Nutritional Sciences 2(2), November, 1999, pp. 102-106

Longitudinal Study on Changes in Nutritional and Health Status of Young Adults on Two-Year Diet*

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ABSTRACT

Changes in nutritional and health status brought on by a two-year balanced diet were assessed with anthropometric measurements as well as hematological and lipid profiles in 56 healthy young men. Recommended dietary allowances (RDA) were adjusted with estimated daily weighted activity factor. The weighted resting energy expenditure factor of the subjects was 2.37 ± 0.05. Compared with RDA, all nutrient intakes were adequate and 56% of energy was supplied by carbohydrates, 18% by protein and 26% by fat. The vitamin and mineral intakes except vitamin B-2 were higher (26.46 – 129.88%) than RDA. Vitamin B-2 intake was 92.15 ? 14.16% of RDA. There was no seasonal variation on nutrient intakes. Height was increased and systolic blood pressure was decreased by balanced diet for two years. Body weight, diastolic blood pressure and body mass index (BMI) were unchanged. The level of hemoglobin and hematocrit was not changed, the level of plasma protein was decreased and the level of plasma total cholesterol and albumin was increased. These results suggest that a balanced diet can increase height and complement health status achieved through vigorous exercise, even in adults, and that the level of Korean RDA for energy is adequate to maintain existing body weight.

KEY WORDS: nutritional status, health status, balanced diet, anthropometric measurements.

INTRODUCTION

The nutrition and health of adults is particularly important because it is this age group that is primarily responsible for sustaining the socioeconomic and cultural integrity of its community. There is an increasing interest in the origins of adult disease in early life. In addition, as evidence grows of the link between the nutrition and health of adults with an increased risk of developing chronic diseases later in life, the importance of good nutrition in adults becomes ever more evident.[1-5] Because the elderly represent the fastest-growing segment of the world population and the nutrition and health status of adults is related to that of the elderly, improving the health status of adults is very important both economically and socially. Although the relationship between the diet and nutritional status or anthropometric indices have been elucidated in the childhood and elderly years,[6-9] there hasn't been much follow-up on previously established relations in young adulthood. Moreover, recent studies in adult diet have focused on extreme overconsumption of dietary components such as energy, fat, cholesterol, and sodium, as well as related health problems. Results of these studies show that the nutritional status of adults is very difficult to change, especially by non-extreme means and in non-diseased states.[10-12] Also it is generally known that exercise can compensate for the effects of diet on nutritional status. Therefore, the aim of this study was to determine the possibility of using diet to change the nutritional and health status of healthy young adults who engage in regular exercise.

SUBJECTS AND METHODS

1. Subjects

Fifty-six highly active young men aged 20 to 22 with no health problems participated in this study. Characteristics of the subjects are given in Table 1. They were recruited from military school. Subjects were screened based on general health history. The balanced diet which was managed by the dietitian was given to the subjects for two years.

2. Dietary intake and physical activity assessment

The balanced diet used in the study, which provided ≒ 100% of recommended dietary allowance (RDA) for energy, was prepared and served by the military school's meal preparation service. Additional food consumed and

*This study was supported by the 1998 Research Fund of the Institute of Natural Science Research, Duksung Women's University

Accepted : June 14, 1999
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leftovers were recorded by the subjects after a detailed pre-study discussion on kitchen scale. Subjects kept 7-day food records for a period of two years on the same days as they engaged in the physical activity. The records were slightly modified from Bouchard *et al.*.[13] Participants were given instructions on how to complete records with exact amounts of all foods and drinks consumed. Recorded food intake was converted into energy and nutrient intakes by using a computerized dietary analysis program.[14] All physical activity was quantified using categorial values ranging from 1 (sleep, rest) to 6 (farming, vigorous exercise, lumbering) which corresponded to weighted resting energy expenditure factor (work equivalent value to resting energy expenditure). The system was adapted from Korean RDA.[15] The weighted resting energy expenditure factor of the subjects was 2.37 ± 0.05. The RDA of the nutrients was compensated by an activity level.

3. Anthropometric measurements and biochemical analysis

The following anthropometric variables were measured for subjects:height measured to the nearest 1 mm; weight to the nearest 1 g. Diastolic and systolic pressure was measured. Fasting blood samples were drawn from antecubital vein. The samples were centrifuged and the plasma was removed and frozen at −70℃ for analysis. Plasma glucose was analyzed with commercial kit based on utilizing glucose oxidase (Youngdong Pharmaceutical Co., Korea). Plasma total cholesterol was analyzed with commercial kit based on utilizing cholesterol oxidase (Youngdong Pharmaceutical Co., Korea). Total protein and albumin were analyzed with commercial kit based on biuret reaction (Youngdong Pharmaceutical Co., Korea). Microhematocrit was determined by reading the percent red cell after centrifuge. Hemoglobin concentration was determined with commercial kit based on cyanmethemoglobin method (Youngdong Pharmaceutical Co., Korea).

Table 1. Characteristics of subjects

Sex	Man (n = 56)
Age (yrs)	20.0 ± 0.5[1)]
Body weight (kg)	67.0 ± 8.7
Height (cm)	171.7 ± 4.0
Weighted REE factor[2)]	2.37 ± 0.05

1) Values are Mean ± SEM 2) REE: Resting energy expenditure

4. Statistical analysis

The difference between the beginning and end of the study was evaluated by t-test. A p value of < 0.05 was considered to be significant.

RESULTS

Total energy and other nutrients consumed by the subjects are shown in Table 2 and 3. The subjects consumed 3976 ± 362.4 Kcal for energy, 180.7 ± 24.4 g for protein, 117.5 ± 19.4 g for fat, 551.0 ± 60.3 g for carbohydrates. The contributions of each energy nutrient to total energy intake were 18.05 ? 1.9% for protein, 26.22 ± 3.13% for fat, 55.73 ± 3.95% for carbohydrates. Compared to Korean recommended dietary allowance (RDA),

Table 2. Daily nutrient intake of the subjects

Nutrient	Season				
	Spring	Summer	Fall	Winter	Average
Energy (kcal)	3888.3 ± 257.9	3971.1 ± 389.1	3855.6 ± 260.4	4191.2 ± 542.1	3976.6 ± 362.4
Protein (g)	172.2 ± 19.3	184.3 ± 26.9	180.0 ± 22.6	186.1 ± 28.9	180.7 ± 24.4
Fat (g)	116.5 ± 18.5	106.7 ± 15.1	108.8 ± 13.8	138.0 ± 30.0	117.5 ± 19.4
Carbohydrate (g)	540.7 ± 53.8	568.3 ± 73.2	541.4 ± 44.5	553.8 ± 69.7	551.0 ± 60.3
Fe (mg)	25.6 ± 3.9	25.5 ± 6.0	25.7 ± 2.40	27.3 ± 4.3	26.0 ± 4.2
Vitamin A (RE)	1421 ± 360	1488 ± 243	1838 ± 399	1881 ± 575	1656 ± 394
Vitamin B_1 (mg)	2.59 ± 0.44	2.55 ± 0.28	2.60 ± 0.39	2.84 ± 0.50	2.64 ± 0.40
Vitamin B_2 (mg)	2.33 ± 0.30	2.305 ± 0.39	2.31 ± 0.37	2.54 ± 0.49*	2.37 ± 0.40
Niacin (mg)	38.6 ± 6	41.6 ± 5.5	40.6 ± 7.6	41.9 ± 8.9	40.7 ± 7.0
Vitamin C (mg)	204.4 ± 68.9	181.2 ± 51.5	214.8 ± 33.6	202.0 ± 47.3	200.6 ± 50.3

Values are Mean ± SEM *Significantly different at $p < 0.05$

Table 3. Energy nutrients as percentage of total calorie intake

Nutrient	Season				
	Spring	Summer	Fall	Winter	Average
Protein	17.6 ± 1.7[1)]	18.8 ± 2.5	18.4 ± 1.8	17.4 ± 1.8	18.0 ± 1.9
Fat	26.7 ± 3.8	24.3 ± 2.7	24.4 ± 2.1	29.5 ± 3.9	26.2 ± 3.1
Carbohydrate	55.7 ± 4.1	56.9 ± 4.2	57.2 ± 2.8	53.1 ± 4.7	55.7 ± 3.9

1) Values are Mean ± SEM

Table 4. Nutrient intake of subjects as percentage of Korean RDA[1)]

Nutrient	Season				
	Spring	Summer	Fall	Winter	Average
Energy	96.4 ± 6.4[2)]	98.5 ± 9.7	95.6 ± 6.4	104.0 ± 13.4	98.6 ± 9.0
Protein	142.4 ± 16.0	152.4 ± 22.2	148.9 ± 18.6	153.9 ± 23.9	149.4 ± 20.1
Fe	132.4 ± 20.0	131.9 ± 32.3	132.6 ± 12.1	140.9 ± 22.0	134.2 ± 21.6
Vitamin A	125.9 ± 32.0	131.9 ± 21.5	162.8 ± 35.4	166.7 ± 50.9	146.8 ± 34.9
Vitamin B_1	123.8 ± 21.3	122.1 ± 13.7	124.1 ± 18.7	135.8 ± 24.1	126.4 ± 19.4
Vitamin B_2	90.5 ± 11.7	89.4 ± 13.1	89.9 ± 14.4	98.8 ± 17.3	92.1 ± 14.1
Niacin	140.9 ± 21.8	151.8 ± 20.2	148.2 ± 27.9	153.0 ± 32.6	148.4 ± 25.6
Vitamin C	230.5 ± 77.8	204.5 ± 58.1	242.3 ± 37.9	227.9 ± 53.4	226.3 ± 56.8

1) RDA: Recommended dietary allowance compensated by an activity level
2) Values are Mean ± SEM

Table 5. Changes in anthropometric measurements by balanced diet for 2 years

Measurement	Beginning	End	Change
Height (cm)	171.7 ± 4.0[1)]	172.8 ± 4.2	1.1 ± 0.08**
Body weight (kg)	67.0 ± 8.7	67.8 ± 6.7	0.8 ± 0.44
SBP (mmHg)[2)]	126.5 ± 11.1	114.3 ± 7.8	-12.2 ± 1.20**
DBP (mmHg)[2)]	77.3 ± 9.6	72.6 ± 6.8	-4.7 ± 11.6
BMI (kg/m^2)[2)]	22.7 ± 2.5	22.6 ± 1.6	0.03 ± 0.15

1) Values are Mean ± SEM
2) SBP: Systolic blood pressure
DBP: Diastolic blood pressure, BMI: Body Mass Index
**significant at $p < 0.01$

Table 6. Changes of biochemical indices in blood by balanced diet for 2 years

Indices	Beginning	End	Change
Hemoglobin (g/dl)	14.0 ± 0.8[1)]	13.9 ± 0.6	-0.10 ± 0.92
Hematocrit (%)	42.4 ± 2.5	41.1 ± 2.0	-1.27 ± 2.87
Cholesterol (mg/dl)	157.3 ± 23.9	164.3 ± 29.0	7.00 ± 2.82*
Total protein (g)	7.83 ± 0.29	7.00 ± 0.32	-0.83 ± 0.04*
Albumin (g/dl)	4.47 ± 0.80	5.05 ± 0.20	0.58 ± 0.08*

1) Values are Mean ± SEM
*significant at $p < 0.05$

the subjects had 98.67 ± 9.0% for energy and 149.42 ± 20.19% for protein. The vitamin and mineral intakes except vitamin B-2 were higher (26.46 - 129.88%) than RDA. Vitamin B-2 intake was 92.15 ± 14.16% of RDA (Table 4). There was no seasonal variation on nutrient intakes except vitamin B-2. Vitamin B-2 intake in winter tended to be higher, although this difference was not statistically significant. The changes in anthropometric measurements by balanced diet for 2 years are shown in Table 5. Differences in weight and BMI between the beginning and end of the study were 0.83 ± 4.41 g and 0.03 ± 1.52 kg/m^2, which were not statistically significant. But height changes were 1.11 ± 0.88, which was significant. Systolic blood pressure decreased (-12.17 ± 12.04 mmHg) significantly while the change in diastolic blood pressure was not significant due to large standard deviation (-4.78 ± 11.63 mmHg). The changes of biochemical indices in blood by balanced diet for 2 years are shown in Table 6. Differences of hemoglobin and hematocrit levels between the beginning and end were -0.10 ± 0.92 g/dl and -1.27 ± 2.87%. Neither were statistically significant. The levels of total cholesterol and albumin in plasma increased (cholesterol: 7.00 ± 28.23 mg/dl, albumin: 0.58 ± 0.80 g/dl) and the levels of total protein in plasma decreased (-0.83 ± 0.40 g), although the biochemical status of the subjects were still within normal ranges.

DISCUSSION

The main purpose of this study was to examine the possibility of using a balanced diet to make improvements in the anthropometric measurement and biochemical indices of young adults who exercise regularly. Efforts to maintain a balanced diet and an active lifestyle in adulthood are necessary as part of long-term steps to ensure good health in later years. Physical activity is associated with an increased energy requirement and thus with an increase in all metabolic processes involved in energy supply. Studies with younger subjects have shown that the quality of diet, determined by nutrient density, percentage of energy from carbohydrates, protein and fat, was unaffected by any amount of exercise in both untrained and trained populations.[16-20)]. However, the quality of diet in this study was significantly different from that of national nutritional survey reports which were 64.8% carbohydrates, 16.1% protein, and 19.1% fat.[21)] The energy percentages from energy nutrients in this study were 55.73 ± 3.95% for carbohydrates, 18.05 ± 1.9% for protein, and 26.22 ± 3.13% for fat and there was no seasonal variation on nutrient intakes. A possible reason for this discrepancy may be the amount of energy intake (3976 Kcal vs 1839 Kcal).

Although the energy consumed was a relatively high 3976 ± 362.4 Kcal, this amount was thought to be adequate for the subjects in this study because the weighted resting energy expenditure factor of the subjects was 2.37

± 0.05 and their activity level was very high. The evidence came from either the unchanged body weight or the levels compared to Korean RDA compensated by activity levels. Also, in addition to weight, BMI should be routinely used and reported when monitoring the response to specific interventions. Differences between the beginning and end BMI were not statistically significant. Thus, it is possible that the lack of change in body weight and body mass index after balanced diet for 2 years might be due to adequate dietary intakes complemented by an increase in exercise. This suggests that unusually high levels of physical activity by young men allows them to consume more energy, including fat, while maintaining a more desirable weight.

In general, the literature supports that there is little increase in height at this age. However, the height in these subjects was increased significantly. Because it is reported that exercise did not affect growth or promote growth, mainly in prepubescent boys, and that exercise can transiently block the expression of statural growth by competitively removing the necessary nutritional support for growth,[22-24] the increase in height in this study may be a result of the balanced diet for two years. Systolic blood pressure decreased significantly while the change in diastolic blood pressure was not significant due to large standard deviation.

Differences of hemoglobin and hematocrit levels between the beginning and end of this study were not statistically significant and the levels of total protein in plasma decreased. Results concerning the effects of moderate diet on adults in terms of biochemical indices were contradictory. It is reported that balanced diet is beneficial to hemoglobin, free erythrocyte porphyrin, and serum ferritin contents[25] and that consumption of moderate doses of antioxidant nutrients, supplied as part of a normal diet, effectively increases the blood levels of these antioxidants.[26] However, unchanged iron and copper in the blood of children after 13 weeks of treatment with balanced diets was also reported[10] and a low protein diet, in which the the protein is mostly vegetable protein, could be adapted.[12] Moreover, physical exercise might increase the turnover rate of regulatory proteins such as hemoglobin[27] and have a negative effect on iron status.[28-31] Thus, unchanged levels of hemoglobin and hematocrit might be complemented by balanced diet in spite of vigorous exercise.

These results suggest that balanced diet provided ≒ 100% of Korean RDA, increased height and complemented the health status brought on by vigorous exercise in adults. The results also suggest the level of Korean RDA for energy was adequate to maintain the subjects' body weight. However, further work is required to establish whether the associations observed have biological significance with regard to micronutrients intake.

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