Yannakoula EK, Al-Qudad MA, El-Uri FI. Dietary intervention versus metformin to improve the reproductive outcome in women with polycystic ovary syndrome. A prospective comparative study. *Saudi Med J* 2007:**11**; 1694-1698.

Rafaeli E, Gleason ME. Skilled support within intimate relationships. *J Fam Theory Rev* 2009:**1**; 20-37.

Ramlau-Hansen H, Thulstrup M, Nohr A, Bonde P, Sørensen I, Olsen J. Subfecundity in overweight and obese couples. *Hum Reprod* 2007:**6**; 1634-1637.

Robertson C, Archibald D, Avenell A, Douglas F, Hoddinott P, Boyers D, Stewart F, Boachie C, Fioratou E, Wilkins D. Systematic reviews of and integrated report on the quantitative, qualitative and economic evidence base for the management of obesity in men. *Health Technol Assess* 2014:**35**; 1-148.

Romero-Corral A, Somers VK, Sierra-Johnson J, Thomas RJ, Collazo-Clavell ML, Korinek J, Allison TG, Batsis JA, Sert-Kuniyoshi FH, Lopez-Jimenez F. Accuracy of body mass index in diagnosing obesity in the adult general population. *Int J Obes (Lond)* 2008:**6**; 959-966.

592 Rosenthal B, Allen GJ, Winter C. Husband involvement in the behavioral treatment of
593 overweight women: initial effects and long-term follow-up. *Int J Obes* 1980:**2**; 165-173.

594 Salama AA, Amine EK, Salem HAE, El Fattah NKA. Anti-Inflammatory dietary combo in
595 overweight and obese women with polycystic ovary syndrome. *North Am J Med Sci* 2015:**7**; 310-
596 316.

597 Scherr AS, Gorin A. Shared behavioral risk factors in spouses presenting for weight loss
598 treatment. *Obesity* 2011:**19**; S97.

599 Schliep KC, Mumford SL, Ahrens KA, Hotaling JM, Carrell DT, Link M, Hinkle SN, Kissell K,
600 Porucznik CA, Hammoud AO. Effect of male and female body mass index on pregnancy and live
601 birth success after in vitro fertilization. *Fertil Steril* 2015:**2**; 388-395.

602 Schneider G, Kirschner A M, Merkowitz R, Ertel H N. Increased estrogen production in obese
603 men. *J Clin Endocrinol Metab* 1979:**4**; 633-638.

604 Scholz U, Ochsner S, Hornung R, Knoll N. Does social support really help to eat a low - fat diet?
605 Main effects and gender differences of received social support within the Health Action Process
606 Approach. *Appl Psychol Health Well-Being* 2013:**2**; 270-290.

607 Sermondade N, Faure C, Fezeu L, Shayeb G A, Bonde P J, Jensen T, Van Wely M, Cao J,
608 Martini C A, Eskandar M et al. BMI in relation to sperm count: an updated systematic review and
609 collaborative meta-analysis. *Hum Reprod Update* 2013:**3**; 221-231.

610 Shukla K, Chambial S, Dwivedi S, Misra S, Sharma P. Recent scenario of obesity and male
611 fertility. *Andrology* 2014:**6**; 809-818.

612 Sim KA, Dezarnaulds GM, Denyer GS, Skilton MR, Caterson ID. Weight loss improves
613 reproductive outcomes in obese women undergoing fertility treatment: A randomized controlled
614 trial. *Clin Obes* 2014a:**2**; 61-68.

615 Sim KA, Partridge SR, Sainsbury A. Does weight loss in overweight or obese women improve
616 fertility treatment outcomes? A systematic review. *Obes Rev* 2014b:**10**; 839-850.

617 Simonen RL, PÉrusse L, Rankinen T, Rice T, Rao D, Bouchard C. Familial aggregation of
618 physical activity levels in the Quebec Family Study. *Med Sci Sports Exerc* 2002:**7**; 1137-1142.

619 Sundaram R, Mumford SL, Buck Louis GM. Couples' body composition and time-to-pregnancy.
620 *Hum Reprod* 2017:**3**; 662-668.

621 The Royal Australian and New Zealand College of Obstetricians and Gynaecologists. Ovarian
622 stimulation in assisted reproduction. 2011; 1.

623 Thomson RL, Buckley JD, Moran LJ, Noakes M, Clifton PM, Norman RJ, Brinkworth GD. The
624 effect of weight loss on anti-Mullerian hormone levels in overweight and obese women with
625 polycystic ovary syndrome and reproductive impairment. *Hum Reprod* 2009:**8**; 1976-1981.

626 Thomson RL, Buckley JD, Noakes M, Clifton PM, Norman RJ, Brinkworth GD. The effect of a
627 hypocaloric diet with and without exercise training on body composition, cardiometabolic risk
628 profile, and reproductive function in overweight and obese women with polycystic ovary
629 syndrome. *J Clin Endocrinol Metab* 2008:**9**; 3373-3380.

630 Tsagareli V, Noakes M, Norman RJ. Effect of a very-low-calorie diet on in vitro fertilization
631 outcomes. *Fertil Steril* 2006:**1**; 227-229.

632 Turner-McGrievy GM, Davidson CR, Wingard EE, Billings DL. Low glycemic index vegan or
633 low-calorie weight loss diets for women with polycystic ovary syndrome: A randomized
634 controlled feasibility study. *Nutr Res* 2014:**6**; 552-558.

635 Vahratian A, Smith YR. Should access to fertility-related services be conditional on body mass
636 index? *Hum Reprod* 2009:**7**; 1532-1537.

637 van Dam EWCM, Roelfsema F, Veldhuis JD, Hogendoorn S, Westenberg J, Helmerhorst FM,
638 Frölich M, Krans HMJ, Meinders AE, Pijl H. Retention of estradiol negative feedback
639 relationship to LH predicts ovulation in response to caloric restriction and weight loss in obese
640 patients with polycystic ovary syndrome. *Am J Physiol Endocrinol Metab* 2004:**4**; E615-E620.

641 Wang X, Hao J, Zhang F, Li J, Kong H, Guo Y. Effects of female and male body mass indices
642 on the treatment outcomes and neonatal birth weights associated with in vitro
643 fertilization/intracytoplasmic sperm injection treatment in China. *Fertil Steril* 2016:**2**; 460-466.

644 Wilson SE. The health capital of families: an investigation of the inter-spousal correlation in
645 health status. *Soc Sci Med* 2002:**7**; 1157-1172.

646 Wing RR, Marcus MD, Epstein LH, Jawad,A. A "family-based" approach to the treatment of
647 obese type II diabetic patients. *J Consult Clin Psychol* 1991:**1**; 156-162.

648 World Health Organization. Obesity and Overweight fact sheet no 311. 2016: **April 17**.

649 Zain M, Norman R. Impact of obesity on female fertility and fertility treatment. *Womens Health*
650 *(Lond)* 2008:**2**; 183-194.

651

652