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Part D. New approaches to assessing diets of diverse populations

Measuring food intake in studies of obesity

Lauren Lissner*
Göteborg University and Nordic School of Public Health, Göteborg, Sweden

Abstract

The problem of how to measure habitual food intake in studies of obesity remains an enigma in nutritional research. The existence of obesity-specific underreporting was rather controversial until the advent of the doubly labelled water technique gave credence to previously anecdotal evidence that such a bias does in fact exist. This paper reviews a number of issues relevant to interpreting dietary data in studies involving obesity. Topics covered include: participation biases, normative biases, importance of matching method to study, selective underreporting, and a brief discussion of the potential implications of generalised and selective underreporting in analytical epidemiology. It is concluded that selective underreporting of certain food types by obese individuals would produce consequences in analytical epidemiological studies that are both unpredictable and complex. Since it is becoming increasingly acknowledged that selective reporting error does occur, it is important to emphasise that correction for energy intake is not sufficient to eliminate the biases from this type of error. This is true both for obesity-related selective reporting errors and more universal types of selective underreporting, e.g. foods of low social desirability. Additional research is urgently required to examine the consequences of this type of error.

Keywords
Dietary intake
Underreporting
Obesity
Social desirability

The problem of how to measure habitual food intake in studies of obesity remains an enigma in nutritional research. The existence of obesity-specific underreporting was rather controversial until the advent of the doubly labelled water technique gave credence to previously anecdotal evidence that such a bias does in fact exist[1]. Studies involving urinary nitrogen as a biomarker for total protein intake have also been consistent with this conclusion[2,3]. However, obesity-related underreporting may not be a universal phenomenon, and there is evidence that fatness *per se* may be less predictive of underreporting than body size[4,5]. This paper briefly reviews a number of issues relevant to interpreting dietary data in studies involving obesity. Topics covered include: participation biases, social desirability biases, importance of matching method to study, selective underreporting, and a discussion of the potential implications of generalised and selective underreporting.

Participation biases in studies of obesity and diet

Although self-selection bias is a well-known problem in population-based research, it has remained a frequently neglected issue in nutritional studies involving obesity. In this context, a key question is whether subjects who agree to participate in dietary surveys are more or less likely to be overweight, compared with non-participants. Different population studies seem to yield different answers. For instance, a Danish study suggested that obesity in young males at the time of their draft board examination is an extremely strong predictor for non-participation in a subsequent health examination survey 4–40 years later[6]. In contrast, a recent publication from the Coronary Artery Risk Development in Young Adults (CARDIA) study found that weight status at the baseline examination was unrelated to participation or non-participation after 10 years[7]. Interestingly, among African-Americans in this study, there was a trend towards more obesity in participants than in non-participants. A final example from the 12-year follow-up of the Prospective Population Study of Women in Gothenburg, Sweden revealed a significantly elevated waist-to-hip ratio among women who subsequently became non-participants, and a non-significant trend towards higher body mass index[8]. Thus, there is some disagreement in the literature as to whether population-based studies have been representative with respect to obesity. However, the latter study suggested that subjects with centralised obesity might be underrepresented in population-based research. Naturally, this affects generalisations that can be made regarding nutritional comparisons of obese vs. non-obese subject groups.

With specific regard to diet, a more recent study examined consequences of non-participation in a survey of dietary habits and attitudes in Swedish adolescents[9]. Because the first stage of the dietary survey was conducted at school in a supervised manner, initial participation was

*Corresponding author: Email lauren.lissner@medfak.gu.se

virtually complete. Moreover, subsequent drop-out in the secondary dietary record portion of the survey made it possible to describe the biased results that would be obtained from using the reduced (secondary) sample. Notably, gender differences in skipping breakfast were exaggerated as a consequence of self-selection, whereas gender differences in the fat content of milk products were obscured. However, the direction and approximate magnitude of the associations was not changed. In summary, biased participation not only affects descriptive epidemiology, i.e. prevalences and means, but also can distort analytical results. Although non-participation is impossible to avoid in population studies, careful attention must be paid to the characteristics of dropouts when possible, in view of our incomplete understanding of participation biases in relation to both obesity and diet.

Social desirability biases and obesity

In addition to participation-related biases described above, a large number of normative biases, relating to perceptions of the acceptable or correct answer, are relevant in analytical epidemiology in general, and are believed to be particularly relevant when considering dietary exposures and obesity. Sackett has catalogued these under various descriptors such as unacceptability bias, obsequiousness bias and expectation bias, to name a few[10]. The term 'social desirability bias' has now been widely adopted in nutritional epidemiology to imply a tendency to supply answers to dietary questions that place the interviewee in a favourable light[11–13]. As elucidated by Roth *et al.*, this type of bias can either be intentional, or a form of self-deception[14]. That social desirability is the driving influence in obesity-related underreporting is often taken for granted. However, in this context it may be noted that Taren *et al.*[15] demonstrated that social desirability and degree of obesity were two independent influences on reporting accuracy, as judged by doubly labelled water measurements. Moreover, in the case of diet and obesity, it is important to keep in mind that an 'attention' bias can produce reporting errors without any intentional or unintentional deception. For instance, the act of keeping food records, a traditional behavioural tool in weight loss programmes, may come into play when subjects who are experienced dieters are instructed to keep records of their diets. This may also be considered a type of normative bias, even if it reflects the truth at the time the records were being kept.

While it is now generally agreed that obesity-related underreporting does occur with most methods, it is also worth asking whether this phenomenon is dependent on the subject knowing he or she is being observed. Data from two metabolic studies of women[16] and men[17] both failed to detect obesity-specific underreporting among subjects who reported their dietary intakes after having been observed in metabolic units. While other types of reporting error did occur in both studies (described below), these errors could not be specifically or disproportionately attributed to the obese condition. Based on these findings, it would be tempting to speculate that the obesity-specific part of underreporting may depend on whether subjects are aware that they have been observed. However, it must be underscored that subjects living in a metabolic unit are unlikely to be consuming a diet resembling their typical one, and the unusualness of the diet itself, rather than the knowledge of being observed, may have improved their recall of the diet. Other research using the 'bogus pipeline method', whereby subjects think their true intake is known by observers, seemed to suggest that belief that the investigator 'knows' is only part of the problem[18]. Specifically, the degree of underreporting in a largely overweight subject group was only partially normalised when subjects believed their true energy requirements were being monitored with doubly labelled water. In summary, the latter findings suggest that a small portion of obesity-related underreporting is likely to be intentional, and the specific conditions in the metabolic studies cited above may have helped minimise the unintentional underreporting, at least in the overweight subjects.

Importance of method

It is has become clear that some methods work better than others for measuring dietary intake in the obese. One example of this became obvious in the development of a questionnaire for severely obese subjects in Sweden. The premise of developing this questionnaire was that a dietary assessment instrument for use by obese individuals must be designed to 'capture' aspects of their eating that are contributing to their obesity. Thus, in a group of obese and non-obese subjects, a new method was tested and found to agree on the group level with estimated energy expenditure in both obese and non-obese subjects, leading investigators to conclude that a valid method had finally been found for obese subjects[19]. In contrast, 4-day food records in the same study groups were found grossly to underestimate intake in obese subjects, but not in normal-weight subjects.

However, further validation of this new method with 24-hour calorimetry and urinary nitrogen in a clinical population suggested that some underreporting was likely to be occurring[20]. Moreover, when testing this method in young adults with and without a familial predisposition for obesity, the predisposed group provided data that were less valid than those provided by subjects with no family history of obesity. Since the majority of the high-risk subjects were already overweight, this is further indication that the method may not work as well in moderately overweight individuals as in severely obese subjects[21]. Similar lack of agreement between this method and doubly labelled water measurements has been seen in a

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study of 15-year-olds[22]. This suggests that food records correlated with energy expenditure much better than did this diet questionnaire, raising the question of whether adolescents are able to generalise their diets to the extent required by a food frequency approach. From this research it may be concluded that a method that works surprisingly well when recruiting highly motivated and severely obese individuals for an intervention may not work quite as well in young adults from high-risk families, in adolescents or in moderately overweight patients. These results serve to highlight the obvious conclusion that dietary methods must be tested and validated in the population for which they are intended.

Food and/or nutrient specificity in underreporting

It is not well documented whether some food types are selectively underreported in the general population. Thus, let us consider the situation in obese subjects, among whom underreporting has been most clearly demonstrated. In a population of Danish men and women who reported their usual diets while collecting urine samples for nitrogen assessment, obesity-related underreporting was confirmed in relation to energy requirement estimated from body composition and physical activity. Additionally, there was proportionally less underreporting of protein compared with other energy sources combined, providing evidence that foods high in fat and/or carbohydrates were being underreported more[3]. A similar trend has been observed in Swedish subjects[23], although these data are less convincing of a macronutrient-related bias, given that obesity-related underreporting is not observed with this particular method. This phenomenon of macronutrient-related reporting error was essentially replicated in a more recently studied Danish cohort, but there was some indication that the phenomenon was no longer limited to obese subjects[24]. Taken together, the findings described above should alert epidemiologists to the possibility that a dual bias may be present in studies of diet and disease: general underreporting among obese subjects compounded by food-specific underreporting. This type of bias in large segments of the population might explain discrepancies that have been observed between per capita fat intake estimated from national consumption surveys compared with higher values obtained from food disappearance data.

How can the problem of selective underreporting be documented more accurately? The further use of biomarkers will be necessary, since comparison of two subjective methods cannot yield definitive results. Another approach for studying sources of underreporting involves direct observation. In a study mentioned previously, researchers in Cambridge recorded the true intakes of 33 women who were being observed in a metabolic facility[16]. After the study was completed 24-hour recalls were conducted, during which subjects most frequently failed to record their between-meal snacks. The only significantly underreported macronutrient was carbohydrate and, in contrast to most previous studies, the magnitude of underreporting was not higher in the obese women. Using a similar approach at the Laboratory of Clinical Metabolism in Gothenburg, we have also observed no obesity-related underreporting in men, although certain food-specific errors of omission were detected across weight groups, e.g. failing to report butter spread and foods in the fruit/vegetable category[17]. Thus, the classic obesity-related reporting bias may be modified by subjects' attention to what they are being fed, together with awareness that they are being investigated.

What implications could generalised underreporting and food-specific reporting errors have in epidemiological studies?

Systematic or non-random errors of the type investigated in the above-mentioned studies could have important implications in nutritional epidemiology. It is often assumed that correction of nutritional data for total energy intake, by one of several generally accepted energy-adjustment methods, will also provide some level of correction for obesity-related underreporting. Clearly, this can only be the case if underreporting is occurring at the whole-diet level, and there is accumulating evidence that this is not always so. The potential implications are interesting to contemplate.

If obese subjects *truly overconsume* high-fat foods but *selectively underreport* them, a simple consequence might be that the overconsumption in the obese group would not be detected. However, other consequences are less clear; for instance, when obesity is both a source of bias in the dietary exposure as well as being a confounding factor for a disease being studied. Such a hypothetical case has been presented by Heitmann[12], whereby it is proposed that an artifactual positive association could be produced via selective underreporting of dietary fat by high-risk individuals. Thus, selective underreporting of certain food types by obese individuals would produce consequences in analytical epidemiological studies that are both unpredictable and complex. Since it is becoming increasingly acknowledged that selective reporting error does occur, it is important to re-emphasise that correction for energy intake is not sufficient to eliminate the biases from this type of error. This is true for both obesity-related selective reporting errors and more universal sources of selective underreporting, e.g. foods of low social desirability. It must be concluded that additional research is urgently required to examine the consequences of this type of error.

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