International Journal of Food Sciences and Nutrition (1999) **50**, 73–79

Comparison of food composition tables and direct chemical analysis for the assessment of macronutrient intake in a military community

G. Bedogni,[1] E. Bernini Carri,[2] G. Gatti,[3] S. Severi,[1] M. Poli,[1] F. Ferrari[1] and N. Battistini[1]

[1]Human Nutrition Chair, Department of Biomedical Sciences, Faculty of Medicine and Surgery, Modena University, Via Campi 287, 41100 Modena, [2]Direction of Medical Services, Military Academy, Modena and [3]NEOTRON Laboratories, Modena, Italy

Food composition tables (FCT) were validated against chemical analysis (CA) to assess energy, carbohydrate, lipid, protein and fibre content of the food consumed by Italian Army cadets. The absolute difference between FCT and CA in 2 separate weeks was ≤0.7% for energy, ≤4.1% for carbohydrates, ≤2.9% for lipids, ≤6.2% for proteins and ≤31.6% for fibre. It is concluded that FCT can be used to assess energy, carbohydrate, lipid and protein but not fibre intake in this military community.

Introduction

Direct chemical analysis (CA) is the recognised gold standard for the assessment of food composition. However, CA is expensive and requires substantial technical expertise so that it is generally used to develop and validate food composition tables (FCT) which are then employed in field studies of nutrient intake (Stock & Wheeler, 1972; Gibson, 1990; Battistini *et al.*, 1992).

Scarce data are available on the composition of food consumed by Italian soldiers and validated FCT would be useful to control their nutrient intake. Using CA as the reference method, we evaluated the accuracy of selected FCT for estimating energy, carbohydrate, lipid, protein and fibre intake of Italian Army cadets. The study offered also the possibility to detect nutritional errors occurring in this community.

Subjects and methods

Cadets

The Italian Army Academy was founded in 1699 in Torino. At present, the cadets undergo a 2-year course in Modena and a subsequent course of the same duration in Torino. Besides a specific military training, the cadets attend university classes. At the end of this 4-year programme, they are granted a university degree along with their military degree. Two hundred and seventy-three male cadets (age: 19.4 ± 1.3 yr, mean ± SD) were recruited into the study, immediately after their admission to the 175th course of the Italian Military Academy. The aim of the study was explained to cadets and their informed consent was obtained.

Ordinary and integrated allowances

Cadets are supplied with an 'ordinary' allowance (OA) for 245 days/year and with an 'integrated' allowance (IA) for the remaining 120 days (this latter is reserved for periods of more intensive physical training). The reference composition of these allowances is susceptible of modifications on the basis of food availability and other factors. Modifications must respect detailed 'exchange lists' aimed at

Correspondence to: N. Battistini.

0963-7486/99/010073-07

safeguarding the nutrient intake of the cadets (Direzione Generale di Commissariato, 1985).

Study protocol

We evaluated the energy, carbohydrate, lipid, protein and fibre content of the reference allowances and analysed the food consumed by the cadets during one randomly chosen week of OA and one of IA by using CA and FCT. We also estimated the energy requirements of the cadets and assessed their body composition at their arrival at the Academy and 6 months later to detect eventual changes in their nutritional status.

Food composition

The analysis of the food consumed by the cadets during the randomly chosen weeks of OA and IA was performed by CA and by employing specific FCT (Cok *et al.*, 1987) coupled to a commercially available software (Food Intake, DS-Medigroup, Milano, Italy). Since the cadets are allowed to lunch outside the Academy on weekends, and the majority of them do so, food analysis was restricted to the first 5 days of the week. Food lists for the weeks of OA and IA were provided by the Academy catering service. These lists gave the exact weight of every single constituent of the dishes on menu, allowing a software-based calculation of their content of energy, carbohydrates, lipids, proteins and fibre. The sampling of the various meals (lunch and dinner separately) for laboratory analysis was performed in the Academy when they were served. The edible matter of the samples was placed in previously weighed plastic containers to determine the gross weight of the meal on a balance accurate to the nearest gram. Samples were then frozen and kept at −20° pending CA. Each sample was measured in triplicate and the value used was the mean of these three measurements. Protein content of samples was evaluated by Kjeldahl method, carbohydrate content by Fehling and UV enzymatic method, lipid content by acid hydrolysis of the dried sample followed by hot ether extraction (AOAC, 1990); total energy content was obtained by summing energy values for each macronutrient (quantity of nutrient in g × KJ/g of nutrient); finally, total fibre content was measured using the enzymatic-gravimetric method (AOAC, 1990).

Evaluation of other food sources

Since the cadets can buy food at their store in the Academy, an attempt was made to evaluate this additional food source so as to improve the accuracy of our estimate of their overall food intake. We calculated the mean caloric contribution of these 'extra' foods to the energy intake of an 'ideal' reference cadet by means of the following scheme: KJ/day/cadet from 'extra' foods = KJ obtained from foods sold over a month of OA or IA (which included the sampled week)/number of days in that month/ number of cadets in the Academy in that month.

Energy requirements

Total energy expenditure is the sum of basal energy expenditure (BEE), thermic effect of food (TEF) and energy spent in intellectual and physical activity (AEE, activity energy expenditure) (Elia, 1992). BEE of the cadets was estimated from weight as suggested by the Italian Society of Human Nutrition (Commission of the European Communities, 1993; Società Italiana di Nutrizione Umana, 1996). [We evaluated the accuracy of the predictive equations in a group (n = 30) of active male university students of age and body composition similar to the cadets. The coefficient of variation (CV) associated to the use of the equations in this group of university students was of 10% (unpublished data).] TEF was calculated as 10% of BEE and AEE by correcting BEE for daily activities. [Correction factor (CF) for sleeping = 1, duration = 8 h; CF for attending school = 1.7, duration = 6 h; CF for recreational physical activity and study = 3.8, duration = 9.5 h; CF for intense physical activity = 6.0, duration = 0.5 h).] TEE was finally calculated by summing BEE, TEF and AEE (Società Italiana di Nutrizione Umana, 1996).

Body composition

Body composition of the cadets was assessed at their arrival in the Academy and 6 months later. They underwent measurements of weight (Wt), height (Ht), triceps skinfold (TSF) and arm circumference (AC). Measurements were performed by the same trained operator following the directions of the *Anthropometric Standardization Reference Manual* (Lohman *et al.*, 1988). Body mass index (BMI) was calculated as Wt

(kg)/Ht (m^2) (Garrow & Webster, 1985). Arm muscle (AMA) and fat (AFA) areas were calculated from AC and TSF (Frisancho, 1990).

Statistical analysis

Statistical analysis was performed on a MacOS computer using a Statview 5.0 software package (SAS Institute, Cary, USA). Differences between values of energy, carbohydrates, lipids proteins and fibre estimated by FCT and measured by CA in the weeks of OA and IA (bias) were used to evaluate the accuracy of FCT. Comparison of body composition at the first and second anthropometric survey was performed by paired *t*-tests.

Results

Composition of reference allowances

As estimated by FCT, reference OA and IA had a total energy content of 11,911 and 15,553 KJ, respectively. As compared to Italian recommended daily allowances (RDA), these diets show a slight excess of proteins (OA: +2% and

Table 1. Sampled menu for a week of 'ordinary' allowance (weekend excluded)

Lunch	*Weight (g)*	*Dinner*	*Weight (g)*
Monday			
Pasta with meat sauce	350	Rice	380
Hamburger	142	Potato pie	400
Tomato sauce	34	Boiled potatoes	210
Green salad + oil	90	Bread	57
Bread	58	Tangerines (2)	100
Pear (1)	196		
Tuesday			
Rice with sausages	342	Pasta with tomato sauce	277
Chicken	84	Findus meat sticks	278
Peas	214	Green salad + oil	87
Bread	58	Bread	58
Tangerines (2)	106	Tangerines (2)	108
Wednesday			
Pasta with meat sauce	220	Pasta with buttermilk curd	318
Meat slice	86	Green salad + oil	88
Bread	60	Pork chop	108
Cauliflower + oil	224	Bread	52
Orange (1)	166	Orange (1)	100
Thursday			
Lasagne	174	Pasta with parsley	220
Braised beef	114	Boiled eggs (2)	96
Green salad + oil	90	Mozzarella cheese	112
Bread	54	Aubergines	70
Tangerines (2)	100	Bread	54
		Orange (1)	94
Friday			
Pasta with tuna fish	200	Rice with tomatoes	208
Baked fish	90	Grilled beef	160
Swiss cheese	50	Green salad + oil	28
Bread	54	Bread	50
Tangerines (2)	100	Tangerines (2)	90
Breakfast (constant all week)			
Milk	276	Nut chocolate spread	18
Croissant	50		

Table 2. Sampled menu for a week of 'integrated' allowance (weekend excluded)

Lunch	*Weight (g)*	*Dinner*	*Weight (g)*
Monday			
Pasta with meat sauce	262	Macaroni with zucchini	228
Meat slice with cheese	150	Beef with mushroom sauce	118
Aubergines	72	Green salad + oil	72
Bread	56	Bread	56
Apple (1)	196	Apple (1)	180
Tuesday			
Pasta with tomato and olives	308	Rice salad	286
Hash with tomato sauce	162	Grilled fish	120
Mashed potatoes	236	Green salad + oil	42
Bread	56	Bread	50
Apple (1)	176	Apple (1)	130
Wednesday			
Pasta with ham and tomatoes	282	Pasta with mushrooms	314
Beef with mushroom sauce	150	Anchovies and capers	170
Beans and celery	170	Green salad + 1/2 tomato	72
Bread	54	Bread	52
Apple (1)	176	Apple (1)	182
Thursday			
Macaroni with meat sauce	462	Rice with tomato	322
Findus fish sticks	44	Braised beef with lemon	110
Cheese	128	Green salad + oil	72
Tomatoes	172	Bread	58
Bread	56	Apple (1)	234
Apple (1)	164		
Friday			
Pasta with meat sauce	242	Pasta with beans	272
Hash with tomato sauce	82	Beef with tomato sauce	88
Green salad + tomatoes	158	Tomatoes	106
Bread	52	Bread	180
Apple (1)	172	Apple (1)	50
Breakfast (constant all week)			
Milk with cocoa	272	Nut chocolate spread	18
Brioche/croissant	52	Sandwich (ham and cheese)	221
Yoghurt with fruits	125		

IA: +3%), a more relevant excess of carbohydrates (OA: +9% and IA: +9%) and a significant deficit of lipids (OA: −15% and IA: −16%) (Società Italiana di Nutrizione Umana, 1996).

Composition of food consumed by cadets

The sampled menus for the week of OA and IA are given in Tables 1 and 2 respectively. The composition of the food consumed by cadets during these weeks along with the bias of FCT is given in Table 3.

Based on CA, carbohydrate content was lower (OA: −6 and IA: −5%), lipid content higher (OA: +5 and IA: +3%) and protein content slightly higher (OA: +1 and IA: +2%) than suggested by RDA. Fibre content was 30% lower than RDA in the OA week but satisfied RDA in the IA week.

For both weeks, the values of energy and macronutrients estimated by FCT were similar to those measured by CA. For energy, the absolute bias of FCT was ≤0.7%. Carbohydrates were slightly underestimated (bias

Table 3. Composition of the food consumed by cadets during a randomly chosen week of 'ordinary' (OA) and 'integrated' (IA) allowance (mean values). Abbreviations: E = energy; C = carbohydrates; L = lipids; P = proteins; F = fibre; RDA = (Italian) recommended daily allowances; CA = chemical analysis; FCT = food composition tables. Diff. (FCT – CA) denotes the difference between values measured by CA and estimated by FCT (bias)

	E (KJ/day)	*C (% of E)*	*L (% of E)*	*P (% of E)*	*F (g)*
RDA (range)	—	55–65	25–30	10–15	≥ 30 g
OA week					
CA	10,802	49	35	16	21
FCT	10,844	47	36	17	21
Diff. (FCT–CA)	42 (0.4%)	– 2 (–4.1%)	1 (2.9%)	+1 (6.2%)	0 (0%)
IA week					
CA	11,915	50	33	17	38
FCT	11,836	49	33	18	26
Diff. (FCT–CA)	–79 (0.7%)	–1 (–2.0%)	0 (0%)	+1 (5.9%)	–12 (–31.6%)

≤4.1%), lipids slightly overestimated (bias ≤2.9%) and proteins overestimated (bias ≤6.2%) by FCT. However, the bias for fibre was very different in the OA and IA weeks (0 and 31.6% respectively), suggesting that the employed FCT do not allow a correct estimate of fibre.

Additional food sources

The list of the food sold by the cadets' store during the months of OA and IA which included the sampled weeks, is given in Table 4. According to FCT, these foods offered an additional energy quantity of 1447 and 1039 KJ/day/cadet for the OA and IA weeks respectively.

Energy requirements and body composition

The estimated TEE of cadets was 12,402 ± 680 KJ/day (mean ± SD). In the randomly chosen week of IA, the cadets did not perform intensive physical activity because they were

Table 4. Food sold in the cadets' store during a month of 'ordinary' (OA) and 'integrated' allowance (IA)

Product (quantity)	*OA month (no. of units sold)*	*IA month (no. of units sold)*
Alcoholic beverages (33 cc)	620	510
Analcoholic beverages (33 cc)	3996	5039
Beer (33 cc)	63	108
Biscuits (100 g)	2000	981
Chips (g 50)	692	782
Chocolate tablets (100 g)	975	331
Chocolate tablets (50 g)	1312	458
Coffee (cups)	11000	10004
Ice cream (75 g)	3120	2636
Juice—fruit (200 g)	2416	2865
Milk (cups)	1810	1059
Pastry (100 g)	3500	2370
Peanuts (g 75)	348	310
Plain pizza (100 g)	3258	3618
Sandwiches (eggs and ham) (100 g)	1170	855
Various snacks (50 g)	5000	1519
Sparkling wine (75 cc)	54	36
Sugar (kg)	199	163
Tea and camomile (cups)	400	244

Table 5. Body composition of the cadets at their arrival to the Academy and 6 months later (mean ± SD). Abbreviations: Wt = weight; Ht = height; BMI = body mass index; AMA = arm muscle area; AFA = arm fat area

	Arrival	*6 months after arrival*
Wt (kg)	72.7 ± 6.9	72.5 ± 6.4
Ht (cm)	176.1 ± 5.5	176.2 ± 5.3
BMI (kg/m^2)	23.5 ± 2.1	23.4 ± 1.9
AMA (cm^2)	57.1 ± 9.4	59.1 ± 8.2*
AFA (cm^2)	13.1 ± 4.6	11.7 ± 3.5*

*$P < 0.0001$ vs arrival.

preparing for university examinations. Therefore, their estimated TEE was the same for the weeks of OA and IA. Based on this value, one could calculate a mean energy deficit of 1600 (–15%) and 487 (–4%) KJ for the OA and IA weeks, respectively. While this energy deficit may have been partly corrected by the food bought by the cadets inside (and outside) the Academy, the indirect estimation of TEE employed by this study may have contributed substantially to the observed discrepancy (Elia, 1992). However, Wt did not change between the two anthropometric surveys and body composition showed a tendency to improve, as detected by an increase in AMA and decrease in AFA (Table 5). The stability of weight and body composition proves that energy intake of cadets was adequate.

Discussion

Assessment of food intake is an essential part of the evaluation of nutritional status (Gibson, 1990). Both retrospective (dietary recalls and food-frequency questionnaires) and prospective (collection of duplicate portions of food eaten, records of weighed intake using scales and food diaries, etc.) methods are available to assess food intake (Dwyer, 1994). While prospective methods are generally preferable for they are less subject to forgetfulness, they may inadvertently stimulate a greater consciousness about intake or otherwise lead the subject to alter intakes during the recording periods (Kim *et al.*, 1984). In this study we collected duplicate portions of food eaten by cadets. Although we did not take into account wastage of food, the study protocol allowed us to sample meals representative of the cadets' food intake as 'ensured' by the Academy catering service. Thus our study offers some information about the food intake of cadets in addition to the validation of FCT vs CA.

Based on this study, FCT appear to be accurate enough to be employed to assess energy and macronutrient intake in Italian Army cadets. However, they do not allow an accurate estimate of fibre. Although the variability in the accuracy of the estimate of fibre between OA and IA weeks (31.6%) is surprising (also because it had no reflection on the estimate of energy and macronutrients), it is well known that fibre is difficult to estimate through FCT (Gibson, 1990).

Our study provided the opportunity to analyse nutrient intake of Italian Army cadets. The stability in body composition observed at 6 months from their arrival to the Academy proves that their energy intake was adequate. This is in contrast with the negative energy balance which can be calculated from their TEE. These data clearly show that an indirect estimate of TEE was not satisfactory to establish the adequacy of energy intake in the cadets and that measurements of body composition have to be employed to obtain a more realistic picture of their nutritional status. Despite the adequacy of their energy intake, a deficit of lipids (by FCT, mean value: –16%) was detected in the theoretical allowances of the cadets and a deficit of carbohydrates (by CA, mean value: –6%) was observed in their actual diet. Some interesting data have emerged from analysis of the food sold by the cadets' store in the Academy. A striking preference for carbohydrate-rich snacks is particularly evident (Table 4). This preference, as we found while interviewing cadets during the anthropometric surveys, appears to stem from the feeling that 'carbohydrates are what I need to improve my performance'. Unfortunately, the energetic and plastic roles of lipids and proteins and their contribution to the overall 'performance' of the body were not equally clear to the interviewed cadets. Taken together, these findings suggest the need for some basic education in nutrition science for the cadets. (This topic is currently limited to the cadets of

the 'Commissariat' Corps of the Italian Army.)

We conclude that FCT can be used to control energy and macronutrient intake of Italian Army cadets. Moreover, we suggest that an increase in the carbohydrate content of their diets would make them more corresponding to RDA.

Acknowledgements—The authors are grateful to the cadets of the 175th Course 'Coraggio' for their enthusiastic participation in this study.

References

Battistini N, Caselli D, Bedogni G & Gatti G (1992): Food intake in University students and its impact on nutritional status. *Nutr. Res.* **12**, 222–233.

Cok P, de Bernard B, Rudillo O & Francescato MP (1987): *Synoptic Food Composition Tables.* Piccin: Padova.

Commission of the European Communities (1993): *Nutrient and Energy Intakes for the European Community.* Luxembourg: Office for Official Publications of the European Communities.

Direzione Generale di Commissariato (1985): *Norme relative alle razioni e spettanze per il servizio vettovagliamento delle Forze Armate (COM-G-001).* Gaeta: Stabilimento Grafico Militare.

Dwyer JT (1994): Dietary assessment. In *Modern Nutrition in Health and Disease*, eds ME Shils *et al.*, pp. 842–860. Philadelphia, PA: Lea & Febiger.

Elia M (1992): Energy expenditure in the whole body. In *Energy Metabolism: Tissue Determinants and Cellular Corollaries*, eds JM Kinney & HN Tucker, pp. 19–47. New York: Raven Press.

Frisancho A (1990): *Anthropometric Standards for the Assessment of Growth and Nutritional Status*, pp. 20–22. Ann Arbor: University of Michigan Press.

Garrow JS & Webster J (1985): Quetelet's index (w/h^2) as a measure of fatness. *Int. J. Obes.* **9**, 147–153.

Gibson RS (1990): Assessment of nutrient intakes from food consumption data. In *Principles of Nutritional Assessment*, ed. RS Gibson, pp. 55–86. New York: Oxford University Press.

AOAC (1990): *Official Methods of Analysis*, 15th edn, ed. KH Helrick. Washington, DC: Association of Official Analytical Chemists.

Kim WW, *et al.* (1984): Effect of making duplicate food collection on nutrient intake calculated from diet records. *Am. J. Clin. Nutr.* **40**, 1333–1337.

Lohman TG, Roche AF & Martorell R, Eds (1988): *Anthropometric Standardization Reference Manual.* Champaign, IL: Human Kinetics Books.

Società Italiana di Nutrizione Umana (1996): Energia. In *Livelli di assunzione raccomandata di energia e nutrienti per la popolazione italiana (LARN)*, pp. 11–48. Società Italiana di Nutrizione Umana.

Stock AL & Wheeler EF (1972): Evaluation of meals cooked by largescale methods: a comparison of chemical analysis and calculation from food tables. *Br. J. Nutr.* **27**, 439–448.