EFFECT OF PROTEIN AND IRON DIETARY SUPPLEMENTATION ON BLOOD COMPONENTS AND PERFORMANCE IN MALE AND FEMALE DISTANCE RUNNERS

by

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ABSTRACT

Since the role of protein and iron in oxygen transport and cellular energy production is crucial, and since the evidence regarding the protein and iron requirements of athletes is conflicting, the purpose of this study was to determine if the addition of protein and/or iron dietary supplements to the regular diet would increase hemoglobin concentration and improve maximum oxygen uptake and endurance performance. Thirty-three male and thirteen female middle and long distance runners were randomly assigned to one of four treatment groups (protein and iron, protein and iron placebo, protein placebo and iron, and protein placebo and iron placebo). The average training volume (Mean $\pm$ SEM) for the male and female runners was 11.3 $\pm$ 0.7 km/day and 9.8 $\pm$ 0.8 km/day respectively. A placebo, double blind, mixed experimental design with two between-subject factors (protein and iron) and one within-subject factor (time) was used. The female subjects were grouped separately from the male subjects. The protein supplement, taken in addition to the regular diet, was 0.5 g/kg body weight of protein from egg albumin, while the iron supplement was 32 mg. elemental iron per day in the form of ferrous fumarate capsules. The duration of the supplementation period was six weeks. Comprehensive hematology, serum chemistry, anthropometry, computerized dietary analysis, maximum oxygen uptake and treadmill endurance performance measurements were taken prior to the administration of the dietary supplements (Control Period) and during the last week of the supplementation period. In the Control Period, the dietary protein

intake of the male and female runners was 1.82 $\pm$ 0.07 g/kg and 1.32 $\pm$ 0.11 g/kg respectively. These intakes are considerably higher than the Canadian RDI of 0.80 g/kg. In both the male and female runners, the addition of protein supplement to the usual diet had no beneficial effects on any of the parameters measured. Thus, in an affluent country such as Canada, the protein intake from a typical balanced diet should be more than adequate for meeting the protein requirements of endurance athletes. The daily dietary iron intake was 18.4 $\pm$ 0.9 mg. for the male runners and 11.7 $\pm$ 0.9 mg. for the female runners during the Control Period. Three percent of the male runners and 82 percent of the female runners had dietary iron intakes less than the Canadian RDI. Although none of the male runners and only one of the female runners showed evidence of iron deficiency anemia, 45 percent of the males and 85 percent of the females showed evidence of either prelatent or latent iron deficiency, based on serum ferritin levels. These percentages are higher than those found in non-athletes. Iron supplementation had no beneficial effects for the male runners, but for the female runners hemoglobin, hematocrit and red blood cell count were increased, without any corresponding increase in VO_2 max. or treadmill endurance performance. However, since the female treatment groups each contained only three or four subjects, these results must be regarded as suggestive, but not conclusive. In both the male and female runners, the six week period of iron supplementation caused no increase in body iron stores. This fact has led to the suggestion that perhaps the oral iron supplement dosage, in the present study, should

have been considerably larger, in the range of 150-200 mg. of elemental iron per day. The possibility that higher dosages of oral iron supplements may be beneficial to both male and female endurance athletes who show signs of either prelatent or latent iron deficiency, cannot be ruled out. However, there is no basis for recommending that all male and female endurance athletes should routinely ingest oral iron supplements for prophylactic purposes.

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CHAPTER I

INTRODUCTION AND LITERATURE REVIEW

Protein Requirements and Athletic Training

The necessary requirement of humans for protein and iron has long been established (Committee for Revision of the Canadian Dietary Standard, 1976; Davidson et al., 1975), but there still remains the question of what constitutes the optimum protein and iron intakes for all the physiological needs of the organism. Increased protein intake during sports training has often been advocated. Only a limited number of controlled scientific studies on the effects of high protein intake levels on training, however, have appeared in the literature. Furthermore, the results of these studies have been conflicting and inconclusive. A number of Japanese studies (Shiraki et al., 1974 Shiraki et al., 1977; Yoshimura, 1965; Yoshimura, 1970) have reported that an anemia, attributable to the destruction of erythrocytes, could be produced when untrained human subjects were exercised at workloads greater than seven times the resting metabolic rate (RMR) for prolonged periods (2-4 hours). Yoshimura (1970) proposed the term sports anemia for this syndrome. This anemia was always associated with hypoproteinemia and it was shown that by increasing dietary protein intake from an average of 1.5 grams per kilogram (g/kg) body weight per day to more than 2.0 g/kg/day, with more than 25 percent of the total dietary protein from animal sources, sports anemia was prevented (Shiraki et al., 1974; Shiraki et al., 1977;

Yoshimura, 1965). Shiraki et al. (1974) also concluded that sports anemia did not occur in well-trained subjects after a group of cyclists with protein intakes of 1.5 g/kg/day trained daily for two hours at RMR 8.0 and showed no decrease in hemoglobin concentration. A workload of RMR 8.0, however, represents a much lower percentage of maximal work capacity in a well-trained subject than in an untrained subject. Thus, if the relative intensity of training had been set as high for the well-trained subjects as for the untrained subjects, a sports anemia may well have been observed in the well-trained subjects also. Although the Japanese studies (Shiraki et al., 1974; Shiraki et al., 1977; Yoshimura, 1965;Yoshimura, 1970) investigated the relationship between prolonged strenuous exercise, hemoglobin concentration, and protein intake, they did not measure corresponding changes in maximal physical performance.

Stucke et al. (1972) conducted an experiment with 20 well-trained sports students in which they administered 2.0 g/kg/day protein supplement in addition to the usual diet. After ten days, hemoglobin concentration was significantly increased and endurance time for a standard workload on a bicycle ergometer was increased by 15 percent. Reports of Russian research (Williams, 1976; Yakolev, 1961) and other Eastern European research (Jarver, 1975) have indicated that amounts of protein ranging from 2.0 to 3.0 g/kg/day are necessary for athletes engaged in middle and long distance running. This is considerably higher than the protein intake of 0.8 g/kg/day recommended by Western authorities (Committee for the Revision of the Canadian Dietary Standard,

1976; Committee on Dietary Allowances, 1974; Smith, 1976; Williams, 1976).

While the studies described above have demonstrated the value of protein supplementation for subjects performing prolonged, strenuous exercise, other studies have found no beneficial effects (Consolazio et al., 1975; Darling et al., 1944; Pitts et al., 1944; Rasch et al., 1969; Steben and Boudreaux, 1978). These studies are deficient from several aspects: (i) the intensity of exercise to which the subjects were exposed was too low (Darling et al., 1944); (ii) the intensity of exercise was not accurately described (Consolazio et al., 1975; Pitts et al., 1944; Rasch et al., 1969; Steben and Boudreaux, 1978); (iv) blood components were not measured (Darling et al., 1944; Pitts et al., 1944); (v) procedures for assessing physical performance were not reported (Consolazio et al., 1975). In the study of Steben and Boudreaux (1978), the protein supplement group of subjects received a mere 1.4 grams of protein supplement per day, a totally insignificant amount. Rasch et al. (1969) assessed physical performance using tests of power and local muscular endurance such as pullups, squat thrusts, standing broad jump and sit-ups. No test of cardiovascular endurance was made. Based on the findings of Shiraki et al. (1974), Shiraki et al. (1977), and Stucke et al. (1972), however, one would expect to see definite beneficial effects on cardiorespiratory performance resulting from protein supplementation.

Iron Requirement and Athletic Training

Iron plays a crucial role in the transport and utilization of oxygen. It is an essential component of hemoglobin, myoglobin and cytochrome molecules, iron-sulphur proteins in the electron transport chain and a cofactor for many cellular enzymes (Lehninger, 1975). While iron is important to every individual's welfare, it is particularly important to endurance athletes wishing to train their oxygen transport and utilization capacity.

Iron deficiency has been shown to decrease physical work capacity via decreased hemoglobin levels (Andersen and Barkve, 1970; Edgerton et al., 1972; Gardner et al., 1975; Woodson et al., 1978) and also via decreased concentration of iron containing enzymes involved in oxidative metabolism (Jacobs, 1977). There is currently disagreement regarding the increased bodily need for iron during heavy physical training. Reports from East Germany indicate that swimmers receive daily iron supplements (Editors, 1977). Russian researchers have indicated a 20 percent increase in the need for iron during athletic training (Williams, 1976). A hematological study by DeWijn et al. (1971) of athletes on the 1968 Dutch Olympic team classified 3.5 percent of the male athletes and 7.5 percent of the female athletes as being iron depleted based on measurements of serum iron concentration and percent transferrin saturation. Haymes (1972) studied serum iron concentration and total iron binding capacity (TIBC) and classified 25 percent of trained female field hockey players, 32 percent of moderately active females, and eight percent of sedentary females as being iron deficient. Studies by Kilbom

(1971) and Bottiger et al. (1971) showed a significant decrease in serum iron levels in women exposed to a physical training program, while a study by Wirth et al. (1976) showed no change in serum iron levels. However, neither Kilbom (1971) nor Bottiger et al. (1971) employed control groups in their studies, while in the study of Wirth et al. (1976) the intensity of training was low.

Kvanta of Sweden (Mann, 1976) reports that sports anemia is common among male athletes and he attributes this to an iron deficiency. He believes that this iron deficiency is created through two mechanisms. Since sweat contains from 0.3 to 0.5 mg. iron per liter (Coltman and Rowe, 1966; Shephard and Kavanagh, 1978), a vigorous male athlete losing one liter of sweat daily in training, would have a total daily iron loss 30 to 50 percent higher than the daily iron loss of a male nonathlete. The athlete's iron losses would thus be equal to or greater than those of a reproductive female. The other mechanism of iron deficiency which Kvanta postulated was an interference with the absorption of dietary iron. Although, on analysis, the diet of the athlete may contain an adequate iron intake, providing excess calories by fat and other natural dietary antagonistic factors such as phytates, carbonates, phosphates, and certain siderophilic protein materials in animal foods may actually inhibit iron absorption. This view is also shared by DeWijn et al. (1971) and by Shephard and Kavanagh (1978). Kvanta (Mann, 1976) reported that administering a beef hemoglobin iron supplement to distance runners increased their hemoglobin levels by 20-40% and their serum iron levels by 25-30%. Kvanta, however, made this report at an International

Symposium on the Nutrition of the Athlete, and he has not yet published detailed methodology and results substantiating this work.

Although iron supplementation has been shown to improve the hematological status and physical work capacity of iron deficient, anemic subjects (Andersen and Barkve, 1970; Edgerton et al., 1972; Gardner et al., 1975), very little controlled research has been done with athletes. In the only controlled scientific study on the effects of iron supplementation on endurance athletes which appears in the literature, Weswig and Winkler (1974) found that iron supplementation had no effect on hemoglobin levels or serum iron concentrations in a group of male college competitive swimmers. However, effects on physical performance were not monitored, and the subjects' regular diets were not analyzed. Ericsson (1970) investigated the effects of iron supplementation on the physical work capacity of normal subjects, 57-71 years of age. Iron and placebo treatments were employed. Neither group showed an increase in hemoglobin concentration after a three month supplementation period. The iron treatment group, however, showed a significant increase in physical work capacity. Thus, iron supplementation may improve physical work capacity without increasing hemoglobin levels.

Objectives of the Present Study

Since protein and iron play a crucial role in oxygen transport and cellular energy production, and since the evidence regarding protein and iron requirements of athletes is conflicting, the purpose of the

present study is to:

(1) determine the normal protein and iron status of Canadian male and female distance runners, and

(2) determine if the addition of protein and/or iron dietary supplements to the regular diet increases hemoglobin concentration and improves maximum oxygen untake and endurance performance.

CHAPTER II

MATERIALS AND METHODS

Experimental Design

The subjects were 33 male (20.9 $\pm$ 1.5 years) and 13 female (18.3 $\pm$ 1.5 years) middle and long distance runners from Greater Vancouver and Victoria. The study began with 40 male and 16 female subjects. Subjects were lost to the study either because of athletic injury, sickness, or job-related travel. Most of these athletes were highly trained, some even national and international class athletes. The average training volume for the male athletes was 11.3 $\pm$ 0.7 km/day while the average training volume for the female athletes was 9.8 $\pm$ 0.8 km/day. A daily record of each subject's training was kept throughout the duration of the study. No attempt was made to rigidly control and standardize the training programs of the subjects, as long as the male athletes were running at least 70 km per week and the female athletes, 60 km per week. All the subjects, under the direction of their coaches, followed their own running programs and were unreceptive to any type of major change in their programs. Since the subjects were serious competitive athletes, they trained regularly at a moderate to a high intensity. A placebo double blind mixed experimental design (Myers, 1972; Winer, 1971) with two between subject factors (protein and iron) and one within subject factor (time) was used. The experimental design is shown in Table 1. During the study, the nature

TABLE 1

Experimental Design: Matrix for a Mixed Design with Two Between-Subject Factors (Protein and Iron) and One Within-Subject Factor (Time)

		Control Period (6 weeks)	Experimental Period (6 weeks)
Protein	Iron (Group PI)	No supplementation Normal diets	0.5 gram/kg/day protein supplement 32 mg/day iron supplement
	No Iron (Group PNI)		0.5 gram/kg/day protein supplement Iron placebo
No Protein	Iron (Group NPI)		Protein placebo 32 mg/day iron supplement
	No Iron (Group NPNI)		Protein placebo Iron placebo

of the dietary supplements being investigated was not revealed to the subjects. Using a table of random numbers (Kirk, 1968), the male and female subjects were dividied into four groups of 10 subjects and four groups of 4 subjects respectively. Although the females received the same experimental treatments as the males, the female subjects were grouped separately. This separation of male and female subjects was done to reduce within group variability and thus reduce the probability of making a Type I error in the statistical analysis (Kirk, 1968), since women are significantly different from men on certain physiological and hematological parameters (Astrand and Rodahl, 1977; Henry et al., 1974; Wintrobe et al., 1974). The subjects ingested the supplements along with their usual diets for six weeks. The subjects who received protein and/or iron supplements, instead of placebos, had their normal daily protein intake increased by 0.5 g/kg body weight and/or their daily iron intake increased by 32 mg. All tests and measurements were performed on two separate occasions--at the start of the study before supplementation and during the last week of the supplementation period.

Supplement Composition and Administration

Dried egg albumin powder, obtained from a local supplier, was used as the protein supplement. The dried egg albumin powder was chosen as the protein supplement because it was a reasonably pure source of high quality protein which was readily available and also relatively palatable. Egg albumin has the highest biological value for human adults of all food

proteins (Davidson et al., 1975). Since the exact chemical composition of the egg albumin powder was not available from the supplier it was chemically analyzed (Horwitz, 1975) locally as:

Moisture	8.1%
Protein	80.7%
Crude Fiber	0.0%
Fat	0.2%
Ash	6.2%
Carbohydrate	4.8%

These values are in close agreement with standard analysis values for powdered egg white (Cook and Briggs, 1973). According to textbook values (Cook and Briggs, 1973), the ash breakdown would be:

Calcium	0.07%
Phosphorous	0.11%
Iron	0.001%
Sodium	1.10%
Potassium	1.00%

The concentration of vitamins with the exception of riboflavin is insignificant (Cook and Briggs, 1973). Since the dried egg albumin powder was only 80.7% protein, 0.62 grams of egg albumin were ingested to provide 0.5 g/kg body weight of protein. Subjects were advised to ingest half of their daily supplement at breakfast and half at their evening meal. Most of the subjects ingested the albumin by mixing 15-20 grams with 8 oz. of milk in a blender and flavouring it with Nestle's

Quik, vanilla extract, nutmeg, etc.

The dose of 0.5 g/kg body weight was chosen for the following reasons:

(1) Since Canadian men and women of comparable age to our athletes have median daily protein intakes of 1.54 g/kg and 1.18 g/km (Nutrition Canada, 1975), an additional 0.5 g/kg/day would project the protein intake of our subjects into the range of protein intakes recommended for athletes in some other nations (Jarver, 1975; Williams, 1975; Yakolev, 1961).

(2) Preliminary experimentation showed that it would not be feasible to have the subject from the present study ingest any more than 0.5 g/kg/day of protein i.e. 0.62 g/kg/day dried albumin powder, without causing a significant alteration in their normal dietary habits. It was also felt that doses higher than 0.5 g/km/day would greatly increase the probability of subject attrition.

The protein placebo was a mixture of oligomers of glucose named "Casco" and produced by Canada Starch Company, Burnaby, B.C. This product was composed of 95% carbohydrates and 4% moisture. The composition of the glucose was analyzed by the Canada Starch Company as:

Monosaccharides	19%
Disaccharides	14%
Trisaccharides	12%
Tetrasaccharides	10%
Pentasaccharides and longer polysaccharides	45%

The dose level of the glucose product was the same as the concentration of the albumin and the same instructions for ingestion were given. The glucose product was white in colour, while the albumin was yellow. Thus the subjects knew that the powders were different. However, since the subjects weren't told which nutrients we were investigating and since they weren't told that there were control (placebo) groups, all subjects seemed to believe that there were special nutrients mixed with both of the powders. The iron supplement consisted of 400 mg. of ferrous fumarate powder in a gelatin capsule (Adams Laboratories, Surrey, B.C.). Each capsule contained 32 mg. of iron. Ferrous fumarate is considered to be a good source of iron (Underwood, 1971). Research studies indicate that the presence of meat and ascorbic acid in the diet enhance the absorption of non heme iron (Underwood, 1971). For this reason, the subjects were advised to ingest their iron supplements with a meal, preferably the evening meal. The Canadian recommended daily intake (RDI) for iron is 10 mg. for men aged 19-35 years, and 14 mg. for women aged 19-35 years (Committee for the Revision of the Canadian Dietary Standard, 1976). Thus, in the Experimental Period the iron supplement represented two to three times the RDI for iron.

Unfortified dessicated liver powder was used as the iron placebo. It was chosen, rather than a product such as lactose, because its brown colour makes it indistinguishable from ferrous fumarate powder. The composition of each 440 mg. capsule of dessicated liver was as follows (Adams Laboratories, Surrey, B.C.):

Protein	365 mg.

Fat	70 mg.
Riboflavin	34 ug.
Niacin	167 ug.
Vitamin B_{12} & Iron	Insignificant

Unfortunately, there was no certain method which could ensure that subjects ingested their proper amount of supplement daily. At each physiological testing session, the subjects were questioned in a friendly manner regarding their adherence to the supplement ingestion schedule. The investigator feels confident that the majority of the subjects answered truthfully. Subjects were advised throughout the study not to change their usual dietary habits. Subjects were also told not to commence any new vitamin or mineral supplementation during the duration of the project, but to continue supplements that they had already been taking prior to the start of the project.

Dietary Survey

In order to assess the eating habits of the subjects and the nutrient composition of their usual diets, seven day individual dietary surveys were taken. On two separate occasions each subject weighed and recorded all the food eaten for seven consecutive days. A seven day dietary survey has been shown to yield a more valid nutritional analysis than either a three day or a one day dietary survey (Marr, 1971). Furthermore, subject cooperation decreases when survey periods last longer than seven days. Each subject weighed all his or her food and fluid intake to the nearest gram using a Hanson Calorie Counter

Diet scale. One calibrated scale, diet recording forms and a Master Foods List (Watt and Merrill, 1963) were given to each subject at the start of the project. The Master Foods List which contained detailed names and code numbers for 2500 different common foods was originally prepared by the United States Department of Agriculture and was revised at S.F.U. to suit the needs of this project better. The nutrient composition of the subjects' diets was determined from the seven day dietary records using a PLI computer program written at S.F.U. and a 2500 food data base supplied on magnetic tape by the U.S. Department of Agriculture (Watt and Merrill, 1963). This food analysis computer program gave values for the following nutrients: percent water, food energy, protein, fat, saturated fatty acids, unsaturated fatty acids, carbohydrate, calcium, iron, vitamin A, thiamine, riboflavin, niacin and ascorbic acid. The computer program provided a daily breakdown of the subjects' intake of each nutrient expressed as a raw value and also expressed in a bar graph as a fraction of the Canadian RDI (Committee for the Revision of the Canadian Dietary Standard, 1976) for that nutrient. In order to facilitate handling and processing of the dietary record data, the recording forms were designed to enable the subjects to perform all of the preliminary coding work. The keypunch operator then only had to enter the food code weight and number into the computer.

Physiological Testing - Performance Assessment

Endurance performance capacity was assessed from a timed

exhaustive run on a standard treadmill running protocol. The subjects reported for each test having performed no strenuous physical activity for at least 12 hours and taken no large meal for at least 4 hours. Before beginning the treadmill test, the subject was required to sign an Informed Consent Form and fill out a Medical History Form. The temperature of the laboratory was maintained at approximately 21^{o} C for each test. A Quinton Instruments Model 24-72 treadmill was used. The treadmill endurance run then began at 11.5 mph, 0% grade for males and 10.5 mph, 0% grade for females. After the first two minutes, the treadmill speed was increased 0.5 mph per minute until the subject could no longer keep up with the treadmill. Heart rate was monitored during the last ten seconds of each minute of exercise using a Fukuda Denshi FD-13 electrocardiograph and three pregelled disposable electrodes affixed in the CR5 position. Treadmill endurance time was recorded to the nearest second. The total number of treadmill belt revolutions during each test was also recorded to check that the treadmill speeds were set correctly. Maximum oxygen uptake was measured during the treadmill endurance run in sixteen of the male subjects and eight of the female subjects. Because of problems with equipment availability it was not possible to measure VO_2 maximum on all of the subjects. The subjects in the maximum aerobic capacity assessment were chosen equally from the four treatment groups using a table of random numbers (Kirk, 1968). Since equal numbers of subjects were chosen from each treatment group for the aerobic capacity assessment, any between group biasing effect of respiratory equipment on treadmill endurance time

was controlled. Expired air was collected using a standard mouthpiece, noseclip, low resistance breathing value (dead space - 70 ml), 31.5 mm i.d. Collins flexible hose, Collins 2 way collection valve and Collins 120 liter neoprene balloons (Warren E. Collins Inc., Braintree, Mass.). Expired air samples from the balloons were analyzed for CO_2 and O_2 using a Godart Capnograph CO_2 Analyzer and an Applied Electrochemistry S-3A/I O_2 Analyzer. Reference gases for calibrating the analyzers were verified with Scholander apparatus (Scholander, 1947). Gas volumes were measured by squeezing the expired air from the balloons through a Parkinson Cowan CD_4 ventilation meter. The volume of gas used during gas analysis was also added to the total volume. The main criteria for attaining VO_2 maximum were a levelling or decrease in VO_2, and heart rates in excess of 190 b/min.

Anaerobic alactacid power was measured according to the procedure outlined by Margaria et al. (1966). Due to architectural considerations, the time of ascent was measured between the 4th and 8th stairs instead of between the 8th and 12th stairs as described by Margaria et al. (1966). The time of ascent was measured to the nearest millisecond using a Dekan Automatic Performance Analyzer (Dekan Timing Devices, Illinois). Each subject was given four practice trials and the best of four test trials was then recorded. The power value calculated from this test has been shown to be highly correlated ($r = 0.097$) with the time of running the 50 yard dash (Mathews and Fox, 1976). The main advantages of this test are that it can be performed indoors under controlled environmental conditions and it is very reliable (Mathews and Fox, 1976).

Anthropometry

In order to assess any changes in body composition which occurred with either protein or glucose supplementation various anthropometric measurements were performed. Somatotype was determined by following the method used by Heath and Carter (Heath and Carter, 1967). Percent body fat was determined from six skinfold measurements (Drinkwater and Ross, 1979). Skinfold measurements were obtained using Harpenden skinfold calipers, while muscle girths and bone diameters were obtained using steel tapes and modified sliding steel calipers respectively.

Hematology and Serum Chemistry

Blood collection and analysis was performed at a local commercial biomedical laboratory (B.C. Biomedical Laboratories Ltd.). The automated instrumentation necessary for performing multiple analyses on blood samples from a large number of subjects was not otherwise available.

A diurnal variation in hemoglobin concentration has been reported by some authors (Biggs and Allington, 1951; McCarthy and Van Slyke, 1939; Stengle and Schade, 1957). Considerable diurnal variation has also been reported in serum iron and other blood constituents (Card et al., 1964; Mardell and Zilva, 1967; Stengle and Schade, 1957) had been shown to raise the concentration of both red blood cells and hemoglobin due to a shift of fluid from the plasma to the interstitial fluid (Novosadova, 1977; Van Beaumont et al., 1972). In order to minimize these sources of error, subjects were requested to report to the laboratory at

approximately 9:00 a.m. after fasting for at least two hours and not training since the previous day. Subjects who, for various reasons could not report to the laboratory at 9:00 a.m., were requested to report at the same time of day for each of their two visits. From a subject's arm vein, 15 ml of blood was taken into a plain vacutainer for serum chemistry analysis, and 5 ml of blood was taken into a vacutainer containing EDTA anticoagulant for hematology. Serum concentrations of B.U.N. (March et al., 1965), total protein (Doumas et al., 1971), albumin (Doumas et al., 1971), and bilirubin (Jendrassik and Grof, 1938) were determined by standard automated methods using a Technicon SMA 12/60 Sequential Multiple Analyzer (Skeggs and Hochstrasser, 1964). Serum iron concentration was measured using the ferrozine spectrophotometric procedure (Stookey, 1970), while total iron binding capacity was determined by the method of Persijn et al. (1971). From these measurements of serum iron and total iron binding capacity, percent transferrin saturation was calculated. Serum ferritin concentration was determined by a modification of the radioimmunoassay procedure described by Miles et al. (1974), using a Ramco Laboratories serum ferritin assay kit. Serum haptoglobin concentration was determined using M-Partigen immunodiffusion plates supplied by the Behring Institute. Hemoglobin concentration, hematocrit, red blood cell count, mean corpuscular volume, mean corpuscular hemoglobin, mean corpuscular hemoglobin concentration and white blood cell count were determined on sequestrenated blood using a Coulter Counter Model S (Coulter Electronics, Inc., Hialeah, Florida).

Data Analysis

Data in the text and tables are given as means $\pm$ SEM. A three factor ANOVA (2 grouping factors and 1 trial factor) was used to test for significant differences in the data between and within the Control and Experimental Periods (Winer, 1971). This analysis was performed using a BMDP2V computer program. After an F-ratio was found to be significant one tailed t-tests, for either independent or correlated samples, were used to test the significance of difference between individual means. In all tests $p \leq 0.05$ has been taken to indicate statistical significance. Inferential statistical procedures were not used to analyze the data collected from the female subjects because the number of subjects in each of the treatment groups was very small (Winer, 1971). Thus, this data must be regarded as pilot project data.

CHAPTER III

RESULTS

Physical Characteristics of Subjects

The physical characteristics of the male and female subjects are shown in Tables 2 and 3. For the male subjects, all four groups gained slightly in body weight (range 0.7 to 1.4 kg) between the Control and Experimental Periods. Percent body fat either remained constant or increased slightly between the Control and Experimental Periods. Thus taking the protein supplement has not altered body composition.

For the female subjects, all four groups also gained slightly in body weight (range 0.9 to 1.5 kg) between the Control and Experimental Periods. This increase in body weight is probably due to the fact that this time period included the Christmas season.

Dietary Analysis

The daily intakes of energy, protein and iron for the Control and Experimental Periods are shown in Tables 4 and 5. For the Control Period the mean daily energy intake for all male subjects was 3091 ± 121 kcal or 47.2 ± 1.6 kcal/kg; the mean protein intake was 1.82 ± 0.07 g/kg, and the iron intake was 18.4 ± 0.9 mg. During the Control Period there were no significant differences in energy, protein or iron intake between the four groups of male subjects. The mean energy intake of all four groups also remained constant during the Experimental Period.

TABLE 2

Physical Characteristics and Racing Performance Characteristics of Male Runners During the Control Period (Mean±SEM)

	Age (Years)	Height (cm)	Weight (kg)	Somatotype	% fat	BEST PERFORMANCE 1500 metres (min:sec)	5000 metres (min:sec)
Group PI (n=8)	20.3±1.4	180.3±1.3	68.1±2.4	1.6-4.3-3.8	8.5±0.5	4:03±:04	15:30±:22
Group PNI (n=8)	18.9±1.2	177.9±2.0	63.0±3.1	1.6-3.9-4.3	8.6±0.5	4:05±:03	15:35±:15
Group NPI (n=8)	20.8±1.1	178.0±2.0	66.1±2.4	1.5-4.3-3.7	7.9±0.4	4:04±:03	15:26±:13
Group NPNI (n=9)	23.2±2.2	176.8±1.8	62.4±2.0	1.5-4.3-4.1	8.6±0.4	4:03±:05	15:14±:18

TABLE 3

Physical Characteristics and Racing Performance Characteristics of Female Runners During the Control Period (Mean±SEM)

	Age (Years)	Height (cm)	Weight (kg)	Somatotype	% fat	BEST PERFORMANCE 800 metres (min:sec)	1500 metres (min:sec)
Group PI (n=2)	19.0±3.0	164.4±1.9	54.8±0.4	2.3-4.3-3.3	12.5±0.1	2:14±:05	4:30±:12
Group PNI (n=3)	18.7±0.7	161.8±2.8	51.7±2.3	2.3-3.5-3.7	11.6±0.3	2:10±:03	4:31±:08
Group NPI (n=4)	16.5±1.2	166.2±1.5	50.8±1.9	1.8-3.0-4.3	10.8±0.7	2:15±:02	4:35±:05
Group NPNI (n=4)	19.3±1.6	166.3±1.9	55.1±1.5	1.9-3.6-3.4	11.0±0.8	2:12±:04	4:34±:09

However, as shown in Appendix 2, the levels of nutrient intakes in individuals can sometimes vary substantially in different time periods. This observation has also been made in a number of other studies (Marr, 1971). Adelson (1960) found that the correlation coefficients between two separate weeks weighed dietary surveys, calculated from food tables for 39 adult men, ranged from means of 0.70 to 0.83 for various nutrients.

The total daily protein intake of the two protein supplement groups (2.33 ± 0.15 g/kg) was much higher than the protein intake of the two groups who didn't receive protein supplement (1.70 ± 0.11 g/kg), in the Experimental Period. However, as shown in Appendix 2, the protein intakes of four of the eight subjects in Group PI and three of the eight subjects in Group PNI were increased by less than 0.5 g/kg in the Experimental Period. These subjects ingested their protein supplements but unintentionally slightly decreased the protein intake from their regular diets. The egg albumin protein which comprised the protein supplement, however, has a net protein utilization (NPU) of 94 (Davidson et al., 1975) while the NPU of the protein in a typical Canadian diet has been determined by assay to be 67 (Committee for the Revision of the Canadian Dietary Standard, 1976). Thus, even if all of the subjects in Groups PI and PNI didn't increase the amount of protein ingested in the Experimental Period by as much as planned (0.5 g/kg), the average quality of protein in their diets was increased. Similarly, in the Experimental Period, the total daily mean iron intake of the two iron supplement groups (50.3 ± 1.9 mg) was significantly higher than the iron intake of the two groups who didn't receive iron supplements

TABLE 4

Daily Intake of Energy, Protein and Iron During Control and Experimental Periods - Male Runners (Mean±SEM)

	Energy (kcal)	% RDI	Energy (kcal/kg)	Protein (grams)	% RDI	Protein (g/kg)	Iron (mg)	% RDI
Group PI								
Control (n=7)	2972.6±185.0	96.9± 7.2	43.6±3.7	123.4± 9.6	222.7±17.4	1.81±0.17	19.7±1.6	180.3±18.0
Experimental	2923.0±230.9	94.5± 7.5	43.0±4.5	156.1±12.6	282.3±24.3	2.27±0.23	51.4±2.5	446.6±20.5
Group PNI								
Control (n=7)	3129.4±197.4	104.1± 5.6	49.1±1.5	120.2±10.2	220.3±18.7	1.89±0.16	17.8±2.3	150.3±20.6
Experimental	3150.3±416.3	103.0±11.9	48.8±5.8	154.4±15.7	281.9±27.2	2.39±0.19	17.4±1.5	146.9±13.6
Group NPI								
Control (n=8)	3388.3±245.2	117.3± 7.0	51.2±2.7	124.6± 6.7	223.6±11.6	1.88±0.06	19.0±1.5	184.9±18.3
Experimental	3267.4±215.3	111.3± 5.2	48.7±2.0	114.1±10.7	204.9±18.9	1.71±0.14	49.2±2.9	476.1±36.0
Group NPNI								
Control (n=7)	2851.9±275.7	102.6±10.4	44.1±4.5	112.7±13.9	204.8±21.8	1.71±0.19	17.0±2.1	166.5±18.2
Experimental	2896.6±316.6	103.5±10.4	44.5±4.5	109.0±13.3	194.7±23.7	1.69±0.17	16.6±2.2	166.1±21.9

(17.0 ± 1.3 mg). As shown in Appendix 2, all of the subjects in the iron supplement groups (PI and NPI) had much higher intakes of iron in the Experimental Period.

During the Control Period, the mean daily energy intake for all female subjects was 1980 ± 151 kcal, or 36.6 ± 2.2 kcal/kg; the mean daily protein intake was 1.32 ± 0.11 g/kg; and the iron intake was 11.7 ± 0.9 mg. During this time, the daily energy intake of the four groups was similar. Subjects in Group PI increased their energy intake during the Experimental Period compared to the Control Period. The mean total daily protein intake of the two protein supplement groups (1.78 ± 13 g/kg) was only slightly higher than the mean protein intake of the two groups ($1.63 \pm .29$ g/kg) not receiving protein supplement during the Experimental Period. This discrepancy was caused by one of the three subjects in Group NPI inadvertently doubling her protein intake from 1.3 g/kg to 2.7 g/kg during the Experimental Period. The protein intakes of the remaining two subjects in Group NPI were similar during the Control and Experimental Periods (1.6 g/kg and 1.5 g/kg versus 1.3 g/kg and 1.5 g/kg). In the Experimental Period, the daily iron intake of the iron supplement subjects was much higher (48.8 ± 4.1 mg) than the iron intake of the subjects (12.6 ± 1.9 mg) not receiving the iron supplement. Table 6 compares the energy, protein and iron intakes of the athletes for the Control Period to values for the general Canadian population (Nutrition Canada, 1975) and to Canadian RDI standards (Committee for the Revision of the Canadian Dietary Standard, 1976). The protein intake of the male distance runners is slightly higher than that of the average Canadian

TABLE 5

Daily Intake of Energy, Protein and Iron During Control and Experimental Periods - Female Runners (Mean±SEM)

	Energy (kcal)	% RDI	Energy (kcal/kg)	Protein (grams)	% RDI	Protein (g/kg)	Iron (mg)	% RDI
Group PI								
Control (n=2)	1702.0±217.0	81.0± 8.2	31.1±3.8	55.1± 5.9	131.5±16.5	1.00±0.10	11.8±0.3	84.5± 2.5
Experimental	2284.5±140.5	107.4± 7.4	41.0±2.0	100.1±10.9	239.0±32.0	1.80±0.20	55.0±7.2	392.5±51.5
Group PNI								
Control (n=3)	1844.5±213.8	92.3± 7.7	35.5±2.5	63.4± 6.6	150.3±17.9	1.23±0.07	10.3±1.7	73.3±11.9
Experimental	2098.0±355.0	103.3±13.7	39.1±4.8	94.7±15.4	228.3±39.7	1.77±0.20	12.4±3.4	88.0±24.3
Group NPI								
Control (n=3)	1900.3±229.8	87.8± 9.4	35.3±3.1	76.7± 6.4	181.3±13.0	1.47±0.09	11.2±2.3	80.0±16.7
Experimental	2038.0±134.1	94.1± 9.8	37.7±2.0	95.4±18.6	227.0±48.5	1.83±0.44	44.7±4.1	319.0±29.5
Group NPNI								
Control (n=3)	2390.3±434.4	109.7±15.8	42.8±6.1	82.3±23.6	191.3±54.9	1.47±0.39	13.6±1.9	97.0±13.3
Experimental	2385.0±518.7	111.1±21.2	42.7±8.1	82.5±25.2	192.0±58.8	1.43±0.43	12.8±2.3	91.0±16.5

TABLE 6

Percent Distribution of Male and Female Runner Control Period Daily Dietary Intakes Compared to Nutrition Canada Survey Percentile Norms for Males and Females of Similar Ages

	PERCENTILES					CLASSIFICATION OF INTAKE		
	0-5	6-25	26-50	51-75	76-100	Inadequate	Marginal	Adequate
Kilocalories/kg/day								
Male Runners	0	13	42	39	6	-	-	-
Female Runners	0	9	45	37	9	-	-	-
Protein Intake (g/kg)								
Male Runners	0	7	19	65	9	0	3	97
Female Runners	0	18	27	37	18	0	9	91
Iron Intake (mg)								
Male Runners	0	3	45	39	13	0	3	97
Female Runners	0	18	18	9	55	27	64	9

There is no intake classification for caloric intake in the Nutrition Canada Standards.

Nutrient intakes are classified into 3 levels: (1) Inadequate intakes - those below minimum requirements; (2) Marginal intakes - those above minimum requirements, but below adequate intakes; (3) Adequate intakes - those providing a desirable measure of safety in meeting the requirements for a nutrient.

male, while energy and iron intake are similar. The energy and protein intake of the female distance runners are similar to those of other Canadian females, but iron intake is slightly higher. Nevertheless, 91 percent of the female athletes are classified as having less than adequate iron intake. The daily dietary intakes of a number of other nutrients are shown in Table 7. For the male runners, the total group mean intake of each nutrient shown in Table 7 was above the Canadian RDI (Committee for the Revision of the Canadian Dietary Standard, 1976). Except for energy intake and iron intake, this was also true for the female runners. The male athletes received 34.5 percent of their calories from fat, 49.7 percent from carbohydrates, and 15.6 percent from proteins. The corresponding values for the female athletes were respectively 36.9 percent, 49.1 percent and 14.0 percent. In a typical Canadian diet fat provides approximately 39-43 percent of the calories, carbohydrates, 47-51 percent and protein, 11-15 percent (Nutrition Canada, 1975).

Hematological Data

Hematological data is shown in Tables 8 and 9. There were no significant ($p < .05$) differences between groups or within groups in red blood cell count, hemoglobin, mean corpuscular volume or mean corpuscular hemoglobin for the male subjects. There was a significant increase in hematocrit ($p < 0.05$) and a significant decrease in mean corpuscular hemoglobin concentration within groups (i.e.) for "time."

TABLE 7

Dietary Intake of Nutrients by Male and Female Runners During the Control Period (Mean±SEM)

	Male Runners (n=29)	RDI*	Female Runners (n=11)	RDI**
Fat (g)	118.6±5.4	-	82.8±8.9	-
Saturated Fat (g)	41.7±2.1	-	28.7±2.2	-
Oleic Acid (g)	48.0±2.5	-	37.8±4.7	-
Linoleic Acid (g)	14.4±1.1	-	11.1±1.8	-
Cholesterol (mg)	467.6±25.1	-	391.1±60.1	-
Carbohydrate (g)	383.9±14.1	-	247.9±17.1	-
Fiber (g)	6.8±0.5	-	6.4±0.8	-
Sodium (mg)	3850±211	-	3160±700	-
Potassium (mg)	4428±156	-	2996±270	-
Phosphorus (mg)	2288±93		1567±208	-
Energy (kcal)	3091±121	3000	1980±151	2100
Protein (g)	120.3±4.9	56.0	70.6±6.7	41.0
Thiamine (mg)	2.1±0.1	1.5	1.2±0.1	1.1
Niacin (mg)	28.5±1.9	20.0	17.4±1.9	14.0
Riboflavin (mg)	3.0±0.2	1.8	2.0±0.3	1.3
Ascorbic Acid (mg)	174.1±17.4	30.0	101.2±15.8	30.0
Vitamin A (IU)	7450±658	5000	6880±1244	4000
Calcium (mg)	1512±74	800	1094±145	700
Iron (mg)	18.4±0.9	10.0	11.7±0.9	14.0

*RDI for average Canadian male, age 19-35 years, weight 70 kg, height 176 cm (Committee for the Revision of the Canadian Dietary Standard, 1976)

**RDI for average Canadian female, age 16-35 years, weight 56 kg, height 161 cm.

TABLE 8

Selected Hematology Measurements During the Control and Experimental Periods
Male Runners (Mean±SEM)

	RBC (10^6)	Hemoglobin (g/dl)	Hematocrit (%)	MCV (um^3)	MCH (pg^3)	MCHC (%)
Group PI						
Control (n=8)	4.91±0.09	15.0±0.2	42.5±0.8	87.1±1.3	30.8±0.5	35.5±0.4
Experimental	4.94±0.09	15.0±0.3	44.5±1.0	88.6±1.4	30.5±0.3	34.0±0.5
Group PNI						
Control (n=8)	4.66±0.13	14.7±0.3	41.6±0.7	87.1±0.6	30.9±0.4	35.5±0.5
Experimental	4.86±0.08	15.0±0.2	43.3±0.7	86.8±0.7	31.0±0.3	34.9±0.3
Group NPI						
Control (n=8)	4.75±0.10	14.7±0.2	41.6±0.7	88.5±1.9	31.1±0.5	35.2±0.5
Experimental	4.72±0.11	14.6±0.4	42.4±0.8	88.8±1.8	31.0±0.5	34.4±0.4
Group NPNI						
Control (n=9)	4.83±0.06	14.9±0.2	42.1±0.6	87.1±0.9	30.8±0.3	35.3±0.2
Experimental	4.83±0.06	14.9±0.2	44.1±0.8	90.0±1.8	31.1±0.3	34.0±0.4
Normal Range†	4.60-6.20	14.1-17.1	40.0-50.0	80.0-100.0	27.0-31.0	32.0-36.0

TABLE 8 (continued)

ANOVA: F ratios						
Time	1.41	0.35	15.29*	3.19	0.00	15.37*
Protein x Time	2.09	1.20	0.24	0.71	0.86	0.00
Iron x Time	1.38	2.06	0.26	0.10	2.61	0.14
Protein x Iron x Time	0.45	0.66	0.76	3.57	0.03	2.08

* Significant at the 0.05 level.

† Normal range used by B. C. Biomedical Laboratories, Burnaby, B. C.

RBC, red blood cells; MCV, mean corpuscular volume; MCH, mean corpuscular hemoglobin; MCHC, mean corpuscular hemoglobin concentration

TABLE 9

Selected Hematology Measurements During the Control and Experimental Periods - Female Runners (Mean±SEM)

	RBC (10^6)	Hemoglobin (g/dl)	Hematocrit (%)	MCV (um^3)	MCH (pg^3)	MCHC (%)
Group PI						
Control (n=2)	4.48±0.21	13.5±0.2	37.2±0.8	83.5±0.8	29.9±1.3	35.8±0.2
Experimental	4.65±0.28	13.6±0.2	40.0±0.1	83.0±5.0	29.4±1.5	34.5±0.3
Group PNI						
Control (n=3)	4.56±0.15	14.0±0.4	38.6±1.0	85.7±2.2	31.0±0.7	36.3±0.2
Experimental	4.50±0.18	13.8±0.2	40.9±0.5	87.7±2.3	30.9±0.8	34.2±0.1
Group NPI						
Control (n=4)	4.31±0.11	12.5±0.3	35.4±1.1	82.5±1.0	29.1±0.2	35.4±0.3
Experimental	4.55±0.11	13.3±0.2	39.7±0.9	84.3±0.3	29.4±0.3	34.0±0.3
Group NPNI						
Control (n=4)	4.28±0.20	13.2±0.6	37.5±1.6	87.5±1.2	31.1±0.3	35.2±0.6
Experimental	4.28±0.18	13.2±0.4	38.7±1.2	87.3±0.8	31.0±0.6	34.7±0.4
Normal Range†	4.00-5.40	12.3-15.3	37.0-47.0	80.0-100.0	27.0-31.0	32.0-36.0

TABLE 9 (continued)

† Normal range used by B.C. Biomedical Laboratories, Burnaby, B.C.

RBC, red blood cells; MCV, mean corpuscular volume; MCH, mean corpuscular hemoglobin; MCHC, mean corpuscular hemoglobin concentration

The increase in hematocrit from the Control Period to the Experimental Period was significant ($p < 0.05$) only in Group PI ($t=1.84$) and in Group NPNI ($t=4.40$). The decrease in mean corpuscular hemoglobin concentration was also significant only in Group PI ($t=2.47$) and Group NPNI ($t=3.61$).

There was an increase in red blood cell count and hematocrit for the two female groups (PI and NPI) receiving the iron supplement. Group NPI was also the only group to show a substantial increase in hemoglobin concentration. All female groups showed a decrease in mean corpuscular hemoglobin concentration during the Experimental Period.

Serum Chemistry

Serum chemistry data is shown in Tables 10 and 11. For the male subjects, there were no significant between group or within group changes in ferritin, iron binding capacity, haptoglobin, BUN, or total protein. Both serum iron and percent transferrin saturation showed significant within group changes for time and a significant protein/iron/time interaction. The largest increases in serum iron concentration and percent saturation occurred in Groups PI and NPNI. The increase in serum iron concentration from the Control Period to the Experimental Period was not significant ($p < .05$) in Group PI ($t=1.67$), but was significant in Group NPNI ($t=2.11$). The increase in percent saturation from the Control Period to the Experimental Period was significant in both Group PI ($t=1.76$) and Group NPNI ($t=2.97$). For

TABLE 10

Serum Chemistry Measurements During the Control and Experimental Periods - Male Runners (Mean±SEM)

	Ferritin (ng/ml)	Serum Iron (ug/dl)	TIBC (ug/dl)	% trans-ferr. satur.	Hapto-globin (mg/100 ml)	BUN (mg/dl)	Total Protein (g/dl)	Albumin (g/dl)	Bilirubin (mg/dl)
Group PI									
Control (n=8)	49.3±12.1	75.4± 8.3	376.3±17.9	20.6±2.5	123.3±48.7	19.1±1.2	7.21±0.1	4.50±0.07	0.43±0.03
Experimental	46.5± 6.1	120.8±25.9	353.1±19.2	36.8±8.9	96.6±23.8	21.0±1.1	7.24±0.1	4.65±0.06	0.48±0.06
Group PNI									
Control (n=8)	27.9± 4.2	82.6±12.1	394.8±19.4	20.4±2.5	89.9±22.6	17.4±0.98	7.14±0.16	4.46±0.08	0.54±0.11
Experimental	28.3± 3.5	87.0±12.8	372.4±20.3	24.3±4.3	80.0±14.6	16.5±1.6	7.11±0.14	4.74±0.05	0.34±0.04
Group NPI									
Control (n=8)	31.0± 5.1	89.4±10.1	401.0±18.7	22.3±2.4	62.5±16.1	17.8±1.5	7.21±0.11	4.70±0.06	0.51±0.06
Experimental	32.9± 7.1	93.9±10.6	376.8±10.6	24.9±2.5	80.5±0.9	16.9±0.9	7.20±0.15	4.64±0.11	0.50±0.08
Group NPNI									
Control (n=9)	43.6± 8.4	102.8±14.7	390.4±27.9	25.4±3.8	93.2±18.9	17.1±1.2	7.31±0.1	4.53±0.06	0.70±0.10
Experimental	39.2± 6.7	145.2 ±19.4	398.9±16.2	36.9±5.2	65.1±9.6	17.9±1.1	7.40±0.1	4.71±0.08	0.50±0.07
Normal Range†	> 20	65.0-175.0	250.0-420.0	20.0-55.0	21.0-195.0	5.0-25.0	6.0-8.0	3.5-5.0	0.15-1.0

TABLE 10 (continued)

ANOVA: F ratios									
Time	0.20	7.40*	2.25	4.67*	0.93	0.09	0.04	11.48*	3.81
Protein x Time	0.00	0.01	0.50	0.02	0.30	0.13	0.09	3.90*	0.18
Iron x Time	0.08	0.01	0.68	0.79	0.37	0.13	0.01	4.68*	5.62*
Protein x Iron x Time	0.73	5.02*	0.62	5.40*	1.70	2.07	0.34	0.61	0.08

* Significant at the 0.05 level

† Normal range used by B. C. Biomedical Laboratories, Burnaby, B. C.

TIBC, total iron binding capacity; BUN, blood urea nitrogen.

albumin, the F ratios for time, protein/time interaction and iron/time interaction were significant. Groups PI (t=2.88), PNI (t=4.24) and NPNI (t=2.10), had significantly higher albumin concentrations in the Experimental Period. The no iron groups, Group PNI and Group NPNI had significantly lower bilirubin levels (t=2.74) in the Experimental Period.

For the female data, the mean ferritin concentration for the groups receiving iron supplement remained constant between the Control Period and the Experimental Period, while these levels decreased in the two groups not receiving iron supplement. Group NPI showed a substantial decrease in TIBC while the decrease in TIBC in the other groups was less pronounced. Serum iron concentration and percent serum transferrin saturation changed similarly in the iron supplement groups compared to the non-iron supplement groups. Although Group NPI showed the greatest increase in percent transferrin saturation, the increase was not large. Haptoglobin and bilirubin remained constant in all groups except Group NPNI where haptoglobin increased during the Experimental Period. The mean bilirubin level was higher in Group PI, because one of the two subjects had a high bilirubin level (2.3 mg/dl) outside the normal range, during the Control Period. BUN, total protein and albumin remained constant between the Control and Experimental Periods in all groups except Group NPNI, where BUN and total protein concentration decreased.

Using criteria established by Valberg et al. (1976) for classifying

TABLE 11

Serum Chemistry Measurements During the Control and Experimental Periods - Female Runners (Mean±SEM)

	Ferritin (ng/ml)	Serum Iron (ug/dl)	TIBC (ug/dl)	% trans-ferr. satur.	Hapto-globin (mg/100 ml)	BUN (mg/dl)	Total Protein (g/dl)	Albumin (g/dl)	Bilirubin (mg/dl)
Group PI									
Control (n=2)	17.0± 3.0	79.0±3.0	397.0±44.0	20.5±1.5	53.0±17.0	19.5±4.5	7.15±0.25	4.65±0.15	1.30±1.00
Experimental	16.0± 1.0	61.0±4.0	384.5±47.5	16.0±3.0	34.0±18.0	18.0±1.0	7.15±0.45	4.50±0.20	0.65±0.45
Group PNI									
Control (n=3)	26.7± 4.8	61.7±30.1	422.0±22.0	14.0±6.1	141.3±31.2	14.3±1.3	7.53±0.07	4.67±0.17	0.53±0.09
Experimental	19.3± 2.3	66.7±8.7	402.3±30.7	16.0±1.5	130.7±7.1	12.7±1.9	7.40±0.15	4.63±0.22	0.53±0.03
Group NPI									
Control (n=4)	11.8± 3.1	81.0±34.5	471.0±21.5	17.7±8.0	120.5±20.0	20.5±2.3	7.35±0.19	4.65±0.12	0.45±0.03
Experimental	12.5± 1.6	103.5±2.3	405.8±13.1	26.3±6.4	131.3±24.5	17.0±0.71	7.35±0.18	4.58±0.05	0.45±0.06
Group NPNI									
Control (n=4)	36.8±14.5	76.8±18.0	391.5±18.2	19.5±4.2	48.3±2.7	18.8±0.9	7.35±0.12	4.63±0.19	0.48±0.09
Experimental	29.0±16.1	86.8±30.1	374.0±18.2	22.5±7.3	91.8±20.8	15.5±0.87	6.98±0.23	4.53±0.13	0.53±0.06
Normal Range†	> 20.0	65.0-175.0	250.0-420.0	20.0-55.0	21.0-195.0	5.0-25.0	6.0-8.0	3.5-5.0	0.15-1.0

†Normal Range used by B. C. Biomedical Laboratories, Burnaby, B. C.
TIBC, total iron binding capacity; BUN, blood urea nitrogen

TABLE 12

Percent Distribution of Male and Female Runners and Non-athletes in Categories of Iron Deficiency Based on Serum Ferritin Levels

	Latent Iron Deficiency (%)	Prelatent Iron Deficiency (%)	No Iron Deficiency (%)
Males			
Runners (Control Period) (n=33)	6	39	55*
Runners (Experimental Period) (n=33)	6	33	61*
Non-athletes+ (n=95)	4	10	86
Non-athletes++ (n=10)	0	20	80
Females			
Runners (Control Period) (n=13)	31	54	15
Runners (Experimental Period) (n=13)	38	54	8
Non-athletes+ (n=100)	35	35	30
Non-athletes++ (n=17)	18	29	53

+ Subjects from Nutrition Canada Study (Nutrition Canada, 1975)
++ Subjects at B. C. Biomedical Laboratory
* Significantly different from non-athletes in Nutrition Canada Study ($p<.05$)
Latent iron deficiency - serum ferritin < 15 ng/ml (Nutrition Canada, 1975)
Prelatent iron deficiency - serum ferritin 15-30 ng/ml
No iron deficiency - serum ferritin > 30 ng/ml

latent iron deficiency (serum ferritin concentration $\leq$ 15 ng/ml) and prelatent iron deficiency (serum ferritin concentration, 15-30 ng/ml), serum ferritin values for our athletes are compared to values for non-athletes collected at B.C. Biomedical Laboratory and to values on Canadians collected in the Nutrition Canada Survey (Valberg et al., 1976), in Table 12. Using a chi-square test of goodness of fit (Winer, 1971) the male runners in the Control Period (X^2=41.0) and in the Experimental Period (X^2=17.7) have a significantly higher ($p < .05$) incidence of iron deficiency than the non-athletes from the Nutrition Canada Study. The female runners also appear to have a higher incidence of iron deficiency than the female non-athletes. Table 12 also shows that the distribution of both male and female athletes in the three iron deficiency categories changed only slightly between the Control and Experimental Periods. In Table 13 a different set of criteria, percent transferrin saturation, has been used to classify the stages of iron deficiency. A comparison of Tables 12 and 13 shows that the distribution of subjects in the three categories of iron deficiency can change substantially as a function of the classification system chosen.

Performance Data

Performance data is shown in Tables 14 and 15. For the male subjects, there were no significant changes ($p < 0.05$) in treadmill endurance or gross VO_2 max. (liters/min.) after supplementation. VO_2 max., expressed per kg body weight, was significantly decreased ($p < 0.05$) and power was significantly increased within groups during the Experi-

TABLE 13

Percent Distribution of Male and Female Runners and Non-athletes in Categories of Iron Deficiency Based Percent Transferrin Saturation Values

	Latent Iron Deficiency (%)	Prelatent Iron Deficiency (%)	No Iron Deficiency (%)
Males			
Runners (Control Period) (n=33)	18	24	58
Runners (Experimental Period) (n=33)	6	15	79
Non-athletes+ (n=1008)	3.5	14.2	82.3
Non-athletes++ (n=10)	20	10	70
Females			
Runners (Control Period) (n=13)	33	17	50
Runners (Experimental Period) (n=13)	50	17	33
Non-athletes+ (n=1332)	10.6	20.9	68.5
Non-athletes++ (n=17)	18	12	70

+ Subjects from Nutrition Canada Study (Nutrition Canada, 1975)
++ Subjects at B. C. Biomedical Laboratory

Latent iron deficiency - percent transferrin saturation < 16 (Nutrition Canada, 1975)
Prelatent iron deficiency - percent transferrin saturation 16-20
No iron deficiency - percent transferrin saturation > 20

mental Period. The decrease in VO_2 max. (ml/kg/min) from the Control Period to the Experimental Period was significant in Groups PNI (t=1.82), NPI (t=1.90) and NPNI (t=1.97). VO_2 (ml/kg/min) was significantly decreased as a result of a slight decrease in gross VO_2 max. and an increase in mean body weight in all groups. Unfortunately, some subjects from all groups caught an influenza virus during the Experimental Period and missed a few days training. This accounts for the slightly lower training volume in the Experimental Period. The four male groups were not as equal in daily training volume as they ideally should have been. Group NPI sustained approximately a 50 percent greater daily training mileage than Group PNI.

For the female subjects, treadmill endurance, VO_2 max. (liters/min.) and VO_2 max. (ml/kg/min.) were decreased in the Experimental Period in all four groups. VO_2 max. (ml/kg/min.) decreased more than gross VO_2 max. (liters/min.) for the reasons described above. Power was slightly increased in all groups in the Experimental Period. Daily training volume remained constant during the Control and Experimental Periods in all four groups. Group PI had a lower daily training volume than the other three groups during both periods.

TABLE 14

Maximal Treadmill Performance, Muscular Power, and Training Characteristics During the Control and Experimental Periods - Male Runners (Mean±SEM)

	Treadmill Endurance (sec)	VO_2 Max (l/min)	VO_2 Max (ml/kg/min)	Power (kgm^2/sec^3)	Training (km/day)
Group PI					
Control (n=8)	422.9±22.1	4.42±0.27	65.2±1.8	1015±41	10.2±1.1
Experimental	425.3±27.6	4.46±0.21	64.6±1.2	1092±52	8.8±1.4
Group PNI					
Control (n=8)	410.0±20.6	4.14±0.19	65.9±1.8	1010±74	8.4±1.8
Experimental	429.4±25.0	4.06±0.19	63.7±1.8	1071±72	8.7±1.6
Group NPI					
Control (n=8)	461.0±20.3	4.47±0.17	67.7±1.4	1001±51	13.1±1.0
Experimental	435.9±19.0	4.37±0.16	65.4±1.2	1075±54	12.1±1.1
Group NPNI					
Control (n=9)	471.0±30.3	4.33±0.19	69.6±2.1	977±35	12.9±1.1
Experimental	453.8±24.6	4.26±0.12	66.6±1.8	1065±52	11.0±7.5

TABLE 14 (continued)

ANOVA: F ratio				
Time	0.22	1.28	9.60*	27.63*
Protein x Time	2.26	0.51	0.48	0.63
Iron x Time	0.34	0.27	0.40	0.00
Protein x Iron x Time	0.05	0.62	0.02	0.37

* Significant at the 0.05 level

TABLE 15

Maximal Treadmill Performance, Muscular Power and Training Characteristics During the Control and Experimental Periods - Female Runners (Mean±SEM)

	Treadmill Endurance (sec)	VO_2 Max. (l/min)	VO_2 Max. (ml/kg/min)	Power (kgm^2/sec^3)	Training (km/day)
Group PI					
Control (n=2)	425.5±59.5	3.21±0.15	58.7±3.1	777±73	6.5±1.5
Experimental	373.4±12.5	3.13±0.08	56.1±0.7	817±47	5.9±0.6
Group PNI					
Control (n=3)	455.0±43.1	3.11±0.13	60.3±2.2	741±27	9.1±1.3
Experimental	391.0±47.0	3.02±0.20	56.9±2.5	799±13	9.1±1.4
Group NPI					
Control (n=4)	413.8±19.0	2.95±0.16	58.1±1.0	738±31	10.3±1.6
Experimental	380.0±3.0	2.95±0.13	56.4±0.2	776±30	9.3±1.7
Group NPNI					
Control (n=4)	415.0±23.9	3.21±0.10	58.2±1.3	746±28	11.7±1.2
Experimental	379.0±18.1	3.18±0.16	56.3±0.9	809±25	10.3±0.6

CHAPTER IV

DISCUSSION

Physical Characteristics of Subjects

The physical characteristics (height, weight, somatotype, percent fat) of our male runners are very similar to the physical characteristics which have been reported for other groups of good male distance runners (Pollock et al., 1977; Costill et al., 1970; Sprynarova and Parizkova, 1971; de Garay et al., 1974). Based on maximum oxygen uptake data and race performance times, our male subjects would be classified as good, but not elite, distance runners (Pollock, 1977). The average percent body fat of our male runners (8.4%) is higher than the values of 4.7 percent which have been reported for elite distance runners (Pollock et al., 1977) but lower than the 15 percent body fat of the average college age male (Mathews and Fox, 1976). The average height and weight of our female distance runners are within the narrow range of values which have been reported in other studies on female distance runners (Wilmore and Brown, 1974; Novak et al., 1977; Burke and Brush, 1979). The 11.3 percent body fat of our female runners is the lowest value which has been reported for any other group of female athletes. Wilmore and Brown (1974) in their study of 11 national and international caliber female distance runners (mean age = 32.4 years) showed an average percent fat of 15.2. Novak et al. (1977) studied eight middle distance runners (mean age = 24.2 years) at the 1972 Olympic Games and found an average percent fat of 13.3. Burke and Brush (1979) in their study of 13 female distance runners (mean age = 16.2 years) found an average percent

fat of 12.8. These values are all much lower than the value of 23-25 percent body fat which has been reported for normal college age females (Wilmore and Behnke, 1970). It is also interesting to note that the mean somatotype of our female runners (2.0 - 3.5 - 3.7) was almost identical to the mean somatotype of female middle distance runners (2.0 - 3.3 - 3.7) in the 1968 Olympics (de Garay et al., 1974). The VO_2 max. of our female runners was also very similar to the values that have been reported by Wilmore and Brown (1974), Novak et al. (1977), and Burke and Brush (1979).

Dietary Analysis

The Canadian RDI for protein (Committee for Revision of the Canadian Dietary Standard, 1976), adopted from the recommendations of the 1973 Joint FAO/WHO Report (Joint FAO/WHO Ad Hoc Expert Committee, 1973), for adults over 18 years of age is for males, 0.80 g/kg/day and for females 0.73 g/kg/day. In their normal diets our male and female runners had mean protein intakes 2.3 and 1.8 times the RDI respectively. Their protein intakes are also slightly higher than the median daily protein intakes of 1.54 g/kg and 1.18 g/kg which have been reported for Canadian males and females, aged 20-39 years (Nutrition Canada, 1975). The protein intake of our male athletes was comparable to the 1.80 g/kg/day protein intake of male athletes on the 1968 Australian Olympic Team, while the intake of our female athletes was lower than the 1.90 g/kg/day protein intake of female athletes on the 1968 Australian Olympic Team (Steel, 1970). The normal dietary protein intakes of our male

and female athletes, however, fall short of the values recommended for athletes in Russia (Yakolev, 1961; Williams, 1976), Eastern Europe (Jarver, 1975), and Japan (Shiraki, 1974). In the Experimental Period, male athletes who received the protein supplement had protein intakes within the range of these recommendations.

The dietary iron intakes of our athletes in the Control Period were similar to those of average Canadian male and female adults (Nutrition Canada, 1975). The male athletes had iron intakes that were well in excess of the RDI (10 mg/day), while 82 percent of the female athletes had iron intakes below the RDI (14 mg/day). This is in contrast to the women on the 1968 Australian Olympic Team who had iron intakes 2.1 times the RDI (Steel, 1970). A normal balanced Canadian diet provides 5 to 6 milligrams iron per 1000 kcal (Committee for Revision of the Canadian Dietary Standard, 1976). Our male athletes have higher iron intakes from their normal diets than our female athletes because they have higher caloric intakes. The male athletes ingest 168 kcal to get one milligram of iron while the female athletes ingest 169 kcal to get one milligram of iron. Thus the differences in iron intake between the male and female athletes are due to quantity of food intake, not quality of food intake. In the Experimental Period, the males and females who received iron supplements had iron intakes greatly in excess of the RDI.

The recommended daily energy intake for average Canadian males and females, aged 19-35 years, is 43 kcal/kg and 37.5 kcal/kg respectively (Committee for Revision of the Canadian Dietary Standard, 1976). During the Control Period 24 percent of the male runners and 63.6 percent

of the female runners had energy intakes below the RDI. However, the energy requirements of our runners should be much higher than the energy requirements of the average Canadian male or female non-athlete. Using a general formula of 1.0 kilocalorie per kilogram body weight per kilometer for energy expenditure when running (Margaria et al., 1963), the mean daily energy expenditure on training during the Experimental Period would be 671 kcal or 10.2 kcal/kg for the male runners and 489 kcal or 9.0 kcal/kg for the female runners. If we add the energy requirements of our runners for training to the recommended daily energy intake for average Canadians, we arrive at daily energy intake requirements of 53 kcal/kg and 46.5 kcal/kg for our male and female runners respectively. During the Control Period 69 percent of the male runners had energy intakes less than 53 kcal/kg and ten of eleven female runners had energy intakes less than 46.5 kcal/kg, while during the Experimental Period 79 percent of the male runners and 82 percent of the female runners had energy intakes below 53 kcal/kg and 46.5 kcal/kg respectively. Based on their average measured energy intakes as compared to their average calculated energy requirements, our male runners should have ingested approximately 11 percent more calories and our female runners should have ingested 27 percent more calories. However, during the Experimental Period, 76 percent of the males and 82 percent of the females increased their body weight. This indicates, contrary to the calculations described above, that the majority of the athletes were receiving an adequate energy intake.

What factors could account for this discrepancy between theoretical

energy requirements, measured energy intake, and actual energy intake? Perhaps the Food Composition Tables which were used do not give an accurate analysis of the nutrient composition of the foods most commonly eaten by our subjects. Chemical analysis of aliquot samples of food is the most accurate method of assessing the nutrient composition of a subject's diet (Marr, 1971). However, this method is very time consuming and thus impractical in situations where more than a few subjects are being studied. Widdowson and McCance (1943) in their discussion on the scope and limitation of food tables wrote:

> There are two schools of thought about food tables. One tends to regard the figures in them as having the accuracy of atomic weight determinations, the other dismisses them as valueless on the grounds that a food stuff may be so modified by the soil, the season, or its rate of growth that no figure can be a reliable guide to its composition. The truth, of course, lies somewhere between these points of view.

Many tables of food analyses have been prepared by national and international authorities (Davidson et al., 1975). The amount of protein, carbohydrate and fat in different samples of the same food is usually quite constant. The error in using tables to calculate the protein or carbohydrate contents of a diet is not likely to be more than seven percent (Davidson et al., 1975). However, there are large variations in the fat content of different helpings of beef, mutton, or pork. These variations can greatly affect the calculated energy value of the meat. For calculating the energy content of a diet, the error introduced by the use of the tables should not be more than 10 percent unless the diet contains large quantities of meat (Davidson et al,

1975). The variations in the vitamin and mineral contents of foods, however, can be great. For example, there are enormous variations in the iron content of different samples of the same food (Davidson et al., 1975). As one example of a study which has been performed to compare chemically analyzed values with calculated values from tables of food composition, Bransby et al. (1948) studied 33 adults for 3 days. The correlation coefficients between analyzed and calculated values were as follows: calories, 0.93; protein, 0.91; fat, 0.81; carbohydrates, 0.89; and iron, 0.49). These factors, described above, must be considered when analyzing the diets of the subjects in the present study. We do not know the actual total daily activity pattern and energy expenditure of our athletes. Perhaps the athletes partially compensate for their training energy expenditure by being less active than normal, moderately active Canadians during the rest of the day, and thus their daily energy expenditure is not as high as calculated. Perhaps some of the athletes were negligent in recording all of their daily food intake on the dietary record forms. There is now evidence that the precise regulation of body weight by appetite does not operate on an hourly basis or even on a daily basis, but on a time scale of several days or even weeks (Davidson et al., 1975). Perhaps during the week when the subjects monitored their diets they consumed less than usual due to the inconvenience of having to weigh and record all food ingested and also due to the fact that they were suddenly made conscious of all the food eaten.

Future research in this area should establish the total daily activity pattern and energy intake requirements of groups of endurance

athletes. This is important in relation to the proper utilization of dietary protein because if carbohydrates and fats are not consumed in sufficient amounts, even from a diet containing an adequate amount of protein, some of the amino acids will be used as a source of energy and will not be available for the synthesis of body protein (Joint FAO/WHO Ad Hoc Expert Committee, 1973; Crampton, 1964; Iyengar and Rao, 1979). If the dietary records obtained in this study underestimate many of the athletes' regular dietary intakes, for the reasons described above, this may also explain our finding of inadequate iron intakes in many of the female athletes.

Hematology

Hemoglobin concentration values may be affected by many factors such as different analysis techniques (Williams et al., 1972; Koepke, 1977), interlaboratory differences using the same analysis technique (Kaplow et al., 1979; Koepke, 1977), and age and sex of subjects (Wintrobe et al., 1974). Kaplow et al. (1979) assessed 20 Veterans Administration hospital laboratories for accuracy and precision in performing hematological measurements using the Coulter Counter Model S. An unexpected finding was that within-day variability was greater than day to day variability which was greater than interlaboratory variability. Based on College of American Pathologists Survey results, Koepke (1977) suggests that a maximum deviation of $\pm$ 0.4 g/dl as an absolute level of good precision for hemoglobin and $\pm$ 0.8 g/dl as acceptable. The Survey of the College of American Pathologists (Koepke,

1977) indicates a consistent bias between the manual cyanmethemoglobin colorimetric method for hemoglobin determination, which is the reference method (Williams, 1972), and the Coulter Counter Model S measurements. The Coulter S hemoglobin values are invariably lower; the difference averages 0.3 g/dl (Koepke, 1977). In a survey conducted by the College of American Pathologists (Koepke, 1977), it was shown that 90 percent of the Coulter S users used Coulter 4C as the primary calibrator for their instrument even though the material is in fact a "control" rather than a "calibrator." The relationsip of Coulter 4C to a certified cyanmethemoglobin standard is tenuous at best (Koepke, 1977). Coulter 4C is manufactured and distributed in monthly batches and these batches can vary slightly from month to month (Lafray, 1979). Furthermore, other companies besides Coulter Electronics, Inc. manufacture reagents for use with Coulter equipment. Using reagents from different companies can also affect measurements obtained on the Coulter Counter Model S (Lafray, 1979). Given this variability that can occur in hematology measurements, measurements taken at different laboratories or in the same laboratory in different time periods, cannot be accurately compared. Statistically significant differences in hematology measurements between groups measured at different laboratories, may be largely due to systematic differences in analysis techniques.

In the present study, the effects of protein and/or iron supplementation on hematological parameters can be evaluated because differences in analysis techniques over time in the same laboratory were accounted for by having a group of subjects which received placebos. However, it

is not possible to accurately compare the hematological measurements for the male and female runners to normal Canadians or to values on other groups of athletes from different studies in different laboratories. For example, the Nutrition Canada Survey, conducted in 1970-1973 (Nutrition Canada, 1975) reported the median hemoglobin concentration of males and females aged 20-39 years to be 15.7 g/dl and 13.8 g/dl respectively. Comparing the hemoglobin concentration of our athletes to the Nutrition Canada data would result in our male runners appearing to have a statistically significant lower hemoglobin level, when much of the difference between the two groups could be due to analysis technique differences. In order to evaluate whether or not our athletes had significantly lower hemoglobin levels than normal non-athletes, a group of male and a group of female age-matched non-athletes should have been monitored at the same time and in the same laboratory. Since this was not done, conclusions about whether or not our male and female runners had "sports anemia" cannot be drawn. All that can be concluded is whether or not the hematology measurements from our subjects fall within the accepted clinically normal ranges as shown in Tables 8, 9 and 16. These ranges are sufficiently broad to account for differences in analysis techniques. Compared to the B.C. Biomedical Laboratory normal ranges shown in Tables 8 and 9, the values of all the hematology measurements for our male and female runners fall within the normal range.

For the male runners, the significant increase in hematocrit and significant decrease in mean corpuscular hemoglobin concentration (MCHC),

TABLE 16

Blood Cell Values in a Normal Population
(Williams et al., 1972)

	Men	Women
Red cell count, ($\times 10^6/\mu l$ blood)	5.11±0.38*	4.51±0.36
Hemoglobin, (gm/100 ml blood)	15.5 ±1.1	13.7 ±1.0
Hematocrit (ml/100 ml blood)	46.0 ±3.1	40.9 ±3.0
Mean corpuscular hemoglobin (pg/red cell)	90.1 ±4.8	90.4 ±4.8
Mean corpuscular hemoglobin concentration, (gm/100 ml RBC)	30.2 ±1.8	30.2 ±1.9

*1 s.d.

Note: The studies were performed on 186 normal adult men and 270 normal adult women, with the Coulter Counter Model S.

which occurred even in Group NPNI was probably due to a systematic analysis error. In the Coulter Counter Model S hematocrit is not measured directly. It is derived from the electronic multiplication of the red blood cell count and the mean cell volume measurement (Williams et al., 1972). Although the precision of the red cell count and the mean cell volume (MCV) using the Coulter S is greatly improved over that attainable by manual means (Koepke, 1977), there still can be systematic sources of error in values obtained from the Coulter S (Williams et al., 1972; Koepke, 1977). In Group NPNI the mean cell volume increased from a mean of 87.1 in the Control Period to a mean of 90.0 in the Experimental Period, while the red cell count did not change. Thus, this increase in MCV caused the increase in hematocrit. With this increase in hematocrit, mean hematocrit for the male runners in the Experimental Period falls into the normal range for hemotocrit shown in Table 16, while in the Control Period the mean hematocrit for the male runners was below the normal range shown in Table 16.
On the Coulter Counter Model S, MCHC is also derived from computations which are performed electronically by analog devices and subsequently digitized for output to a printer or, alternatively, directly to a computer. MCHC is derived by dividing the hemoglobin value by the computed hematocrit (Williams et al., 1972). Thus, low hematocrit values as obtained in the Control Period for the male runners, automatically result in high MCHC values which were observed in the Control Period. Thus, what appear to be erroneously low MCV measurements in the Control Period has resulted in the computation of erroneously low hematocrit

values and erroneously high MCHC values. Problems such as a dirty aperture on the aperture tube of the Coulter S in the time period when the Control Period measurements were performed could result in a systematically low MCV reading (Lafray, 1979; Howard, 1972). This same explanation can also be used to explain much of the change in hematocrit and MCHC between the Control and Experimental Periods in the female runners.

As explained above, it is not possible to conclude whether our athletes, as a group, have a significantly lower hemoglobin concentration than average non-athletes. There is widespread belief among athletes and sports physicians that a mild degree of anemia is common among distance runners. Yet there is no firm evidence for this belief which may have arisen from the wide scatter of results obtained by hemoglobin determinations in different laboratories throughout the world using different analysis techniques. The only studies in the literature where hematological parameters on endurance athletes and age-matched non-athlete control subjects have been measured together are those of Brotherhood et al. (1975) and Martin et al. (1977). The subjects in both of these studies were elite runners whose training mileage ranged between 75-130 miles per week. Some of the hematology measurements from these two studies are shown in Table 17. In the study of Brotherhood et al. (1975), the hemoglobin, hematocrit and red blood cell values are lower, but not significantly lower, in the runners. In the study of Martin et al. (1977), hematocrit, but not hemoglobin concentration, was significantly lower in the runners as compared to

TABLE 17

Selected Hematology Measurements for Endurance Runners and Age-Matched Non-Athletes from the Studies of Brotherhood et al., (1975) and Martin et al., (1977) (Mean±S.D.)

	Hemoglobin	Hematocrit %	RBC (10^6)
Brotherhood et al.			
Runners (n=39)	14.61±0.72	43.0±2.0	4.77±0.27
Non-athletes (n=12)	15.06±0.98	44.0±2.0	4.97±0.45
Martin et al.			
Runners (n=20)	15.50±0.90	*43.8±2.5	5.11±0.35
Non-athletes (n=95)	15.80±1.11	*47.2±3.3	--

* Significant at the 0.05 level

the non-athlete. Martin et al. (1977) did not explain the lower hematocrit values in their runners. Thus, these two studies provide no definitive answer as to whether or not distance runners have a mild degree of anemia. However, Table 17 does illustrate the importance of collecting data on athletes and non-athletes in the same laboratory. The hemoglobin values in the study of Brotherhood et al. (1975) for both runners and non-athletes were lower than the values in the study of Martin et al. (1977). If the runners in the study of Brotherhood et al. were compared with the non-athletes from the study of Martin et al. (independent T test, p - 0.05) a significant difference in hemoglobin levels would be obtained.

Scientists at conferences occasionally report that they have observed the phenomenon of sports anemia in endurance athletes, without actually describing experiments or presenting any data (Mann, 1976; Mann, 1977). However, there have been only a small number of published studies in which sports anemia has been shown to occur (Shiraki et al., 1974; Shiraki et al., 1977; Lindemann et al., 1978; O'hara and Radomski, 1978). In all of these studies the subjects were exposed to strenuous and prolonged physical activity and they were monitored longitudinally over a period of days or weeks. The Japanese (Shiraki et al., 1974; Shiraki et al., 1977) performed a number of small studies with humans, rats, and dogs in which substantial decreases in hemoglobin and red cell count were shown in untrained subjects exposed to strenuous and prolonged exercise. Their results indicated that sports anemia did not occur in men on high protein diets (2.0 g/kg/day) or trained

men. However, the training load which they administered to their trained subjects was not relatively as strenuous as the load administered to their untrained subjects. In the study of Lindemann et al. (1978) untrained male cadets participated in a combat course for four days during which time they worked at an average workload of 35 percent of maximum capacity for 21-23 hours per day. Daily blood samples showed a steady decrease in hemoglobin and hematocrit levels. Over the four day period, mean hemoglobin levels were reduced by 4.0 g/100 ml (24%) while mean hematocrit levels were reduced by 9.2 percent absolute (20%). In the study of Lindemann et al. (1978) and in a number of the Japanese studies (Shiraki et al, 1974; Shiraki et al., 1977), the results were not analyzed with inferential statistics, perhaps because of small subject numbers. This factor leaves the validity of their results open to suspicion.

In the study of O'hara and Radomski (1978), 16 Canadian national caliber male and female swimmers were monitored weekly for 20 weeks during the winter season, and 24 male and female swimmers were monitored weekly for 10 weeks in the summer season. In the winter phase of the study significant decreases in hemoglobin, hematocrit and red cell count occurred in the male swimmers after the week of most intensive training (76 km swam in six days). Thereafter hemoglobin and hematocrit values increased during the swim taper period towards initial values, whereas RBC counts remained depressed. The changes in the female swimmers, although similar in pattern to the males, were not statistically significant. In the summer phase of the study, however, the correlation

between hemoglobin concentration and training intensity was poor. Thus, although the authors in this study reported the occurrence of sports anemia (O'hara and Radomski, 1978), the results are not conclusive. In the present study, the training intensity of the male and female runners in the Control and Experimental Periods was relatively constant and thus individual longitudinal analyses of the relationship between hemoglobin concentration and training intensity could not be performed.

In the studies described above, the decrease in hemoglobin concentration associated with prolonged strenuous physical activity was attributed to accelerated red blood cell destruction because of mechanical damage (Shiraki et al., 1974; Shiraki et al., 1977; Lindemann et al., 1978; O'hara and Radomski, 1978). A number of studies using athletes as subjects (Poortmans and Haralambie, 1979; Refsum et al., 1976; Bichler et al., 1972; Williams and Ward, 1979) have also shown that intravascular hemolysis occurs as a result of prolonged strenuous exercise (5-10 hours). This hemolysis is evidenced by decreased serum haptoglobin levels, increased serum bilirubin levels and increased levels of free hemoglobin in the plasma. In these studies, the total extent of the hemolysis was so insignificant that hemoglobin concentration was either unchanged or only decreased very slightly. However, there are two main differences between these studies and those of Shiraki et al. (1974), Shiraki et al. (1977), Lindemann et al. (1978) and O'hara and Radomski (1978). Firstly, the subjects in the studies of Poortmans and Haralambie (1979), etc. were all well-trained while the subjects in the studies of Shiraki et al. (1974), Shiraki et al. (1977),

and Lindemann et al. (1978) were untrained. Secondly, while the exercise in the studies of Poortmans and Haralambie (1979), etc. was more prolonged and severe, it was only performed once. In the studies of Shiraki et al. (1974), etc. the exercise was less severe, but it was performed daily for a period of days or weeks. These two differences may account for the more pronounced hematological response in the studies of Shiraki et al. (1974), Shiraki et al. (1977), Lindemann et al. (1978), and O'hara and Radomski (1978).

In the present study, based on serum haptoglobin and bilirubin levels there was no consistent evidence that intravascular hemolysis was occurring. The best indication of hemolytic anemia is a high reticulocyte count (Hillman and Finch, 1974). Measurement of this parameter in this study and in the studies discussed above would have yielded more conclusive evidence about the occurrence of hemolysis. However, given the relatively moderate mean training load of our subjects, compared to the studies in which hemolysis has been reported, one would probably not expect hemolysis to be occurring in the present study. No explanation for why the two male no-iron groups (PNI and NPNI) had significantly lower serum bilirubin levels in the Experimental Period is available.

Protein Supplementation

For both the male and female runners protein supplementation had no beneficial effects. Hemoglobin levels were not changed, nor were treadmill endurance time or VO_2 max. improved in any of the groups who

received protein supplements. Our results agree with those of Rasch et al. (1969), Consolazio et al. (1975), Steben and Boudreaux (1978), Pitts et al. (1944), and Darling et al. (1944). Our results disagree with those of Shiraki et al. (1974), Shiraki et al. (1977) and Stucke et al. (1972). Shiraki's studies can be distinguished from our study and other studies by the size of the training stress placed on the subjects. Relative to fitness levels, Shiraki's subjects were trained much harder than the subjects in our study and other studies, except the study of Steben and Boudreaux (1978). In Steben's study high school runners ran 70-100 miles per week. This would be considered to be heavy training for athletes of this age. The results of Steben's study, however, must be discounted because the extra protein received by the protein supplement group was very small (1.4 g/day). Another difference between the Japanese studies (Shiraki et al., 1974; Shiraki et al., 1977) and our study is in the quality of protein ingested in the regular diets. In Shiraki's studies the subjects received 25-33 percent of their protein from animal sources, while in the typical Canadian diet approximately two-thirds of the protein comes from animal sources and one-third from vegetable sources (Committee for the Revision of the Canadian Dietary Standard, 1976). The net protein utilization (NPU) value of a typical Canadian diet is higher than the NPU value of a typical Japanese diet (Davidson et al., 1975). A given quantity of balanced essential amino acids can be obtained from a smaller intake of protein from a high quality protein diet than from a lower quality protein diet. In fact, Shiraki et al. (1974) in one of their studies showed that subjects who consumed 1.25 g/kg protein per day of very high quality protein (NPU = 90) and who were exposed to

prolonged strenuous exercise did not show evidence of sports anemia. Thus protein quality is an important factor to consider when determining protein requirements.

For both our male and female runners, the mean values for BUN, serum total protein, and serum albumin were all within the normal clinical range as defined by B.C. Biomedical Laboratory, for all groups in both the Control and Experimental Periods. Thus, there was no evidence of protein deficiency in any of the male or female athletes. BUN and serum total protein levels were not increased by protein supplementation. This absence of a change in BUN would be expected with a moderate increase in protein intake with normally functioning kidneys. Our results for serum albumin, BUN and serum total protein levels agree with those of Consolozio et al. (1975), and Rasch et al. (1969) but disagree with the results of Shiraki et al. (1974) and Shiraki et al. (1977). There were significant increases in serum albumin between the Control and Experimental Periods. Serum albumin levels increased not only in the two male protein supplement groups (PI and PNI) but also in the placebo group (NPNI). Thus the increase in serum albumin levels was quite possibly caused by some extraneous variable such as a systematic difference or error in analysis techniques.

If strenuous physical activity results in a greater destruction of tissue protein and causes an increased protein requirement as shown by Shiraki et al. (1974), and Shiraki et al. (1977), then how is the protein being lost from the body? An increased protein requirement must indicate an increased protein turnover and loss from the body.

There are several routes of loss:

(1) There is always a certain amount of nitrogen excreted in the urine because of the endogenous metabolism of protein, the protein turnover that occurs continuously in the tissues. Although there is variability in urinary nitrogen (N) excretion, the mean estimate for men and women is about 37 mg N/kg body weight per day (Joint FAO/WHO Ad Hoc Expert Committee, 1973). Protein is regularly found in the urine after moderately severe to severe exercise (Wesson, 1974; Castenfors, 1977). This phenomenon has been termed exercise proteinuria and is different from march hemoglobinuria and exercise myoglobinuria which are rare pathological conditions (Ohno et al., 1975; Stahl, 1957). Protein appears in the urine during the first 30 minutes after exercise and for 15-60 minutes is excreted at 10-20 times the control rates. A lesser excretion rate at 2-10 times the control rate may persist for 24 hours (Wesson, 1974; Castenfors, 1977). The amount of protein normally excreted by healthy humans at rest has been estimated at between 30 and 70 mg per day (Poortmans and Jeanloz, 1968). Thus, using the above figures, the maximum amount of protein that would ever possibly be excreted in the urine in the 24 hours following strenuous exercise would be approximately 750 mg. This is an insignificant amount when it is considered that the average daily dietary protein intake for our male and female athletes in the Control Period was 120.2 grams and 70.7 grams respectively. Furthermore, even in very severe exercise, proteinuria may not be observed in all subjects. In particular, the degree of proteinuria at a given exercise level is related to the degree of

physical fitness or training of the subject (Taylor, 1960). The increased protein excretion seen in exercise proteinuria comes almost entirely from the serum proteins--albumins and globulins (Coye and Rosandich, 1960).

(2) There is also loss of N in the feces, even when no protein is being consumed, presumably because of loss of cells and secretions from the intestinal tract. There is no suggestion that exercise has an influence here.

(3) Normally, about 200 mg of nitrogen per day is lost dermally (Calloway et al., 1971). Sweating as a result of vigorous physical activity increases N loss (Calloway et al., 1971; Durnin, 1978) and this may amount to a total of about 600 mg in a one hour period of strenuous exercise (VO_2 = 3.0 - 4.0 liters/min.) in trained subjects (Calloway et al., 1971). Even if this strenuous level of exercise lasted for two hours, requiring an energy expenditure of approximately 1800-2400 kcal, the N loss in the sweat would be 1.2 grams, requiring an extra (N x 6.25) 7.5 grams of protein to replace this loss--not a very large amount!

The RDI for protein for adult males is 0.80 g/kg or 56 grams per day for a 70 kg man (Joint FAO/WHO Ad Hoc Expert Committee, 1973). This protein requirement is stated in terms of "safe levels of intake" which accounts for individual variability in physiological requirements and differences in protein quality in various diets. Considering maximal protein losses that have been reported in urine and sweat as a result of strenuous exercise (0.75 g + 7.5 g), the daily protein

requirement for a very fit 70 kg man engaging in strenuous exercise for two hours per day could possibly be increased from 56 grams to approximately 64 grams, or 0.91 g/kg. This value is substantially less than the average daily protein intake of Canadian adult males of 1.54 g/kg (Nutrition Canada, 1975), and the average daily protein intake of our male runners of 1.82 g/kg. Similar calculations could be performed for females.

Furthermore, although there are a few reports to the contrary (Shiraki et al., 1974; Gonteza et al., 1974), the majority of nitrogen balance studies which have been conducted have shown that the nitrogen excretion does not significantly rise following muscular work (Durnin, 1978). Consolazio et al. (1975) studied nitrogen retention in men consuming either 1.4 or 2.8 g/kg/day protein during heavy physical training. Nitrogen retention was higher for subjects consuming the higher protein levels, but all subjects were in positive nitrogen balance throughout the study. Scientific reports have established that, although the metabolism of amino acids and other nitrogenous substances is increased by prolonged exercise (Felig and Wahren, 1971; Brodan et al., 1976; Dohm et al., 1977), when the caloric supply is sufficiently high protein is not used as a fuel to any appreciable extent (Poortmans, 1973). It seems more likely that, in exercise, protein metabolism occurs to provide an amino acid source for: (1) pyruvate removal and/or gluconeogenesis (Felig and Wahren, 1971; Brodan et al., 1976), and (2) maintaining the level of certain Krebs cycle intermediates (Brodan et al., 1976; Dohm et al., 1977).

Thus theoretical considerations support the finding of our study and other studies (Rasch et al., 1969; Consolazio et al., 1975) which have shown that a well balanced abundant diet will easily meet the protein needs of people engaged in strenuous physical activity.

Iron Supplementation

When the body is in a state of negative iron balance, increased iron deficiency results. The term "iron deficiency" is used to designate a condition in which the total body iron content has been depleted, no matter what the cause. Since body stores of iron must be exhausted before red cell production is restricted, anemia is a late stage of iron deficiency (Williams, 1972). Three phases of iron deficiency can be recognized (Jacobs, 1974). In the first phase iron is gradually mobilized from the body stores to meet the needs for hemoglobin synthesis and other metabolic activities. This process continues until the stores have been greatly decreased. This phase has been called prelatent iron deficiency (Jacobs, 1974). Further iron depletion results in a fall in serum iron concentration and percent transferrin saturation, although the blood hemoglobin concentration remains above the lower limit of normal. This phase is termed latent iron deficiency. In the third phase of iron deficiency, manifest iron deficiency, a reduction in iron supply to the bone marrow leads to iron deficient erythropoesis and a falling hemoglobin concentration. At this stage when hemoglobin concentration falls below 14.0 g/100 ml in adult males and 12.0 g/100 ml in adult females, iron deficiency anemia exists

(Williams et al., 1972).

The sequence of changes occurring during the development of iron deficiency are generally agreed upon (Jacobs, 1974; Williams, 1972). However, there is not full agreement on the precise levels of the various parameters that should be applied in describing the various stages. The prevalence of iron deficiency described for a given population is a reflection of the levels set for diagnostic criteria (Beaton, 1974). Variations in definition makes the comparison of data in the literature particularly difficult. The seriousness of this problem can be appreciated by comparing Tables 12 and 13 where two different criteria have been used to classify the stages of iron deficiency, using data from the present study and the Nutrition Canada Study (Nutrition Canada, 1975). Using serum ferritin levels as compared to percent transferrin saturation values to classify the stages of iron deficiency results in markedly different numbers of subjects being classified as having no iron deficiency. Even when the same parameter such as percent transferrin saturation is used to classify the stages of iron deficiency, different authorities will use different cut-off points for the various stages (Nutrition Canada, 1975; Wintrobe et al., 1974; Beck et al., 1978; DeWijn et al., 1971). While the terms prelatent, latent, or manifest iron deficiency are often applied (Jacobs, 1974), the terms iron depletion, and iron deficiency with or without anemia have also found favor. Both systems imply comparable stages of depletion (Beaton, 1974).

Making a diagnosis of iron deficiency anemia is not difficult.

A history of blood loss, hypochromic anemia, and greatly diminished transferrin saturation (<10%) and serum ferritin concentration (<15 ng/ml) are characteristic features (Wintrobe et al., 1974). Using these criteria none of the male athletes and only one of the female athletes showed evidence of iron deficiency anemia in the Control Period. This incidence of iron deficiency anemia remained the same in the Experimental Period. Prelatent and latent iron deficiency are, however, more difficult to accurately detect. It has been shown in a number of studies that there is a substantial diurnal and also day to day biologic variation in serum iron and percent transferrin saturation (Statland and Winkel, 1977; Statland et al., 1976; Hover, 1944; Hamilton et al., 1950). This variation in normal subjects limits the diagnostic value of these measurements. It has also been shown that levels of serum iron and percent transferrin saturation correlate poorly with direct measurements of bone marrow iron stores and other accurate methods of assessing iron status (Beck et al., 1978; Mazza et al., 1978). Serum iron concentration and percent transferrin saturation are often within normal limits in people with prelatent iron deficiency (Mazza et al., 1978). Furthermore, commonly used criteria for diagnosing iron deficiency based on measurements of serum iron concentration and percent transferrin saturation have been shown to have an unacceptably high error rate (Beck et al., 1978; Mazza et al., 1978). Ferritin is a high-molecular weight iron containing protein that functions in the body as an iron storage compound. It is found in a number of tissues in the body (Harrison et al., 1974) and the recent development of a sensitive immunoradiometric assay for ferritin

(Miles et al., 1974) has resulted in its demonstration as a normal constituent of serum. Serum ferritin concentration in healthy adults is proportional to the size of body iron stores (Jacobs et al., 1972; Cook et al., 1974). A highly significant correlation has been found between serum ferritin concentration and two other indices of body iron status: hemosiderin content of bone marrow (Lipschitz et al., 1974); and size of body iron stores as measured by quantitative phlebotomy (Walters et al., 1973). Furthermore, the serum ferritin concentration is a sensitive index of the earliest stage of iron deficiency, a decrease in body iron stores (Cook et al., 1974; Lipschitz et al., 1974). Thus, a system for classifying the stages of iron deficiency based on serum ferritin levels, as shown in Table 12, will be more accurate than a system based on percent transferrin saturation, as shown in Table 13. However, until recently, commercial sources of serum ferritin assay kits have not been readily available. Thus the routine tests used by physicians for assessing iron status are still serum iron concentration, total iron binding capacity, and percent transferrin saturation, in spite of their limitations (Lafray, 1979). In the future, measurement of serum ferritin concentration will possibly replace these other less accurate tests.

What explanations can be advanced to explain the lower levels of serum ferritin in our athletes as compared to normal Canadians? As discussed above, the dietary iron intakes of our male and female athletes were similar to those of normal Canadian males and females of similar age (Nutrition Canada, 1975). There is no experimental or

theoretical evidence to suggest that iron absorption in endurance athletes should be any different from non-athletes. The total quantity of endogenous iron lost in the urine, feces, and sweat amounts to 0.6-1.0 mg/day in the average individual (Underwood, 1971). A loss of this magnitude is not inconsiderable when it is realized that the average amount of iron absorbed from ordinary diets is about 10 percent of the dietary intake of iron (Underwood, 1971). The iron content of sweat has been reported to be in the range of 0.2-0.5 mg/liter (Underwood, 1971; Coltman and Rowe, 1966). Shephard and Kavanagh (1978) recorded sweat concentrations for iron of 0.46 mg/liter in a group of post coronary distance runners participating in the Boston Marathon. From pilot project data, we have estimated that the average daily training volume of our athletes (approximately 10 km/day) would result in an extra sweat production of approximately 0.5 liters per day. This would mean an extra iron loss of approximately 0.2 mg/day. Assuming an average dietary iron absorption of 10 percent in our male and female athletes (Davidson et al., 1975), an extra 2.0 mg of iron would have to be ingested in order to get an extra 0.2 mg absorbed into the body tissues. Thus our male runners would have their dietary iron requirement increased by 20 percent as compared to male non-athletes, while our female runners would have their dietary iron requirement increased by 14 percent as compared to female non-athletes. This argument assumes that with increased iron losses via sweat there are not partial compensatory decreases in the loss of iron via urine and feces. No studies of this matter have been found. Thus, increased sweat loss of iron could possibly, at least, partially explain the lower body iron

stores in our athletes as compared to normal Canadians (Nutrition Canada, 1975).

As shown in Table 12, 45 percent of the male runners and 85 percent of the female runners have either a prelatent or latent iron deficiency. Given this high incidence of iron deficiency, a relevant question is what effect, if any, iron deficiency without anemia has on exercise performance? One can only speculate as to whether or not these levels of iron deficiency are significant enough to cause iron shortages at the cellular level. In addition to the hemoglobin molecule, iron is an important constituent of other haem iron compounds such as myoglobin and cytochromes, iron-sulphur proteins of electron transport, and many important enzymes such as succinate dehydrogenase, catalase, glycerophosphate dehydrogenase, etc. (Underwood, 1971). A wide range of tissue abnormalities have been described both in iron deficient patients and in experimental animals and these abnormalities occur at different stages in the process of iron depletion (Jacobs, 1977; Dallman, 1974). Most of these studies, however, have restricted their subjects' dietary iron intake and thus have produced a more severe iron deficiency than is seen in our athletes.

For the male runners iron supplementation had no beneficial effects. Hemoglobin levels were not changed, nor were treadmill endurance time or VO_2 max. improved in the groups (PI and NPI) who received iron supplements. Serum iron concentration and percent transferrin saturation increased significantly in the Experimental Period in Group PI and also in Group NPNI, which was the double placebo group. Thus,

this increase in serum iron concentration and percent transferrin saturation must be due to some factor other than iron supplementation.

For the female runners, iron supplementation did cause substantial increases in hemoglobin concentration, red cell count and hematocrit in three of the four subjects in Group NPI. These three subjects had borderline hemoglobin levels (12.0-12.4 g/100 ml) in the Control Period. The other subjects in Group NPI and the two subjects in Group PI had normal hemoglobin levels in the Control Period and showed less substantial increases in hemoglobin concentration, red cell count and hematocrit after iron supplementation. It must be remembered that the subject numbers in the female treatment groups were very small and no tests of statistical inference were performed. Thus, this data is suggestive but by no means conclusive. Furthermore, the subjects in Group NPI had lower hemoglobin levels and poorer iron status than the other three groups in the Control Period. Thus Group NPI was biased because it initially had a higher probability of being benefitted by iron supplementation. The studies of Kilbom (1971), Bottiger et al. (1971), and Wirth et al. (1976) are all lacking in their attempts to determine if there is a significant iron cost associated with physical training in women. Each of these studies only measured serum iron levels in order to evaluate iron status. They should ideally have measured serum ferritin concentrations, or at least, total iron binding capacity or percent transferrin saturation. Since they did not do this, their conclusions regarding the iron cost of physical training cannot be accepted. The results of the present study are in agreement with the

results of recently published studies dealing with the iron status and requirements of athletes (Fitch, 1977; Cooter and Mowbray, 1978; Pate et al., 1979). Fitch (1977), in a study of the 1976 Australian Olympic swimming team noted that for both male and female athletes, the hemoglobin levels and percent transferrin saturation of those athletes taking iron supplements were no higher than in athletes not taking iron supplements. However, Australian athletes (Steel, 1970), especially females, have dietary iron intakes much higher than those of average Canadians (Nutrition Canada, 1975) and our athletes. Whereas in our study the serum ferritin levels were not increased in the iron supplement groups, the serum ferritin levels of the Australian swimmers were twice as high in the male iron supplement group and 5½ times as high in the female iron supplement group. Our subjects, however, ingested iron supplements for only six weeks while the Australian swimmers had been taking high dosages of iron supplements (average of 120 mg elemental iron per day) for a period of years.

Cooter and Mowbray (1978), and Pate et al. (1979) have recently investigated the effects of dietary iron supplementation on female athletes. Cooter and Mowbray (1978) used basketball players as subjects while Pate et al. (1979) used female college athletes from a number of sports, such as softball, tennis, basketball, gymnastics and swimming. No details of training intensity, training frequency, or fitness levels of subjects were given in either of these studies. Furthermore, no measurements of physical performance were taken. In both of these studies iron supplementation was of no value in raising serum iron

concentration, total iron binding capacity, percent transferrin saturation or hemoglobin levels. Serum ferritin levels were not measured, so an accurate assessment of changes in iron status was not obtained.

Even though, in the present study, 85 percent of the female athletes and 45 percent of the male athletes showed evidence of either prelatent or latent iron deficiency, body iron stores as assessed by serum ferritin levels, were not increased in the iron supplement groups. Although hemoglobin levels were increased in some of the women who received iron supplement, serum ferritin levels did not increase. This lack of change in body iron stores may be an indication that the size of the daily iron supplement was too small. Many sources recommend that for the therapy of iron deficiency in adults, the oral dosage should be sufficient to provide between 150 and 200 mg of elemental iron daily (Wintrobe et al., 1974; Williams et al., 1972; Hillman and Finch, 1974). With this dosage low hemoglobin levels will be returned to normal within one month. In order to fully replenish and build up deficient iron stores, it is recommended that this therapy be continued for at least six months (Wintrobe et al., 1974; Williams et al., 1972). In the present study the dosage of iron supplement was 32 milligrams of elemental iron per day for six weeks, while Weswig and Winkler (1974) administered 60 mg, six days per week for four months. Cooter and Mowbray (1978) administered 18 mg of elemental iron five days per week for four months and Pate et al. (1979) administered 50 mg per day for 5-9 weeks depending on the sport a particular subject was involved in. All of these dosages are much lower than the dosages recommended for

iron deficient adults (Wintrobe et al., 1974; Williams et al., 1972; Hillman and Finch, 1974). If an oral iron dosage of 150-200 mg of elemental iron per day had been administered in these athlete studies, perhaps significant increases in hemoglobin levels, body iron stores and physical performance would have been obtained.

Reports from countries in Eastern Europe such as Rumania indicate that male and female distance runners are regularly given intramuscular injections of iron dextran (Imferon). It is still commonly believed that parenteral iron therapy produces a much faster response than oral iron therapy in the treatment of iron deficiency anemia. This view is not supported by therapeutic comparisons by McCurdy (1965) or Olsson (1975). Parenteral iron administration does, however, have a definite place in therapy. In the small number of patients with intestinal malabsorption problems or intolerance to oral iron preparations parenteral iron administration, either intramuscularly or intravenously, may be required. In the great majority of cases, however, oral iron is safer, cheaper, and equally effective (Williams et al., 1972; Olsson, 1975). The relative ease with which iron dextran can be administered should not lead one to extend the indications for parenteral iron treatment, since a number of unpleasant side-effects can occur (Williams et al., 1972). Thus, until it is proven that parenteral iron treatment gives superior results in athletes, oral iron therapy should be used to correct iron deficiency problems in athletes.

Conclusions

Within the limitations of this study, the following conclusions seem justified:

(1) For male and female distance runners, the addition of protein supplements to an already balanced and abundant diet has no effects on hemoglobin concentration, VO_2 max. or performance on a maximal running task of seven to ten minutes duration. In an affluent country such as Canada where high quality protein is readily available and comprises about two-thirds of the protein ingested in a typical diet, the protein intake from a typical balanced diet should be more than adequate for meeting the protein requirements of endurance athletes.

(2) There is a high incidence of prelatent iron deficiency among male and female distance runners. Adult male runners have normal dietary intakes of iron well in excess of the RDI. For male distance runners, at the level of training of the subjects in the present study i.e., 60-90 kilometers of running per week, the ingestion of 32 milligrams of elemental iron per day, in addition to the usual diet for a period of six weeks, has no beneficial effects on hemoglobin concentration, VO_2 max., performance on a maximal running task of seven to ten minutes duration, or body iron stores. However, the possibility that higher dosages of oral iron supplements, in the order of 150-200 milligrams of elemental iron per day, may be beneficial to male endurance athletes who show signs of either prelatent or latent iron deficiency, cannot be ruled out.

Although the sample size of female distance runners was too small to enable us to form any definite conclusions, it appears that many female distance runners have inadequate dietary intakes of iron, and many of them, especially those with hemoglobin concentrations bordering on clinical anemia, could increase their hemoglobin concentrations by increasing their iron intake. However, there is no proof in the present study that increasing the hemoglobin concentration in female runners via iron supplementation will result in improved endurance performance. There is also no basis for recommending that all female endurance athletes should routinely ingest oral iron supplements for prophylactic purposes. Coaches, trainers, or team physicians should periodically monitor hemoglobin concentrations and assess body iron stores from measurements of serum ferritin concentration, in both male and female endurance athletes. They should pay particular attention to the female athlete who has a heavy menstrual flow. Oral iron supplements should be administered at a dosage of 150-200 milligrams of elemental iron per day to those athletes who are iron deficient, until the iron deficiency is corrected.

(3) Since a group of age-matched non-athletes were not monitored in the present study, it is not possible to determine whether male and female distance runners have lower hemoglobin concentrations than non-athletes. Given the variability that occurs in hemoglobin measurements using different analysis techniques or the same analysis technique in different laboratories, in order to determine whether sports anemia exists in endurance athletes, athletes and age-matched

non-athletes must be monitored in the same laboratory in the same time periods. There is yet no conclusive proof that sports anemia occurs in endurance athletes.

Future Research

Since the present study is the only one that has been conducted on the effects of iron supplementation on serum ferritin concentration, hemoglobin concentration and endurance performance in male and female endurance athletes, additional investigation is warranted. The effects of high doses of oral iron supplements (150-200 mg of elemental iron per day) on various hematology measurements, VO_2 max., endurance performance and body iron stores in male and female endurance athletes should be investigated. Additional information is needed on the effects of various stages of iron deficiency on iron containing cellular enzymes. Research studies are also needed to compare the effects of oral versus parenteral iron supplementation on athletes who are iron deficient. Since the present study has shown that male and female endurance athletes have comparable dietary intakes of iron to non-athletes but lower body iron stores than non-athletes, radioisotope iron absorption studies should be performed with endurance athletes to trace the routes of iron loss from their bodies. Future experimental protocols should include an adequate number of subjects to give high statistical power (Kirk, 1968), a long and strenuous training regimen, computerized dietary analysis, and an accurate method of assessing body iron stores. For the female athletes, records should also be kept of any changes in menstrual cycles since amenorrhea may accompany heavy training in female athletes (Ullyot, 1979).

Further studies are needed to determine if sports anemia occurs in endurance athletes. Endurance athletes should be followed longitudinally along with a group of age-matched non-athletes. Variations in hematology measurements, if any, could be noted as the volume and intensity of training was changed. The presence of the age-matched non-athletes would control for any extraneous variables which could affect the measurements being taken. In addition to the hematology measurements performed in the present study, measurements of blood volume, total body hemoglobin, erythrocyte osmotic fragility, and reticulocyte count should be done regularly in order to determine if any decrease in hemoglobin concentration is due to an increase in plasma volume or to actual destruction of erythrocytes.

Finally, since fad diets and misconceptions regarding nutrition are prevalent in athletics more information is needed about the nutritional knowledge and attitudes of Canadian coaches and athletes, and the dietary habits of athletes in a variety of sports. Athletes will not achieve optimal results from their training programs if their diets are inadequate.

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APPENDIX 1

Individual Data on Physical Characteristics and Racing Performance Characteristics During the Control and Experimental Periods

Key

C: Control Period

E: Experimental Period

Male Runners - Group PI

Subjects		Age (Years)	Height (cm)	Weight (kg)	Somatotype	% fat	BEST PERFORMANCE 1500 meters min:sec	5000 meters min:sec
41	C	16	172.6	55.0	1.0-3.0-4.5	7.9	4:13	16:22
	E			54.2		7.7		
24	C	26	179.0	76.3	2.0-7.0-2.5	7.2	4:15	16:53
	E			75.4		7.9		
14	C	18	179.9	67.7	6.5-4.5-3.5	8.2	4:10	16:40
	E			68.4		7.9		
31	C	15	179.4	62.0	1.5-4.0-4.5	10.2	4:08	15:42
	E			63.3		9.9		
11	C	19	181.5	67.6	1.5-3.5-4.0	8.5	3:57	15:05
	E			69.2		8.9		
12	C	21	182.8	72.9	1.5-4.0-3.5	8.2	3:50	14:41
	E			73.3		6.9		
20	C	24	183.6	71.3	2.5-3.5-4.0	11.4	3:54	14:12
	E			71.8		10.2		
22	C	23	183.7	72.1	1.0-4.5-3.5	6.7	3:50	14:25
	E			74.0		6.2		

Male Runners - Group PNI

Subjects		Age (Years)	Height (cm)	Weight (kg)	Somatotype	% fat	BEST PERFORMANCE 1500 meters min:sec	5000 meters min:sec
	C			54.6		11.3		
19		14	180.8		2.0-2.5-6.5		4:22	16:38
	E			55.8		11.2		
	C			65.5		9.1		
33		19	176.5		2.0-4.5-3.5		4:06	15:56
	E			66.0		9.0		
	C			60.2		8.4		
10		18	173.2		1.5-4.0-3.5		3:51	14:30
	E			60.8		8.5		
	C			65.9		8.2		
65		16	175.5		2.0-4.0-3.5		4:11	15:54
	E			65.9		8.2		
	C			77.1		6.9		
4		19	186.8		1.5-5.0-3.5		4:11	15:54
	E			75.6		6.7		
	C			58.1		8.1		
44		25	171.3		1.5-4.5-4.0		3:53	14:35
	E			60.1		8.6		
	C			50.8		8.3		
62		18	173.6		1.0-2.5-5.5		4:04	15:39
	E			51.5		8.8		
	C			72.1		7.5		
21		22	185.1		1.0-4.0-4.0		4:06	15:39
	E			74.4		7.8		

Male Runners - Group NPI

Subjects		Age (Years)	Height (cm)	Weight (kg)	Somatotype	% fat	BEST PERFORMANCE 1500 meters min:sec	5000 meters min:sec
2	C	22	186.0	68.5	2.0-3.0-4.5	10.3	4:00	15:12
	E			65.1		9.0		
7	C	21	176.8	71.8	1.5-5.5-2.5	6.9	3:50	14:11
	E			70.9		7.3		
16	C	22	179.3	69.6	1.5-4.5-3.5	7.3	4:15	16:09
	E			71.0		7.7		
15	C	27	181.8	66.6	1.0-4.0-4.5	6.6	4:08	15:38
	E			68.2		7.1		
26	C	19	171.5	65.4	1.5-6.0-2.5	7.2	4:03	15:47
	E			68.0		7.2		
53	C	19	184.1	74.8	2.0-4.0-3.5	8.5	4:06	15:35
	E			75.7		8.2		
58	C	19	173.8	56.8	1.5-3.5-4.5	8.6	3:59	15:09
	E			57.9		9.1		
57	C	17	170.7	55.2	1.0-4.0-4.0	7.9	4:08	15:50
	E			57.4		7.9		

Male Runners - Group NPNI

Subjects		Age (Years)	Height (cm)	Weight (kg)	Somatotype	% fat	BEST PERFORMANCE 1500 meters min:sec	5000 meters min:sec
37	C	37	173.9	65.5	2.0-4.5-3.0	8.6	4:20	16:25
	E			67.1		8.1		
29	C	24	175.8	61.4	1.0-4.5-4.0	7.4	3:54	14:27
	E			62.4		7.3		
39	C	17	175.8	64.3	2.0-5.5-3.5	9.1	4:18	16:23
	E			66.1		8.7		
18	C	14	170.8	52.2	1.5-3.5-5.0	10.5	4:20	16:30
	E			54.6		10.2		
23	C	24	170.5	57.1	1.0-4.5-4.0	7.1	4:03	14:55
	E			57.9		7.5		
55	C	27	178.3	58.4	1.0-3.5-5.0	8.0	3:47	14:20
	E			60.8		8.4		
64	C	24	186.8	72.3	2.0-3.5-4.0	9.5	3:58	14:29
	E			73.3		9.0		
25	C	22	184.0	68.6	1.5-4.5-4.5	8.6	3:54	14:48
	E			68.5		8.4		
8	C	20	174.9	61.8	1.5-4.5-4.0	8.3	3:56	14:47
	E			63.9		8.3		

Female Runners - Group PI

Subjects		Age (Years)	Height (cm)	Weight (kg)	Somatotype	% fat	BEST PERFORMANCE 1500 meters min:sec	5000 meters min:sec
49	C	22	162.5	54.4	2.0-4.0-3.0	12.4	2:09	4:18
	E			56.4		13.1		
38	C	16	166.3	55.2	2.5-4.5-3.5	12.7	2:20	4:42
	E			55.0		10.9		

Female Runners - Group PNI

Subjects		Age (Years)	Height (cm)	Weight (kg)	Somatotype	% fat	BEST PERFORMANCE 1500 meters min:sec	5000 meters min:sec
60	C	18	157.3	48.6	2.5-3.0-4.0	11.0	2:12	4:30
	E			49.1		11.1		
63	C	18	161.4	50.2	2.5-3.5-3.5	11.9	2:05	4:18
	E			51.4		12.0		
52	C	20	166.8	56.3	2.0-4.0-3.5	11.8	2:14	4:44
	E			58.7		12.7		

Female Runners - Group NPI

Subjects		Age (Years)	Height (cm)	Weight (kg)	Somatotype	% fat	BEST PERFORMANCE 1500 meters min:sec	5000 meters min:sec
61	C	18	168.8	56.1	2.05-3.5-3.5	10.8	2:12	4:29
	E			58.6		11.5		
56	C	15	163.3	50.3	2.0-3.0-4.0	12.3	2:19	4:45
	E			53.4		12.5		
48	C	19	163.8	49.7	1.5-3.5-4.0	8.8	2:11	4:23
	E			49.3		8.9		
42	C	14	168.8	46.9	1.5-2.0-5.5	11.4	2:18	4:43
	E			47.8		11.4		

Female Runners - Group NPNI

Subjects		Age (Years)	Height (cm)	Weight (kg)	Somatotype	% fat	BEST PERFORMANCE 1500 meters min:sec	5000 meters min:sec
46	C	24	163.0	55.3	2.0-3.5-2.5	12.6	2:03	4:16
	E			56.4		12.5		
47	C	18	164.5	54.0	1.5-4.0-3.5	9.6	2:15	4:41
	E			55.3		10.2		
59	C	18	165.8	52.1	2.5-3.0-4.0	12.0	2:09	4:24
	E			52.5		11.1		
43	C	17	171.8	59.1	1.5-4.0-3.5	9.7	2:19	4:55
	E			61.5		11.0		

APPENDIX 2

Individual Data on the Daily Dietary Intakes of Energy, Protein, and Iron in the Control and Experimental Periods

Key

C: Control Period

E: Experimental Period

% RDI: Percentage of the Canadian recommended daily intake

Male Runners - Group PI

Subjects		Energy (kcal)	% RDI	Energy (kcal/kg)	Protein (grams)	% RDI	Protein (g/kg)	Iron (mg)	% RDI
41	C	3375	122.8	61.4	144.3	267.0	2.6	18.5	132.0
	E	3316	121.0	60.5	172.0	318.0	3.1	52.0	371.0
24	C	3178	96.7	41.6	151.0	270.0	2.0	20.7	207.0
	E	2257	69.5	29.9	153.8	275.0	2.0	46.5	465.0
14	C	2433	71.8	35.9	107.0	198.0	1.6	21.7	155.0
	E	3896	114.0	57.0	209.7	388.0	3.1	64.0	457.0
11	C	2893	99.5	42.8	109.8	196.0	1.6	18.1	181.0
	E	2695	90.5	38.9	122.0	217.0	1.8	48.0	480.0
12	C	3754	119.8	51.5	154.5	276.0	2.1	27.4	274.0
	E	3296	104.9	45.1	172.0	307.0	2.3	55.5	555.0
20	C	2468	80.5	34.6	97.3	174.0	1.4	15.5	155.0
	E	2773	89.8	38.6	153.2	274.0	2.1	48.4	484.0
22	C	2707	87.2	37.5	99.6	178.0	1.4	15.8	158.0
	E	2230	71.9	30.9	110.1	197.0	1.5	45.5	454.0
31	C								
	E	Dietary records not received							

Male Runners - Group PNI

Subjects		Energy (kcal)	% RDI	Energy (kcal/kg)	Protein (grams)	% RDI	Protein (g/kg)	Iron (mg)	% RDI
19	C	2593	86.4	47.5	144.4	278.0	2.6	30.6	236.0
	E	1713	55.8	30.7	93.5	180.0	1.7	12.9	100.0
33	C	3297	117.0	50.3	93.1	166.0	1.4	15.5	155.0
	E	3217	113.2	48.7	198.7	355.0	3.0	15.5	155.0
10	C	2986	99.0	49.5	105.0	195.0	1.7	14.6	105.0
	E	2972	97.8	48.9	150.3	278.0	2.5	18.7	138.0
65	C	2767	84.0	42.0	95.3	176.0	1.4	14.3	102.0
	E	5198	157.8	78.9	193.0	357.0	2.9	24.6	176.0
4	C	4075	123.0	52.9	162.0	289.0	2.1	21.2	212.0
	E	3753	192.5	49.6	192.5	344.0	2.5	20.1	201.0
62	C	2725	107.4	53.7	105.9	196.0	2.1	14.5	104.0
	E	2512	97.6	48.8	116.0	215.0	2.3	14.9	106.0
21	C	3463	111.6	48.0	135.6	242.0	1.9	13.8	138.0
	E	2687	136.7	35.8	136.7	244.0	1.8	15.2	152.0
44	C								
	E			Dietary records not received					

Male Runners - Group NPI

Subjects		Energy (kcal)	% RDI	Energy (kcal/kg)	Protein (grams)	% RDI	Protein (g/kg)	Iron (mg)	% RDI
2	C	2572	87.4	37.6	116.1	207.0	1.7	21.8	218.0
	E	3548	126.7	54.5	163.2	291.0	2.5	63.0	630.0
7	C	3626	117.4	50.5	135.6	242.0	1.9	21.3	213.0
	E	3393	111.4	47.9	105.6	189.0	1.5	46.5	465.0
16	C	3380	113.0	48.6	125.8	225.0	1.8	17.3	173.0
	E	3453	112.8	48.5	126.9	227.0	1.8	47.7	477.0
15	C	3529	123.0	52.9	122.5	219.0	1.8	17.5	175.0
	E	3044	103.7	44.6	93.9	168.0	1.4	41.7	417.0
26	C	3809	135.0	58.2	138.1	247.0	2.1	15.7	157.0
	E	2946	100.7	43.3	94.4	169.0	1.4	42.9	429.0
53	C	4644	144.4	62.1	156.0	279.0	2.1	27.5	275.0
	E	4493	138.1	59.4	151.0	270.0	2.0	61.0	610.0
58	C	3027	126.0	54.2	96.6	173.0	1.7	17.0	170.0
	E	2611	104.9	45.1	76.0	136.0	1.3	46.3	463.0
57	C	2527	91.6	45.8	106.0	197.0	1.9	13.7	98.0
	E	2651	92.4	46.2	102.0	189.0	1.8	44.5	318.0

Male Runners - Group NPNI

Subjects		Energy (kcal)	% RDI	Energy (kcal/kg)	Protein (grams)	% RDI	Protein (g/kg)	Iron (mg)	% RDI
37	C	2921	103.7	44.6	133.1	238.0	2.0	25.9	259.0
	E	2937	101.9	43.8	144.4	258.0	2.2	26.7	267.0
29	C	3252	123.3	53.0	120.4	215.0	2.0	17.6	176.0
	E	3071	114.4	49.2	86.4	154.0	1.4	16.4	164.0
23	C	1086	44.2	19.0	38.9	69.0	0.7	7.3	73.0
	E	1094	46.0	19.8	53.4	95.0	1.0	6.9	69.0
5	C	2780	110.7	47.6	97.3	174.0	1.7	16.7	167.0
	E	3152	120.5	51.8	96.1	172.0	1.6	15.1	151.0
64	C	3229	104.0	44.7	128.4	229.0	1.5	18.3	183.0
	E	3032	96.3	41.4	102.4	183.0	1.4	18.0	180.0
25	C	3749	127.2	54.7	153.6	274.0	2.2	15.6	156.0
	E	3749	127.2	54.7	153.6	274.0	2.2	15.6	156.0
8	C	2796	105.1	45.2	116.9	209.0	1.9	17.8	178.0
	E	3241	117.9	50.7	127.0	227.0	2.0	17.6	176.0
39	C								
	E	Dietary records not received							
18	C								
	E	Dietary records not received							

Female Runners - Group PI

Subjects		Energy (kcal)	% RDI	Energy (kcal/mg)	Protein (grams)	% RDI	Protein (g/kg)	Iron (mg)	% RDI
49	C	1485	72.8	27.3	60.9	148.0	1.1	11.5	82.0
	E	2425	114.7	43.0	111.0	271.0	2.0	62.1	444.0
38	C	1919	89.2	34.8	49.2	115.0	0.9	12.1	87.0
	E	2144	100.0	39.0	89.2	207.0	1.6	47.8	341.0

Female Runners - Group PNI

Subjects		Energy (kcal)	% RDI	Energy (kcal/mg)	Protein (grams)	% RDI	Protein (k/kg)	Iron (mg)	% RDI
60	C	1516	80.0	31.2	51.6	120.0	1.1	7.5	54.0
	E	1466	76.7	29.9	70.1	163.0	1.4	7.5	54.0
63	C	1772	90.5	35.2	64.0	149.0	1.3	10.0	71.0
	E	2134	110.7	41.5	91.0	222.0	1.8	10.6	75.0
52	C	2246	106.4	39.9	74.5	182.0	1.3	13.3	95.0
	E	2693	122.4	45.9	123.0	300.0	2.1	19.0	135.0

Female Runners - Group NPI

Subjects		Energy (kcal)	% RDI	Energy (kcal/mg)	Protein (grams)	% RDI	Protein (k/kg)	Iron (mg)	% RDI
61	C	2324	106.1	41.4	88.4	206.0	1.6	14.1	101.0
	E	2295	100.5	39.2	78.0	181.0	1.3	42.9	307.0
56	C	1843	74.9	33.7	75.5	176.0	1.5	6.6	47.0
	E	1843	74.9	33.7	75.5	176.0	1.5	38.6	275.0
48	C	1534	82.4	30.9	66.3	162.0	1.3	12.9	92.0
	E	1976	106.9	40.1	132.6	324.0	2.7	52.5	375.0
42	C								
	E	Dietary records not received							

Female Runners - Group NPNI

Subjects		Energy (kcal)	% RDI	Energy (kcal/mg)	Protein (grams)	% RDI	Protein (g/kg)	Iron (mg)	% RDI
46	C	Dietary records not received							
	E								
47	C	2183	103.6	40.4	89.5	208.0	1.7	13.8	99.0
	E	2513	124.0	46.5	94.4	220.0	1.7	12.9	92.0
59	C	1746	85.9	33.5	38.2	89.0	0.7	10.3	73.0
	E	1429	69.7	27.2	34.1	79.0	0.6	8.7	62.0
43	C	3212	139.7	54.4	119.1	277.0	2.0	16.7	119.0
	E	3212	139.7	54.4	119.1	277.0	2.0	16.7	119.0

APPENDIX 3

Individual Data on Selected Hematology Measurements in the Control and Experimental Periods

Key

C: Control Period

E: Experimental Period

MCV: Mean Cell Volume

MCH: Mean Cell Hemoglobin

MCHC: Mean Cell Hemoglobin Concentration

Male Runners - Group PI

Subject		RBC (10^6)	Hemoglobin (g/dl)	Hematocrit (%)	MCV (um^3)	MCH (pg^3)	MCHC (%)
41	C	5.09	15.3	45.2	90	30.2	33.8
	E	5.02	14.9	44.8	87	29.9	33.7
24	C	4.73	15.1	43.0	92	33.0	35.9
	E	5.01	15.5	50.1	97	31.0	31.3
14	C	4.91	15.8	43.1	88	31.8	36.6
	E	5.00	15.9	45.1	87	31.8	35.7
31	C	5.05	15.1	42.8	85	29.7	35.2
	E	5.14	15.1	43.2	85	29.5	34.9
11	C	4.71	14.1	38.0	82	30.1	37.1
	E	4.64	13.7	41.6	87	29.7	33.4
12	C	4.57	14.5	42.3	90	31.8	34.6
	E	4.48	14.1	40.9	92	31.8	34.5
20	C	4.81	14.8	41.2	87	30.9	35.4
	E	5.15	15.6	46.4	87	30.3	33.9
22	C	5.38	15.6	44.5	83	28.7	35.1
	E	5.09	15.1	43.9	87	29.9	34.3

Male Runners - Group PNI

Subject		RBC (10^6)	Hemoglobin (g/dl)	Hematocrit (%)	MCV (um^3)	MCH (pg^3)	MCHC (%)
19	C	4.46	13.6	39.6	89	30.3	34.5
	E	5.10	15.3	45.0	86	30.2	34.4
33	C	5.03	16.1	44.1	88	31.8	36.4
	E	4.90	15.7	44.3	87	32.0	35.8
10	C	4.42	14.6	39.4	89	32.8	37.2
	E	4.65	15.1	43.3	90	32.6	35.2
65	C	4.00	15.0	43.0	87	30.5	34.5
	E	5.00	15.0	43.6	88	30.1	33.6
4	C	4.94	14.2	43.7	85	28.9	33.0
	E	4.63	13.9	39.6	83	30.1	35.6
44	C	4.59	14.5	39.9	88	31.7	35.7
	E	4.65	14.7	41.6	86	31.7	35.8
62	C	5.07	15.3	42.2	84	30.4	36.3
	E	5.23	15.8	46.5	86	30.2	34.3
21	C	4.75	14.0	41.2	87	31.0	36.2
	E	4.69	14.6	42.7	88	31.3	34.7

Male Runners - Group NPI

Subject		RBC (10^6)	Hemoglobin (g/dl)	Hematocrit (%)	MCV (um^3)	MCH (pg^3)	MCHC (%)
2	C	4.72	14.1	39.5	85	30.1	35.7
	E	4.44	12.9	39.0	88	29.1	33.0
7	C	4.36	14.7	42.9	99	34.0	33.9
	E	4.42	14.9	44.1	101	33.6	32.9
16	C	4.44	14.4	40.4	90	32.5	35.1
	E	4.52	14.3	41.4	91	31.6	34.5
15	C	4.76	14.6	44.8	94	30.5	32.5
	E	4.76	14.7	42.1	86	31.1	35.6
26	C	5.13	16.0	42.9	85	31.3	36.7
	E	5.17	16.2	44.5	87	31.5	35.5
53	C	5.14	15.4	42.5	84	30.2	36.3
	E	5.18	15.8	45.6	85	30.7	35.2
58	C	4.64	13.8	39.2	86	29.9	35.1
	E	4.64	13.9	41.9	87	30.1	33.6
57	C	4.82	14.5	40.3	85	30.2	36.0
	E	4.62	14.0	40.8	85	30.6	35.0

Male Runners - Group NPNI

Subject		RBC (10^6)	Hemoglobin (g/dl)	Hematocrit (%)	MCV (um^3)	MCH (pg^3)	MCHC (%)
37	C	4.82	15.2	43.8	88	31.6	35.0
	E	4.86	15.3	44.6	89	31.7	34.9
29	C	4.81	14.1	39.1	81	29.1	36.3
	E	4.85	14.0	40.2	84	28.8	33.8
39	C	4.94	15.5	44.0	89	31.1	35.1
	E	4.97	15.3	45.4	88	30.9	34.2
18	C	4.62	14.4	41.1	89	31.0	34.6
	E	4.75	14.6	41.8	88	30.8	34.8
23	C	4.71	14.5	41.5	89	31.0	34.6
	E	4.42	13.9	43.2	98	31.6	32.1
55	C	5.18	15.9	44.7	88	30.9	35.6
	E	5.03	15.7	46.9	90	31.4	33.9
64	C	4.86	15.4	42.1	88	31.7	36.4
	E	4.93	15.7	45.5	90	32.0	35.0
25	C	4.72	14.6	42.7	87	30.9	34.5
	E	4.83	15.3	47.6	99	31.8	31.9
8	C	4.69	14.1	40.0	85	29.9	35.3
	E	4.80	14.0	41.8	84	30.5	35.4

Female Runners - Group PI

Subject		RBC (10^6)	Hemoglobin (g/dl)	Hematocrit (%)	MCV (um^3)	MCH (pg^3)	MCHC (%)
49	C	4.27	13.3	36.5	86	31.2	36.0
	E	4.37	13.4	40.0	88	30.9	34.2
38	C	4.69	13.6	38.0	81	28.6	35.6
	E	4.93	13.7	39.9	78	27.9	34.8

Female Runners - Group PNI

Subject		RBC (10^6)	Hemoglobin (g/dl)	Hematocrit (%)	MCV (um^3)	MCH (pg^3)	MCHC (%)
60	C	4.41	13.2	36.8	84	30.1	36.1
	E	4.53	12.7	40.9	87	30.5	34.0
63	C	4.86	14.7	40.1	83	30.4	36.7
	E	4.79	14.2	41.8	84	29.7	34.4
52	C	4.40	14.2	39.2	90	32.4	36.1
	E	4.18	13.5	39.9	92	32.4	34.2

Female Runners - Group NPI

Subject		RBC (10^6)	Hemoglobin (g/dl)	Hematocrit (%)	MCV (um^3)	MCH (pg^3)	MCHC (%)
61	C	4.34	12.4	34.5	80	28.8	36.1
	E	4.52	13.3	39.6	84	29.6	34.6
56	C	4.28	12.2	35.5	84	28.7	34.6
	E	4.87	13.7	42.1	84	28.4	33.1
48	C	4.04	12.0	33.1	82	29.8	35.7
	E	4.34	12.8	37.9	84	29.6	34.4
42	C	4.58	13.5	38.5	84	29.2	35.1
	E	4.47	13.3	39.2	85	30.0	34.5

Female Runners - Group NPNI

Subject		RBC (10^6)	Hemoglobin (g/dl)	Hematocrit (%)	MCV (um^3)	MCH (pg^3)	MCHC (%)
46	C	4.61	14.3	39.3	86	31.1	35.7
	E	4.38	13.6	39.0	86	31.2	35.4
47	C	3.72	11.7	32.9	89	31.8	35.3
	E	3.91	12.0	36.0	88	31.0	34.1
59	C	4.50	13.7	37.7	85	30.5	36.4
	E	4.73	13.9	41.6	86	29.5	33.8
43	C	4.28	13.2	40.1	90	31.0	33.5
	E	4.11	13.2	38.1	89	32.4	35.4

APPENDIX 4

Individual Data on Serum Chemistry Measurements in the Control and Experimental Periods

Key

C: Control Period

E: Experimental Period

TIBC: Total Iron Binding Capacity

Male Runners - Group PI

Subjects		Ferritin (ng/ml)	Serum Iron (ug/dl)	TIBC (ug/dl)	% trans ferr. satur.	Haptoglobin (mg/100 ml)	BUN (mg/dl)	Total Protein (g/dl)	Albumin (g/dl)	Bilirubin (mg/dl)
41	C	34	83	418	20	52	22	7.5	4.6	0.4
	E	30	97	396	24	64	24	7.2	4.6	0.2
24	C	130	51	327	16	18	20	7.3	4.6	0.3
	E	78	137	270	57	58	17	7.2	4.8	0.7
14	C	44	62	298	21	208	15	6.4	4.2	0.5
	E	50	269	318	85	145	20	6.7	4.7	0.7
31	C	25	62	414	15	400	23	7.0	4.5	0.4
	E	52	33	381	9	208	18	7.9	4.7	0.4
11	C	27	59	437	14	52	18	7.6	4.6	0.4
	E	24	101	442	23	160	18	7.4	4.8	0.4
12	C	32	113	367	31	32	23	7.0	4.2	0.6
	E	34	175	341	51	4	23	7.1	4.3	0.5
20	C	50	108	339	32	14	17	7.6	4.7	0.4
	E	58	78	366	21	74	22	7.4	4.7	0.5
22	C	52	65	410	16	210	15	7.3	4.5	0.4
	E	46	76	311	24	60	26	7.0	4.6	0.4

Male Runners - Group PNI

Subjects		Ferritin (ng/ml)	Serum Iron (ug/dl)	TIBC (ug/dl)	% trans ferr. satur.	Haptoglobin (mg/100 ml)	BUN (mg/dl)	Total Protein (g/dl)	Albumin (g/dl)	Bilirubin (mg/dl)
19	C	20	104	439	24	4	21	6.7	4.5	0.5
	E	15	82	465	18	48	17	7.1	4.9	0.5
33	C	14	120	422	28	140	14	7.5	4.6	1.0
	E	20	167	336	50	64	14	7.1	4.8	0.4
10	C	26	66	344	19	64	14	6.3	4.0	0.4
	E	30	102	319	32	41	17	6.5	4.4	0.4
65	C	34	85	417	20	198	19	7.6	4.5	0.2
	E	17	93	401	23	106	17	6.9	4.8	0.3
4	C	19	108	481	22	58	19	7.5	4.7	1.0
	E	34	53	425	12	144	12	7.4	4.8	0.3
44	C	52	109	377	29	25	20	7.3	4.6	0.2
	E	44	64	364	18	26	24	6.9	4.7	0.2
62	C	34	36	364	10	114	15	7.2	4.6	0.4
	E	32	62	378	16	97	21	7.9	4.7	0.4
21	C	24	33	314	11	116	17	7.1	4.2	0.5
	E	34	73	291	25	114	10	7.1	4.8	0.2

Male Runners - Group NPI

Subjects		Ferritin (ng/ml)	Serum Iron (ug/dl)	TIBC (ug/dl)	% trans ferr. satur.	Haptoglobin (mg/100 ml)	BUN (mg/dl)	Total Protein (g/dl)	Albumin (g/dl)	Bilirubin (mg/dl)
2	C	36	104	421	24	144	18	6.9	4.8	0.5
	E	35	64	386	16	74	21	6.7	4.3	0.2
7	C	46	94	320	29	72	16	6.9	4.4	0.3
	E	38	90	352	26	113	17	7.0	4.5	0.3
16	C	56	91	452	20	105	21	7.2	4.8	0.5
	E	74	120	391	31	155	17	7.5	4.4	0.5
15	C	19	119	418	28	35	25	7.2	4.8	0.5
	E	44	80	337	24	80	14	7.0	4.5	0.3
26	C	34	85	348	24	72	19	7.1	4.5	0.4
	E	14	148	393	38	80	18	6.7	4.5	0.8
53	C	18	81	375	22	25	18	7.3	4.8	0.6
	E	19	70	346	22	58	18	7.8	4.8	0.6
58	C	22	27	394	7	43	14	7.3	4.6	0.4
	E	26	65	354	18	72	17	7.6	4.9	0.5
57	C	17	114	480	24	4	11	7.8	4.9	0.9
	E	13	111	455	24	12	13	7.3	5.2	0.8

Male Runners - Group NPNI

Subjects		Ferritin (ng/dl)	Serum Iron (ug/dl)	TIBC (ug/dl)	% trans ferr. satur.	Haptoglobin (mg/100 ml)	BUN (mg/dl)	Total Protein (g/dl)	Albumin (g/dl)	Bilirubin (mg/dl)
37	C	82	73	440	17	115	18	7.3	4.4	0.3
	E	68	113	315	36	79	18	7.4	4.6	0.5
29	C	28	106	415	26	12	16	6.7	4.6	0.8
	E	32	144	357	40	65	12	6.8	4.6	0.4
39	C	44	99	420	24	190	20	7.3	4.9	0.9
	E	46	166	401	41	48	21	7.4	4.8	0.5
18	C	8	113	444	25	18	20	7.1	4.3	0.7
	E	11	129	453	28	14	18	7.4	4.8	0.2
23	C	46	20	180	11	90	11	7.8	4.4	0.8
	E	34	82	398	21	66	15	8.2	4.8	0.5
55	C	50	183	382	48	64	14	7.6	4.6	1.3
	E	22	278	377	74	113	16	7.6	5.0	0.8
64	C	82	134	363	37	130	14	7.2	4.6	0.7
	E	70	111	380	29	48	17	7.2	5.0	0.6
25	C	28	107	434	25	90	21	7.4	4.4	0.3
	E	44	106	448	24	58	23	7.6	4.3	0.2
8	C	24	90	436	16	130	20	7.4	4.6	0.5
	E	26	170	461	39	95	21	6.9	4.5	0.8

Female Runners - Group PI

Subjects		Ferritin (ng/dl)	Serum Iron (ug/dl)	TIBC (ug/dl)	% trans ferr. satur.	Haptoglobin (mg/100 ml)	BUN (mg/dl)	Total Protein (g/dl)	Albumin (g/dl)	Bilirubin (mg/dl)
49	C	20	76	353	22	36	15	6.9	4.5	0.3
	E	15	65	337	19	52	17	6.7	4.3	0.2
38	C	14	82	441	19	70	24	7.4	4.8	2.3
	E	17	57	432	13	16	19	7.6	4.7	1.1

Female Runners - Group PNI

Subjects		Ferritin (ng/dl)	Serum Iron (ug/dl)	TIBC (ug/dl)	% trans ferr. satur.	Haptoglobin (mg. 100 ml)	BUN (mg/sl)	Total Protein (g/dl)	Albumin (g/dl)	Bilirubin (mg/dl)
60	C	36	121	461	26	194	13	7.6	4.5	0.5
	E	24	84	453	19	144	9	7.5	4.8	0.5
63	C	20	41	420	10	86	17	7.4	4.5	0.4
	E	17	59	407	14	120	14	7.1	4.2	0.5
52	C	24	23	385	6	144	13	7.6	5.0	0.7
	E	17	57	347	15	128	15	7.6	4.9	0.6

Female Runners - Group NPI

Subjects		Ferritin (ng/dl)	Serum Iron (ug/dl)	TIBC (ug/dl)	% trans ferr. satur.	Haptoglobin (mg/100 ml)	BUN (mg/dl)	Total Protein (g/dl)	Albumin (g/dl)	Bilirubin (mg/dl)
61	C	8	113	492	23	130	20	7.9	5.0	0.5
	E	16	125	409	31	115	17	7.8	4.6	0.6
56	C	9	12	493	2	158	19	7.3	4.5	0.4
	E	9	60	440	14	133	16	7.4	4.5	0.3
48	C	21	-	-	-	130	27	7.1	4.6	0.5
	E	11	72	396	18	80	19	7.3	4.7	0.5
42	C	9	118	428	28	64	16	7.1	4.5	0.4
	E	14	157	378	42	197	16	6.9	4.5	0.4

Female Runners - Group NPNI

Subjects		Ferritin (ng/dl)	Serum Iron (ug/dl)	TIBC (ug/dl)	% trans ferr. satur.	Haptoglobin (mg/100 ml)	BUN (mg/dl)	Total Protein (g/dl)	Albumin (g/dl)	Bilirubin (mg/dl)
46	C	80	76	353	22	43	19	7.2	4.5	0.7
	E	76	56	362	15	115	14	6.6	4.3	0.7
47	C	25	73	371	20	50	17	7.1	4.2	0.3
	E	7	170	399	43	34	17	7.2	4.5	0.5
59	C	24	35	408	8	52	18	7.6	5.1	0.5
	E	24	32	328	10	128	14	7.5	4.9	0.5
43	C	18	123	434	28	-	21	7.5	4.7	0.4
	E	9	89	407	22	90	17	6.6	4.4	0.4

APPENDIX 5

Individual Data on Maximal Treadmill Performance, Muscular Power, and Training Volume in the Control and Experimental Periods

Key

C: Control Period

E: Experimental Period

Male Runners - Group PI

Subjects		Treadmill Endurance (sec)	VO_2 max. (l/min)	VO_2 max (ml/kg/min)	Power (kgm^2/sec^3)	Training (km/day)
41	C	360	3.34	60.7	832	6.7
	E	345	3.27	59.7	871	3.7
24	C	445	5.05	66.2	1114	14.5
	E	422	4.86	64.4	1297	8.9
14	C	390	3.76	61.7	1012	6.8
	E	300	4.13	60.4	1145	5.1
31	C	363	3.78	60.9	927	7.2
	E	439	4.17	65.8	1006	7.2
11	C	458	4.45	65.9	943	13.4
	E	517	4.68	67.6	1059	16.1
12	C	442	5.03	68.6	1212	12.3
	E	504	4.95	67.0	1190	12.3
20	C	380	4.42	62.0	1051	11.2
	E	385	4.47	62.3	1073	7.2
22	C	545	5.54	75.4	1029	9.8
	E	490	5.16	69.2	1092	10.0

Male Runners' - Group PNI

Subjects		Treadmill Endurance (sec)	VO_2 max (l/min)	VO_2 max (ml/kg/min)	Power (kgm^2/sec^3)	Training (km/day)
19	C	393	3.43	62.8	770	8.4
	E	451	3.40	60.0	824	8.7
33	C	302	3.73	57.0	1142	4.9
	E	361	3.92	59.4	1184	3.6
10	C	453	4.42	73.7	860	3.9
	E	575	4.51	74.3	1018	10.6
65	C	416	4.25	64.3	1167	4.6
	E	360	4.00	60.7	1216	4.0
4	C	431	4.96	65.3	1345	6.7
	E	389	4.73	62.6	1356	10.1
44	C	432	4.16	70.5	935	12.1
	E	405	3.70	61.5	955	11.4
62	C	490	3.52	69.2	768	16.6
	E	470	3.48	67.6	804	15.0
21	C	360	4.64	64.5	1091	10.2
	E	425	4.75	63.8	1213	6.2

Male Runners - Group NPI

Subjects		Treadmill Endurance (sec)	VO_2 max (l/min)	VO_2 max (ml/kg/min)	Power (kgm^2/sec^3)	Training (km/day)
2	C	440	4.51	65.9	1001	13.0
	E	480	4.46	68.5	889	11.5
7	C	465	5.05	70.9	959	15.0
	E	508	4.87	68.8	1065	15.1
16	C	480	4.77	68.5	1065	11.5
	E	366	4.34	61.1	1173	10.9
15	C	420	4.30	64.6	890	12.3
	E	424	4.43	64.9	1039	12.1
26	C	488	4.51	69.0	1001	8.6
	E	429	4.43	65.2	1123	5.7
53	C	427	4.87	65.1	1305	12.1
	E	431	4.94	65.3	1366	11.1
58	C	578	4.25	74.9	820	17.7
	E	487	4.00	69.0	913	15.6
57	C	390	3.46	62.7	964	14.7
	E	362	3.49	60.8	1030	14.7

Male Runners - Group NPNI

Subjects		Treadmill Endurance (sec)	VO_2 max (l/min)	VO_2 max (ml/kg/min)	Power (kgm^2/sec^3)	Training (km/day)
37	C	334	4.04	62.1	1028	9.2
	E	387	4.13	61.6	1154	8.1
29	C	520	4.37	71.1	977	13.6
	E	514	4.65	73.8	964	16.6
39	C	360	3.90	60.7	997	6.0
	E	300	3.75	56.8	1012	6.0
18	C	392	3.28	62.8	819	12.0
	E	444	3.69	66.2	945	12.0
23	C	520	4.49	79.5	824	14.2
	E	494	4.09	70.6	836	13.1
55	C	543	4.24	72.6	978	17.5
	E	528	4.35	71.6	1004	14.6
64	C	560	5.33	73.7	1032	14.3
	E	423	4.75	64.8	1180	3.0
25	C	441	4.72	69.4	1077	14.6
	E	490	4.44	64.3	1362	11.6
8	C	570	4.60	74.4	1059	14.4
	E	504	4.48	70.1	1130	13.9

Female Runners - Group PI

Subjects		Treadmill Endurance (sec)	VO_2 max (l/min)	VO_2 max (ml/kg/min)	Power (kgm^2/sec^3)	Training (km/day
49	C	485	3.36	61.8	704	7.9
	E	386	3.20	56.7	770	5.3
38	C	366	3.07	55.6	849	5.0
	E	361	3.05	55.4	863	6.4

Female Runners - Group PNI

Subjects		Treadmill Endurance (sec)	VO_2 max (l/min)	VO_2 max (ml/kg/min)	Power (kgm^2/sec^3)	Training (km/day)
60	C	425	2.85	58.7	686	11.8
	E	325	2.63	53.5	775	11.5
63	C	540	3.25	64.7	769	7.8
	E	482	3.17	61.7	822	8.9
52	C	400	3.23	57.4	768	7.8
	E	366	3.26	55.6	798	6.8

Female Runners - Group NPI

Subjects		Treadmill Endurance (sec)	VO_2 max (l/min)	VO_2 max (ml/kg/min)	Power (kgm^2/sec^3)	Training (km/day)
61	C	449	3.36	59.9	819	13.7
	E	376	3.29	56.2	845	14.2
56	C	421	2.94	58.5	751	9.0
	E	383	3.02	56.5	808	9.0
48	C	425	2.92	58.7	679	11.9
	E	374	2.76	56.0	737	7.6
42	C	360	2.59	55.3	701	6.4
	E	387	2.71	56.7	714	-

Female Runners - Group NPNI

Subjects		Treadmill Endurance (sec)	VO_2 max (l/min)	VO_2 max (ml/kg/min)	Power (kgm^2/sec^3)	Training (km/day)
46	C	480	3.40	61.6	822	10.0
	E	367	3.14	55.7	833	-
47	C	420	3.16	58.5	692	9.8
	E	371	3.06	55.9	789	9.2
59	C	389	2.96	56.8	719	14.8
	E	347	2.87	54.6	749	9.9
43	C	371	3.30	55.9	749	12.0
	E	431	3.63	59.0	867	12.0

APPENDIX 6

Explanation of Computerized Dietary Analysis and Instructions to Subjects for Monitoring Their Diets

SFU SPORT-NUTRITION STUDY

The purpose of this project is to determine the nutrient composition of your USUAL diet. We will feed the information you give us into the computer, and you will receive a print-out of the results. Using the resulting information, we can make specific recommendations for improvement in your diet.

Since we are interested in your NORMAL diet, we do not want you suddenly to change your eating habits during the survey week. Be sure to record everything you eat and drink during the week, and keep in mind that your dietary information will be kept confidential.

ABOUT THE SFU NUTRITION PROGRAM

Due to day-to-day variations in the average person's diet, a reliable nutritional analysis requires food intake information for a minimum period of 7 days. Your own daily eating habits will be more apparent to you when you receive your print-out.

The computer assesses each food by its WEIGHT in GRAMS. This means that liquids must be weighed, as well as solids.

At the present time, the SFU Nutrition Program can provide an analysis of almost 2500 variations of common foods. Each variation has a unique 7-digit number, which can be found in the Master Foods List. These numbers must be recorded on a data recording form in order for your food intake to be analyzed properly. It is impossible to over-stress the importance of your accuracy in finding and copying these numbers. The analysis you receive can be no more reliable than you are in recording the proper number for each food you eat. In addition, it is essential that you weigh your food accurately; the further you are from an exact weight, the less reliable will be your final nutritional analysis. Thus, if you estimate your intake, rather then weigh it, or if you neglect to subtract food waste from the total weight, you introduce into your data a measure of error for which no correction can be made. In the same way, if you do not take the time to find the code number for exactly what you ate, you cannot expect to receive an accurate assessment of your nutritional intake.

ABOUT THE MASTER FOODS LIST

The Master Foods List is arranged in three columns. The first column, on the far left, contains the common food name (see examples). Generally, this food name is listed only once, in order to facilitate reading through the list. The second column, in the center of the page, contains descriptions of the food. These descriptions can relate to varieties and/or parts and/or preparations of the food (see examples). Where no part of the food is specified, the whole of the edible portion is assumed. On the same line as the food descriptions, in the right-hand column, is the food code number for that food as described exactly as it appears, on the recording sheet. Some foods, such as nuts, are listed only by their common name, with no description in the center column. However, the code name is on the same line, appearing as always in the last column on the right.

EXAMPLES

BRAUNSCHWEIGER. SEE SAUSAGE, COLD CUTS & LUNCHEON MEATS		
BRAZILNUTS		0443000
BREAD	CRACKED WHEAT, PLAIN	0444000
	CRACKED WHEAT, TOASTED	0445000
	ITALIAN, ENR, PLAIN	0450000
	ITALIAN, UNENR, PLAIN	0451000
	WHOLE WHEAT, W WATER, PLAIN	0473000
	WHOLE WHEAT, W WATER, TOASTED	0474000
BREADCRUMBS	DRY, GRATED	0475000
BREAD PUDDING	W RAISINS	0476000
BREAD STICKS, VIENNA. SEE SALT STICKS		
EGGS, CHICKEN	RAW, WHOLE, FRESH & FZN	0968000
	RAW, YOLKS, FRESH	0970000
	CKD/FRIED	0973000

Due to space restrictions, abbreviations are employed in some of the food descriptions. A complete listing of these abbreviations precedes the food list. A quick reading through them before you begin to use the Master Food List will probably save you a great deal of

time in the future, since many of the abbreviations will be familiar to you, and almost all of them are obvious.

Some foods are listed under broader names than their commonly used ones. In most of these cases, you will find a reference to the broader food name in the alphabetical listing (see examples). The following are the main broad categories of foods which are not listed alphabetically, but under these headings:

BABY FOODS
BEVERAGES, ALCOHOLIC
BEVERAGES, CARBONATED NON-ALCOHOLIC
BREAD
CAKES
CANDIES
COOKIES
PIES
PLATE OR TV DINNERS
SAUSAGE, COLD CUTS & LUNCHEON MEATS
SOUPS, COMMERCIAL

In addition, all muscle meats are listed by type, ie., BEEF, CHICKEN, PORK, etc. Organ meats are listed under the name of the organ, ie., HEART, LIVER, etc. Flours and cereals are listed under the name of the grain from which they are made, ie., WHEAT, RICE, OATS, etc.

RECORDING YOUR DATA

The recording form

You will need a separate recording sheet for each day during the recording period. Make sure that your name and subject number appear on every sheet in the appropriate spaces, and be sure to write in the number of day you are recording (#1, #2, #3, etc.--not dates). You have been given extra forms, in case you eat more than you have room to record on one sheet. If you use a second sheet, be sure to mark it with the proper day number.

The recording form provides lines for the raw data--what you ate, and how much--and marked blanks for the food code number and weight in grams of the portion you ate.

Recording what you eat

As you eat during the day, record your food on the lines in the "food eaten column" in any way that makes sense to you, so that you can find the proper food in the Master Foods List. In the "amount" column, write down the weight in grams of the food. Record your intake within 15 minutes of eating, so that you will be able to remember the little things--butter, catsup, etc. Carry your form with you during the day, so that you don't forget to record your snacks.

Be sure to break things like sandwiches and salads down into their component parts, because each one is different, and only the ingredients will be found in Master Foods List. In addition, if you have made a special recipe of some food that IS listed (such as beef stew or meatloaf), you should break that down as well, listing the portion you ate of each ingredient. Remember, the more accurate you are in recording your data, the more reliable your analysis will be.

Weighing your food

Weigh cooked food AFTER preparation. Don't forget to subtract waste--ie. bones, skin, fat, and fruit cores and pits--from the total weight, in order to obtain the weight of what you actually ate.

Do not compute the gram weight of the food you eat from a measure, unless absolutely necessary (see "Eating out"), as this introduces error. Use the Hanson Calorie Counter Diet Scale, which you have been given, to weigh your food to the nearest 5 grams. Once you have weighed a portion of a given fluid in your favorite glass or cup, you may use the weight as a standard thereafter, so long as you keep the portion size constant. Although solids are easier to weigh, the same principle applies to them. If you eat 1 cup of cornflakes every morning, weight the portion the first time, and as long as you

keep the portion size constant, it is not necessary to reweigh the food each time you eat it. Thus, it is not necessary to weight EVERY food EVERY time you eat it. You should, however, weigh each NEW food, even though you may use the same type of glass or dish each time. There is a 25 gram difference between the weight of 8 oz of water and the same volume of buttermilk. Similar differences exist with many foods.

Although the scale comes with its own dish, you may find various other containers more convenient for certain foods. A plastic or metal measuring cup, a margarine or yogurt container, or the styrofoam tray from packaged meat may be very handy in some cases. Just be sure to adjust the pointer to zero (by means of the screw in back) with the container or the scale, before you weigh your food. You should check the pointer every time you weigh food, always making sure that it reads zero without food on it--just to make sure you are not recording the weight of the container along with what you ate!

To make it easier:

1) determine the weight of foods eaten in small quantities by weighing the entire container before and after you take the food out; the difference between the two weights is the amount you ate.

2) if the container is too heavy for the scale, pour some of the food into a smaller container and weigh that.

3) if you eat some foods in small quantities throughout the day, such as milk and sugar with coffee, put some of each into smaller containers (from which no one else will take the food), and weigh them in the morning and again in the evening; the difference represents what you ate during the day, and can be recorded as a lump sum on your recording sheet.

4) make a note of the weights of foods you always eat in the same portion-sizes; you may find it useful to do this next to the food listing in the Master Foods List, so that the information will be there for the next survey period.

Eating out

It isn't necessary to drag your scale to a restaurant if you decide to eat out. Make a reasonable estimate of the gram weight of each food you eat, using previously weighed portions, where possible. If you have eaten a similarly sized potato or piece of chicken, pie or cake, you can make a fair estimate from the weight you have already determined. You may also find the following list helpful, but PLEASE use it ONLY when you have no other, better way of determining the gram weight of the food you have eaten. This list is not intended for use when you have the opportunity to weigh on your scale; the measures are only approximate.

1 slice bread = 25 grams
1 T jam, jelly, marmalade, preserves or honey = 28 grams
2 pats butter or margarine (1T) = 15 grams
1 T salad dressing, mayonnaise, or oil = 15 grams
1 T catsup = 17 grams
1 frankfurter (3/4 x 7") = 50 grams
2 slices bacon = 16 grams
4 oz of meat or fish = 115 grams
1 med baked potato = 100 grams
10 pcs french fries = 60 grams
1 cup mashed potato w milk & butter - 200 grams
1 cup noodles = 160 grams
1 cup pudding = 200 grams
1 cup white rice = 190 grams
1 slice cake w icing = 120 grams
1 slice pie (1/7 of 9" diameter) = 135 grams
1 cake doughnut = 35 grams
1 cup ice cream = 190 grams
2 cups beer (16 oz) = 480 grams
1 oz hard liquor = 28 grams
1/2 cup wine = 120 grams
12 oz soda pop = 350 grams
1 cup coffee or tea = 230

2 T milk = 25 grams

1 teaspoon white sugar = 4 grams

1 cup yogurt = 250 grams

2 cups popcorn w oil & salt = 30 grams

1 pc cheese pizza (1/8 of 14" diameter) = 75 grams

Finding the food code number

Locating the proper food code number is a simple procedure. First, find the common food name in the alphabetical listing of the Master Foods List. Next, look thru the descriptions in the center column, until you find the one which is closest to what you ate. The number to the right, on the same line, is the food code number for that food.

It is not necessary to look up a food every day, even though you may eat it that often. Once you are sure that you have the right number, you can copy it rather than search the Master Foods List for it.

To make it easier:

1) use a card or ruler under the food descriptions to help you keep your place, and to keep the numbers straight.

2) circle the foods you eat often so that you can find them right away during the next survey period.

3) keep a separate list of the food code numbers for the things you eat often; this will eliminate both using the Master Foods List excessively, and searching the records of previous days.

Recording the food code numbers and the weight in grams

The food code numbers and the weight in grams are the only information that will be fed into the computer. The person who types this data into the computer will not check it against the Master Foods List, to correct for mistakes. Therefore, it is imperative that you find the correct numbers and enter them accurately. At the end of the day, find the food code numbers and enter them in the proper spaces. Every food code number has 7 digits, and every one of them must be recorded in the appropriate blanks.

Because of the amount of time it takes to process a set of data, it is important to consolidate the information being fed into the computer. Therefore, each food code will appear only once on each day's record. If you eat the same food more than once, record it on the lines, but at the end of the day, add up the number of grams you ate each time, and record only the TOTAL, next to the food code for that food, which will appear ONE TIME ONLY, next to the first occurrence of the food name in your raw data list. In other words, if you drink 5-8 oz (250 grams) glasses of whole milk during the day, then "whole milk" will be on your list 5 times; however, the code number "1321000" will appear once, next to the first listing. In the column for the weight in grams, you will write "1250"--or whatever number of grams you had for the whole day. Ignore the blank lines which will appear in the "food code number" and "wt in grams" columns; just be sure to get the code number next to the first listing of the food. (Don't forget that we are talking here about EXACTLY the same food; whole wheat bread and whole wheat toast are two DIFFERENT foods, and if you eat them both in the same day, you will have two food code numbers listed for them.)

Because of computer keypunching requirements, the weight in grams must be recorded as if it were a 4-digit number. In other words, the final digit of each number must appear in the far-right space of the wt in grams column, thus

5 grams = 5
25 grams = 25
370 grams = 370
1255 grams = 1255

You may fill in the blank spaces to the left of the number with zeros if you like, but this is not important. It IS, however, VERY IMPORTANT to record the units, tens, hundreds and thousands digits in the proper columns.

Recording nutritional supplements

Record the composition of any nutritional supplement(s) you are taking on a separate recording sheet. Write the name of each ingredient

on a separate line, and on the same line in the 'wt in grams' column, record the number of milligrams of that ingredient. Also indicate on that recording sheet how often you take each supplement. It is not necessary to record your supplementation anywhere else.

APPENDIX 7

Computer Programs for Dietary Analysis

```
//DLROSJOB  JOB (0979,U6144),'FOODS',REGION=300K,MSGCLASS=R
//       EXEC PLICKCG
*  PROCESS NOATTRIBUTES, NOXREF, NOAGGREGATE, STORAGE, NOOPTIONS;

 USAFDS : PROCEDURE OPTIONS (MAIN);

 /*****************************************************************/
 /*                                                               */
 /*        USA FOODS - RUNNERS STUDY    VERSION 1.3   MAY 23 78   */
 /*                                                               */
 /*                                                               */
 /*         NUTRITIONAL ANALYSIS PROGRAM - STUDENT VERSION        */
 /*                                                               */
 /*                                   WRITTEN BY DON DRINKWATER   */
 /*                                   KINESIOLOGY DEPARTMENT      */
 /*                                   SIMON FRASER UNIVERSITY 1977*/
 /*                                                               */
 /*     THIS PROGRAM IS DESIGNED TO ENABLE THE NAIVE USER WHO     */
 /* HAS LITTLE IF ANY EXPERIENCE IN COMPUTER PROCESSING TO        */
 /* ENTER DIETARY INTAKE DATA FOR AN INDIVIDUAL OR ENTER A LIST OF*/
 /* FOOD ITEMS, SUCH AS IN A RECIPE, AND RECEIVE A COMPREHENSIVE  */
 /* ANALYSIS OF THIS DATA.                                        */
 /*                                                               */
 /*     INFORMATION IS ENTERED INTO THIS PROGRAM ON PUNCHED       */
 /* CARDS.  THE DATA REQUIRED AND THE ORDER IN WHICH IT MUST BE   */
 /* LISTED IS AS FOLLOWS:                                         */
 /*                                                               */
 /*                    * IMPORTANT NOTE *                         */
 /*                                                               */
 /*     ALL DATA ENTERED MUST BEGIN IN THE FIRST COLUMN OF THE    */
 /* GROUPS   OF   COLUMNS    INDICATED.    ALL  NUMERIC  DATA     */
 /* MUST  INDICATE  THE  POSITION  OF  THE  DECIMAL  POINT,  IE.  */
 /* HEIGHTS, WEIGHTS, AGES, QUANTITIES, ETC. MUST BE LISTED AS    */
 /* 180.5  76.  23.  5.0 .  FAILURE TO INDICATE THE DECIMAL POINT */
 /* WILL RESULT IN ERRORS IN CALCULATION IN THE PROGRAM.          */
 /*                                                               */
 /*                                                               */
 /*    DATA CARD 1: COL 1-25     NAME OF SUBJECT                  */
 /*                 28-30        SUBJECT #  (3 DIGITS)            */
 /*                 32-33        SEX OF SUBJECT (M,F,I,FP,FL)     */
 /*                                                               */
 /*                              M FOR MALES, F FOR FEMALES,      */
 /*                              I FOR INFANTS TO 1 YEAR OLD,     */
 /*                              FP FOR PREGNANT FEMALES,         */
 /*                              FL FOR LACTATING FEMALES         */
 /*                                                               */
 /*                 35-39        AGE OF SUBJECT IN YEARS          */
 /*                                                               */
 /*                 40-44        WEIGHT OF SUBJECT (KG)           */
 /*                 45-49        HEIGHT OF SUBJECT (CM)           */
 /*                                                               */
```

```
/*                  & 50-54      LEAN BODY MASS OF SUBJECT          */
/*                  & 55-59      ESTIMATED MUSCLE MASS OF SUBJECT   */
/*                  & 61-63      FRAMESIZE OF SUBJECT               */
/*                                   (SML,MED,LRG)                  */
/*                                                                  */
/*                       & THESE VALUES ARE DETERMINED USING        */
/*                  THE 'DRINKWATER TACTIC' FOR BODY COMPOSITION.   */
/*                       FRAMESIZE IS DETERMINED FROM THE           */
/*                  SKELETAL MASS OF SUBJECT. SMALL(SML) BEING      */
/*                  -0.5 Z-VALUES OR SMALLER THAN THE 'PHANTOM',    */
/*                  MEDIUM(MED) BEING -0.5 TO 0.5 Z-VALUES, AND     */
/*                  LARGE(LRG) BEING GREATER THAN +0.5 Z-VALUES.    */
/*                                                                  */
/*                    65-67      ACTIVITY LEVEL OF SUBJECT          */
/*                               (SED,LOW,MOD,HIG,VIG)              */
/*                                                                  */
/*                  SEDENTARY (SED) -- INACTIVE MOST OF THE DAY.    */
/*                      VERY LITTLE STANDING OR WALKING.            */
/*                                                                  */
/*                  LOW (LOW) -- SEATED A MAJOR PORTION OF THE      */
/*                      DAY.  ABOUT FOUR HOURS OF STANDING AND      */
/*                      WALKING.  TYPICAL OF THE OFFICE WORKER      */
/*                      AND THOSE WITH SIMILAR OCCUPATIONS.         */
/*                                                                  */
/*                  MODERATE (MOD) -- STANDS AS OFTEN AS IS         */
/*                      SEATED.  TYPICAL OF THE TEACHER, YOUNG      */
/*                      HOUSEWIFE, SALES CLERK, ETC.                */
/*                                                                  */
/*                  HIGH (HIG) -- STANDING AND WALKING MOST OF      */
/*                      THE DAY.  VERY LITTLE SITTING. TYPICAL OF   */
/*                      THE FACTORY WORKER, FARMER, CONSTRUCTION    */
/*                      WORKER, ETC.                                */
/*                                                                  */
/*                  VIGOROUS (VIG) -- VERY HARD PHYSICAL WORK.      */
/*                      TYPICAL OF THE LUMBERJACK OR THE ATHLETE    */
/*                      IN TRAINING.                                */
/*                                                                  */
/*                    70-73      DAY-BY-DAY ANALYSIS WANTED??       */
/*                               (YES OR NO - DEFAULT IS 'YES')     */
/*                                                                  */
/*    DATA CARD 2: COL 1- 3      SUBJECT #                          */
/*                     4- 5      PERIOD(DAY)                        */
/*                                                                  */
/*    DATA CARD 3: COL 1- 7      FOOD NUMBER                        */
/*                     8-11      WEIGHT OF FOOD IN GRAMS            */
/*                                   (NO FRACTIONAL GRAMS )         */
/*                                                                  */
/*    DATA CARD 4,5,6....        SAME AS CARD 3, REQUIRE ONE CARD   */
/*                               FOR EVERY FOOD ITEM BEING ENTERED  */
/*                                                                  */
/*    FINAL DATA CARD: COL  1- 3  SUBJECT #                         */
```

```
/*                          4- 5  THE LETTERS 'ND'                    */
/*                                                                    */
/*   * NOTE - THE FINAL CARD SIGNALS THE END OF THE INPUT AND         */
/*   IS NEEDED TO ENSURE THAT THE PROGRAM RUNS CORRECTLY.             */
/*                                                                    */
/*                                                                    */
/**********************************************************************/


        DCL FOODLST FILE RECORD KEYED ENV(REGIONAL(3)),
            RCMDD FILE KEYED ENV(REGIONAL(2)),
            COVER FILE RECORD SEQL INPUT,
            1 F(-1:1),
                2 NUM PIC '9999999',
                2 ITEM CHAR(30),
                2 PREP CHAR(50),
                2 GP CHAR(3),
                2 AMT(3,2) FLOAT BIN,
                2 V(2:87,2) FLOAT BIN,

             1 RK,
               2 GP CHAR(2),
               2 CTGRY CHAR(9),
               2 RDA(20),
                  3 NUTR CHAR(15),
                  3 UNITS CHAR(3),
                  3 VAL FLOAT BIN,

            1 S,
               2  NAME CHAR(30) VARYING INIT(' '),
               2  SEX CHAR(2) INIT (' '),
               2  AGE FIXED(5,1) INIT(0),
               2  WT FIXED(6,1) INIT(0),
               2  HT FIXED(6,1) INIT(0),
               2  LBM FIXED(6,1) INIT(0),
               2  MUSC FIXED(6,1) INIT(0),
               2  FRMSZ CHAR(3),
               2  ACTLVL CHAR(3) INIT(' '),
               2  DAILY CHAR(3) INIT('YES'),

            IDEAL FLOAT BIN,
            INSERT CHAR(16),
            TITLE CHAR(30) INIT('PERIOD'),
            SERVINGS FIXED(5,1) INIT(0),

            1 R,
               2 FOOD# CHAR(7) INIT(' '),
               2 AMT FIXED(4) INIT(0),

            Z(20) FLOAT BIN INIT(0),
            CODE PIC '99999999',
```

```
          PERIOD CHAR(2) INIT('1'),
          FDNUM PIC '9999999',
          CVR CHAR(80) INIT(' ');

       DCL   L(87) CHAR(10) INIT('WT    GM  ','WATER GM  ',
          'ENRGY KAL ',
          'CHO   GM  ','CHO  KAL ','ALCHL GM  ',
          'FIBRE GM  ','T.FAT GM  ','FAT  KAL ',
          'S.FAT GM  ','U.FAT GM  ','ARACH GM  ',
          'LINOL GM  ','OLEIC GM  ','OTH.U GM  ',
          'CHLST MG  ','T.PRO GM  ','PROT KAL ',
          'ESSAA GM  ','NESSA GM  ','S. AA MG  ',
          'CYS   MG  ','HIS   MG  ','ISL   MG  ',
          'LEU   MG  ','LYS   MG  ','MET   MG  ',
          'PHE   MG  ','THR   MG  ','TRY   MG  ',
          'TYR   MG  ','VAL   MG  ','ALA   MG  ',
          'ASP   MG  ','ARG   MG  ','CYS   MG  ',
          'GLU   MG  ','GLY   MG  ','HPR   MG  ',
          'PRO   MG  ','SER   MG  ','OTH AAMG  ',
          'PURIN MG  ','PYRIM MG  ',
          'VITA IU   ','ASCRB MG  ','VITD IU   ',
          'VITE MG   ','VITK MG   ','THIAM MG  ',
          'RIBO  MG  ','NIAC  MG  ','FOLA  MG  ',
          'PANTO MG  ','BIOT  MG  ','B6  MCG  ',
          'B12 MCG   ','CHOL  MG  ','CALC  MG  ',
          'CHLOR MG  ','CHROM MG  ','COBLT MG  ',
          'COPPR MG  ',
          'FLUOR MG  ','IODIN MG  ','IRON  MG  ',
          'MAGN  MG  ','MANGN MG  ','MOLYB MG  ',
          'NICKL MG  ','PHOSP MG  ','POTAS MG  ',
          'SELEN MG  ','SILCN MG  ','SOD   MG  ',
          'SULFR MG  ',
          'TIN   MG  ','VANAD MG  ','ZINC  MG  ',
          'OTHR1 MG  ','OTHR2 MG  ',
          'INOS  MG  ','LIPOI MG  ','OTHR1 MG  ',
          'OTHR2 MG  ','OTHR3 MG  ','COST CTS  ');

       DCL   (I,J,K,M,N,GTT,CNT) FLOAT BIN INIT(0);

BEGIN  : F.V=0; N=0;
         ON ENDFILE(COVER) GO TO CONT;
         ON ENDFILE(SYSIN) STOP;
         ON KEY(FOODLST) BEGIN;
         PUT FILE(SYSPRINT) SKIP(1) EDIT(R.AMT,'GRAMS',R.FOOD#,
             '* NOT LISTED')(F(9,3),X(3),A(10),X(3),A(30),X(1),A(12));
         GO TO GETR;
         END;

         OPEN FILE(COVER) SEQL INPUT;
         OPEN FILE(FOODLST) DIRECT INPUT,
              FILE(RCMDD) DIRECT INPUT;
```

```
GETS  :GET FILE(SYSIN) EDIT(S.NAME,S.SEX,S.AGE,S.HT,S.WT,S.LBM,S.MUSC,
       S.FRMSZ,S.ACTLVL,S.DAILY)(COL(1),A(30),COL(32),A(2),COL(35),
       F(5,1),COL(40),F(5,1),COL(45),F(5,1),COL(50),F(5,1),
       COL(55),F(5,1),COL(61),A(3),COL(65),A(3),COL(70),A(3));

      IF S.SEX='M' THEN INSERT='MALE';
      IF S.SEX='F' THEN INSERT='FEMALE';
      IF S.SEX='I' THEN INSERT='INFANT';
      IF S.SEX='FP' THEN INSERT='PREGNANT FEMALE';
      IF S.SEX='FL' THEN INSERT='LACTATING FEMALE';

GETCVR: READ FILE(COVER) INTO(CVR);
      PUT FILE(SYSPRINT) SKIP EDIT(CVR)(COL(25),A(80));
      GO TO GETCVR;
CONT  : PUT FILE(SYSPRINT) SKIP(2) EDIT('FOR',S.NAME,INSERT,'AGE',
         S.AGE,'WEIGHT',S.WT,'KG','HEIGHT',S.HT,'CM',
         FRMSZ,'FRAME')
         (A(3),X(2),A(30),X(1),A(16),X(1),A(4),F(5,1),X(3),A(7),
         F(6,2),X(1),A(3),X(3),A(7),F(6,2),X(1),A(3),X(3),A(4),
         A(5),X(2));

 GETR : GET FILE(SYSIN) EDIT(R)(COL(1),A(7),COL(8),F(4));

      IF SUBSTR(R.FOOD#,4,2)='ND' THEN DO;
         IF DAILY=' '|DAILY='YES' THEN PUT FILE(SYSPRINT) PAGE;
         J=0; GTT=1;
         IF DAILY=' '|DAILY='YES' THEN CALL ANALYSS;
         GO TO GRTOTL;
      END;

      IF SUBSTR(R.FOOD#,6,2)='  ' THEN DO;
        SERVINGS=1; N=N+1; PERIOD=SUBSTR(R.FOOD#,4,2);
        IF N=1 THEN DO;
           IF DAILY=' '|DAILY='YES' THEN CALL HEADER;
           GO TO GETR;
        END;
        IF N>1 THEN DO;
           GO TO NEXT;
        END;
      END;

      IF CNT>=48 THEN CALL HEADER;

      FDNUM=R.FOOD#;
      J=FDNUM/100;
      CODE=MOD(J,249)+1;
      READ FILE(FOODLST) INTO(F(1)) KEY(R.FOOD#||CODE);

      M=R.AMT/100;
      F.AMT(1,1,1)=M*100;
```

```
          V(1,*,1)=M*V(1,*,1);
          V(0,*,1)=V(0,*,1)+V(1,*,1);
          V(-1,*,1)=V(-1,*,1)+V(1,*,1);

          IF DAILY=' '|DAILY='YES' THEN DO;
          PUT FILE(SYSPRINT) SKIP(1);
          PUT FILE(SYSPRINT) SKIP(1) EDIT(F.AMT(1,1,1),'G',F.ITEM(1),
            '#',F.NUM(1),F.AMT(1,1,1),(V(1,I,1)DO I=2,3,17,8,4,7,59))
            (F(7),X(2),A(3),A(30),A(1),A(7),8 F(10,2));
          PUT FILE(SYSPRINT) SKIP(1) EDIT(F.PREP(1),
           (V(1,I,1)DO I=71,66,75,72,45,50,51,52))(A(50),
            8 F(10,2));
          PUT FILE(SYSPRINT) SKIP(1) EDIT
            ((V(1,I,1)DO I=46,10,14,13,16))(X(50),5 F(10,2));

          CNT=CNT+4;
          END;


          GO TO GETR;

 NEXT   :IF DAILY=' '|DAILY='YES' THEN  PUT FILE(SYSPRINT) PAGE;
          J=0;GTT=1;
          IF DAILY=' '|DAILY='YES' THEN DO;
          CALL ANALYSS; CALL HEADER;
          GO TO GETR;
          END;
          ELSE GO TO GETR;

GRTOTL:  TITLE='GRAND TOTAL';
          J=-1;
          GTT=N; PUT FILE(SYSPRINT) PAGE;
          PUT FILE(SYSPRINT) SKIP(0) EDIT('AVERAGE DIETARY INTAKE FOR',
              N, ' PERIOD(S)')(COL(40),A(26),F(4),A(10));
          CALL ANALYSS; CALL GRAPH;

HEADER:  PROCEDURE;
          CNT=0;
          PUT FILE(SYSPRINT) PAGE; PUT FILE(SYSPRINT) SKIP(1);
          PUT FILE(SYSPRINT) SKIP EDIT (TITLE,PERIOD)(A(30),A(2));

          PUT FILE(SYSPRINT) SKIP(1) EDIT('TOTAL NUTRIENT',
              ' INTAKE PER FOOD')(COL(54),A(14),A(16));
          PUT FILE(SYSPRINT) SKIP(1);

          PUT FILE(SYSPRINT) SKIP EDIT('FOOD',(L(I)DO I=1,
              2,3,17,8,4,7,59))(COL(26),A(4),COL(53),8 A(10));
          PUT FILE(SYSPRINT) SKIP EDIT((L(I)DO I=
              71,66,75,72,45,50,51,52))(COL(53), 8 A(10));
          PUT FILE(SYSPRINT) SKIP EDIT((L(I)DO I=
```

```
        46,10,14,13,16))(COL(53), 5 A(10));

    RETURN;
    END HEADER;

ANALYSS: PROCEDURE;
    DCL GG FIXED(2) INIT(0),
        GGP CHAR(2),
        GP CHAR(6),
        (EA,EB,NEWNRGY) FLOAT BIN INIT(0),
        L1(20) CHAR(30) INIT('ENERGY','PROTEIN','THIAMINE',
            'NIACIN','RIBOFLAVIN','FAT','CARBOHYDRATE',
            'FIBER','VITAMIN C','VITAMIN A','SODIUM','POTASSIUM',
            'CALCIUM','WATER','SATFAT','OLEIC ACID','IRON',
            'CHOLESTEROL','LINOLEIC ACID','PHOSPHORUS'),
        L2(20) CHAR(3) INIT('KAL','GM ','MG ','MG ','MG ',
               'GM ','GM ','GM ','MG ','IU ','MG ','MG ','MG ',
               'GM ','GM ','GM ','MG ','MG ','GM ','MG ');

    Z(1)=V(J,3,1)/GTT;
    Z(2)=V(J,17,1)/GTT;
    Z(3)=V(J,50,1)/GTT;
    Z(4)=V(J,52,1)/GTT;
    Z(5)=V(J,51,1)/GTT;
    Z(6)=V(J,8,1)/GTT;
    Z(7)=V(J,4,1)/GTT;
    Z(8)=V(J,7,1)/GTT;
    Z(9)=V(J,46,1)/GTT;
    Z(10)=V(J,45,1)/GTT;
    Z(11)=V(J,75,1)/GTT;
    Z(12)=V(J,72,1)/GTT;
    Z(13)=V(J,59,1)/GTT;
    Z(14)=V(J,2,1)/GTT;
    Z(15)=V(J,10,1)/GTT;
    Z(16)=V(J,14,1)/GTT;
    Z(17)=V(J,66,1)/GTT;
    Z(18)=V(J,16,1)/GTT;
    Z(19)=V(J,13,1)/GTT;
    Z(20)=V(J,71,1)/GTT;

/*****************************************************************/
/* THIS ROUTINE DETERMINES THE RDA VALUE GROUP FOR AGE AND SEX   */
/*****************************************************************/

    IF S.SEX='I' THEN IF AGE
    ELSE GG=2;
    IF S.SEX='M'|S.SEX='F' THEN IF AGE
    IF S.SEX='M'|S.SEX='F' THEN IF AGE
    IF S.SEX='M' THEN IF AGE>6  THEN GG=5;
    IF S.SEX='F' THEN IF AGE>6 THEN GG=12;
    IF AGE>=7 THEN
```

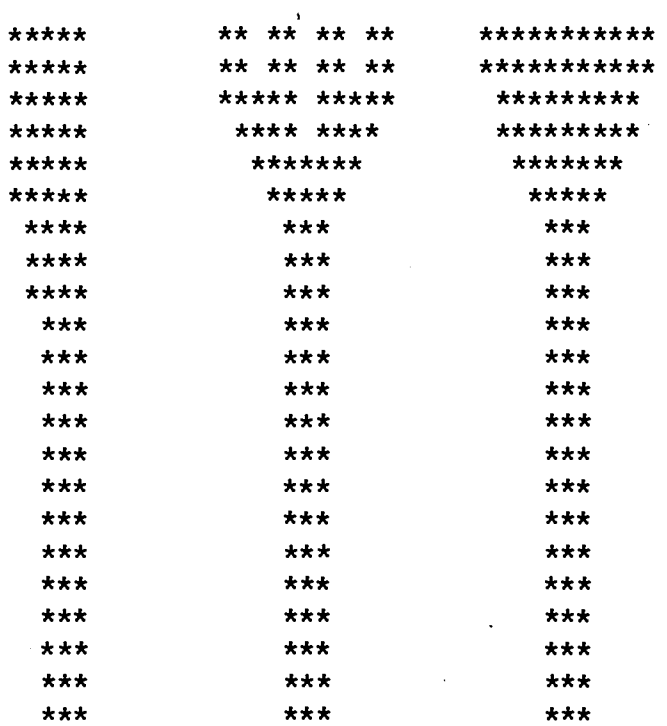
```
            IF AGE>=10 THEN
               IF AGE>=13 THEN
                  IF AGE >=16 THEN
                     IF AGE >=19 THEN
                        IF AGE>=35 THEN
                           IF AGE>=50 THEN GG=GG+6;
                        ELSE GG=GG+5;
                     ELSE GG=GG+4;
                  ELSE GG=GG+3;
               ELSE GG=GG+2;
            ELSE GG=GG+1;
         ELSE GG=GG;
         IF S.SEX='FP' THEN GG=19;
         IF S.SEX='FL' THEN GG=20;
         GP=GG;
         GGP=SUBSTR(GP,4,2);

         READ FILE(RCMDD) INTO(RK) KEY(GGP);

         PUT FILE(SYSPRINT) SKIP(2) EDIT('DIETARY ANALYSIS FOR',
             NAME,'AGE',S.AGE,'WEIGHT',S.WT,'KG','HEIGHT',S.HT,
             'CM',FRMSZ,'FRAME','ACTIV LVL',ACTLVL)
             (A(21),A(31),A(4),F(4),X(8),A(7),F(5,1),X(1),A(2),X(3),
             A(7),F(5,1),X(1),A(2),X(3),A(5),A(5),X(3),A(10),A(3));

         PUT FILE(SYSPRINT) SKIP(2) EDIT('AS COMPARED TO THE AVERAGE',
             ' CANADIAN ',INSERT,'AGE',CTGRY,'WEIGHT',RK.VAL(1),
             'KG','HEIGHT',RK.VAL(2),'CM')
             (A(26),A(10),A(16),A(4),A(9),X(3),A(6),F(4),X(3),A(4),
              X(1),A(6),F(4),X(3),A(4));

/*****************************************************************/
/*                                                               */
/*          ANTONETTI'S ALGORITHM FOR ENERGY EXPENDITURE         */
/*     (AMERICAN JOURNAL OF CLINICAL NUTRITION 26:1 JAN 1973)    */
/*                                                               */
/*        MODIFIED FOR METRIC MEASURE OF HEIGHT AND WEIGHT       */
/*                                                               */
/*****************************************************************/

         IF ACTLVL='SED' THEN EA=WT*8.10;
         IF ACTLVL='LOW' THEN EA=WT*9.50;
         IF ACTLVL='MOD' THEN EA=WT*12.65;
         IF ACTLVL='HIG' THEN EA=WT*17.60;
         IF ACTLVL='VIG' THEN EA=WT*27.06;
         IF ACTLVL='   ' THEN EA=WT*12.65;

         IF SEX='I' THEN GO TO CONT;

         IF SEX='M' THEN DO;
            IF AGE
```

```
            IF AGE >=35|AGE
            IF AGE >=55 THEN EB=WT**0.425*HT**0.725*5.85;
         END;

         ELSE DO;
            IF AGE
            IF AGE >=35|AGE
            IF AGE >=55 THEN EB=WT**0.425*HT**0.725*4.88;
         END;

         NEWNRGY=1.11*(EA+EB);

         PUT FILE(SYSPRINT) SKIP(2) EDIT('ADJUSTED ENERGY REQUIREMENT',
         'BASED ON YOUR SEX, SIZE, AND ACTIVITY LEVEL IS',NEWNRGY,
         ' KAL')(COL(46),A(28),A(47),F(6),A(4));


CONT:    PUT FILE(SYSPRINT) SKIP(3) EDIT('NUTRIENT','TOTAL',
             '*RDI','% OF *RDI','PER KG WT','PER KG LBM','PER KG MUSC')
             (COL(6),A(8),X(30),A(5),X(9),A(4),X(9),A(9),X(7),A(9),
             X(7),A(10),X(7),A(11));
         PUT FILE(SYSPRINT) SKIP(1) EDIT('INTAKE')
             (COL(44),A(6));
         PUT FILE(SYSPRINT) SKIP(1);

         DO I=14,6,15,16,19,18,7,8,11,12,20;
         PUT FILE(SYSPRINT) SKIP EDIT(L1(I),Z(I),L2(I),Z(I)/S.WT,
         Z(I)/S.LBM,Z(I)/S.MUSC)
             (A(35),F(11,3),X(15),A(3),X(22),F(8,1),X(9),F(8,1),
             X(10),F(8,1));
         END;

         DO I=1 TO 5,9,10,13,17;
         PUT FILE(SYSPRINT) SKIP EDIT(RK.NUTR(I+2),Z(I),
             RDA.VAL(I+2),RDA.UNITS(I+2),
             Z(I)/RDA.VAL(I+2)*100,'%',Z(I)/S.WT,Z(I)/S.LBM,
             Z(I)/S.MUSC)(A(35),F(11,3),X(3),F(11,3),X(1),A(3),X(8),
             F(6),A(1),X(7),F(8,1),X(9),F(8,1),X(10),F(8,1));
         END;

         F.V(0,*,*)=0;

         RETURN;
         END ANALYSS;

  GRAPH: PROCEDURE;
/*****************************************************************/
/* THIS PROCEDURE PLOTS A LOGARITHMIC GRAPH OF TOTAL NUTRIENT    */
/* INTAKE AS DETERMINED BY THE ANALYSIS PROCEDURE.               */
/*****************************************************************/
```

```
          DCL X(17) FIXED(6);
          ON ZERODIVIDE BEGIN;
          X(I)=0;
          END;
          PUT FILE(SYSPRINT) SKIP(5);
PRNTLP :  DO I=1 TO 5,9,10,13,17;
             X(I)=Z(I)/RK.VAL(I+2)*100;
             IF X(I) =0 THEN DO;
             X(I)=LOG10(X(I))*20;
             END;
             IF X(I)>100 THEN X(I)=100;
             PUT FILE(SYSPRINT) SKIP(1) EDIT (RK.NUTR(I+2),'|',
                REPEAT('*',X(I)))(A(14),COL(15),A(1),COL(16),A(X(I)));
             PUT SKIP(0) FILE(SYSPRINT) EDIT ('|')(COL(55),A(1));
  NDLP :  END PRNTLP;

          PUT SKIP(1) FILE(SYSPRINT) EDIT (REPEAT('|____',8),'|')
              (COL(15),A(80),A(1));
          PUT SKIP(2) FILE(SYSPRINT) EDIT ('0','10','100',
             '1000','10000')
             (COL(15),A(1),X(5),5 (X(14),A(6)));
          PUT FILE(SYSPRINT) SKIP(0)
              EDIT(REPEAT('     2    3   5  7  ',4))
              (COL(15),A(80));
          PUT SKIP(2) FILE(SYSPRINT) EDIT ('PERCENT OF MINIMUM',
            ' RECOMMENDED DAILY INTAKE')(COL(43),A(18),A(25));

          RETURN;
          END GRAPH;


STOPP  :  PUT FILE(SYSPRINT) SKIP(2) EDIT('PROGRAM WRITTEN BY ',
               'DON DRINKWATER, KINESIOLOGY DEPARTMENT -- SIMON FRASER',
               ' UNIVERSITY, BURNABY 2, B.C., V5A 1S6')(A(19),A(54),
               A(37));

          CLOSE FILE(FOODLST),FILE(COVER),
                FILE(RCMDD);
          PUT FILE(SYSPRINT) PAGE;
          GO TO BEGIN;


          END USAFDS;

//GO.COVER DD  DSN=SC.A0791.FCOVER,UNIT=DISK,DISP=(OLD,KEEP)
//GO.FOODLST DD   DSN=SC.A0791.USDA,UNIT=DISK,DISP=(OLD,KEEP)
//GO.RCMDD DD   DSN=SC.A0791.FRDA,UNIT=DISK,DISP=(OLD,KEEP)
//GO.SYSIN DD *
```

```
//A294DEBC JOB (0791,U5259)
//  EXEC PLICKCG
//PLI.SYSCIN DD *

 /*****************************************************************/
 /*                NUTRITIONAL ANALYSIS PROGRAM                   */
 /* WRITTEN BY DON DRINKWATER                                     */
 /* KINESIOLOGY DEPT.  S.F.U.                                     */
 /*                                                               */
 /*                        FRDA PROCEDURE                         */
 /*                                                               */
 /*      THIS ROUTINE LOADS THE 1975 EDITION OF THE CANADIAN      */
 /* RECOMMENDED DAILY ALLOWANCE TABLES FOR INFANTS, MEN AND WOMEN */
 /* FROM 1 YEAR OF AGE TO > 65 YEARS.  THE TABLE IS LOADED ONTO   */
 /* DIRECT ACCESS DISC AND IS KEYED BY SEX AND AGE VIA A ROUTINE  */
 /* GENERATED BY THE MAIN PROGRAM, 'SURVEY'.  FOURTEEN NUTRIENTS  */
 /* ARE LISTED BY THE TABLES AS BEING ESSENTIAL TO HEALTH.        */
 /* VALUES ARE ALSO GIVEN FOR PREGNANT AND LACTATING FEMALES.     */
 /*                                                               */
 /*****************************************************************/

 REQUIRE: PROC OPTIONS (MAIN);
          DCL RCMDD FILE RECORD KEYED ENV(REGIONAL(2)),
          1 GROUP,
             2 GP CHAR(2),
             2 CTGRY CHAR(9),
             2 RDA(20),
               3 NUTR CHAR(15),
               3 UNITS CHAR(3),
               3 VAL FLOAT BIN;

          OPEN FILE(RCMDD) DIRECT OUTPUT;
          ON ENDFILE(SYSIN) GO TO NEXT;
          ON ENDFILE(RCMDD) GO TO FINISH;

 IN     : GET FILE(SYSIN) LIST(GROUP);
          WRITE FILE(RCMDD) FROM(GROUP) KEYFROM(GP);
          GO TO IN;
 NEXT   : CLOSE FILE(RCMDD);
          OPEN FILE(RCMDD) SEQL UPDATE;
 AGAIN  : READ FILE(RCMDD) INTO(GROUP);
          PUT FILE(SYSPRINT) SKIP LIST (GROUP);
          GO TO AGAIN;
 FINISH : CLOSE FILE(RCMDD);

          END REQUIRE;
/*
//GO.RCMDD DD DSN=SC.A0791.FRDA,UNIT=DISK,DISP=(NEW,CATLG),
//         DCB=(RECFM=F,BLKSIZE=489,DSORG=DA,KEYLEN=2),
//          SPACE=(CYL,(1,1))
//GO.SYSIN DD *
```

```
//A294DEBD JOB (0791,U5259)
//  EXEC PLICKR
//GO.SYSCIN DD *

 /*****************************************************************/
 /*                NUTRITIONAL ANALYSIS PROGRAM                   */
 /* WRITTEN BY DON DRINKWATER                                     */
 /* KINESIOLOGY DEPT.  S.F.U.                                     */
 /*                                                               */
 /*                    COVERPAGE PROCEDURE                        */
 /*                                                               */
 /*      THIS ROUTINE LOADS A SEQUENTIAL DATA SET WHICH           */
 /* GENERATES THE COVERPAGE FOR THE NUTRITIONAL ANALYSIS MAIN     */
 /* PROCEDURE 'SURVEY'.  THIS FILE IS ALSO LOADED ONTO DISK FOR   */
 /* RAPID ACCESS.                                                 */
 /*                                                               */
 /*****************************************************************/

 PRETTY : PROC OPTIONS (MAIN);
          DCL COVER FILE RECORD,
              CVR CHAR(80),
              A FLOAT BIN;
          ON ENDFILE(SYSIN) GO TO NEXT;
          ON ENDFILE(COVER) GO TO FINISH;

          OPEN FILE(COVER) SEQL OUTPUT;
 IN     : GET FILE(SYSIN) EDIT(CVR)(A(80));
          WRITE FILE(COVER) FROM(CVR);
          GO TO IN;

 NEXT   : CLOSE FILE(COVER);

          OPEN FILE(COVER) SEQL INPUT;
 AGAIN  : READ FILE(COVER) INTO(CVR);
          PUT FILE(SYSPRINT) SKIP EDIT(CVR)(A(80));
          GO TO AGAIN;

 FINISH : CLOSE FILE(COVER);
          END PRETTY;
/*
//GO.COVER DD  DSN=SC.A0791.FCOVER,UNIT=DISK,DISP=(NEW,CATLG),
//   DCB=(RECFM=FB,LRECL=80,BLKSIZE=4480),SPACE=(TRK,(2,1))
//GO.SYSIN DD *
                      **        ** ** ** **          ***
                     ***        ** ** ** **        *****
                    ****        ** ** ** **       *******
                    ****        ** ** ** **      *********
                   *****        ** ** ** **      *********
                   *****        ** ** ** **     ***********
                   *****        ** ** ** **     ***********
                   *****        ** ** ** **     ***********
```



```
//DLROSJOB JOB (0979,U6144),TIME=6,REGION=300K,MSGCLASS=R
//  EXEC PLIXCG
//PLI.SYSCIN DD *

 /*****************************************************************/
 /*                NUTRITIONAL ANALYSIS PROGRAM                   */
 /* WRITTEN BY DON DRINKWATER                                     */
 /* KINESIOLOGY DEPT.  S.F.U.                                     */
 /*                                                               */
 /*                      DATAGET  PROCEDURE                       */
 /*                                                               */
 /*      THIS ROUTINE TRANSFERS THE MASTER FOODS DATA SET FROM    */
 /* DIRECT ACCESS DISC TO A SEQUENTIAL FILE IN CARD IMAGE FORMAT  */
 /* FROM WHERE IT MAY BE TRANSFERRED TO TAPE FOR PERMANENT STORAGE.*/
 /*                                                               */
 /*****************************************************************/

 DTAGET: PROC OPTIONS (MAIN);
          DCL INFOOD FILE RECORD KEYED ENV(REGIONAL(3)),
              OUTFOOD FILE STREAM,
              1 F,
                  2 NUM PIC '9999999',
                  2 ITEM CHAR(30),
                  2 PREP CHAR(50),
                  2 GP CHAR(3),
                  2 AMT(3,2) FLOAT BIN,
                  2 V(2:87,2) FLOAT BIN;

          ON ENDFILE(INFOOD) GO TO NEXT;
          ON ENDFILE(OUTFOOD) STOP;
          OPEN FILE(INFOOD) SEQL INPUT, FILE(OUTFOOD) OUTPUT;

  IN    : READ FILE(INFOOD) INTO(F);

          AMT(*,1)=AMT(*,1)*100; V(*,1)=V(*,1)*100;

  OUT   : PUT FILE(OUTFOOD) EDIT(F)(COL(1),A(7),A(30),
              COL(1),A(50),A(3),
              COL(1),7 (F(8),F(2)),COL(1),7 (F(8),F(2)),
              COL(1),7 (F(8),F(2)),COL(1),7 (F(8),F(2)),
              COL(1),7 (F(8),F(2)),COL(1),7 (F(8),F(2)),
              COL(1),7 (F(8),F(2)),COL(1),7 (F(8),F(2)),
              COL(1),7 (F(8),F(2)),COL(1),7 (F(8),F(2)),
              COL(1),7 (F(8),F(2)),COL(1),7 (F(8),F(2)),
              COL(1),5 (F(8),F(2)));

          GO TO IN;

 NEXT   : CLOSE FILE(OUTFOOD);
          OPEN FILE(OUTFOOD) INPUT;
```

```
 AGAIN  : GET FILE(OUTFOOD) EDIT(F)(COL(1),A(7),A(30),
              COL(1),A(50),A(3),
              COL(1),7 (F(8),F(2)),COL(1),7 (F(8),F(2)),
              COL(1),7 (F(8),F(2)),COL(1),7 (F(8),F(2)),
              COL(1),7 (F(8),F(2)),COL(1),7 (F(8),F(2)),
              COL(1),7 (F(8),F(2)),COL(1),7 (F(8),F(2)),
              COL(1),7 (F(8),F(2)),COL(1),7 (F(8),F(2)),
              COL(1),7 (F(8),F(2)),COL(1),7 (F(8),F(2)),
              COL(1),5 (F(8),F(2)));

          PUT FILE(SYSPRINT) SKIP(1) EDIT(NUM,ITEM)(A(10),A(30));
          GO TO AGAIN;

          END DTAGET;
/*
//GO.INFOOD DD  DSN=SC.A0791.USDA,UNIT=DISK,DISP=(OLD,KEEP)
//GO.OUTFOOD DD  DSN=DTD.OUTFOOD,UNIT=DISK,DISP=(NEW,CATLG),
//         DCB=(RECFM=FB,LRECL=80,BLKSIZE=3120),SPACE=(TRK,(300,10))
//GO.SYSIN DD *
```

```
//A294DEBB JOB (0979,U6144),TIME=3,REGION=300K
//  EXEC PLIXCG
//PLI.SYSCIN DD *

 /*****************************************************************/
 /*                NUTRITIONAL ANALYSIS PROGRAM                   */
 /* WRITTEN BY DON DRINKWATER                                     */
 /* KINESIOLOGY DEPT.  S.F.U.                                     */
 /*                                                               */
 /*                      DATAPUT  PROCEDURE                       */
 /*                                                               */
 /*             THIS ROUTINE LOADS THE MASTER FOODS DATA SET FROM */
 /* TEMPORARY DISC STORAGE TO PERMANENT STORAGE.                  */
 /*             A REGIONAL KEY IS GENERATED FOR EACH FOOD FROM    */
 /* THE FIRST THREE DIGITS OF A UNIQUE NUMBER FOR THAT FOOD.      */
 /*                                                               */
 /*****************************************************************/

DTAPUT: PROC OPTIONS (MAIN);
        DCL FOODLST FILE RECORD KEYED ENV(REGIONAL(3)),
            NEWDATA FILE STREAM INPUT,
             1 F,
                2 NUM PIC '9999999',
                2 ITEM CHAR(30),
                2 PREP CHAR(50),
                2 GP CHAR(3),
                2 AMT(3,2) FLOAT BIN,
                2 V(2:87,2) FLOAT BIN,
            (I,J) FLOAT BIN INIT('0'),
            CODE PIC '99999999';
        ON ENDFILE(NEWDATA) GO TO NEXT;
        ON ENDFILE(FOODLST) STOP;
        OPEN FILE(FOODLST) DIRECT OUTPUT;

 IN     : GET FILE(NEWDATA) EDIT(F)(COL(1),A(7),A(30),COL(1),A(50),A(3),
            COL(1),7 (F(8),F(2)),COL(1),7 (F(8),F(2)),
            COL(1),7 (F(8),F(2)),COL(1),7 (F(8),F(2)),
            RLG\4*ç7 (F(8),F(2)),COL(1),7 (F(8),F(2)),
            COL(1),7 (F(8),F(2)),COL(1),7 (F(8),F(2)),
            COL(1),7 (F(8),F(2)),COL(1),7 (F(8),F(2)),
            COL(1),7 (F(8),F(2)),COL(1),7 (F(8),F(2)),
            COL(1),5 (F(8),F(2)));

        J=NUM/100;
        CODE=MOD(J,249)+1;

        AMT(*,1)=AMT(*,1)/100; V(*,1)=V(*,1)/100;

        WRITE FILE(FOODLST) FROM(F) KEYFROM(NUM||CODE);

        GO TO IN;
```

```
NEXT   : CLOSE FILE(FOODLST);
         OPEN FILE(FOODLST) SEQL INPUT;
AGAIN  : READ FILE(FOODLST) INTO(F);
         J=NUM/100;
         CODE=MOD(J,249)+1;
         PUT FILE(SYSPRINT) SKIP(1) EDIT(NUM,CODE)(A(7),A(8));
         GO TO AGAIN;

         END DTAPUT;
/*
//GO.FOODLST DD  DSN=DTD.USDA,UNIT=DISK,DISP=(NEW,CATLG),
//          DCB=(RECFM=F,BLKSIZE=802,DSORG=DA,KEYLEN=15),
//          SPACE=(TRK,(250,1))
//GO.NEWDATA DD  DSN=DTD.TEMPFDS,UNIT=DISK,DISP=(OLD,KEEP)
//GO.SYSIN DD *
```

```
//KINOSJOB JOB (0791,U5259),REGION=240K,TIME=1,MSGCLASS=R
//  EXEC PLICKCG
//PLI.SYSCIN DD *

 /*****************************************************************/
 /*                  NUTRITIONAL ANALYSIS PROGRAM                 */
 /*                                                               */
 /* WRITTEN BY DON DRINKWATER              VERSION 1.4  MAY 23 78 */
 /* KINESIOLOGY DEPT.  S.F.U.                                     */
 /*                                                               */
 /*                       ADDATA  PROCEDURE                       */
 /*                                                               */
 /*       THIS PROCEDURE ALLOW THE ADDITION OF DATA TO THE MASTER */
 /* DATA SET.  THE PROGRAM CHECKS FIRST TO SEE IF THE FOOD (NUM)  */
 /* CURRENTLY EXISTS.  IF SO, A FOOD UNDER THAT NAME CANNOT BE    */
 /* ADDED.    TO UPDATE EXISTING RECORDS, USE PROCEDURE #CHDATA.  */
 /*                                                               */
 /*****************************************************************/

 ADDATA : PROC OPTIONS (MAIN);
          DCL FOODLST FILE RECORD KEYED ENV(REGIONAL(3)),
               1 F,
                  2 NUM PIC '9999999',
                  2 ITEM CHAR(30) INIT('  '),
                  2 PREP CHAR(50) INIT('  '),
                  2 GP CHAR(3) INIT('  '),
                  2 AMT(3,2) FLOAT BIN,
                  2 V(2:87,2) FLOAT BIN,
               1 G,
                  2 NUM PIC '9999999',
                  2 ITEM CHAR(30) INIT('  '),
                  2 PREP CHAR(50) INIT('  '),
                  2 GP CHAR(3) INIT('  '),
                  2 AMT(3,2) FLOAT BIN,
                  2 V(2:87,2) FLOAT BIN,
              (I,J) FLOAT BIN INIT(0),
              CODE PIC '99999999';

          ON ENDFILE(SYSIN) GO TO FINISH;

          OPEN FILE(FOODLST) DIRECT UPDATE;

          ON KEY(FOODLST)BEGIN;
          WRITE FILE(FOODLST) FROM(G) KEYFROM(G.NUM||CODE);
          PUT FILE(SYSPRINT) SKIP(1) EDIT(G.NUM,G.ITEM)
              (A(7),COL(11),A(30));
          GO TO IN;
          END;


          F.V=0; G.V=0;
```

```
 IN     : GET FILE(SYSIN) EDIT(G.NUM,G.ITEM,G.PREP,
            (G.V(I,1)DO I=2,3,17,8,4,7,59,71,66,75,72,45,50,51,52,46,
               10,14,13,16))
              (COL(1),A(7),COL(1),A(30),A(50),COL(1),8 F(10,3),
               COL(1),8 F(10,3),COL(1),4 F(8,3));

          DO I=2,3,17,8,4,7,59,71,66,75,72,45,50,51,52,46,
               46,10,14,13,16;
               F.V(I,2)=99;
          END;

          J=G.NUM/100;
          CODE=MOD(J,249)+1;
          READ FILE(FOODLST) INTO(F) KEY(G.NUM||CODE);
          PUT FILE(SYSPRINT) SKIP(2) EDIT('FOOD',G.ITEM,G.NUM,
              'PRESENTLY EXISTS IN MASTER DATA SET')(COL(10),
              A(5),A(32),A(8),A(30));
          GO TO IN;

 FINISH : CLOSE FILE(FOODLST);
          END ADDATA;
/*
//GO.FOODLST DD  DSN=SC.A0791.USDA,UNIT=DISK,DISP=MOD
//GO.SYSIN DD *
```

```
//KINOSJOB JOB (0791,U5259),REGION=240K,TIME=1,MSGCLASS=R
//  EXEC PLICKCG
//PLI.SYSCIN DD *

 /*****************************************************************/
 /*                  NUTRITIONAL ANALYSIS PROGRAM                 */
 /*                                                               */
 /* WRITTEN BY DON DRINKWATER              VERSION 1.4  MAY 24 78 */
 /* KINESIOLOGY DEPT.  S.F.U.                                     */
 /*                                                               */
 /*                        CHDATA  PROCEDURE                      */
 /*                                                               */
 /*      THIS PROCEDURE ALLOWS THE CHANGING OF DATA IN THE MASTER */
 /* DATA SET.  THE PROGRAM CHECKS FIRST TO SEE IF THE FOOD (NUM)  */
 /* CURRENTLY EXISTS.  IF SO, A FOOD UNDER THAT NAME CAN BE       */
 /*CHANGED.     THIS FEATURE DOES NOT ALLOW THE CREATION OF NEW   */
 /* RECORDS.    IT  IS  BETTER  TO  USE  PROCEDURE  #ADDATA TO    */
 /* PERFORM THIS FUNCTION.                                        */
 /*                                                               */
 /*****************************************************************/

 CHDATA : PROC OPTIONS (MAIN);
          DCL FOODLST FILE RECORD KEYED ENV(REGIONAL(3)),
               1 F,
                  2 NUM PIC '9999999',
                  2 ITEM CHAR(30) INIT('  '),
                  2 PREP CHAR(50) INIT('  '),
                  2 GP CHAR(3) INIT('  '),
                  2 AMT(3,2) FLOAT BIN,
                  2 V(2:87,2) FLOAT BIN,
               1 G,
                  2 NUM PIC '9999999',
                  2 ITEM CHAR(30) INIT('  '),
                  2 PREP CHAR(50) INIT('  '),
                  2 GP CHAR(3) INIT('  '),
                  2 AMT(3,2) FLOAT BIN,
                  2 V(2:87,2) FLOAT BIN,
              (I,J) FLOAT BIN INIT(0),
              CODE PIC '99999999';

          ON ENDFILE(SYSIN) GO TO FINISH;

          OPEN FILE(FOODLST) DIRECT UPDATE;

          ON KEY(FOODLST)BEGIN;
          PUT FILE(SYSPRINT) SKIP(2) EDIT('FOOD',G.ITEM,G.NUM,
              'PRESENTLY EXISTS IN MASTER DATA SET')(COL(10),
              A(5),A(32),A(8),A(30));
          GO TO IN;
          END;
```

```
          F.V=0; G.V=0;

 IN     : GET FILE(SYSIN) EDIT(G.NUM,G.ITEM,G.PREP,
            (G.V(I,1)DO I=2,3,17,8,4,7,59,71,66,75,72,45,50,51,52,46,
               10,14,13,16))
              (COL(1),A(7),COL(1),A(30),A(50),COL(1),8 F(10,3),
               COL(1),8 F(10,3),COL(1),4 F(8,3));

          DO I=2,3,17,8,4,7,59,71,66,75,72,45,50,51,52,46,
               46,10,14,13,16;
               F.V(I,2)=99;
          END;

          J=G.NUM/100;
          CODE=MOD(J,249)+1;
          READ FILE(FOODLST) INTO(F) KEY(G.NUM||CODE);
          REWRITE FILE(FOODLST) FROM(G) KEYFROM(G.NUM||CODE);
          PUT FILE(SYSPRINT) SKIP(1) EDIT(G.NUM,G.ITEM)
              (A(7),COL(11),A(30));
          GO TO IN;

 FINISH : CLOSE FILE(FOODLST);
          END CHDATA;
/*
//GO.FOODLST DD  DSN=SC.A0791.USDA,UNIT=DISK,DISP=MOD
//GO.SYSIN DD *
```