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Assessment of nutritional and metabolic status of paraplegics

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Abstract—Nutritional and metabolic assessment using anthropometric, biochemical, immunological, and indirect calorimetric techniques was performed on 17 healthy paraplegic males with a mean age of 44.2 ± 14.6 years and mean duration of injury of 17.8 ± 12.3 years. Significant differences in energy expenditure were observed; only 29.4 percent were normometabolic [measured resting energy expenditure: (MREE) 90-110 percent of predicted resting energy expenditure (PREE)], 35.3 percent were hypermetabolic (MREE>110 percent of PREE) and 35.3 percent were hypometabolic (MREE<90 percent of PREE). Obesity (weight>110 percent ideal body weight) was maximum in hypometabolic patients (83.3 percent) due to the imbalance between caloric intake and energy expenditure ($p<0.05$). None of the patients had normal values for all four objective measurements of nutritional assessment (albumin, transferrin, total lymphocyte count, and cutaneous hypersensitivity). Mild malnutrition was evidenced in 47 percent of patients; 53 percent of patients demonstrated some index of moderate malnutrition. We conclude that nutritional therapy based on measurements of energy expenditure instead of predictive equations will benefit these patients. A larger long-term study is needed to determine the ideal predictive measurements of nutritional assessment with their optimal cutoff values applicable to the spinal cord–injured patient.

INTRODUCTION

Spinal cord injury results in various metabolic and endocrine disorders (8). Earlier studies (8, 10, 18, 32) demonstrated that spinal cord–injured patients have decreased body cell mass, increased proportion of body fat, and high incidence of malnutrition. In the early period after spinal cord injury, there is a decrease in the metabolic rate that is roughly proportional to the magnitude of the "spinal shock" (9, 31). Because little is known about the energy needs of the chronic spinal cord–injured patient, nutritional requirements are based on the assumption that such patients have decreased caloric needs. The absence of data concerning the nutritional and metabolic status of these patients may lead to overfeeding or underfeeding. We present data from anthropometric, biochemical, immunological and indirect calorimetric techniques in an attempt to define the nutritional and metabolic status of the spinal cord–injured patient.

METHODS

Patient Population

Included in this study were 17 males with chronic paraplegia who ranged in age from 27 to 75 years (mean ±SD 42.8 ± 12.7 yr). Spinal cord lesions were at the level of T_4 to L_2, with a mean duration of injury of 17.8 ± 12.3 years (range 1.5 to 39 yr). All 17 patients had completed a rehabilitation program and were receiving a regular diet. Patients were free of severe cardiac, renal, or hepatic disease; exhibited no acute

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TABLE 1
Parameters used for classification of malnutrition

	Level of Malnutrition			Positive
Parameter	mild	moderate	severe	Responses
Serum albumin, gm/dL	<3.5	<3.0	<2.1	
Serum transferrin, mg/dL	<175	<150	<100	
Total lymphocyte count, mm^3	<2,000	<1,200	<800	
Delayed hypersensitivity				
Normal				2 or more
Relatively anergic				1 or more
Anergic				none

distress; and were without large decubitus ulcers.

Assessment of Nutritional and Metabolic Status

An automated metabolic profile was used (1). Anthropometric evaluation included body weight, height, wrist circumference, and triceps skinfold. Triceps skinfold was taken as the mean of three readings at the back of the nondominant arm at a point midway between the acromial and olecranon processes. The percentage of ideal body weight and triceps skinfold was calculated from adult standards (20, 33). Measurements of serum albumin and serum transferrin (derived from total iron-binding capacity) were used as an indication of visceral protein status. Total lymphocyte count and delayed cutaneous hypersensitivity were used to assess immunocompetency. Twenty-four-hour urine was used to determine creatinine excretion and urinary creatinine excretion per kilogram and as an index of muscle mass. The prognostic nutritional index (PNI; in percent) was derived as (28)

$$PNI = 158 - 16.6A - 0.78TSF - 0.20TR - 5.8D$$

where A is serum albumin, TSF is triceps skinfold, TR is serum transferrin, and D is delayed cutaneous hypersensitivity.

Malnutrition was classified as mild, moderate, or severe based on serum albumin and transferrin levels, total lymphocyte count, and delayed hypersensitivity (Table 1). Indirect calorimetric techniques using the metabolic measurement cart (30) were used to determine resting energy expenditure. Measurements were done more than 2 hours after a morning or afternoon meal using a nonrebreathing valve mouthpiece and nose clip. The abbreviated Weir formula (36) was used to calculate the resting energy expenditure from a mean of four or five 1-minute measurements obtained after steady-state conditions. The predicted resting energy expenditure (PREE) was calculated using the formula of Harris and Benedict (19) and used to convert the measured resting energy expenditure (MREE) to percent PREE. The metabolic status of the patients was classified as hypometabolic (MREE <90 percent PREE), normometabolic (MREE >90 percent <110 percent PREE) or hypermetabolic (MREE >110 percent PREE) as previously reported (7). Data for MREE and PREE were corrected for kilogram of body weight, metabolic body size ($kg^{0.75}$) according to Kleiber (21); data for body surface area (BSA in m^2) were corrected according to DuBois (13).

A registered dietician determined the total daily caloric and protein intake, and a 24-hour record of diet was maintained.

Statistical analysis. A one-way analysis of variance was used and differences between sample groups were established using the f test. Differences were considered significant at a level of $p<0.05$.

RESULTS

Table 2 summarizes patient characteristics and the results of the nutritional and metabolic status of the 17 patients as a whole and according to metabolic group (based on percent PREE). The mean body weight of the 17 patients (73.9 kg) represents a wide range from 69.1 to 199.6 percent of ideal body weight. Of these 17 patients, 8 weighed over 110 percent and 2 weighed less than 90 percent of ideal body weight. According to metabolic group, five (83.3 percent) hypometabolic, three (60 percent) normometabolic and no hypermetabolic patients had a body weight greater than 110 percent of ideal (Fig. 1). Both patients with body weight less than 90 percent of ideal were hypermetabolic.

Triceps skinfold measurements ranged from 5

TABLE 2
Nutritional status of total patient population and each metabolic group*

	Metabolic Group†			
	hypo, <90%PREE	normo, 90–110% PREE	hyper, >110% PREE	Total
Patients	$N = 6$	$N = 5$	$N = 6$	$N = 17$
Age	44.2 ± 14.6	41.0 ± 5.2	48.3 ± 15.5	42.8 ± 12.7
Duration of injury, yr	15.6 ± 9.3	19.3 ± 14.3	18.6 ± 12.0	17.8 ± 12.3
Height, cm	178.0 ± 8.9	175.3 ± 4.5	180.3 ± 5.9	177.8 ± 6.0
Weight, kg	81.4 ± 12.7§	77.1 ± 18.5	63.7 ± 8.9	73.9 ± 15.7
Ideal body weight, %	122.6 ± 13.3§	126.5 ± 38.2	94.4 ± 14.1	113.8 ± 27.8
Body surface area, m^2	2.0 ± 0.2	1.9 ± 0.1	1.8 ± 0.1	1.9 ± 0.1
Triceps skin fold, mm	12.8 ± 9.2	13.8 ± 9.6	9.0 ± 3.1	11.5 ± 7.8
Ideal triceps skin fold, %	114.1 ± 84.5	121.2 ± 88.8	77.8 ± 28.2	101.5 ± 72.0
Serum albumin, gm/dL	3.7 ± 0.2	4.0 ± 0.3	4.0 ± 0.5	3.9 ± 0.4
Serum transferrin	189.4 ± 43.5	151.4 ± 32.1	194.0 ± 49.1	179.9 ± 46.5
Total lymphocyte count × 10^2mm^3	15.5 ± 2.8§	22.6 ± 13.1	24.0 ± 7.3	20.6 ± 9.3
24-Hr urinary creatinine, mg/kg	17.3 ± 4.4	13.1 ± 5.2	19.8 ± 5.4	16.9 ± 5.8
Delayed hypersensitivity‡				
Normal	1	1	1	3
Relatively anergic	2	3	2	7
anergic	3	1	3	7

All values are mean ± SD. * One percent predicted resting energy expenditure (PREE). † One-way analysis of variance showed no statistically significant differences among metabolic groups. ‡ Normal = 2 or more positive responses; relatively anergic = 1 positive response; anergic = no positive response. § Difference between hypometabolic and hypermetabolic significant at $p<0.05$.

to 13 mm (45 to 272 percent; 50th percentile of ideal TSF). No significant statistical differences were observed among the groups due to this wide range. In general, however, hypermetabolic patients had lower TSF measurement than hypometabolic and normometabolic patients.

Fifteen of seventeen patients (88 percent) had serum albumin levels greater than 3.5 gm/dL and only two patients had mildly decreased levels (3.3 gm/dL and 3.4 gm/dL, respectively). Six patients had serum transferrin values between 150 and 175 mg/dL, and three had moderately decreased levels of serum transferrin (between 100 and 150 mg/dL).

Immunocompetency, as determined by total lymphocyte count, revealed that only six patients (35 percent) had counts over 2000/mm^3. Nine patients had counts between 1200 and 2000/mm^3, and only two patients had counts between 800 and 1200/mm^3 (i.e., moderate immunodeficiency). Similarly, there was an extremely variable response to skin test antigens. Only three patients (17.6 percent) had a normal response; seven patients (41.2 percent) were relatively anergic, whereas the remaining seven were anergic.

Nutritional status assessment using serum albumin (>3.5 gm/dL), serum transferrin (>175 mg/dL), total lymphocyte count (>2,000/mm^3) and skin test reactivity revealed that, although mean values (Table 1) were normal for serum albumin, serum transferrin and lymphocyte count, none of the patients were normal for all four parameters. Three patients (18 percent) had three normal values, eight patients (47 percent) had two normal values, and six patients (35 percent) had only one of four normal values. Therefore, eight patients (47 percent) had evidence of mild malnutrition and nine (53 percent) demonstrated a degree of moderate malnutrition. However, as shown in Table 2, there were no significant differences among the metabolic groups with respect to serum albumin, serum transferrin, total lymphocyte count, and delayed cutaneous hypersensitivity.

The mean MREE was similar to PREE, 102.7 percent of PREE, with no statistically significant differences. The mean values were also similar when energy-expenditure data were calculated for per kilogram body weight, body surface area, or metabolic body size. Individual