



# Meal replacements and energy balance<sup>☆</sup>

Steven B. Heymsfield<sup>\*</sup>

Clinical Research, Metabolism, Merck Research Laboratories 126 E. Lincoln Avenue PO Box 2000, RY34A-A238 Rahway, NJ 07065-0900, United States

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## ABSTRACT

Induction and maintenance of a period of negative energy balance are required for overweight and obese subjects to lose weight. Meal replacements, particularly in beverage form, have now evolved as part of the "toolbox" used by researchers and clinicians to achieve negative energy balance. This overview traces the historical development of beverage meal replacements, reviews key studies supporting their clinical efficacy, and examines concerns related to their safe use. This collective information supports the view that meal replacements, particularly in beverage form, are now an effective and safe component for use in the clinical setting. Further studies are needed to identify those subjects most likely to benefit from use of meal replacements as part of their comprehensive weight control program.

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## 1. Introduction

### 1.1. Historical background

Beverage meal replacements occupy an important position in the "toolbox" used by health care practitioners in managing overweight and obese subjects. The beverage meal replacement concept can be traced back to the early studies of pioneering physiologists such as Gamble in the 1940s who first defined the main nutrients needed for survival during periods of severe food restriction [1]. Spaceflight in the late 1950s necessitated the development of highly compact liquid meal replacements that were associated with low residue and a very small fecal output. Aqueous mixtures of free amino acids, minerals, vitamins, and a carbohydrate source provided all nutrients required for long-term survival without solid food [2]. These prototype nutritional formula diets evolved into the broad array of products now available for feeding hospitalized patients, providing specialized diets for inborn errors of metabolism and other chronic diseases, and for weight loss.

Early formulas for weight loss were relatively rich in protein or amino acids and provided minimum required amounts of other essential nutrients. These very low calorie liquid formulations were used under medical supervision as weight loss was rapid, large, and often associated with clinically important side effects [3]. Moreover, profound weight loss over short time periods was typically associated with equally rapid weight regain [4]. From these early experiences emerged what we refer to as modern beverage meal replacements used

in managing excess adiposity. Unlike their predecessors, beverage meal replacements are now widely available to consumers and no longer require medical supervision for their use at higher calorie intakes. Beverage meal replacements for weight control can be used as the sole source of nutrition for extended periods or as a partial meal replacement (PMR) in association with additional intake provided by solid foods.

### 1.2. Scientific foundation

Now that the field has matured to the current level over the past century, we can pose two key questions related to the use of beverage meal replacements for weight control: Is this general approach efficacious for promoting weight loss and weight maintenance? Are there any risks of meal replacements, notably in promoting eating disorders, fostering poor eating habits, or worsening pre-existing glucose control in type 2 diabetics?

We can begin our analysis by setting out a general theory that provides a rationale for beverage meal replacements for weight control. Our construct is as follows:

- Our contemporary environment has available abundant amounts of highly palatable foods in great variety that promote excess weight gain in susceptible people
  - Endogenous regulatory mechanisms are inadequate to achieve zero energy balance at a "healthy" body mass
  - Those susceptible to weight gain fail to accurately perceive and regulate the amount of foods eaten
  - Negative energy balance and a reduced body weight can be achieved by providing those susceptible to excess adiposity calorie-controlled meal replacement beverages.

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<sup>\*</sup> Tel.: +1 732 594 4448; fax: +1 732 594 5179.

E-mail address: [Steven\\_Heymsfield@Merck.Com](mailto:Steven_Heymsfield@Merck.Com).

The working hypothesis is that weight loss can be achieved and then maintained over the long term by providing calorie-controlled beverage meal replacements that form the basis of a "structured" eating plan to overweight and obese subjects.

Early evidence in support of the structured meal replacement concept in general was provided by studies such as those reported by Metz et al. [5]. Metz and colleagues recognized that noncompliance with therapeutic diets is an impediment to achieving improvements in cardiovascular disease morbidity and mortality. The authors compared dietary compliance and cardiovascular disease risk factor response to two dietary interventions, a self-selected mixed-food plan or a nutrient fortified prepared meal plan. The subject's nutrient intake was estimated from food records collected throughout the ten week intervention. Compliance with energy, fat, and specific recommended cardiovascular disease diet criteria was significantly better in the participants who followed the prepared meal plan than in those who followed the self-selected diet ( $P < 0.001$ ). Compliant participants in both of the diet groups had greater lowering of body weight and blood pressure along with improvements in lipid risk factors than the noncompliant participants ( $P < 0.05$ ). Metz et al. [5] arrived at the important conclusion that a structured meal plan is a simple and effective strategy for providing recommended amounts of nutrients for cardiovascular disease risk reduction and for improving dietary compliance. This study supports the hypothesis that providing portion-controlled meals helps to improve compliance and promote weight loss.

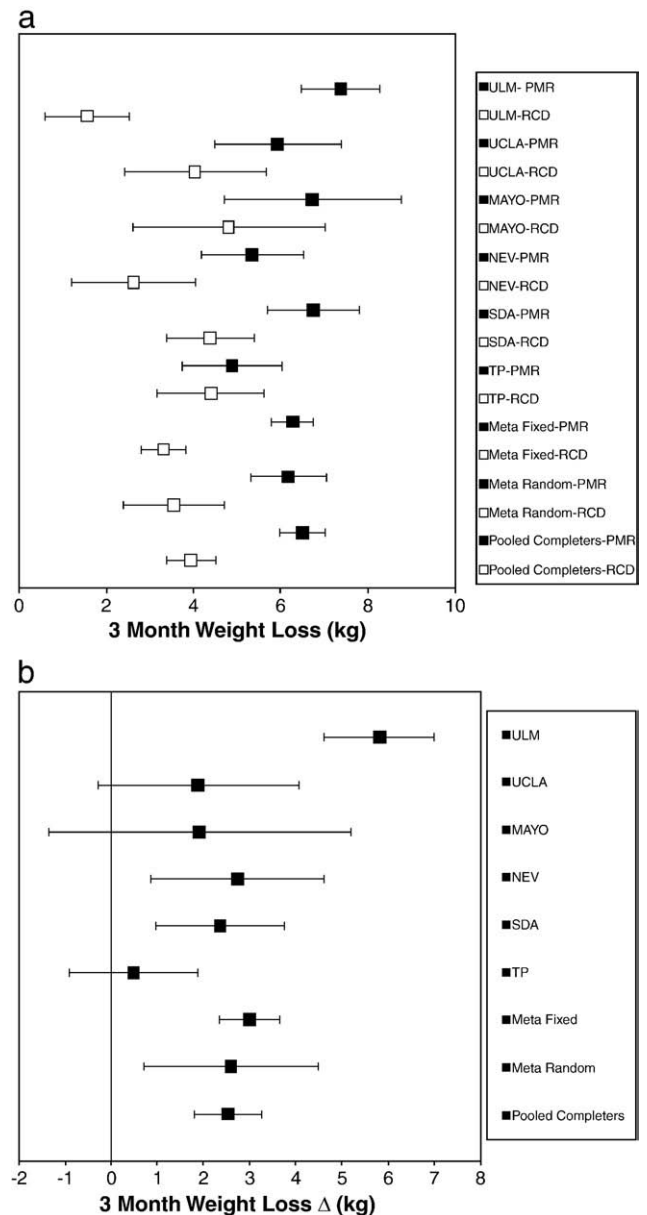
## 2. Meal replacement efficacy

An important question is if beverage meal replacements promote weight loss beyond that of a self-selected regular-food diet. There are relatively few studies in which randomly assigned subjects are compared who are treated with the two alternative weight loss options. Heymsfield et al. [6] reviewed, by use of a meta- and pooling analysis, the existing literature on the safety and effectiveness of a PMR plan that consisted of one or two vitamin/mineral fortified meal replacements combined with regular foods for long-term weight management.

The authors defined a PMR plan as a program that provides a low calorie (~3349–6699 kJ/d; ~800–1600 kcal/d) diet in which one or two meals are replaced by a reduced energy product(s) fortified with vitamins and minerals and that includes at least one meal of regular foods. The group evaluated randomized, controlled PMR studies of at least 3 months duration with subjects 18 years of age or older and a BMI > 25 kg/m<sup>2</sup>. Interventions that had self-reported weights and heights were excluded. Medline, Embase, and the Cochrane Clinical Trials Register searches from 1960 to January 2001 were conducted and from reference lists detected 30 potential studies for further analysis. Of these 30 studies, only six met all inclusion criteria and used beverage meal replacement products with the prescribed plan.

Subjects who were overweight or obese were randomized to the PMR plan or a typical reduced calorie diet (RCD) plan. The recommended calorie intake was identical for both the PMR and RCD groups. The authors of these six publications were then contacted and requested to supply primary outcome data (e.g., body weight) for analysis. The primary study data from the six studies was used for both meta- and pooling analyses.

Subjects who were prescribed either the PMR or RCD treatment plans lost a significant amount of weight at both the 3-month (Fig. 1) and 1-year (Fig. 2) evaluation time points. All methods of statistical analysis indicated a significantly larger weight loss in subjects receiving the PMR plan compared to the RCD group. Depending on the analysis and length of follow-up, the PMR group lost ~7–8% of body weight and the RCD group lost ~3–7% body weight. A random effects meta-analysis estimate indicated a 2.54 kg ( $P < 0.01$ ) and a 2.43 kg ( $P < 0.14$ ) larger weight loss in the PMR group for the 3-month



**Fig. 1.** (a) Effect sizes of weight loss with 95% CI ( $X \pm 1.96$  SE) for individual PMR studies and all studies combined at 3 months. (b) Weight loss difference ( $\Delta$ ) with 95% CI ( $X \pm 1.96$  SE) between the PMR and RCD programs at 3 months. From Ref. [6], with permission.

and 1-year periods, respectively. A completer pooling analysis showed a larger weight loss in the PMR group of 2.54 kg ( $P < 0.01$ ) and 2.63 kg ( $P < 0.01$ ) during the same time period.

Risk factors of chronic disease linked with excess adiposity improved with weight loss in both the PMR and RCD groups at the two time points. The magnitude of improvement was also dependent on the respective baseline risk factor levels. The dropout rate for PMR and RCD groups was equivalent at 3 months and significantly less in the PMR group at 1 year. There were no reported adverse events attributable to either of the weight loss regimens.

This systematic evaluation of randomized beverage meal replacement controlled trials utilizing PMR plans for weight management supports the view that this type of intervention can safely and effectively produce clinically meaningful sustainable weight loss and improve weight-related disease risk factors of disease.

More recent support for the value of a PMR plan is provided by the ongoing Look AHEAD (Action for Health in Diabetes) study report

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