Effects of variation in protein and carbohydrate intake on body mass and composition during energy restriction: a meta-regression
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CRD summary
This review concluded that, compared with traditional diets, low-carbohydrate diets may increase the loss of body mass, fat-free mass, fat mass and percentage body fat during weight reduction. Limitations of the literature search, failure to consider study quality, insufficient detail of the included studies, and the exploratory nature of meta-regression analyses mean that these conclusions should be interpreted with caution.

Authors' objectives
To evaluate how variation in carbohydrate and protein intake affects body mass and composition during a restricted energy dietary intervention.

Searching
PubMed, the Cochrane CENTRAL Register, CINAHL and SPORTDiscus were searched from 1950 to September 2005 for studies published in English. Full details of the searches were reported. The reference lists of retrieved articles were screened to identify additional studies, in particular those published prior to 1950.

Study selection
Study designs of evaluations included in the review
Inclusion criteria were not defined in terms of the study design. No details were provided of the study designs included in the review.

Specific interventions included in the review
Studies that assessed dietary interventions of at least 4 weeks’ duration were eligible for inclusion. Studies had to meet a minimum level of dietary control; where dietary intake was self-reported, biological marker measurements were required as objective measures of compliance. If biological markers were not used to assess dietary intake, investigators had to supply at least 60% of the participants’ energy intake for the study to be included. Levels of dietary control were classed as moderate (food records and a biological marker, and where only partial energy intake was supplied to the participants) or high (all energy intake was supplied). Studies in which the energy intake was less than 4,200 kJ (1,000 calories) per day, in which drugs or supplements that affected weight loss were used, or that reported that participants were not in full compliance with the dietary intervention, were excluded. The duration of the dietary interventions ranged from 4 to 26 weeks.

Participants included in the review
Studies of participants aged at least 19 years were eligible for inclusion. Studies of postpartum women or people with hypokinesia were excluded. Some studies included only men, others included only women, and some included both men and women. The mean ages of the participants ranged from 20 to 68 years.

Outcomes assessed in the review
Studies had to report pre- and post-dietary measurements of body mass or body composition to be included in the review. Studies that did not report sufficient data for extraction were excluded. Studies that did not find any energy deficit or weight loss were excluded. Body composition was either based on laboratory measurement (dual-energy X-ray absorptiometry, air densitometry or hydrodensitometry) or field measures (skinfold thickness, bioelectric impedance analysis or total body electrical conductivity). The outcomes reported in the review were change in body mass, fat-free mass, percentage body mass and fat mass.

How were decisions on the relevance of primary studies made?
The authors did not state how the papers were selected for the review, or how many reviewers performed the selection.
Assessment of study quality
The authors did not state that they assessed validity.

Data extraction
Data were only extracted from treatment arms or participants that fulfilled all inclusion criteria; periods of energy balance or insufficient dietary control were excluded. The data were extracted as means and standard errors of means (SEM) for the difference between pre- and post-diet outcomes. If such data were not reported, they were calculated from individual patient data (where available). If SEMs were not available then these were calculated using the p-value or confidence interval (CI). Carbohydrate intake (% energy) and protein intake (g/kg body mass) were classified into quartiles or as high or low. One reviewer extracted the data from the included studies, while a second reviewer independently extracted 10 randomly selected studies.

Methods of synthesis
How were the studies combined?
Pooled mean differences in pre- and post-diet outcomes, together with their 95% CIs, were estimated using hierarchical linear mixed models. Publication bias was assessed using the Macaskill funnel plot regression method.

How were differences between studies investigated?
Meta-regression was used to investigate the effects of the following covariates: study design, age, gender, baseline body mass, quality of dietary control, duration of treatment, exercise intervention, method to measure body composition, energy intake, percentage of energy from carbohydrate intake, and protein intake. Models were reduced by removing variables one at a time, starting with the least statistically significant variable. Different models were compared and the results from the best fitting model were presented. Separate models were constructed for each of the outcomes assessed. Protein and carbohydrate intake were retained in all models. A sensitivity analysis was carried out for each model to identify the presence of highly influential studies: one study was removed at a time and the impact on the model was examined.

Results of the review
Eighty-seven studies reporting 165 treatment groups (2,634 participants) were included in the review.

Body mass change (87 studies, 165 treatment groups).
The mean reduction in body mass was 5.99 kg (95% CI: 5.26, 6.71). Low-carbohydrate diets (carbohydrate intake =<35%) were associated with a greater loss in body mass than diets containing high levels of carbohydrates; the size of this increased loss was greater in studies with longer duration of the dietary intervention. In studies conducted for more than 12 weeks, low-carbohydrate diets were associated with a significantly greater loss in body mass than high-carbohydrate diets (p=0.002). Other variables shown to affect the size of the reduction in body mass were age, baseline body mass, energy intake, quality of diet control, and study design. There was no evidence of publication bias (p=0.48) and none of the studies were found to be influential.

Fat-free mass change (51 studies, 102 treatment groups).
The mean reduction in fat-free mass was 1.20 kg (95% CI: 0.87, 1.51). The amount of fat-free mass lost increased with low protein (=<1.06 g/kg) and carbohydrate intake (=<41.4%) and duration of the dietary intervention. Greater loss was only seen for the intervention studies of longer duration: in studies conducted for more than 12 weeks, the additional fat-free mass lost was 1.21 kg (95% CI: 0.25, 1.70) by the low-protein group and 1.74 kg (95% CI: 0.01, 3.47) by the low-carbohydrate group, compared with high-protein and high-carbohydrate groups, respectively. There was no evidence of publication bias (p=0.10) and none of the studies were found to be influential.

Percentage change in body fat (49 studies, 98 treatment groups).
The mean reduction in body fat was 3% (95% CI: 2.5, 3.5). There was a trend towards greater loss of body fat (0.64%, 95% CI: -0.09, 1.38, p=0.09) with high protein intake (>1.06 g/kg) compared with low protein intake. Study duration did not affect the size of the reduction in body fat related to protein intake. Studies conducted for greater than 12 weeks showed a greater effect of carbohydrate intake on reduction in body fat; low-carbohydrate diets were associated with
3.55% decrease in body fat (95% CI: 1.62, 5.49). Other variables found to affect change in body fat were gender, energy intake and quality of diet control. There was no evidence of publication bias (p=0.27) and none of the studies were found to be influential.

Fat mass change (52 studies, 108 treatment groups).

The mean reduction in fat mass was 4.71 kg (95% CI: 4.00, 5.41). There was no difference between high- and low-protein groups in the size of the reduction in fat mass. Low-carbohydrate diets (=<40%) conducted for at least 12 weeks were associated with a 5.57 kg (95% CI: 2.47, 8.67) greater loss of fat mass in comparison with high-carbohydrate diets. None of the studies were found to be influential. There was evidence of publication bias (p=0.001).

Authors’ conclusions
Compared with traditional diets, low-carbohydrate diets may increase the loss of body mass, fat-free mass, fat mass and percentage body fat during weight reduction.

CRD commentary
The review addressed a focused question that was supported by inclusion criteria defined in terms of the intervention, population and outcome. It appears that studies of any design were eligible for inclusion, although this was not explicitly stated. The literature search was limited to studies published in English, thus the review may be subject to language and publication bias; the reviewers did assess the possibility of publication bias. A formal quality assessment was not conducted and so the validity of the included studies, and hence the review, remains unclear, especially as there were a lot of very small studies (less than 10 participants). Some steps were taken to avoid bias and error when extracting the data, but it is unclear whether such steps were also taken when selecting the studies.

Very few details relating to the included studies, especially their design, were presented, thus the applicability of the review findings is unclear. A complex analysis was undertaken as the main aim of the paper was to use meta-regression to explore the effects of changes in dietary intake on weight-loss outcomes. However, although the authors said that they modelled variation between groups within studies, as well as variation between the studies, it is unclear whether the results for each study were based on a comparison with a control group. The authors’ conclusions are supported by the data presented, but should be interpreted with extreme caution given the limitations of the literature search, failure to consider study quality, limited details of the included studies presented, and the fact that the results from meta-regression analyses should be treated as only exploratory.

Implications of the review for practice and research
The authors did not state any implications for practice or research.

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