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Nutrient Intake of Marathon Runners

Janice V. Butler

Abstract

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Three-day food records from a large group of marathon runners were analyzed and compared to various standards of dietary quality. Nutrient intake by the runners exceeded two-thirds the Recommended Dietary Allowance for all nutrients except for vitamin D and zinc in female runners. Energy and nutrient intake levels in the marathon runners were higher than those of the general US population except for fat and zinc in both males and females, and vitamin B12 in females. In general this group of runners consumed diets that would be considered more optimal than those of the general population. However, both caloric intake and percent energy as carbohydrate were lower than recommended for individuals engaging in endurance exercise. Professional help in planing high-carbohydrate diets for runners is indicated. Increasing amounts of training were not associated with significant increases in nutrient densities across three activity categories. Our data support the concept that the adoption of a regular running program may be more important than the quantity of training conducted when considering the quality of nutrient intake. It would appear prudent to emphasize public health measures that promote the adoption of regular physical activity by sedentary individuals in that a concomitant improvement in the quantity and quality of nutrient intake may result.

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Each person whose signature appears below certifies that this manuscript in his/her opinion is adequate, in scope and quality, in lieu of a thesis for the degree Master of Science.

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Introduction

Apart from the limits imposed by heredity and training-induced physiological improvements, no factor plays a larger role in exercise performance than nutrition (1). As a consequence, athletes have been bombarded with a wide variety of dietary recommendations from many avenues, including their coaches, friends and competitors, popular magazines, and medical personnel. Unfortunately, despite the efforts of dietitians and physiologists, considerable misinformation and exaggeration exist regarding the relationship between nutrition and exercise. For dietitians, data on the dietary habits of endurance athletes on which to base professional counsel are scarce.

Despite the plethora of sports nutrition publications, very few formal studies of the dietary intake of endurance athletes have been reported (2,3). There are several reasons why more information is needed on the dietary intake of endurance athletes. Some evidence indicates that the nutritional stresses imposed by endurance training may be greater than can be met by the conventional diet (e.g., carbohydrate, protein, iron, zinc, magnesium, chromium, vitamin B-6, riboflavin, and ascorbic acid) (1,4-9). Additionally, preliminary evidence also suggests that the dietary habits of some endurance athletes are associated with suboptimal intakes of various important nutrients, especially carbohydrate and iron, which may lead to impaired performance (1,5,7,8). Accurate assessment of the dietary intakes of endurance athletes is needed to help explore these issues.

As reviewed by Blair et al (3), the established effects of physical activity on the incidence of certain diseases may be produced through both direct and indirect mechanisms. For example, increase in physical activity may help lower serum cholesterol directly by affecting lipoprotein metabolism while also exerting indirect effects by producing weight loss or perhaps, improvement in the quality of the diet. The association between physical activity and health can be appreciated only when both the direct and indirect effects are considered. To evaluate the health-related benefits associated with physical activity, the connection between increasing levels of physical activity and improvement in the quality of the diet needs to be explored.

A limited number of dietary studies have been conducted on endurance runners. These surveys have included relatively small numbers of subjects and have analyzed few nutrients (1,10-18). The data reported in this article represent the most complete and extensive dietary study of endurance runners published. Comparisons were conducted with various standards of reference, national surveys on the general population, and information from other published research to better define the dietary intake of a large group of endurance runners. In addition, nutrient intake across physical activity strata is summarized to explore the relationship between differing levels of physical activity and the quality of dietary intake. This information should help assist dietitians and researchers as they attempt to answer the questions posed in this introduction.

Methods

With the cooperation of the Los Angeles Marathon administrators and Tandem Computers Incorporated, 4926 runners were randomly selected from the 12,200 applicants of the 1987 Los Angeles Marathon. A pilot-tested questionnaire investigating training and demographic information was mailed to each, of which 2311 responded. These data are being published elsewhere (19).

Eight months later (October of 1987), the respondents were recontacted, and asked to participate in a dietary assessment research project. Three hundred and forty-seven runners voluntarily complied with instructions, and recorded all food, water, and supplement intake during a three-day period. The three-day food record booklets contained detailed instructions on how and when to record all food intake. A questionnaire to collect demographic and exercise training data was also included.

Subjects were requested to record all foods, beverages, special recipes, and supplements immediately after each meal in household measures in the food diary booklet. A sample record demonstrating these procedures was included along with detailed instructions. The food record booklet was organized to ensure that subjects recorded intake during a Sunday, Monday, Tuesday sequence during either late October or early November. Subjects were asked to supply telephone numbers so that the investigators could clarify any ambiguous food entries.

The dietary records were coded by two trained nutrition graduate students using the Nutritionist III data base (N-Squared Computing, Silverton, OR). Analysis for nutrient composition was conducted using the Nutritionist III software program (version 3.0, 1988). Nutritionist III contains nutrient information on 1887 foods and analyzes them by weight and percent RDA for 58 nutrients. The nutrient data are based primarily on the revised USDA Agriculture Handbooks No. 8-1 through 8-16, and have been found to compare closely with the USDA Nutrient Data Base for Standard Reference (20). Food items not included in the data base were substituted with the closest possible food item of similar food value or broken down by ingredients. Recipes supplied by the subjects were analyzed separately and included within the analysis.

The Statistical Package for the Social Sciences (SPSS/PC+) software program (21) was used for all statistical analyses. Data across the three training categories were tested using one-way and 3 x 2 analysis of variance (ANOVA). Results are expressed as means$\pm$SE and statistical signficance was tested at the $P<.05$ level.

Results

Subject characteristics are outlined in Table 1 for male and female runners separately. Although all subjects are experienced marathon runners, the training and performance data when evaluated in its entirety describe a group that is far from elite in their abilities. Most of these runners can be regarded as serious fitness runners who have been running for many years. This group can also be characterized as well educated. The average Quetelet Index for the male and female runners reveals a generally lean group, with only 12%

of the runners (in comparison to 52% of all U.S. adults) possessing a Quetelet Index above 25, a level that is associated with obesity (22) Figure 1 and Table 2 show that in general, the marathon runners' diets as a whole compare favorably with the recommendations published by the American Heart Association (23) and the National Cancer Institute (24). Total energy consumption falls below the levels recommended by the Food and Nutrition Board for males and females doing light work (2700 and 2000 kilocalories respectively) (25). Nevertheless, when compared with results from the USDA Nationwide Food Consumption Survey (26), the energy consumption of the runners is substantially higher (11.3% and 23.4% respectively). Males and females averaged 35.0±0.6 and 34.3±1.5 kilocalories per kilogram of body weight respectively.

The percent kilocalories consumed as fat, carbohydrate, and protein are close to the 30%, 55%, 15% respective levels recommended by the American Heart Association (23) (see Figure 1). However, the percent kilocalories consumed as carbohydrate falls below the 60-65% recommended by The American Dietetic Association for athletes (4). Dietary fiber is nearly double the national average as reported recently by Lanza (12.9 grams per day for men, 9.4 grams per day for women) (27), and very close to the National Cancer Institute's (24) recommendation of 20-30 grams per day.

Cholesterol intake averaged slightly higher than the 100 mg/1000 kcal recommended by the American Heart Association (23). Thirty-eight percent of the runners consumed more than 200 mg of caffeine per day, a somewhat greater prevalence than the estimated 30% in the general population (28). The various nutrient ratios are somewhat closer to optimal levels than those of the general population. The polyunsaturated to saturated fatty acid ratio (P/S) in our sample is slightly above the 0.5 level reported in various national studies (30). Although the intake of saturated fatty acids is nearly doubled the polyunsaturated fatty acids, percent total energy as saturated fatty acids falls slightly below 10% level recommended by the American Heart Association (23). The sodium to potassium ratio (Na/K) in our sample is lower than the reported US average of 1.2-1.4, but substantially higher than the recommended level of 0.58 (31).

Intake of vitamins and minerals are compared with the Recommended Dietary Allowance (RDA) in Figures 2 and 3. For both males and females, average intake of all nutrients was above two-thirds the RDA except for vitamin D and zinc in females. Table 3 shows that in general, all additional selected nutrients were within the estimated safe and adequate range recommended by the Food and Nutrition Board (25) except for lower levels of fluoride in males and copper in both males and females. These may reflect deficiencies in the data base. For example, approximately 67% and 24% of values for fluoride and copper respectively were indicated by Nutritionist III as unknown.

In Table 4, average nutrient intake by our sample marathon runners is compared with results from the USDA Nationwide Food Consumption Survey (26) and the Food and Drug Administration's Total Diet Study (31). Nutrient intake levels in the marathon runners are higher than those of the general US population for all nutrients except for fat and zinc in both males and females, and vitamin B12 in females. A published in the 1986 Exchange Lists for Meal Planning (29) are expressed per 1000 kilocalories across three training categories. ANOVA showed no significant differences across these categories, although there was a trend for greater vegetable intake in the highest km/wk category. For the runner group as a whole, food exchanges averaged 1.4±0.1 per day for milk, 11.2±0.3 per day for bread, 1.6±0.1 per day for vegetables, 3.9±0.2 per day for fruit, 7.4±0.3 per day for meat, and 15.0±0.5 for fat.

Figure 4 (A and B) shows the results from analysis of the questionnaire regarding changes in diet since starting a regular running program that accompanied the three-day food record. More than 75% of the runners reported somewhat or definitely higher intakes of fruits, vegetables, whole grains, poultry and fish, and lower intakes of red meat, eggs, and fats since starting a regular running program as compared with pre-running years.

The Food and Nutrition Board has published recommendations for essential amino acid intake, expressed as milligrams per kilogram of body weight (mg/kg) (25). Amino acid intake (mg/kg) by the marathon runners is expressed as a percentage of these recommended levels in Figure 5. Essential amino acids intakes ranged from four to eight times the recommended levels. Protein intake overall averaged 1.4±0.03 and 1.3±0.1 grams per kilogram of body weight for males and females respectively, which is well above the published recommendations of the Food and Nutrition Board (25) for the general population (0.8 g/kg) and the American Dietetic Association (4) for endurance athletes (1 g/kg).

Discussion

Three-day food records from a large group of marathon runners were analyzed and compared to various standards of dietary quality. These data demonstrate that overall nutrient intake by the runners was adequate and substantially higher when compared to the general population. The runners' diet also resembled current prudent dietary recommendations more closely. However, both caloric intake and percent energy as carbohydrate were lower than recommended for individuals engaging in endurance exercise (4). Increasing amounts of training were not associated with improvement in the quality of the diet within this group of runners.

Results from the present study are compared with previous findings from the literature in Table 7. In the two studies that compared amenorrheic and eumenorrheic women runners, results from the amenorrheic subjects are excluded (33,34) in that amenorrheic women have been found to have significantly different diets (35). Our results are in agreement with other studies. The composition of the diet when expressed as a percentage of total energy intake is surprisingly consistent across the wide range of km/wk training distances reported. Both energy and carbohydrate intake are lower than recommended but higher than observed in the general population, in agreement with our findings. However, with increase in km/wk trained, an increase in energy consumption when expressed as kcal/kg is generally seen. In all studies, which measured vitamin and mineral intake of their subjects, including our own, consumption of at least 67% of the RDA for the major nutrients was reported. Intake of zinc and vitamin D was assessed slightly below this level in our female runners.

Data from the present study and those outlined in Table 7 demonstrate that runners in general have unexpectly low energy intakes (2,36). Although dietary assessment methodologies are undoubtedly a factor, Barr (36) has concluded that the question of how athletes are able to train and compete successively while consuming what appears to be inadequate energy intakes remains unanswered for the present. Despite the low absolute energy intake in relationship to training levels, our data do support the consistent observation of others that energy intake when adjusted for body weight shows a positive association with levels of training (3,10).

Blair et al (3) have suggested the adoption of a regular exercise program may be associated with a concomitant improvement in dietary quality. Our data support this view in that the majority of the runners reported their present dietary habits were much improved when compared to pre-running years. In addition, intake of nearly all nutrients were higher in the runners when compared to the general population, perhaps resulting from the higher kilocalorie and carbohydrate consumption but lower fat intake. However, comparisons across activity strata showed nutrient densities did not improve with increase in kilometers per week of running, similar to the findings of several other researchers (10,15,17). In general, our data support the concept that the adoption of a regular running program may be more important than the quantity of training conducted when considering the quality of the diet.

A commom problem inherent in studies that require diet record keeping is a low return rate. Only 15% of the group responded to our study. In general, our responders were 2yrs older and somewhat more skilled as runners than non-reponders. However, the percentage of male and female in both groups were the same (85% and 15% respectively). Therefore our conclusion may not be applicable to runners in general.

Application

In a recent technical support paper from the American Dietetic Association (4), a position was taken that extended physical activity may increase the need for protein and some vitamins and minerals, but that these could easily be met by consuming a balanced diet in proportion to the extra caloric requirement. Our data support this viewpoint. However, concern was expressed that consuming the RDA for iron and calcium for women may require special attention by female athletes. In our sample of female runners, calcium intake of 750 mg was nearly 270 mg higher than reported for the general population. Iron and calcium intake was sufficient. Iron intake averaged 14 mg a day, which may still not be adequate to counter exercise-induced losses (8).

The ADA technical support paper also urged that foods high in complex carbohydrates be emphasized in the caloric distribution to promote glycogen storage in individuals engaging in regular endurance exercise. Our runners consumed less than the recommended amounts of carbohydrate and we agree that they may need professional help in planning a high complex-carbohydrate diet. In general, however, this group of runners consumed diets that would be considered better than those of the general population. It would appear prudent to emphasize public health measures that promote the adoption of regular physical activity by sedentary individuals. Along with other exercise related benefits, improvement in the quantity and quality of nutrient intake may result.

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Table 1. Subjects characteristics (mean±SE)

	males (n=291)	females (n=56)
age (yrs)	40.1±0.6	37.8±1.2
weight (kg)	73.1±0.5	55.6±0.9
height (cm)	177.8±0.4	163.8±0.8
Quetelet index * (kg/m^2)	23.1±0.1	20.9±0.3
education (yrs)	16.5±0.1	16.1±0.3
† marathon pr (min)	229.0±2.8	268.4±8.8
‡ 10k pr (min)	41.7±0.3	49.5±1.6
running experience (years)	8.2±0.3	6.7±0.6
# avg km/wk	46.3±1.6	39.7±3.2
¶ avg days/wk	4.4±0.1	4.2±0.2
][avg time/km (min)	5.0±0.04	5.6±0.1

* Quetelex index = body weight in kilograms by height in meters squared

† marathon pr = marathon race personal record

‡ 10k pr = ten kilometer race personal record

avg km/wk =average kilometer per week running during previous month

¶ avg days/wk = average days running per week during previous month

| avg time/km = average minutes to run one kilometer in training during previous month

Table 2. Mean daily intakes of selected nutrients from 3-day dietary records of marathon runners (mean±SE)

nutrients	males (n=291)	f males (n 56)
energy (kcal)	2526 ±43	1868 ±81
protein (gm)	105 ± 2	73 ± 5
fat (gm)	86.7 ± 2.1	66.4 ± 4.6
safa (%kcal) *	9.2 ± 0.2	9.3 ± 0.6
pufa (%kcal) †	4.5 ± 0.1	5.0 ± 0.4
mufa (%kcal) ‡	7.6 ± 0.2	7.7 ± 0.5
carbohydrates (gm)	327 ± 7	246 ±11
dietary fiber(gm)	20.9 ± 0.7	17.1 ± 1.2
cholesterol (mg)	295 ±12	224 ±35
caffeine (mg)	207 ±14	185 ±26
c/p #	0.64± 0.02	0.67± 0.02
na/k ¶	0.95± 0.03	0.96± 0.06
p/s ‖	0.56± 0.02	0.62± 0.06

* safa = saturated fatty acids

† pufa = polyunsaturated fatty acids

‡ mufa = monounsaturated fatty acids

\# c/p = calcium phosphate ratio

¶ na/k = sodium potassium ratio

‖ p/s = polyunsaturated saturated fatty acid ratio

Table 3. Selected vitamins and minerals compared with estimated safe and adequate daily dietary intakes. (means±SE)

	marathon runners males (n=291)	marathon runners females (n=56)	* safe and adequate range
panto acid (mg)	5.11± 0.12	3.98± 0.25	4.0-7.0
vitamin K (g)	291 ±23	324 ± 59	70-140
sodium (mg)	3303 ±81	2583 ±149	1100-3300
potassium (mg)	3795 ±86	3037 ±176	1875-5625
fluoride (mg)	1.32± 0.16	1.69± 0.48	1.5 -4.0
selenium (mg)	0.11± 0.01	0.08± 0.01	0.05-0.2
copper (mg)	1.86± 0.07	1.32± 0.09	2.0 -3.0
chromium (mg)	0.23± 0.03	0.21± 0.08	0.05-0.20
manganese (mg)	2.87± 0.16	2.45± 0.24	2.5 -5.0

* From the Food and Nutrition Board: Recommended Dietary Allowances 9th ed. Washington, D.C: National Academy of Sciences, 1980.

Table 4. Nutrient levels of marathon runners compared with data from national surveys*

nutrients	males: marathon runners	males: national average	females: marathon runners	females: national average
energy (kcal)	2526	2270	1868	1514
carbohydrate (gm)	327	219	246	152
protein(gm)	105	94	73.5	64.5
fat (g)	86.7	108	66.4	71.0
vit A (IU)	11174	6002	11360	5195
vit C (mg)	147	83.0	115	75.0
thiamin (mg)	1.95	1.47	1.38	1.01
riboflavin (mg)	2.28	1.86	1.62	1.31
niacin (mg)	30.5	23.4	20.6	16.2
vit B-6 (mg)	2.58	1.71	1.64	1.17
vit B-12 ( )	5.98	5.70	2.98	4.60
calcium (mg)	1033	750	797	530
phosphorus (mg)	1685	1359	1176	933
magnesium (mg)	385	308	299	222
iron (mg)	19.5	15.6	14.0	10.9
zinc (mg)	12.0	16.5	8.21	9.56
iodine (mg)	0.75	0.52	0.64	0.27
copper (mg)	1.85	1.24	1.32	0.93
manganese (mg)	2.87	2.72	2.45	2.05
selenium (mg)	0.12	0.10	0.08	0.06
sodium (mg)	3302	3097	2583	2016

potassium (mg)	3795	2889	3036	1938

*Based on USDA Nationwide Food Consumption Survey (1977-78) 35-50 yrs old age groups and selected minerals from the FDA's total Diet Study, 1982-1984, (25-30 yrs old age group) (26,36).

Table 5. Nutrient / 1000 kcal of marathon runners

	kilometer/week category							
nutrient	≤ 32 (n=102)		32 - 56 (n=125)		56 ≥ (n=107)		f	p value
protein (gm)	41.9	±1.1	40.6	±1.1	42.0	±1.3	.52	.60
carbohydrates (gm)	128	±3	130	±3	135	±3	2.14	.12
diet fiber (gm)	8.47	±0.45	8.40	±0.36	8.90	±0.36	0.44	.64
caffeine (mg)	83.3	±12.5	98.81	±0.4	88.4	±9.1	0.63	.53
fat (gm)	34.9	±0.9	34.6	±0.8	32.4	±0.9	2.14	.12
cholesterol (gm)	120	±7	110	±6	120	±9	.71	.49
saturated fatty acids (mg)	10.5	±0.4	10.3	±0.4	9.70	±0.4	.97	.38
vit A (IU)	4587	±558	4922	±464	5322	±7.15	.38	.68
vit D ( )	83.8	±8.2	69.1	±4.0	77.7	±8.6	1.08	.34
vit C (mg)	59.7	±3.9	54.1	±3.2	66.8	±5.5	2.34	.10
vit E/T (mg TE)	7.78	±0.44	7.36	±0.04	7.20	±0.42	.50	.61
vit K ( )	115	±12	118	±13	167	±28	2.41	.09
thiamin (mg)	0.81	±0.03	0.78	±0.03	0.78	±0.02	.42	.66
riboflavin (mg)	0.94	±0.04	0.89	±0.04	0.92	±0.03	.50	.61
niacin (mg)	12.7	±0.5	11.8	±0.4	12.1	±0.6	.82	.44
vit B-6 (mg)	1.05	±0.05	0.98	±0.04	1.03	±0.04	.67	.51
folacin ( )	152	±9	143	±7	150	±7	.45	.64
vit B-12 ( )	2.43	±0.29	2.32	±0.33	2.04	±0.14	.50	.61
calcium (mg)	406	±15	403	±13	443	±17	2.27	.11
phosphorus (mg)	663	±17	640	±13	673	±17	1.36	.26

magnesium (mg)	159 ±6	153 ±4	156 ±5	.37	.69
iron (mg)	8.00 ±0.343	7.94±0.256	7.82 ±0.239	.10	.90
zinc (mg)	4.69 ±0.166	4.66±0.120	4.79 ±0.231	.17	.84
iodine ( )	31.7 ±3.5	30.4 ±2.5	32.8 ±2.9	.19	.83
panto acid (mg)	2.05 ± 0.06	1.98±0.05	2.17 ±0.07	2.69	.07
copper (mg)	0.700 ±0.025	0.741±0.040	0.78 ±0.051	.96	.38
manganese (mg)	1.13 ±0.08	1.17 ±0.076	1.23 ±0.108	.32	.73
chromium (mg)	0.086 ±0.018	0.084±0.013	0.121±0.026	.20	.30
selenium (mg)	0.046 ±0.002	0.044±0.002	0.047±0.003	.43	.65
sodium (mg)	1358 ±41	1380 ±43	1280 ±46	1.44	.24
potassium (mg)	1514 ±48	1510 ±37	1634 ±64	1.93	.15

Table 6. Food exchanges for marathon runners per 1000 kcal

	kilometer per week category				
	≤ 32 (n=101)	32 - 56 (n=125)	56 ≥ (n=107)	f	p value
milk	0.56±0.06	0.54±0.05	0.63±0.06	.60	.55
bread	4.66±0.14	4.76±0.12	4.65±0.14	.23	.80
vegetables	0.65±0.08	0.60±0.06	0.88±0.12	3.08	.05
fruit	1.54±0.11	1.61±0.12	1.73±0.12	.59	.56
fat	6.26±0.29	6.15±0.23	5.71±0.25	1.26	.29
meat	3.15±0.16	3.0 ±0.14	3.03±0.17	0.28	.75

Table 7 Summary of dietary studies on long distance runners

reference	N	wt (k)	*km/wk	kcal	carb (%)	fat (%)	prot (%)	alco (%)	RDA met†	kcal/kg
<u>males</u>										
Blair (10)	34	71	65	2959	40	41	14	6	--	‡ 41.7
Clement (11)	35	--	77	3020	49	34	16	--	--	--
Peters (12)	15	68.9	91	3292	49	31	15	5	yes	
Short (13)	9	--	--	4121	49	36	14	--	yes	
Weight (14)	30	70.2	≥70	2468	60	21	19	--	yes	
Nieman #										
total gp	281	73.1	46	2552	52	31	17	3	yes	34.9
low km/wk gp	82	74.2	18	2447	51	31	17	3	yes	33.0
mid km/wk gp	106	73.4	42	2624	52	31	16	3	yes	35.7
high km/wk gp	93	71.7	76	2560	29	17	17	2	yes	35.7
females										
Blair (10)	27	54.0	55	2386	39	42	16	5	--	
Clement (11)	17	--	70	2026	50	39	15	--	--	
Dale (15)	37	51.6	73	2217	46	39	15	--	yes	
Deuster (16)	51	51.7	113	2397	55	32	13	--	yes	
Moore (17)	45	55.5	50	1765	40	42	17	4	--	
Nieman										
total gp	53	55.6	40	1882	54	31	16	1	yes	33.8
low km/wk gp	20	57.2	16	1774	54	32	15	1	yes	31.0
mid km/wk gp	19	53.9	42	1760	55	30	16	1	yes	32.6

high km/wk gp	14	55.3	70	2193	54	30	17	2	yes 39.7

* average kilometers per week of training

† at least 67% RDA met for protein and all major vitamins and mineral that were analyzed

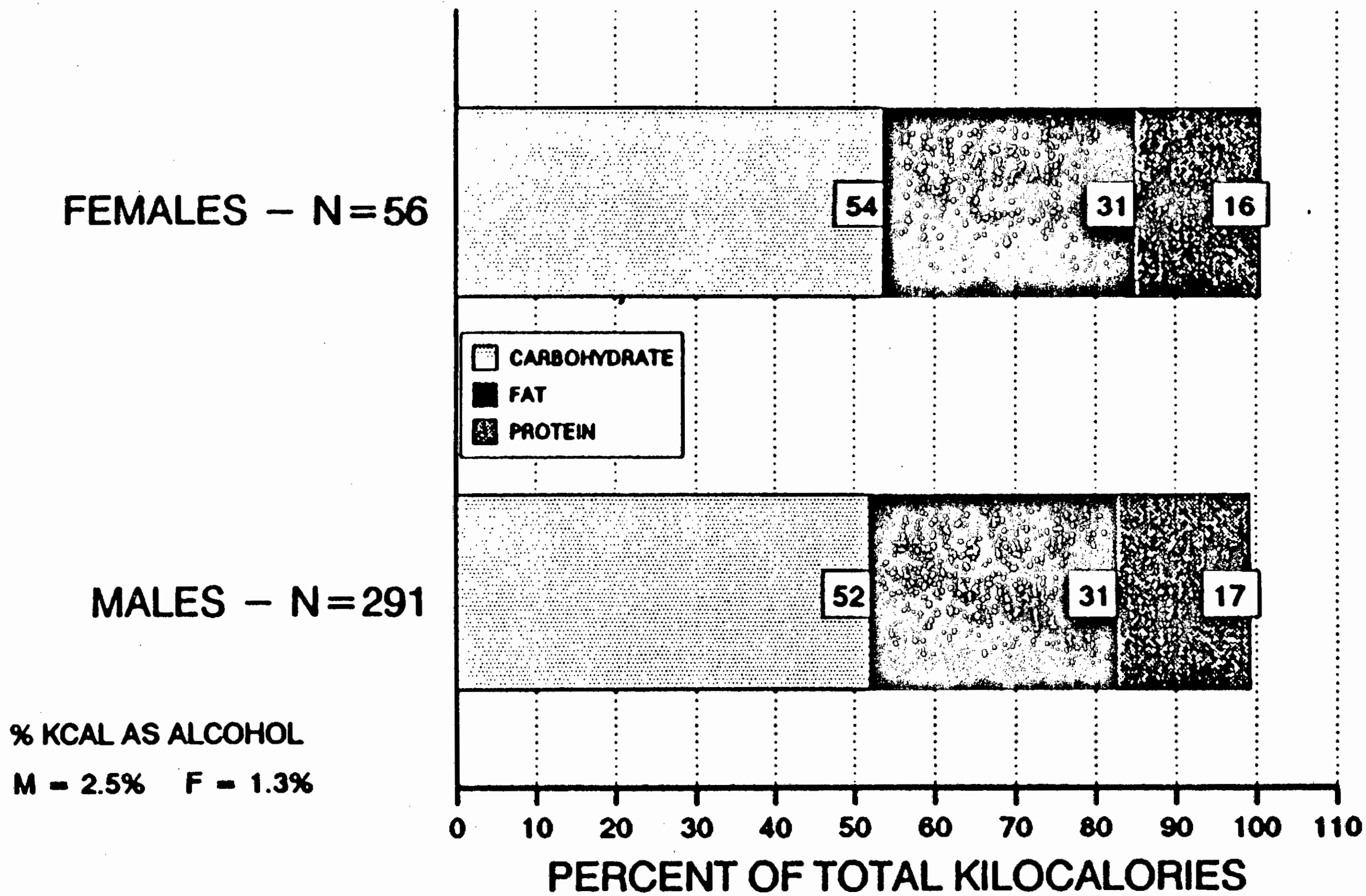
data not availble = --

subgroups both males and females not significantly different from one another for all dietary variables shown in table despite significant differences in km/wk running

¶ total group met 67%RDA for all nutrients except zinc and vitamin D; the high km/wk group was low only in zinc

MARATHON RUNNERS — PERCENT KILOCALORIES
CARBOHYDRATE, PROTEIN, FAT

Figure 1



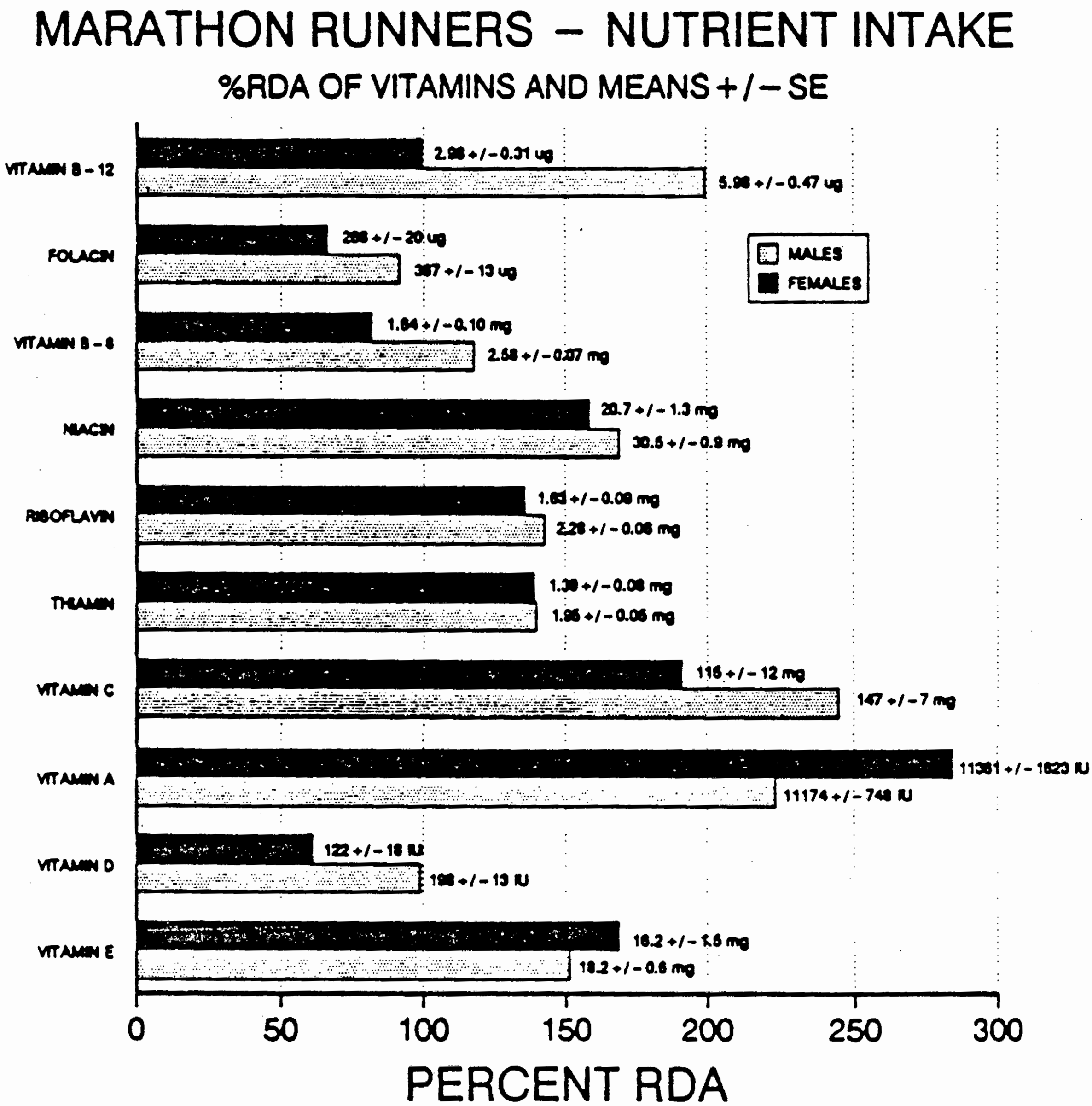

MARATHON RUNNERS – NUTRIENT INTAKE
%RDA OF VITAMINS AND MEANS +/– SE
VITAMIN B-12
FOLACIN
VITAMIN B-6
NIACIN
RIBOFLAVIN
THIAMIN
VITAMIN C
VITAMIN A
VITAMIN D
VITAMIN E
MALES
FEMALES
147 +/- 7 mg
11174 +/- 748 IU
0
50
100
150
200
250
300
PERCENT RDA

Figure 2

MARATHON RUNNERS – NUTRIENT INTAKE

%RDA OF MINERALS AND MEANS +/– SE

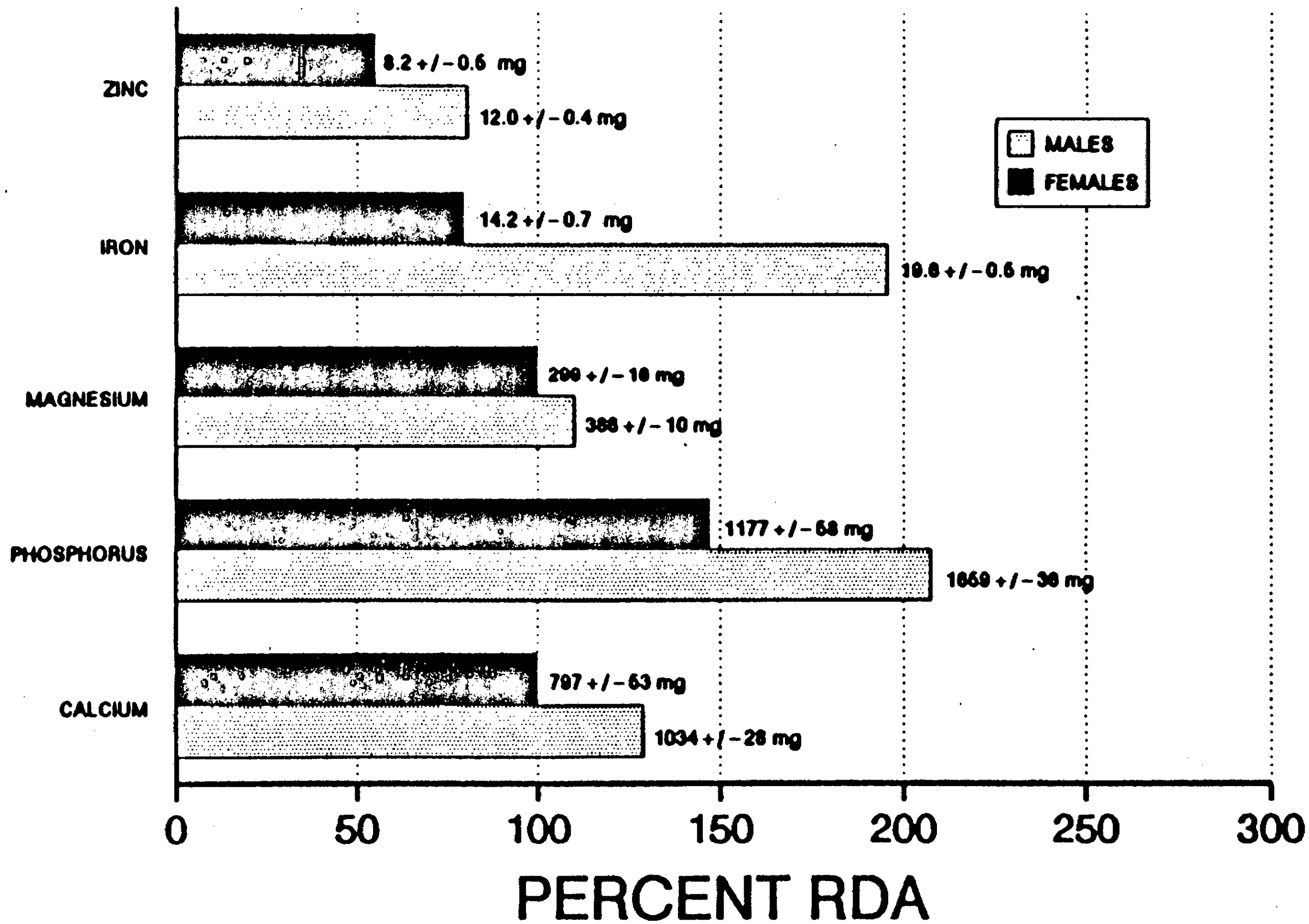


Figure 3

MARATHON RUNNERS – QUESTIONNAIRE RESPONSES

RUNNING COMPARED WITH PRE – RUNNING YEARS

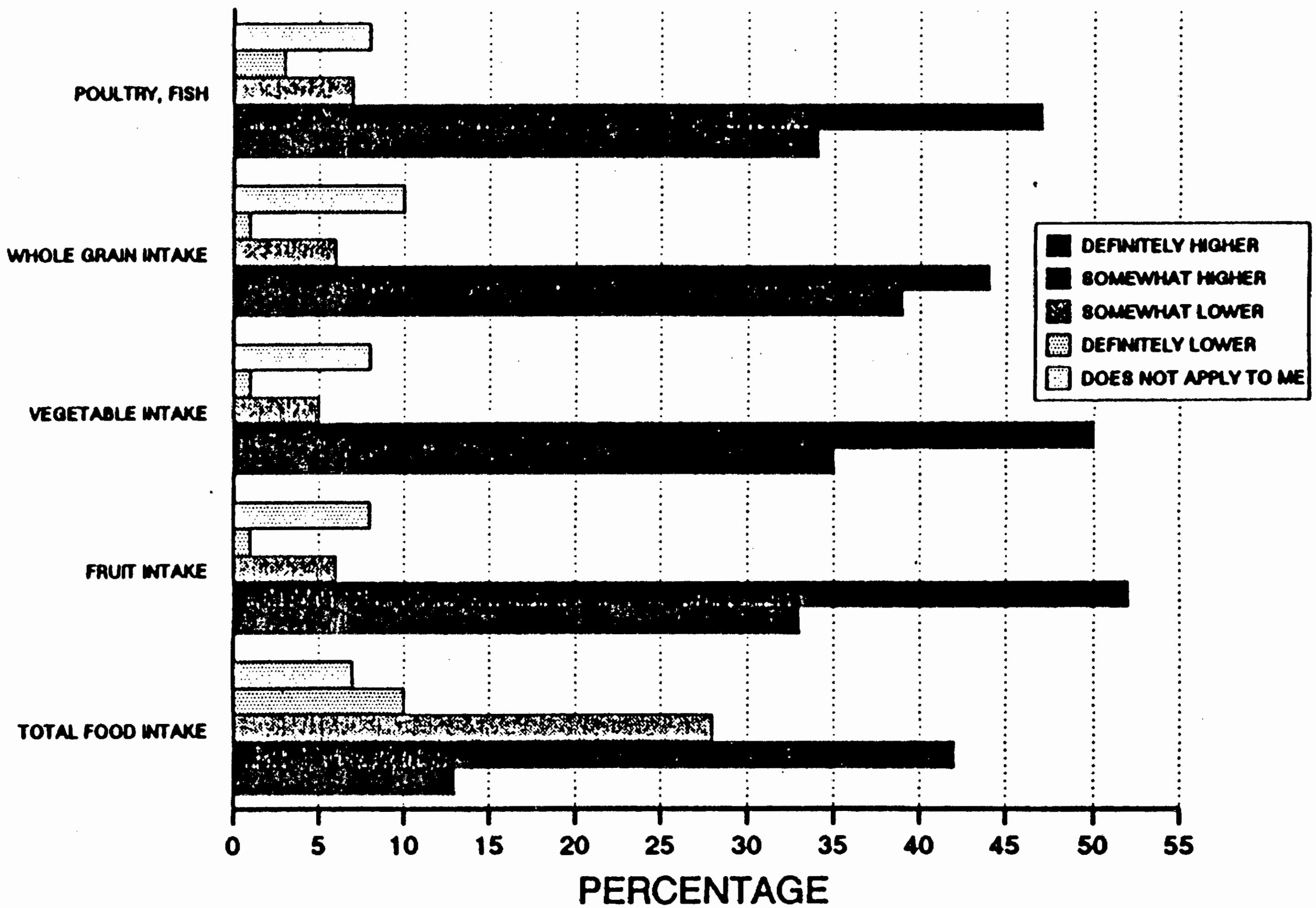
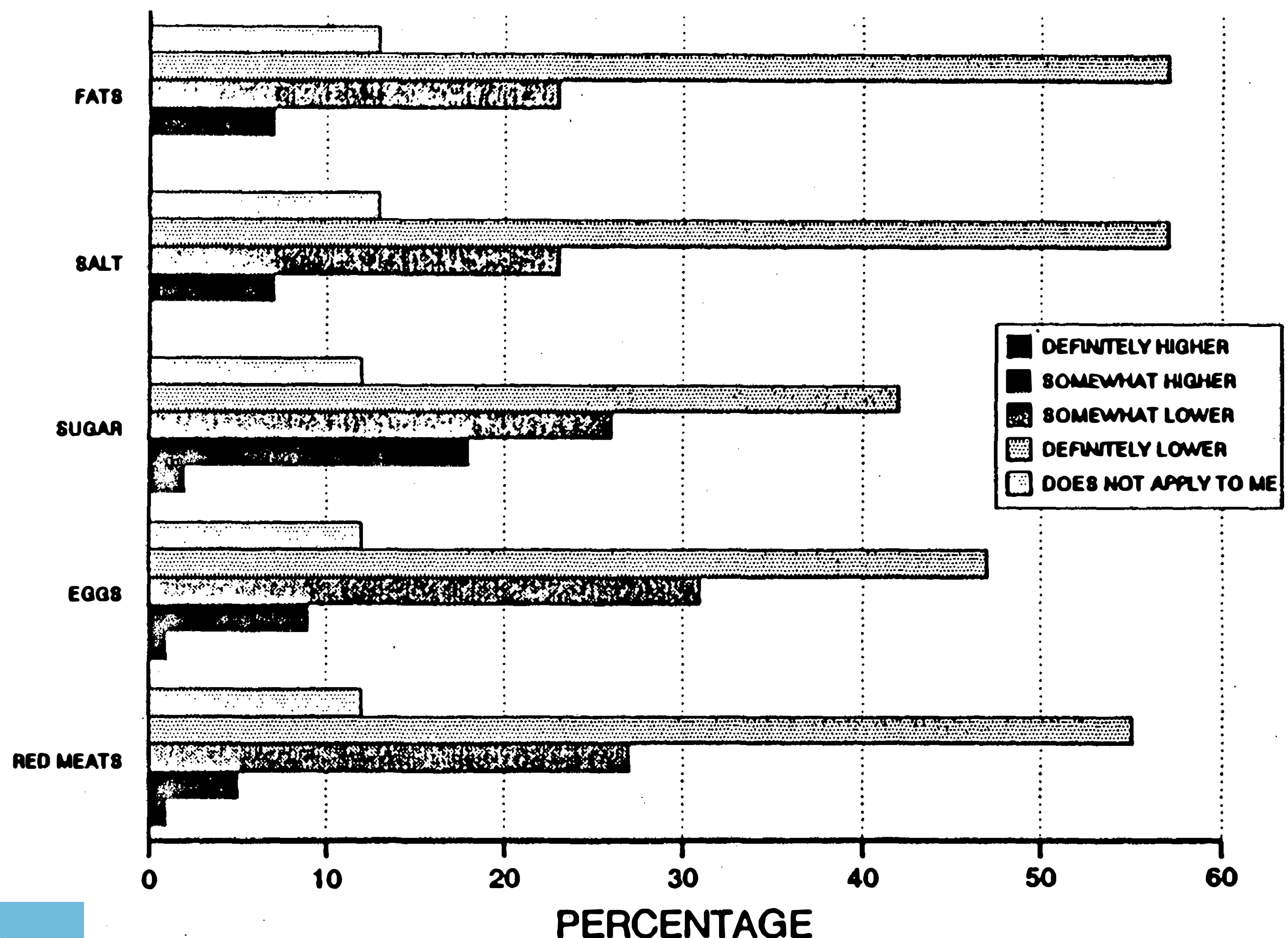


Figure 4 A

Figure 4 B

MARATHON RUNNERS – QUESTIONNAIRE RESPONSES

RUNNING COMPARED WITH PRE – RUNNING YEARS



MARATHON RUNNERS – AMINO ACID INTAKE

% RECOMMENDED AND MEANS +/– SE MG/KG

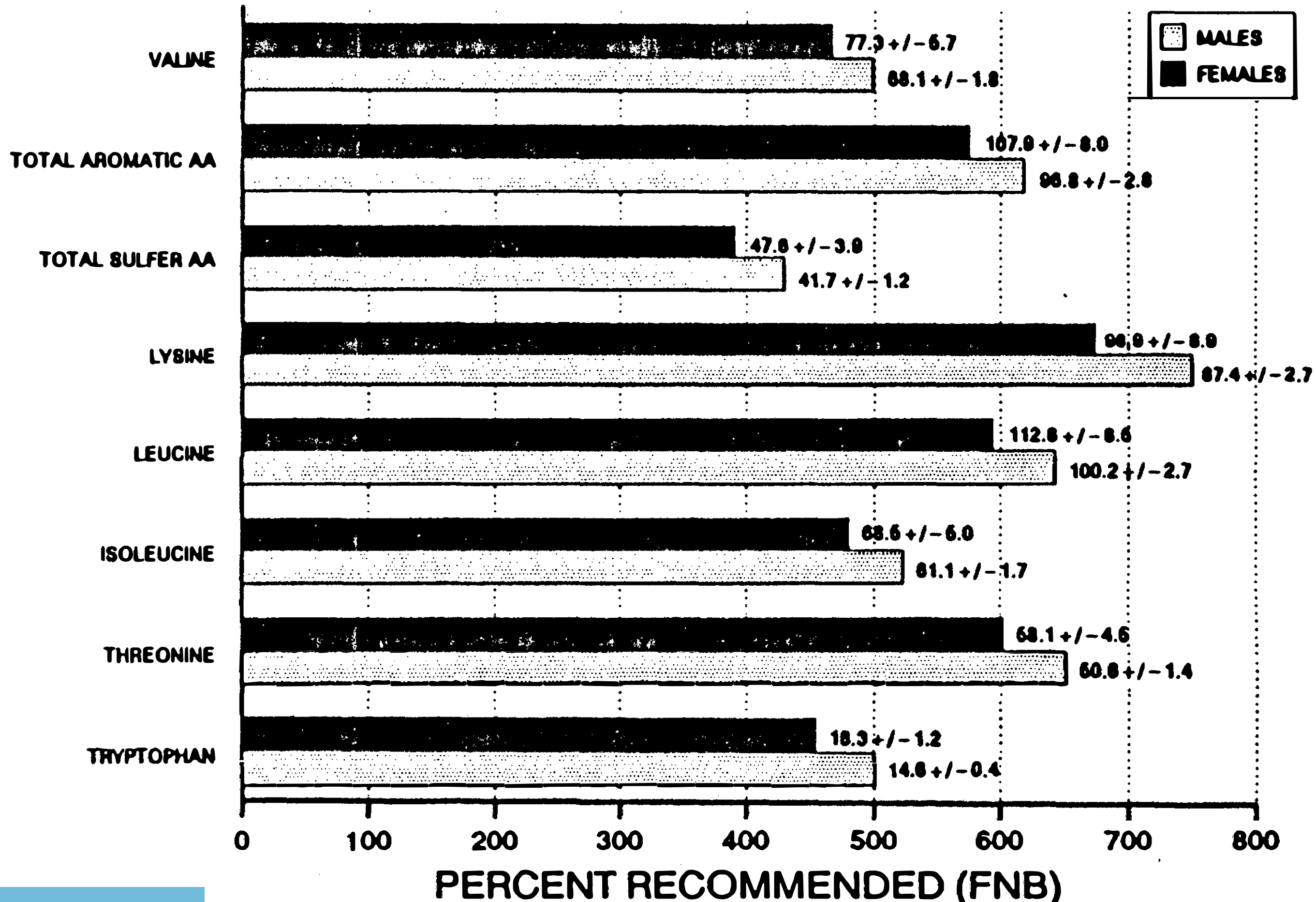


Figure 5

NIA