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Original Research Article

Evaluation of calculated energy and macronutrient contents of diets provided in controlled dietary intervention trials by chemical analysis of duplicate portions

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ABSTRACT

The purpose of this study was to investigate whether Dutch food composition databases (Dutch-FCDB) are accurate enough to plan experimental diets with specified amounts of energy and macronutrients. From 2003 to 2012, 10 controlled dietary intervention trials lasting from 2 to 13 weeks were conducted in different seasons. The energy, macronutrients, dietary fibre, water and fatty acids contents of the test diets were calculated with 3 releases of the Dutch-FCDB and compared with the chemically analyzed nutrients in 25 duplicate diets, except for fatty acids which were analyzed in 10 diets. Calculated values of energy and macronutrient content, especially carbohydrates, were higher than values based on analysis. Correlation coefficients ranged from 0.57 for energy to 1.00 for polyunsaturated fatty acids (PUFA). Bland–Altman plots showed considerable differences for the individual diets, limits of agreement (mean ±1.96 SD) were −11.0 to +11.0 g/day for protein, −14.2 to +21.6 g/day for total fat, −4.8 to +57.0 g/day for carbohydrates and −10.7 to +11.5 g/day for dietary fibre. We therefore conclude that Dutch-FCDB can be considered accurate enough for planning of experimental diets to be provided in controlled dietary intervention trials.

1. Introduction

Food composition databases (FCDBs) are expected to represent the nutrient composition of foods, thereby meeting certain standards with regard to representativeness, food descriptions, coverage of foods and nutrients and documentation (Burlingame, 2004). Also, users of food composition data expect the nutrient values to be of sound quality. Updating FCDBs must be a constant process because of implementation of new products and changes to the nutritional composition of foods. This is a challenge for FCDB compilers considering the difficulty in acquiring reliable nutrient data: FCDBs are compiled from analyzed foods, by imputation of nutrient values derived from similar foods, by calculation of the nutrient contents based on ingredients, by copying data from other FCDBs or by presuming values such as zero values, and by collecting data from the food industry (Greenfield and Southgate, 2003).

The diverse origin of food composition data requires a systematic and documented approach to warrant good quality data. In Europe harmonized approaches and standards have been developed recently to assure the quality of the data compilation process (Westenbrink et al., 2009). In addition, standards were developed to assess the quality of nutrient data from original scientific literature or reports (Salvini et al., 2012). These standards are embedded in an overarching quality assurance framework to meet the requirements of the users to have access to consistent and transparent data (Castanheira et al., 2009).

So, overall the verification of the quality of food composition data has improved over the past few years, but guidelines for the evaluation of the quality of existing data are mostly limited to internal validity checks (e.g. FAO/INFOODS, 2012). The main approach used to verify accuracy of existing food composition information is by comparing calculated values with chemical analysis. Several studies have reported on the comparison of calculated versus analyzed nutrient composition (Heinonen et al., 1997; McCullough et al., 1999; Pennington and Wilson, 1990; van der Watt et al., 2008). Apart from the databases used for evaluation, the main differences between these studies are the inclusion of nutrients (macronutrients versus micronutrients), comprehensiveness of the foods, dishes or menus included, and the time

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window of the observation, which is often of a shorter term than of the nutrient database.

For many years, controlled dietary intervention trials have been performed at the Division of Human Nutrition of Wageningen University. The purpose of a controlled dietary intervention trial is to study the effect of one dietary component or nutrient on an intermediate marker of disease or health outcome. The controlled dietary intervention trials investigated, among others, the effect of type of fat on blood lipids, the effect of micronutrient intake on bioavailability markers, and the identification of different sources of amino acids as potential biomarkers of dietary protein.

To evaluate the accuracy of the calculated composition of the experimental diets, we collected duplicate portions of the total diet provided every day during the controlled dietary intervention trials and submitted them to chemical analyses after each study. Using these data, we were able to investigate whether Dutch-FCDBs are accurate enough for planning of experimental diets with a specified amount of energy and macronutrients to be provided in controlled dietary intervention trials.

The aim of the present study was to compare calculated and analyzed values over a time period of 10 years in 10 different controlled dietary intervention trials calculated with 3 consecutive releases of the Dutch-FCDB.

2. Material and methods

2.1. Controlled dietary intervention trials

From 2003 to 2012, 10 controlled dietary intervention trials, with a duration of 2–13 weeks, were conducted in different seasons. Six trials were designed as cross-over interventions, and the other 4 trials had a parallel design. The experimental diets differed in the composition of micronutrients, minerals, fatty acids or protein (see Table 1 for an overview).

In total 418 men and women took part in the trials; the number of participants per trial ranged from 24 to 72. The participants were mostly students, but in some trials older people participated, depending on the purpose of the study.

Participants were provided with 90% of their total daily energy needs and they chose the remaining 10% of energy from a so-called free-food item list.

According to the purpose of each trial, participants needed to maintain stable body weights in all trials, except for the second phase in trial 5 and in trial 8 where the intervention aimed at weight loss or weight gain, respectively.

Based on their estimated energy needs by a food frequency questionnaire (Siebelink et al., 2011), participants were allocated to one of 14 energy levels between 7 and 20 MJ.

Table 1
Overview of the controlled dietary intervention trials from 2003 to 2012.

Acronym of the trial and year		Design	Duration week	Type of intervention	Month of the year	Specific ingredients	Number (53) of duplicate portions	Number (25) of different test diets	Previously reported[d]
1	Caro 2003[a]	Cross-over	6	Low vs high beta-carotene	May–June	–	12	2	1
2	Folfood 2005[a]	Parallel	4	Basic diet low in folic acid supplemented with top diet low or high in folic acid	June	–	8	2	2
3	Maris 2007[a]	Parallel	10	Different fatty acid compositions in a Western diet, a diet with olive-oil and a Mediterranean diet	Jan–April	Butter vs olive-oil vs olive-oil and Mediterranean products analyzed	3	3	3
4	Clarinet 2007[a]	Cross-over	9	Different fatty acids in diets from CLA, trans fatty acids and oleic-acid	Sept–Nov	Special margarines and yoghurt drink analyzed	9	3	4
5	Balans 2008[a+b]	Parallel	4	Basic diet (100% of energy needs) and energy restricted diet (70%)	Jan–Feb	–	2	2	5
6	Protime 2010[a]	Cross-over	6	High vs low protein; exchanged with carbohydrates	Sept–Nov	–	3	3	6
7	Biomerker 2011[a]	Cross-over	4	Protein from different sources: dairy, meat and grain	March–April	–	10	4	7
8	Lifpro 2011[a+c]	Cross-over	6	High fat-low protein (118% energy) vs low fat-high protein (118% energy); low fat–low protein (100% energy)	Sept–Nov Jan–Feb	–	3	3	8
9	Probrain 2012[a]	Cross-over	5	High vs low protein; exchanged with carbohydrates	April–May	–	2	2	9
10	Kanatrial 2012[a]	Parallel	13	Diet low potassium and low sodium	March–July	Supplements: control-high potassium-high sodium	1	1	10

[a] Duplicate portions pooled at 11 MJ.
[b] Duplicate portions pooled at 7.7 MJ.
[c] Duplicate portions pooled at 13 MJ.
[d] 1 = (Van Loo-Bouwman et al., 2009), 2 = (Winkels et al., 2007), 3 = (Bos et al., 2010), 4 = (Wanders et al., 2010), 5 = (Winkels et al., 2011), 6 = (Griffioen-Roose et al., 2012), 7 = (Altorf-van der Kuil et al., 2013), 8 = (Rietman et al., 2013), 9 = (Griffioen-Roose et al., 2014), 10 = unpublished results.