THE EFFECTS OF A RUNNING LIFESTYLE ON BODY COMPOSITION AND CALORIC INTAKE IN FEMALE DISTANCE RUNNERS

by

KRISTEN JANE WILLIAMS

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Department of Foods and Nutrition

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Approved by:

Beth Fryer
Major Professor

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INTRODUCTION

Control of body weight is a growing concern in today's society. Obesity, which is defined as the excessive accumulation of adipose tissue or body fat, has become a major health problem in the United States and other industrialized nations. About 50 million men and 60 million women in the United States between the ages of 18 and 79 are obese (1,66). The health risks associated with obesity are well-known: impairment of cardiac function, hypertension, diabetes, renal disease, gallbladder disease, pulmonary respiratory diseases, osteoarthritis, degenerative joint disease and abnormal lipid and lipoprotein concentrations (28,72,54).

Until recently, the major cause of obesity was thought to be overeating. However, it is now thought that exercise plays a large role in achieving and maintaining ideal body weight. Mayer (38) stated that no factor by itself is more often responsible for the development of obesity in adolescents than physical inactivity. This inactivity also prevails in the adult population.

The use of exercise in weight control often has been overlooked or criticized because of ideas that such a large amount of exercise is needed to counteract caloric intake and that by increasing exercise there also is an increase in appetite and food intake. Both of those ideas suggest that exercise is ineffective in weight loss. Mayer (39) provided information showing that a sound approach to exercise can result in an increase in caloric expenditure large enough to produce a substantial change in caloric balance. The claim that exercise consistently stimulates appetite is not backed by sufficient experimental or clinical findings.

Research data on both laboratory animals and humans have indicated that exercise does not always stimulate appetite and that it may even suppress food intake. Several previous studies have involved male laboratory animals, with little emphasis on the effects of exercise on appetite in female animals. Most of the information obtained regarding humans has not been from studies whose purpose it was to directly examine the effects of exercise on appetite, but from studies whose purpose was to examine other problems. The purpose of this study was to investigate the effects of a regular running program on caloric intake and body composition in female human subjects.

REVIEW OF LITERATURE

ANIMAL STUDIES

Effects of exercise on the appetite of male animals

Studies on male rats have indicated that exercise affects food intake. However, there is lack of agreement in regard to whether it increases or decreases food intake.

Increase. Gleeson et al, (19) observed a net increase in calorie intake of adult male rats run on a treadmill for 56 d compared to control rats. The exercise regimen, which consisted of 1 h of daily running at an 8^{o} incline and a speed of 0.09 km/h, was considered to be low intensity as it only required approximately 30% of maximum areobic capacity. There was an initial reduction in food intake ($P \leq 0.01$), followed by a return to control levels and then an increase of 25% more than that of controls (per 100 g body weight), for a 4.9% greater net intake for the exercisers.

No effect. In contrast to the studies which have shown that exercise is related to appetite suppression, and consequently lowered food intake of male rats, other studies have shown that exercise does not affect appetite, or that it stimulates it. Obviously, in those cases where food intake is not affected, there is a caloric deficit due to the fact that there was no compensation for the increase in energy expenditure. Oscai et al. (47) exercised male rats by swimming for 6 h/d, 6 d/wk until they had completed an average of 162 h of swimming and found no increase in food intake to compensate for the increased energy expenditure. Their results support the idea that prolonged light exercise has no effect on appetite suppression. In another study, Oscai et al. (44) exercised male rats by swimming 6 d/wk. Swimming time was increased from 15 to 360 min over a 4 wk period and maintained for 28 weeks. Food intake remained unchanged in the exercisers compared to sedentary controls. The exercisers consumed an average of 59 kcal/d versus 60 kcal/d for the controls.

In a more recent study, Bell et al. (4) found that a moderate exercise program of swimming 1 h, 3 times per week for 10 weeks had no influence on caloric intake. Similarly, Stevenson et al. (65) found that 4 h of swimming, 4 d/wk for 4 wk, did not affect food intake of rats compared to controls. Thomas and Miller (67) subjected male rats to forced exercise on the treadmill in which duration and intensity were gradually increased from 0.075 miles/d at 0.33 mph to 1.08 miles/d at 0.54 mph at the end of a 19 wk period. Food intake of the exercisers was below that of the controls on days of exercise at an exercise level up to about 1 mile/d, and, at more than 1 mile/d was greater than controls, even on exercise days. The differences, however, were small and insignificant. The weekly food intake of the exercised rats was not significantly lower than that of controls due to a compensation of increased food intake on rest days. Parizkova and Stankova (49) exercised male rats on a treadmill with training gradually increased from 3 to 5 min at a rate of 8 m/min up to 50 min at a rate of 18 m/min/d. The daily caloric intake per 100 g body weight did not differ from the control group. They concluded that the rats adapted to the stress and, thus, there was no need to increase total caloric intake.

Decrease. A number of studies have reported a decrease in food intake as a result of endurance training. Ahrens et al. (2) reported that treadmill running of moderate intensity lowered ($P \leq 0.01$) food intake of male rats. The rats were forced to run .25 mile/d on a treadmill in 30 min. The mean caloric intake per day was significantly lower in exercised rats than in sedentary control rats fed the same diets. Calories per day for the exercisers was 59 versus 71 for controls. Crews et al. (10) also found that when intensity and then duration of treadmill running were increased, there was a decrease in the appetite of male rats. The rats were exercised 5 d/wk during a 12 wk period. A significantly lower ($P \leq 0.01$) caloric intake of 6090 kcal for the runners versus 7638 kcal for the controls was observed for the 12 weeks. Stevenson et al. (65) found that forced treadmill running for 180 min on 4 consecutive days each week for 4 wk decreased food intake of male rats. The exercised rats consumed an average of 11.3 g of food per day over the 4 weeks, compared to 14.7 g for the sedentary controls. In addition, they reported that 1 to 2 h of swimming, 4 d/wk for 4 weeks decreased food intake in male rats. An average of 10.1, 9.6 and 9.2 g/d was consumed by controls, 2 h swimmers and 1 h swimmers, respectively.

In yet another study, swimming 2 h/d, 6 d/wk for 18 weeks resulted in a negative caloric balance in rats (45). The mean caloric intake for the 18 wk period was 9985 for the controls and 8935 for the exercisers ($P \leq 0.02$). Harri et al. (20) found that when male rats were run on a treadmill for 1 h/d up a 17^{o} grade, 5 d/wk for 9 weeks, food intake was decreased compared to controls. In spite of the increased energy expenditure, the runners food intake was 1187 g compared to 1246 g for the control group. Similarly, Pitts and Bull (52) exercised male rats on a treadmill up a 14% grade for 106 d. Caloric intake over the last 20 d of exercise, during which period the animals were running 1.08 km/d, was significantly lower ($P \leq 0.01$) in the exercised group as compared to that of sedentary controls. Nance et al. (43) also found a decrease ($P \leq 0.05$) in food intake on days 2-6 in male rats forced to exercise on a treadmill at 1 mph with a 10^{o} incline, relative to their control group.

When fed highly palatable diets, a decline in food consumption as a result of exercise also was observed (35,36). LeBlanc et al. (35) fed male rats a highly palatable diet and subjected them to 2 h of swimming per day for 10 weeks and found a decrease in food intake compared to controls also fed the highly palatable diet. Rolls and Rowe (56) observed male rats who were given the opportunity to exercise freely on a running wheel and fed a highly palatable diet. The exercising males consumed less food compared to sedentary controls fed the same diet.

Exercise intensity or severity has been related to appetite suppression. In other words, light exercise of long duration may not suppress food intake, while a more severe stress of shorter duration may suppress it. Dohm et al. (13) found that when male rats were exercised on a treadmill at intensities of 20, 27 and 35 m/min for 1 h daily for 6 weeks, food intake decreased, but not significantly, at each intensity. Katch et al. (30) subjected male rats to 1 of 2 exercise conditions of differing intensity but of equal caloric cost. Both exercise groups consumed less food ($P \leq 0.05$) than the control group. Food intake in grams per day was not significantly different for the two exercise groups. However, when food intake was expressed per gram body weight, the high intensity exercise group had a lower ($P \leq 0.05$) intake than the low intensity exercise group.

Effects of exercise on the appetite of female animals

Female rats respond to exercise differently than males in relation to food intake. Most of the studies on female animals show that appetite is increased as a result of exercise.

Increase. In the classic study of Mayer et al. (40), food intake of female rats increased linearly with increasing duration of exercise in the range of 1 to 5 or 6 h has been termed the 'range of proportional response' or normal activity. Rolls and Rowe (56) also exercised female rats on a running wheel and found that the rats appeared to adjust to the increased energy expenditure of exercise by a greater energy intake compared to controls. Nance et al. (43) forced female rats to exercise on a treadmill for a 7 d period and observed an increase in food intake compared to controls. This difference was statistically significant ($P \leq 0.05$) on days, 3, 4, 5 and 7.

Appetite stimulation of female rats who were subjected to a swimming program of 6 h, 6 d/wk was observed by Oscai et al. (47). The females increased ($P \leq 0.001$) their food intake, resulting in weight gain at the same rate as the sedentary controls. The exercisers consumed an average of 75 kcal/d versus 61 kcal/d for the controls. In another study, Oscai et al. (46) exercised female rats by swimming for 16 weeks. Exercise was increased to 6 h/d, 5 d/wk and resulted in an intake of approximately 46% greater ($P \leq 0.001$) than that of the sedentary controls. Mean food intakes for the 16 weeks were 2759 g for swimmers and 1888 g for controls.

<u>No effect or decrease</u>. LeBlanc et al. (35) found that food intake was not affected or was decreased as a result of exercise, depending on whether female rats were fed a standard chow or a highly palatable diet. The exercise training consisted of swimming 2 h/d for 10 weeks. In rats fed standard chow and exercised, there was no difference in food intake compared to controls also fed chow. In rats fed a highly palatable diet and exercised, there was a decrease ($P \leq 0.01$) in food intake compared to controls fed the highly palatable diet. In addition, food intake of those fed the highly palatable diets was always greater than food intake of those fed standard chow. This suggests that consumption of a highly palatable diet promotes food intake (57,58) independent of exercise.

When fed a standard chow diet, it appears there is a possible sex-related difference in appetite response to exercise. In contrast to male rats, female rats have usually exhibited an increased appetite as a result of exercise. The physiological reason behind this difference has yet to be defined.

HUMAN STUDIES

Effect of exercise on appetite in male humans

It is a commonly held belief that exercise increases human appetite and food intake and, thus, counteracts the extra energy expenditure, so that exercise is ineffective in weight loss. However, this belief is not in agreement with results of a number of studies performed on male human subjects.

Increase. A number of studies have shown that there is a corresponding increase in caloric intake with an increase in energy expenditure in male subjects. Vodak et al. (69) compared middle-aged tennis players to sedentary controls and found there was a higher caloric intake ($P \leq 0.05$) by those engaging in exercise. Average caloric intake for the tennis players was 2726 versus 2450 for the controls. Blair et al. (6) observed a greater ($P \leq 0.001$) caloric intake by men running an average of 65 km/wk than by controls. The runners consumed 2959 kcal/d versus 2361 kcal/d for controls. When expressing calories per kg body weight, the differences were even more exaggerated since the runners were significantly lighter in weight. These values were 42 kcal/kg for runners and 30 kcal/kg for controls.

When analyzing results of the Tecumseh Health Study, Montoye et al. (42) found that when subjects were divided into three activity groups (least active, intermediate, most active) that total caloric intake per kg body weight was greater ($P \leq 0.01$) in the most active group. Daily caloric intake expressed as calories per kg body weight was 38.2 for the most active group, 37.4 for the intermediate group and 33.9 for the least active group. Kirsch and Ameln (33) also found that food intake increased in endurance athletes compared to sedentary controls. The subjects studied were 13 long distance runners, 8 cyclists and 8 sedentary controls. The athletes were well trained and trained at least

3 h/d. The total caloric intake for the runners exceeded estimated basal metabolic rate by 103% and the cyclists caloric intake was 250% greater ($P \leq 0.01$) than basal metabolic rate. In comparison, controls consumed only 56% more than BMR. Mayer et al. (41) studied millworkers with varying degrees of physical activity, ranging from sedentary to very hard work. They found that caloric intake increased in proportion to energy expenditure demands of the job, in the classes ranging from medium to very heavy work. This is termed the "normal activity range".

Decrease. Johnson et al. (26) looked at 3 groups of middle-aged men: those who jogged approximately 10 km/wk, men who trained with weights 3 d/wk for 45-60 min and a group of sedentary controls. Although insignificant, they found a trend toward lower caloric intake in the joggers compared to the other two groups. There was little difference between food intake in the other two groups. Edholm et al. (15) also found that food intake of cadet men in training tended to be low on days of high energy expenditure. However, they found that the deficit was compensated for by an increase ($P \leq 0.02$) in caloric intake some 24-48 h later. Watt et al. (71) found a decrease ($P \leq 0.01$) in caloric intake as a result of exercise in 30 postmyocardial infarction patients. The men participated in 36 exercise sessions during a 12 wk period that consisted of a warm-up, walk-jog activities, flexibility exercises and aerobic game activities such as swimming and volleyball. Caloric intake at the start of the program was 2867 and it was 2088 at the end of the 12 wk period. Leon et al. (36) subjected young men to an exercise program of walking where intensity and duration were gradually increased over a 4 month period. An initial increase in food intake failed to keep pace with the increased energy expenditure and by the fourth month, caloric intake had decreased ($P \leq 0.01$) below control levels, which suggested a reduction in appetite. At week zero caloric intake was 2288 and at week 4 it was 2149.

No effect. In contrast to studies reporting a decrease in caloric intake, some studies have shown that there is no effect of exercise on the food intake of male subjects. Dempsey (11) subjected young males to three different phases of activity : 1. daily training of 1 h for 8 weeks, 2. lower or normal activity for 5 weeks, and 3. daily training of 1 h for 5 weeks, and found there was no significant difference in mean caloric intake among the 3 phases. The daily training sessions consisted of calisthenics, interval running, circuit training, weight training, isometric contractions and individual and dual sports. Caloric intake also was recorded 3 weeks prior to the first phase of exercise and there were no significant differences between this pre-phase and the other phases. Holloszy et al. (23) also found that exercise had no effect on food intake when he subjected middle-aged men to a 6 month program of running and endurance calisthenics. The men ran 2 to 4 miles on an average of 3.35 times per week for the 6 month period. Wood et al. (78) subjected middle-aged men to a running program and found no significant differences in food intake between the exercisers and sedentary controls.

Effect of exercise on the appetite of female humans

Most of the research on female subjects has shown that exercise increases food intake or has no effect. However, it also has been shown to decrease food intake.

Increase. Researchers have found that exercise produced an increase in food intake in both male and female tennis players (69) and runners (6). The tennis players consumed an average of 2417 kcal/d versus 1490 kcal/d for the sedentary controls. The runners reported a daily intake of 2368 kcal compared to 1871 kcal by the controls. When expressed as kcal/kg body weight, the difference ($P \leq 0.001$) between the runners and controls was even greater. The runners consumed 42 kcal/kg and the controls consumed 27 kcal/kg. Smith et al. (62) examined competitive and synchronized female swimmers and compared them to sedentary controls for a 24 wk period. The competitive swimmers swam 6 d/wk with an average of 8000 yd/d, while the synchronized swimmers swam an average of 3 d/wk, 1500 yd/d. They found that as physical activity increased, there was a significant increase in caloric intake. The competitive swimmers consumed 7.5% more ($P \leq 0.05$) calories than the synchronized swimmers and 21.5% more ($P \leq 0.05$) than the sedentary controls. Parizkova and Poupa (48) studied female gymnasts who had attended a sports school for 3 to 4 years and found that caloric intake was 25% greater during intensive training than during periods of relative rest. Similarly, Stefanik et al. (64) found that caloric intakes paralleled increases in exercise in college females. Food intake was recorded in the fall and then again at the end of a spring camp where exercise was increased for a 4 wk period. Caloric intake per day in the fall was 2015; it had increased to 2806 per day at the end of the spring camp.

No effect. In contrast to an increase in caloric intake as a result of exercise by normal weight persons, Woo et al. (76,77) found that there was no compensatory increase in caloric intake due to exercise of mild to moderate intensity in obese subjects. Katch et al. (31) also found no significant differences in food intake before and after a 16 wk training program undertaken by college females on the tennis and swimming teams. The training was considered moderate for the tennis players and strenuous for the swimmers. The tennis players consumed 1811 kcal/d before training and 1797 at the end of the training period. Caloric intake for the swimmers was 2091/d before training and was 2065/d after the 16 weeks of training.

Decrease. Johnson et al. (27) found that mean daily caloric intake decreased significantly as a result of a 10 wk exercise program undertaken by college women. The exercise program consisted of 30 min periods, Monday through Friday on a bicycle ergometer. Caloric intake decreased 9.5% from the start of the program to week 10 (1751 kcal to 1584 kcal).

METHODOLOGY AND PROCEDURES

Subjects

The subjects were 26 adult women, 20-32 years of age, in good general health, and within the ranges for suggested desirable weights for heights, according to the Recommended Dietary Allowances, 1980 (55). For the purpose of recruitment, notification and a brief description of the study was sent to all faculty and graduate students in the College of Home Economics at Kansas State University and announcements were made in several nutrition classes (see Appendix). A screening questionnaire, 'Exercise, Diet and Medical Questionnaire' (see Appendix) was distributed to interested participants to eliminate persons with special health or dietary problems and to categorize the potential subjects into groups, based on physical activity.

Sixteen females were selected and grouped into two exercise groups: a low mileage group (n=10) that had run 20-30 miles/wk and a high mileage group (n=6) that had run 40 or more miles/wk for at least one year. Ten females who were not participating in any regular exercise programs were selected as controls. Neither exercisers nor controls were actively seeking weight loss or gain by dietary means. All subjects were instructed concerning the procedures of the investigation and provided informed consent (see Appendix).

Body composition

Body composition was determined in the Exercise Physiology Laboratory by use of the hydrostatic weighing methods described by Behnke and Wilmore (3). Subjects were weighed on a balance beam scale (HOMS,model 150 TK) to the nearest $\pm$ 50 grams. Hydrostatic weights were determined on a 9 kg autopsy scale (Chatillon) accurate to $\pm$ grams. Consecutive underwater weights were recorded until a plateau value could be verified as described by Katch (32). Three plateau values were averaged and used to calculate body density (D_b). The Siri equation was used to convert D_b to percent body fat (61): Percent body fat $= \left(\frac{495}{\text{Density}}\right) - 450$

Subjects were instructed to report to the laboratory after a minimal 6 hour fast and to eliminate gas forming foods from their diets prior to testing. No corrections were made for gastrointestinal air volume. Subjects wore nylon swimming suits during all weighings and subsequent anthropometric measurements.

Pulmonary residual lung volume was determined just prior to the underwater weighings. The residual lung volumes were determined by a nitrogen analyzer (model 47302A - Hewlett-Packard) using the closed-circuit oxygen dilution technique described by Wilmore (73).

Anthropometrics

Skinfold thickness was measured at various body sites to describe fat distribution. Skinfold thickness was measured at the triceps, subscapula, suprailiac, abdomen and thigh. Sites for the skinfold measurements were selected from those used in previous studies for estimating body density of females and those considered most appropriate for age and sex (14,24,25,29,74).

All anatomical landmarks for the skinfold measurements have been previously described by Behnke and Wilmore (3). The measurements were taken to the nearest mm with a Harpenden skinfold caliper (Holtain Ltd.) with a constant pressure of 10 g/mm^2. Measurements were taken on the right side, with the subject standing. Although no statistical differences have been found between measurements on the right and left sides of the body (7,75), measurements are usually taken on the right and norms have been established from the United States Health and Nutritional Examination Survey I of 1971 to 1974, using triceps skinfold measurements taken from the right side (16). All measurements were taken with triplicate determinations made to assure accuracy. If the three readings were not in agreement, additional measurements were taken until agreement was obtained. The three values were then averaged.

Caloric cost of running

Subjects ran for 10 min on a treadmill at their self-selected training pace. Oxygen consumption was determined for each of the last three minutes of the run. The 3, 1-minute determinations were compared to establish that the runners were in steady-state during the run (i.e. that oxygen supply to the tissues was sufficient to meet demands).

Subjects running on the treadmill breathed through a Daniels 3-way valve, with exhaled gas sampled from a 4 liter mixing chamber. An Alpha Technologies ventilation meter measured expired volume. Gases were analyzed using the Beckman LB-2 analyzer for carbon dioxide and the Beckman OM-11 analyzer for oxygen. The gases were sampled in series for oxygen and carbon dioxide content. The gas analyzers were calibrated by previously verified gases prior to each test.

The respiratory quotient was determined by calculating the ratio of the volume of CO_2 expired to the volume of O_2 consumed. This calculation was then used to determine the non-protein caloric expenditure per minute of running, according to a table of caloric equivalents for oxygen at different non-protein respiratory quotients (9).

Record keeping

The control group recorded on a diet record form (see Appendix) the type and quantity of all foods and beverages consumed for a period of 7 consecutive days. The exercise groups also recorded on a running and diet form (see Appendix) the type and quantity of all foods and beverages consumed, as well as amount of time spent running and the estimated mileage each day for a 7 day period. Prior to the recording period the subjects were instructed on food record keeping. Food/running records were turned into the researcher(s) daily and checked for completeness and adequacy. Additional information was then obtained when necessary. Although 7 day food records have been shown to be valid tools for the assessment of most nutrients during the early stages of record keeping, validity does decline in the later days (18). The daily cross checking of records served as reinforcement of accuracy in recording and was important to minimize the possibility of bias in data analysis.

Diet analysis

Estimated nutrient intakes from 7-day food records were analyzed for calories, protein, carbohydrate and fat. The items from the diet records were computer coded and run on a nutrient data program using USDA data from the Agricultural Handbook No. 456, Nutritive Value of American Foods and Agriculture Handbook No. 8, (1-9).

Statistical analysis

An analysis of variance design was used to determine if any significant differences occurred in caloric intake attributable to miles run. This mixed-effects model was also used to study differences in body composition measurements as a result of miles run. The analysis of variance was as shown in Table 1. Correlation coefficients were determined on body composition measurements, dietary data and miles run by using the Pearson product moment correlation formula.

Table 1. Analysis of variance

Source of variation	DF
Groups (fixed)	2
Subjects: Group	23
Total	25

RESULTS AND DISCUSSION

Body composition

Mean skinfold measurements and percent body fat are shown in Table 2. The controls had a greater ($P \leq 0.05$) percentage of body fat, as well as a greater ($P \leq 0.05$) amount of subcutaneous fat in the subscapular, triceps, suprailiac and abdominal areas, than the two exercise groups. The thigh skinfold of the controls was higher ($P \leq 0.05$) than that of the high mileage group, but was not significantly different between the controls and the low mileage group. These measurements were similar to those of other studies (14,24,25,29,31,60) which showed that those who exercise are leaner than those who do not (Table 3).

Although skinfold measurements and percent body fat were slightly higher for the low mileage group than for the high mileage group, there were no significant differences in any of the variables between the two exercise groups. There appears to be little doubt that exercise had a significant effect on improving body composition, however, increasing running distance did not further decrease indicators of fat.

The skinfold measurements were not strongly correlated with percent body fat in either of the two running groups (Table 4). The best correlations with percent body fat for the low mileage group was the triceps ($r = .29$, $P \leq .42$) and the thigh ($r = .26$, $P \leq .46$). The triceps ($r = .70$, $P \leq .12$) and suprailiac ($r = .52$, $P \leq .29$) skinfolds were slightly more correlated with percent body fat in the high mileage group. Suprailiac ($r = .62$, $P \leq .05$) and abdominal ($r = .70$, $P \leq .01$) skinfolds were significantly correlated with percent body fat in the control group. Other investigators (25,29,53) of athletes and non-athletes have found better overall correlations of percent body fat with the five skinfolds

Table 2. Means* for physical characteristics of running and control groups.

	Groups			
	Controls (n=10)	Low mileage (n=10)	High mileage (n=6)	Pooled Estimate of SD **
Age (yr)	23.9	23.6	26.8	
Height (cm)	168.5	161.7	163.4	
Weight (kg)	61.3	53.9	53.4	
Triceps (mm)	20.7	14.3	11.5	± 4.3
Subscapula (mm)	14.3	8.2	8.0	± 4.2
Abdomen (mm)	19.3	13.0	10.2	± 5.7
Suprailiac (mm)	15.6	10.2	9.0	± 4.9
Thigh (mm)	29.3	23.0	19.9	± 6.4
Body fat (%)	32.8	21.9	18.8	± 3.6
Weight/height	36.4	33.2	32.7	± 3.3

* Figures with different letters in each horizontal row are different at $P \leq 0.05$.

** Pooled estimate of standard deviation using 23 degrees of freedom.

Table 3. Means* for other studies of body composition of women.

	Jackson and Pollock (1976)	Sinning and Wilson (1984)	Katch and McArdle (1973)	Katch, Michael and Jones (1969)	Jackson, Pollock and Ward (1980)	Durnin and Womersly (1974)
Number & age	83 (18-22)	79 (17-22)	69 (college age)	15 (college age)	249 (18-55)	100 (20-29)
Activity group	about 15% P.E. majors or athletes	collegiate athletes	P.E. class	5 swimmers 10 tennis players	activity & exercise varied	moderately sedentary
Triceps (mm)	18.8 ± 5.0	15.1 ± 4.4	21.6 ± 5.3	10.5 ± .7 12.7 ± 2.4	17.6 ± 5.7 **	21.0 ± 10.0
Subscapula (mm)	15.3 ± 6.5	12.0 ± 4.6	18.8 ± 6.0	10.9 ± 1.9 9.0 ± 1.6	13.8 ± 6.1	18.0 ± 11.0
Abdomen (mm)	22.8 ± 7.2	14.7 ± 5.1	25.0 ± 7.4	14.8 ± 3.3 13.9 ± 6.2	23.4 ± 9.4	
Suprailiac (mm)	15.3 ± 6.2	15.5 ± 6.4	26.8 ± 7.7	13.6 ± 3.0 14.4 ± 4.0	13.5 ± 6.9	18.0 ± 12.0
Thigh (mm)	28.8 ± 6.8	25.8 ± 6.6	29.8 ± 6.7		29.2 ± 7.9	
Body fat (%)	24.8 ± 6.4	20.1 ± 5.3	25.6	23.2 ± 2.0 24.2 ± 3.3	21.8 ± 6.4 †	29.0 ± 10.0

* Figures represent mean ± SD.
** Skinfold values are means for entire age group.
† % body fat is mean for 20-29 year olds (n = 102).

Table 4. Correlations(r) of anthropometric measurements with percent body fat and weight/height index and the correlation of % body fat with weight/height index.

	Controls		Low mileage		High mileage	
	with wt/ht	with % body fat	with wt/ht	with % body fat	with wt/ht	with % body fat
Triceps (mm)	0.56 †	0.29	0.41	0.29	- 0.42	0.70
Subscapula (mm)	0.45	0.34	0.28	0.08	- 0.40	- 0.24
Suprailiac (mm)	0.31	0.62 **	0.66**	- 0.01	- 0.005	0.52
Abdomen (mm)	0.01	0.75 *	0.62 †	0.04	- 0.29	0.47
Thigh (mm)	0.37	0.54	0.41	0.26	0.40	0.30
Body fat (%)	0.35		0.15		- 0.54	

* Significant at $P \leq 0.01$.
** Significant at $P \leq 0.05$.
† Signficant at $P \leq 0.10$.

used in this study.

There was a difference ($P \leq 0.05$) in the weight/height index only between the control and high mileage groups (Table 2). There were no significant correlations between weight/height index and percent body fat. The triceps skinfold was most highly correlated with weight/height index ($r = .56$, $P \leq .09$) in the control group, while the suprailiac ($r = .66$, $P \leq .04$) and abdominal ($r = .62$, $P \leq .06$) skinfolds were correlated with it in the low mileage group. No skinfolds were significantly correlated with weight/height index in the high mileage group. Watson et al. (70) in predicting body fat from individual weight and height indices, found that the weight/height index was the best single indice for women. They stated that the best weight and height indices for predicting body fat are those that are not only poorly correlated with height and strongly correlated with weight, but also well correlated with other indicators of body fat.

Mean caloric intake per day

Caloric evaluations were made from seven-day dietary records. Table 5 presents the mean caloric intakes for the three groups, as well as percent of total calories consumed as carbohydrate, protein, fat and alcohol. Mean caloric intakes of all three groups in the present study fall at the lower end of the recommended range of 1600 to 2500 kcal/d for 19-50 year old females doing light work (55).

There were no significant differences in mean calories consumed per day among the three groups (sedentary controls, low mileage runners and high mileage runners)(Table 5). The finding that caloric intake was not different is in contrast to other studies that have shown that caloric intake increased or decreased as a result of exercise. In three different studies (6,62,69), groups of established female exercisers consumed more calories than sedentary control groups. In other studies (27,31,64), caloric intake was recorded for sedentary female subjects prior to initiating an exercise program and then again on the same subjects at the end of the program. In two of the studies (31,64), caloric intake was greater after the exercise program and in one study (27), it was less. The appetite response to a newly undertaken exercise program by sedentary individuals may be quite different than the appetite of established exercisers. It would, thus, seem most appropriate to make comparisons to studies involving established exercisers, rather than to those initiating exercise programs.

The findings in this study that the mean caloric intake of the high mileage runners (40 miles/wk) was not significantly different from that of the low mileage runners (20-30 miles/wk) does not agree with those of Smith et al. (62). They examined competitive swimmers, synchronized swimmers and sedentary controls and found that as exercise increased, caloric intake increased.

In the present study there was no linear relationship between exercise

Table 5. Means* for caloric intake of runners and controls.

Measurement	Groups: Controls	Low mileage	High mileage	Pooled estimate of SD**
Total calories	1796a	1624a	1874a	± 478
Carbohydrate, % of kcal	49.5a	50.7a	49.2a	± 9.7
Protein, % of kcal	14.1a	15.5a	18.1b	± 2.6
Fat, % of kcal	36.9a	36.0a	31.7a	± 7.3
Alcohol, % of kcal	0.66a	0.77a	3.09b	± 1.9
Calories/kg body weight	29.7a	30.3a	34.9a	± 8.6
Calories/kg lean body weight	44.4a	38.8a	42.7a	± 11.0

* Figures represent means ± SD. Numbers with different letters in each horizontal row are different at $P \leq 0.05$.
** Pooled estimate of standard deviation using 23 degrees of freedom.

and caloric intake, however, there was a lower (but nonsignificant) caloric intake for the low mileage group as compared to both control and high mileage groups. Mayer and associates (40,41) found that food intake of animals and man increased with activity only within a certain range or zone, termed the 'normal activity range'. Below that range, which has been termed 'sedentary', a further decrease in activity was not followed by a decrease in caloric intake, but by an increase. They observed that light work resulted in a decrease in caloric intake, followed by a linear increase in caloric intake as activity increased. Depending on the energy expenditure of the activity, the caloric intake may equal that of the sedentary or surpass it. The present study can be compared to Mayer's findings if the low mileage group is considered to be participating in light activity or work. This would explain the fact that the sedentary controls consumed more than the low mileage group and that once activity was greater than that of "light work", caloric intake increased so that it was slightly greater than that of the control group.

Although the exercise performed by the high mileage group in this study was vigorous, it certainly cannot be compared to that of lumberjacks, farm laborers and endurance athletes whose energy expenditure is maintained for long periods of time, and who may consume more than twice the calories per day than do sedentary individuals. One would expect to see a linear increase in caloric intake as exercise increased in those individuals mentioned, where exercise was prolonged. When considering the dietary intake for people such as our subjects who train for comparatively short periods at a time, the apparent appetite-stimulating effect of exercise and corresponding calorie increase was noticeably reduced.

The caloric intake (1796) for our controls was lower than that (2031) reported by Stefanik et al. (64) for college women in physical education classes by Fry (17) for 18 to 25 year old women (2024) and by Blair et al. (6), who also reported a higher intake (1871) in middle-aged female controls than in the present study. Johnson et al. (27) reported a similar intake of 1751 calories, while Vodak et al. (69) reported a lower intake by controls of 1490 calories. The caloric intakes by our low and high mileage runners of 1626 and 1874, respectively, is somewhat lower than that found by Blair et al. (6) of 2836 for runners. Vodak et al. (69) also found that tennis players consumed more calories (2417) than was found in the present study. Katch et al. (31) reported that swimmers consumed 2091 calories, which is more than found in our study, while tennis players consumed a comparable amount, at 1811 calories. Berning et al. (5) found that female runners who trained more than 40 miles per week consumed 1763 kcal/d, which is about 100 kcal/d less than the comparable high mileage group ($\geq$40 miles/wk) in the present study.

Calories per kilogram body weight

Division of calories consumed by weight (kg) standardizes caloric intake for body size and strengthens the relationship between dietary measures and physical activity (50). As with total caloric intake, there were no significant differences in kcal/kg among the three groups. However, there was a trend to increased kcal/kg intake as exercise increased (Table 5), whereas total calories were less for the low mileage runners than for the controls or high mileage runners.

A negative, though nonsignificant, relationship was found beween kcal/kg and percent body fat in both the high mileage group ($r = -0.70$, $P \leq 0.12$) and the low mileage group ($r = -0.41$, $P \leq 0.24$). Thus, runners who had the highest caloric intake/kg tended to have the lowest body fat. It has been found that total daily caloric intake correlates poorly with obesity (68,79) and that there is an inverse relationship between kcal/kg and body fatness (34,63). In the present study, kcal/kg decreased as body fatness increased in both exercise groups. Therefore, a high caloric intake, when corrected for body size, did not necessarily reflect a high percent of body fat, indicating that other factors, such as training, were stronger influences.

Calories per kilogram lean body weight

Division of total calories consumed by lean body weight (kcal/kgLBW) standardizes for body composition. As with mean calories consumed and kcal/kg body weight, there were no significant differences in kcal/kgLBW among the three groups. However, there was a trend to lower kcal/kgLBW in the low mileage group, similar to that found in mean caloric intake.

Carbohydrate, protein and fat as percentage of total calories

The percentage of total calories from carbohydrate (49.5, 50.7, 49.2) for the three groups were lower than that (58%) proposed in the U.S. dietary goals (59), but comparable to that (48%) of the current U.S. diet. The percentages of calories from protein (14.1, 15.5, 18.1) were higher than that (12%) proposed in the U.S. dietary goals, while both control and low mileage groups consumed a considerably higher percentage of total calories from fat (36.9, and 36.0 respectively) than that (30%) suggested by the U.S. dietary goals. The high mileage group consumed a percentage of total calories as fat (31.7) comparable to the U.S. dietary goal. All groups consumed less calories as fat than the average American diet of 40-45%.

Carbohydrate. A high percentage of calories as carbohydrate often is recommended to those taking part in endurance events to increase glycogen stores and to increase overall muscular efficiency (12,39). During steady-state exercise, the respiratory quotient gradually increases from a resting value of about 0.85 to about 0.90 or 0.95. Thus, although fat utilization is occurring, there is the preference to burn carbohydrate during muscular activity (12). DeVries stated that while fat produces more than twice as much energy per gram as carbohydrate, more oxygen is required for each calorie. Thus, there would appear to be an advantage for use of carbohydrate when engaged in aerobic exercise.

Neither the high mileage runners or the low mileage runners consumed a greater percentage of total calories as carbohydrate (49.2 and 50.7, respectively) than did the sedentary controls (49.5). However, percentages of total calories from carbohydrates was higher than those found in other studies of female runners and controls. The percentage of carbohydrate consumed by 18-25 year old women studied by Fry (17) was 45. Johnson et al. (27) found the percentage of calories from carbohydrate was 44.9 for college age women during a control period, and it was 41.9 after ten weeks of exercise. Blair et al. (6) found in middle-aged females that controls consumed 39.1 percent of their calories as carbohydrate and runners consumed 39.5 percent.

Protein. Percentage of protein tended to increase as exercise increased, but was significantly different only between the controls and the high mileage group. The results are in contrast to other studies that indicate a lower percentage of calories from protein in exercisers than in controls. Johnson et al. (27) reported 16.2 percent and 15.2 percent for the control period and after 10 weeks of exercise, respectively. Blair et al. (6) found that female runners consumed 14.2 percent of calories from protein and controls consumed 17.4 percent ($P \leq 0.0006$).

Fat. There were no significant differences between the groups in percentage of calories from fat. Although the differences were not significant, the high mileage group did consume the least amount of their calories as fat (31.7%) and was quite close to the U.S. dietary goal for percentage of calories from fat (30%) (59). All groups consumed less calories as fat than have been found in other studies. Johnson et al. (27) reported 38% of calories as fat during a control period and 41.5% after 10 weeks of exercise. Similarly, Blair et al. (6) found that controls consumed 40.3% of calories as fat, while runners consumed 41.4%. The results found in the present study of a decrease in percentage of calories as fat as exercise increased is in contrast to the above studies.

Alcohol

Four out of ten, six out of ten and five out of six subjects in the control, low mileage and high mileage groups, respectively, reported the consumption of alcohol on their food records. There was no significant difference between the control group (0.66%) and the low mileage group (0.77%) in the percent of calories from alcohol consumed. However, the high mileage group consumed significantly more calories as alcohol (3.09%) than did either of the other two groups (Table 5). Thus, runners were more likely than controls to report drinking alcohol and the percent of calories consumed as alcohol tended to increase as exercise increased.

Similarly, others (6,78) have found that exercisers consumed more alcohol than nonexercisers. Wood et al. (78) found that female runners consumed 6.2% and controls 4.6% of their calories as alcohol. Blair et al. (6) reported 5.1% and 3.3% of calories from alcohol for female runners and controls, respectively. Other studies have reported contrasting results that show marathon runners consumed less alcohol than joggers or inactive subjects (21,22).

Eating frequency

The eating habits of the three groups revealed that only 19% of the subjects consumed 3 regular meals on each day of the 7 day period (Table 6). There were no

Table 6. Frequency of food consumption.*

	Meals	Snacks	Total
Controls	2.7	2.3	5.0
Low mileage	2.6	2.3	4.9
High mileage	2.5	3.5	5.9

*Means for values are on a per day basis and are averaged over the 7 day period.

statistical differences in the frequency of meals and snacks consumed by the three groups, even though the high mileage group tended to consume more snacks and slightly fewer meals that the other groups. This observations may be of importance, when considering the study by Cohn and Joseph (8) who divided experimental rats into two groups: those which ingested their calories in small frequent feeding ("nibbling") and those who consumed large amounts of food as spaced full meals ("meal eating"). They found that the manner of eating appears to alter metabolic reactions. When meal eating was compared to nibbling, it was found that meal eating was associated with increased body fat, decreased body protein, altered enzymatic activities within tissues and changed thyroid activity. These concepts and implications may be applicable to man. Our high mileage group had the lowest percentage of body fat and appeared to eat more frequently than the other groups.

Miles run, days run and calories expended

The low mileage group trained at an average running pace of 6.6 mph while the high mileage group trained at an average pace of 7.4 mph (Table 7). The low mileage and high mileage groups expended 10.5 kcal/min and 15.5 kcal/min, respectively, during running. Calories expended per mile were 96 for the low mileage group and 94 for the high mileage group.

As would be expected, there were differences ($P \leq 0.0001$) between the two groups in average miles run per day and calories expended in running per day (Table 7). However, there were only small differences in number of days run between the two

Table 7. Mean miles run/day, kcal expended per day, per mile and per minute and running pace.†

	Low mileage group	High mileage group
Running pace (mph)	6.6*	7.4
Miles run/day	3.7 ± 2.0a	6.9 ± 4.06
Kcal expended/mile	96*	94
Kcal expended/min	10.5*	15.5
Kcal expended/day **	329 ± 193a	643 ± 398b

* Figures represent means of 9 subjects (data was not obtained on 1 subject).
** Figures are based on calories expended/min.
† Figures with different letters in each horizontal row are different at $P \leq 0.001$.

groups. Runners in the low mileage group ran an average of 5.8 days and 25.6 miles/week, while the high mileage group ran an average of 6.2 days and 47.9 miles/week (Table 8). Since calories expended during running is a function of duration, or in this case, distance, it would follow that those who ran longer, or further, would expend a greater amount of calories.

Body weight is an important factor that affects the energy expended in running. The energy cost of running is generally greater for heavier people (37). The generalization that a person expends 100 calories per mile does not take body size into account. To eliminate this error and closer approximate calories expended during running, the caloric cost of running was determined at a pace selected by each subject. Unfortunately, this method is not yet free of error since one cannot be guaranteed that the selected pace is the one at which the subject trained daily. The total caloric cost of running a given distance is approximately the same whether the pace is fast or slow, based on the linear relationship between oxygen consumption and running speed (37). Thus, there are small variations in calories expended per mile due to fluctuations in running pace. Calories expended per mile in this study ranged from 81.1 - 124.5 and averaged 95. The value of 95 calories per mile is slightly lower than the average value of 100 calories per mile, but can be explained by the small size of the runners, who averaged 57.2 kilograms (125.9 lbs) body weight.

Table 8. Total miles and days run/wk by the two running groups.

Subject No.	Low Mileage Group Total Miles	Days Run	High Mileage Group Total Miles	Days Run
1	26.2	6	59.0	7
2	24.0	6	44.5	6
3	24.0	6	46.8	7
4	22.5	5	30.7*	5
5	29.0	7	60.0	5
6	27.5	5	46.2	7
7	33.8	7		
8	21.7	6		
9	24.8	5		
10	22.0	5		
mean	25.6	5.8	47.9	6.2

* This subject normally ran ≥ 40 miles/wk, but did not during the 7 day recording period.

Calories expended versus calories consumed

The high mileage group expended approximately 4439 calories/wk and spent an average of 6.5 h/wk during running. The low mileage group expended approximately 1216 calories/wk in running and ran an average of 3.8 h/wk. The caloric intakes for both groups, 1874 and 1624 calories per day, for high mileage and low mileage groups, respectively, appear insufficient to support the level of running consistently undertaken by the two groups (Table 9). By using the estimated values of 643 calories expended in running per day for the high mileage group and 329 calories expended in running per day for the low mileage group, and subtracting these values from average caloric intake, these runners existed on 1231 (high mileage) and 1295 (low mileage) calories per day. In addition, these runners reported being active in other activities such as aerobics, bicycling, swimming and weight training, which would further increase average daily energy expenditure and put them in even greater negative caloric balance. Similar results have been found by Berning et al. (5).

Table 9. Calories expended and consumed by low mileage and high mileage groups.

Subject No.	Low Mileage Group		High Mileage Group	
	Kcal expended*	Kcal consumed**	Kcal expended	Kcal Consumed
1	366	1895	680	1346
2	340	1550	685	1004
3	315	1581	728	3358
4	254	1716	419	1896
5	†	1076	843	2309
6	278	1381	505	1332
7	367	1434		
8	405	1642		
9	310	2238		
10	322	1695		
means	328.5	1623.7	643.3	1874.1

* There were significant differences in kcal expended between groups ($P \leq 0.05$).
** There were no significant differences in kcal consumed between groups.
† Data was not obtained.

The runners were not actively seeking weight loss through dietary means and they had reported a recent change in body weight. Considering the fact that basal metabolic rate declines as an adaptive mechanism to conserve energy in chronic undernutrition (51), it is logical to apply this reasoning to a number of individuals in the running groups and conclude that they have adapted to a low energy intake, and as a result, body weight remained constant even though calorie intake was low.

SUMMARY

The effects of a consistent running program on caloric intake and body composition were studied in women aged 20 to 32. The subjects were divided into three groups: 10 sedentary controls, 10 low mileage runners, who ran 20-30 miles/wk and 6 high mileage runners, who ran 40 or more miles/wk. Body composition was determined by underwater weighing and anthropometric measurements. Body density was determined by hydrostatic weighing and then converted to percent body fat. Skinfold thickness was measured at the triceps, subscapula, abdomen, suprailiac and thigh sites to describe fat distribution. The caloric cost of running was calculated by steady-state treadmill running and determination of the respiratory quotient by calculating the ratio of the volume of CO_2 expired to the volume of O_2 consumed. Seven-day food records were kept by all subjects. The runners also recorded time spent running and estimated mileage for the same 7-day period. Items from the food records were computer coded and analyzed for calories, carbohydrate, protein, fat and alcohol, using U.S.D.A. food composition tables.

There were no significant differences in percent body fat and skinfold measurements between the two running groups. Both running groups had significantly lower ($P \leq 0.05$) values for percent body fat and all skinfold measurements than the control group, except the thigh skinfolds were not significantly different between the low mileage runners and the controls. The skinfold measurements were not strongly correlated with percent body fat in either of the two running groups, but suprailiac ($r = .62$, $P \leq .05$) and abdominal ($r = .75$, $P \leq .01$) skinfolds were significantly correlated with percent body fat in the control group. There was a difference ($P \leq 0.05$) in the weight/height index only between the controls and high mileage runners. The triceps skinfold was most

highly correlated with the weight/height index ($r = .56$, $P \leq .09$) in the control group, while the suprailiac ($r = .66$, $P \leq .04$) and abdominal ($r = .62$, $P \leq .06$) skinfolds were correlated with it in the low mileage group. No skinfold measurements were significantly correlated with weight/height index in the high mileage group.

There were no significant differences in mean total calories, kcal/kg body weight or kcal/kg LBW among the three groups. A negative, though nonsignificant, correlation was found between kcal/kg body weight and percent body fat in both the high mileage and low mileage groups. Thus, runners who had the highest caloric intake/kg tended to have the lowest body fat.

There was no significant difference in percentage of total calories as carbohydrate among the three groups. Percentage of protein tended to increase as exercise increased, but was significant only between the controls and the high mileage group. Percentage of calories as fat tended to decrease as exercise increased, however, there were no significant differences among the groups. The high mileage group consumed more ($P \leq 0.05$) calories as alcohol than did either of the other two groups.

Runners in the low mileage group ran an average of 5.8 days and 25.6 miles/wk, while the high mileage group ran an average of 6.2 days and 47.9 miles/wk. The low mileage and high mileage groups expended approximately 1216 and 4439 kcal/wk, respectively, during running. By using the estimated values of 329 calories expended in running/d for the low mileage group and 643 calories expended in running/d for the high mileage group, and subtracting these values from average caloric intake (1624 and 1874, respectively), these runners existed on 1295 (low mileage) and 1231 (high mileage) kcal/d.

Only 19% of the subjects consumed 3 regular meals on each day of the 7-day period. There were no significant differences in the frequency of meals or snacks consumed by the three groups, even though the high mileage group tended to consume more snacks and slightly fewer meals than the other groups.

This study indicated that a consistent running program in young females resulted in significantly smaller skinfold measurements and lower percent body fat than in sedentary individuals. However, total caloric intake, percentages of total calories from carbohydrate, protein and fat and frequency of eating were not significantly influenced by running.

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APPENDIX

FEMALE RUNNERS NEEDED !

For: a Master's research project investigating the effects of running on appetite. Your body composition and caloric cost of running will be determined.

CRITIERIA:

-female
-20 to 30 years of age
-must have been running (or jogging) a minimum of 2 miles per day, 5 times per week consistently for at least 1 year.

Controls who do not engage in any regular exercise are also needed.

__________ I would be interested in being a subject (runner).

__________ I would be interested in being a control.

Name ______________________________

Dept. ______________________________

Phone ____________________

Please return to: Kris Williams
Foods and Nutrition
Justin Hall 209

EXERCISE, DIET AND MEDICAL QUESTIONNAIRE

This information is strictly confidential and will be used only by the researchers.

Please fill out the following form as completely as possible.

Name ____________________ Date ________ Age ___ Birthdate ________

Campus Address ________________________ Phone __________

Home Address ________________________ Phone __________

Occupation (student, faculty, etc.) ______________ Sex _____

Activity level: very sedentary ____
sedentary ____
light ____
moderate ____
heavy ____
very heavy ____

Height ________

Weight ________

Number of miles run per week __________

Number of days run per week __________

Minutes run per exercise bout __________

How long (in months, years) have you been running?

Do you engage in any regular type of exercise other than running? If so, list the activities and frequency of participation:

What are your reasons for running?

Are you trying to lose weight? gain weight?

Has your food intake increased or decreased since you have been running? If so, explain:

Do you notice a difference in your food intake on days you run versus days you do not? If so, explain:

Do you have any type of disease that might influence your food intake? (i.e. diabetes, hypoglycemia, etc.)

Do you have any health problems that might limit you in some way when exercising?

Do you smoke? If so, how much?
Do you consume alcohol? If so, how much and how often?

Do you take oral contraceptives?

Questionnaire - continued

Do you take any regular medications? If so, for what purposes?

List medications

Check if you have any of the following:

____ diabetes mellitus

____ thyroid disorder

____ high blood pressure

____ chest pains

____ heart murmur

____ kidney disorder

____ any type of infection

____ any type of tumor

____ frequent colds

____ frequent sore throat

____ irregular menstrual cycle

____ chronic constipation or irregularity

____ diarrhea

____ gall bladder disease

____ gastric or duodenal ulcer

____ anemia

____ any nervous or emotional problems

____ recent weight change

____ poor appetite

____ excessive weakness or tiredness

____ vomiting

____ menstrual cramps

Questionnaire - continued

What do you consider a good weight for yourself?

What is the most you have ever weighed? At what age?

Weight now: Weight one year ago:

Number of meals you usually eat per day ____

Number of snacks you usually eat per day ____

List any vitamin-mineral supplement or any other supplements taken on a regular basis. Also list the brand name and nutrient composition.

Number of times per week you usually eat:

____ beef

____ pork

____ fish

____ fowl

____ eggs

____ variety meats

____ cheese

____ milk

____ other dairy products - list items

____ bread

____ cereals

____ cakes, cookies, pastries

____ other desserts - list items

____ fruit or juices

____ vegetables

____ fats - oils, salad dressing, butter, margarine, etc.

Questionnaire - continued

____ legumes, beans, etc.

____ other (indicate)

____ regular soft drinks

____ diet soft drinks

____ beer

____ other alcoholic beverages - list

PROJECT TITLE: EFFECTS ON YOUNG WOMEN OF A REGULAR RUNNING PROGRAM

INVESTIGATORS: Beth Fryer, Project Director
Kris Williams, Graduate Assistant
Karen Wiese, Graduate Assistant

JUSTIFICATION: Running is one of the more popular forms of exercise for many young women. Reports of the effects of running on women have not always been in agreement. In this study, two groups of young female runners (20-30 miles/wk and 40 or more miles/wk) will be compared with each other and with a sedentary control group. Factors to be studied will include: 1) caloric intake and body composition; 2) iron status; and 3) plasma lipids and nutrient intake.

AGREEMENT AND RELEASE

1. I volunteer to participate in the study of "Effects on Young Women of a Regular Running Program" to be conducted during October and November, 1984 in the Department of Foods and Nutrition, Kansas State University by Beth Fryer, Project Director and Kris Williams and Karen Wiese, Graduate Assistants.

2. I wil keep a record of all foods and beverages consumed for a period of 7 days.

3. I also will keep a record of the amount of time spent running and the estimated mileage during the same 7-day period.

4. I will allow the researchers to perform the following procedures to determine body composition and caloric cost of running:

   a. Hydrostatic (underwater) weighing. This involves sitting in a chair in a water tank, exhaling to a maximum, and bending over until your body is completely under water while your weight is recorded. Since the level of the water in the tank is not over your head, you need only to raise your head to breathe once more.

   b. Skinfold thicknesses will be measured at the triceps, scapula, suprailiac, abdomen and thigh by means of a caliper.

   c. Oxygen consumption will be measured while you are running for 10 minutes on a treadmill at your accustomed running pace. The sedentary control subjects will not undergo this procedure.

5. I will allow the researchers to draw blood from a fingerprick for determination of hemoglobin, hematocrit, protoporphyrin and ferritin and from a venipuncture for determination of plasma lipids. Minor discomforts may be associated with blood collection but there will be only minor risks since trained persons will be drawing the blood and there will be a chair and/or cot available should you feel faint.

6. I have been completely informed as to and understand the nature and purpose of this research. The researchers have offered to answer any further questions that I may have. I understand that I will be able to withdraw from the study at any time of my own accord.

7. I realize that reports will be made of this study and I consent to publication of such if strict confidentiality is maintained by identifying my data

only by a number and not by my name.

8. I have been informed that this study should increase our knowledge of the benefits of running for young women. The benefits to me will include gaining information about my 1) caloric and nutrient intake, 2) caloric cost of running, 3) body composition, 4) iron status and 5) blood lipid levels.

Date ______________________ Signed ______________________________

DAILY FOOD RECORD

Subject Identification:______________________________

Date:______________ Day of the Week:__________________

TIME	MEAL OR SNACK (M or S)	DESCRIPTION OF FOOD/BEVERAGE	AMOUNT

DAILY RUNNING AND FOOD RECORD

Subject Identification:______________________________

Date:________________________ Mileage:__________________

Day of the Week______________ Time of day:______________

Minutes run:______________

Vitamin, mineral or nutrient supplement____________________________________

Name of supplement and amount____

TIME	MEAL OR SNACK (M or S)	DESCRIPTION OF FOOD/BEVERAGE	AMOUNT

GUIDELINES FOR YOUR FOOD RECORD

These guidelines will help you to describe the foods and beverages that you eat. It is important to understand and follow the guidelines so that you can make an accurate record of food intake.

Measure amounts in cups, ounces, etc. of serving sizes you most often consume so you can accurately record amounts consumed (i.e. if you normally drink the same amount of milk or eat the same amount of cereal, measure the amount so you will know how much it is without having to measure each time you consume that food). By doing this beforehand you will also have a better idea of serving sizes and can thus better judge amounts of food that you don't normally consume.

Please start a new sheet for every day of your intake. Record the date and day of the week on each sheet.

GUIDELINES

1. Record all foods and beverages after each meal or snack. Do not expect to remember all that you have eaten at the end of the day.

2. Record name and description of the food or beverage. Please include how the food was prepared and brand names when possible.

   EXAMPLE: 3/4 c Campbell's tomato soup vs. 3/4 c homemade chicken noodle soup

   1 fried chicken leg vs. 1 baked chicken thigh

3. Record the amount of each food and beverage that is eaten in standard measuring units - i.e. cups, spoons, etc.

   EXAMPLE: 1/2 c grape juice vs. 1 c grape drink

   1 teaspoon butter vs. 1 tablespoon margarine

4. Remember to include and record any additional sauces, gravies, salad dressing, margarine or sugar.

   EXAMPLE: 1/2 c mashed potato/ 2 Tbsp gravy

   3/4 c Rice Krispies with 1/2 c whole milk and 1 tsp sugar

5. Remember to include ALL between meal snacks and beverages. Include also beverages such as coffee (with cream or sugar), tea, diet or regular sodas and beer or any other alcoholic beverages.

6. Record any nutritional supplements or vitamins as a part of the food intake and give brand names.

7. For homemade dishes, estimate the amount of each ingredient in the portion size, or list ALL the ingredients and the number of servings in the TOTAL recipe. Record these recipes and their ingredients on the back of the food record sheet for that particular day.

ADDITIONAL GUIDELINES

1. PLEASE EAT AS YOU ORDINARILY DO.
   This is very important because we are interested in your usual food intake.

2. MORE EXAMPLES AND INSTRUCTIONS:

   Describe foods eaten as accurately as you can. Use brand names to clarify descriptions. Indicate method of preparation. For example:

   Fruit juice: Orange, grape, tomato, grapefruit, V-8, Hi-C, Tang, fresh, frozen and reconstituted, canned, reconstituted powder.

   Cereal: Oatmeal, Wheaties; cooked, dry; with sugar added (granulated or brown); with whole milk

   Bread or toast: White, whole wheat, cracked wheat, rye; homemade; dry with butter, margarine, grape jelly

   Milk: Whole, skim, 2%, reconstituted non-fat dry milk; chocolate

   Coffee or tea: Black, with cream (half and half, Coffee Mate) or sugar

   Mixed dishes and drinks: Give name of dish or drink and list the amount of ingredients consumed. If you give the recipe, indicate how much it makes. Be specific.

   Fruit and vegetables: Raw or fresh, canned, frozen: plain, with butter margarine, white or cheese sauce, sugar

   Meats and fish: Fried, breaded, broiled, baked; trimmed of seperable fat: cod, haddock, etc.

Estimate amounts eaten as carefully as you can and record amounts in household measures as suggested below:

	Household measures
Beverages (fruit juice, milk, tea, coffee, soft drinks, liquor, etc.)	Measuring cups or ounces
Breakfast cereals, cooked vegetables, canned fruits, gravies, sauces, ice cream, nuts, snack foods	Measuring cups or tablespoons
Meat, cheeses, cake, pizza	Ounces or inches Example: 4" by 2" by 1/2"
Foods in small amounts (margarine, butter, sugar, grated foods, cream, etc.)	Teaspoons or tablespoons 1 pat butter = 1 teaspoon
Bread, packaged luncheon meats	Slices
Rolls, cookies, crackers, fresh fruits, boiled potatoes, etc.	Small, medium, large or inches

3. PLEASE KEEP A FOOD RECORD FOR THE 7 DAYS STARTING ________________________ AND ENDING ________________________.

4. IF YOU HAVE ANY QUESTIONS REGARDING THE FOOD RECORDS FEEL FREE TO CALL ME, KRIS WILLIAMS, 539-0243 (home) or 532-5508 (office) OR KAREN WIESE, 539-1502 (home) or 532-5508 (office).

Table 10. Age, height, weight and weight/height index for each subject.

Subject	Age (yr)	Height (cm)	Weight (kg)	Weight/height index
		Control group		
1	22	162.0	59.5	36.7
2	30	172.7	58.1	33.5
3	22	184.4	77.1	41.8
4	29	149.0	51.2	34.4
5	21	163.9	52.9	32.3
6	22	174.5	61.1	35.0
7	25	172.0	58.5	34.0
8	24	170.8	58.9	34.5
9	22	164.0	73.0	44.5
10	22	172.0	63.2	36.8
		Low mileage group		
1	21	165.5	64.5	39.0
2	21	158.1	50.8	31.7
3	21	157.8	45.4	28.8
4	21	161.3	46.7	29.0
5	21	163.9	56.7	34.6
6	25	161.2	51.5	31.9
7	26	157.8	51.0	32.3
8	27	160.4	59.4	37.0
9	29	165.1	57.1	34.6
10	24	166.0	55.3	33.3
		High mileage group		
1	24	158.1	51.3	32.5
2	20	166.0	55.3	33.3
3	31	166.5	55.5	33.3

Table 10. (cont'd)

Subject	Age (yr)	Height (cm)	Weight (kg)	Weight/height index
4	23	165.3	56.7	34.3
5	32	160.0	53.5	33.4
6	31	164.4	47.8	29.1

Table 11. Mean caloric intake for each subject.

Subject	Total Calories	% of total calories from Carbohydrate	Protein	Fat	Alcohol	Kcal/kg BW	Kcal/kg LBW
1	2206	56.1	10.1	34.9	1.1	37.1	59.1
2	1961	43.8	18.5	39.8	0.0	33.8	46.5
3	1963	55.2	13.5	33.7	0.0	25.5	37.2
4	1817	46.8	16.1	38.4	0.0	35.5	54.9
5	1517	51.9	14.6	29.7	2.0	28.7	42.3
6	2082	54.2	10.7	33.6	1.4	34.1	56.4
7	1547	46.6	14.1	40.8	0.0	26.4	37.6
8	1866	50.1	15.8	32.8	2.2	31.7	43.3
9	1545	45.4	15.0	41.7	0.0	21.2	34.3
10	1454	45.2	13.0	43.9	0.0	23.0	32.2
		Low mileage group					
1	1895	43.6	17.0	40.8	0.9	29.3	37.7
2	1550	38.0	16.0	44.1	2.5	30.5	39.6
3	1581	48.8	12.9	40.0	0.6	34.8	42.7
4	1716	53.2	16.3	31.7	1.5	36.8	47.4
5	1076	36.0	18.0	46.9	2.0	19.0	23,8
6	1381	69.3	17.9	17.3	0.0	26.8	36.3
7	1434	56.4	16.1	30.2	0.2	28.1	36.4
8	1643	54.5	14.5	34.9	0.0	27.7	37.6
9	2265	47.2	13.3	41.6	0.0	39.7	47.9
10	1695	59.3	12.7	32.2	0.0	30.6	38.1
		High mileage group					
1	1346	54.8	16.4	31.0	0.0	26.3	33.0
2	1004	37.6	16.5	36.3	10.2	18.2	22.4

Table 11. (cont'd)

Subject	Total Calories	% of total calories from Carbohydrate	Protein	Fat	Alcohol	Kcal/kg BW	Kcal/kg LBW
3	3358	26.4	24.5	46.0	2.7	60.5	71.8
4	1896	63.4	16.4	22.0	2.1	33.4	40.5
5	2309	61.2	15.2	25.0	2.7	43.2	53.7
6	1332	51.7	19.3	30.2	0.9	27.9	35.0

Table 12. Percent body fat and skinfold measurements for each subject.

Subject	% Body fat	skinfold measurements Subscapula	Triceps	Suprailiac	Abdomen	Thigh
		Control group				
1	37.3	10.9	20.8	23.1	24.5	35.3
2	27.4	11.6	21.2	8.2	15.2	20.7
3	31.6	11.4	21.0	14.8	10.3	23.4
4	35.4	20.5	28.7	26.2	33.2	44.3
5	32.8	18.9	18.0	16.3	19.6	26.6
6	39.6	8.1	13.8	11.8	23.2	22.7
7	29.7	8.4	18.3	9.8	14.3	25.3
8	26.9	12.6	14.2	13.9	12.9	26.2
9	38.3	28.6	31.9	21.8	25.3	42.7
10	28.5	12.2	20.1	10.2	14.9	26.2
		Low mileage group				
1	22.2	9.7	14.6	20.9	19.7	21.9
2	23.1	10.0	16.7	10.7	19.2	29.4
3	18.7	9.6	9.7	9.0	8.3	18.5
4	22.5	6.1	13.4	5.7	10.3	19.0
5	20.2	8.7	15.9	8.9	11.5	29.7
6	26.2	9.1	17.0	12.1	10.0	23.0
7	22.7	5.3	10.7	4.5	5.7	16.0
8	26.4	8.9	15.2	9.2	17.4	28.7
9	17.2	8.3	16.6	12.2	19.4	22.7
10	19.6	6.7	12.8	9.2	8.9	20.8
		High mileage group				
1	20.5	7.9	15.4	11.6	14.9	19.4

Table 12. (cont'd)

Subject	% Body fat	skinfold measurements Subscapula	Triceps	Suprailiac	Abdomen	Thigh
2	19.0	8.7	8.7	10.2	8.7	15.9
3	15.7	9.4	9.9	8.2	10.3	20.8
4	17.5	6.5	8.1	5.5	6.6	15.0
5	19.7	6.8	14.0	10.6	10.3	25.7
6	20.4	8.6	12.7	7.7	10.1	22.5

Table 13. Total calories, kcal/kg body weight, kcal/kg lean body weight and calories from carbohydrate, protein, fat and alcohol for each subject during 7 days.

				% of total calories					
Group*	Subject	Day	Total calories	Carbohy-drate	Protein	Fat	Alcohol	Kcal/kg BW	Kcal/kg LBW
1	1	1	2108	52.7	8.2	33.3	7.6	35.5	56.5
1	1	2	2967	52.1	9.1	40.3	0.0	49.9	79.5
1	1	3	930	53.3	5.2	44.1	0.0	15.6	24.9
1	1	4	1516	54.1	14.9	34.0	0.0	25.5	40.6
1	1	5	1958	46.8	10.8	43.4	0.0	32.9	52.5
1	1	6	1884	65.1	12.8	23.4	0.0	31.7	50.5
1	1	7	4078	68.3	8.7	26.1	0.0	68.5	109.3
1	2	1	1621	40.8	17.5	43.2	0.0	27.9	38.4
1	2	2	1855	36.2	23.3	43.4	0.0	31.9	44.0
1	2	3	2331	52.5	15.6	34.6	0.0	40.1	55.2
1	2	4	2701	52.4	17.0	32.3	0.0	46.5	64.0
1	2	5	1572	35.1	18.3	48.5	0.0	27.1	37.3
1	2	6	1891	53.5	16.8	32.7	0.0	32.6	44.8
1	2	7	1755	35.8	20.9	43.9	0.0	30.2	41.6
1	3	1	1859	57.0	11.6	35.4	0.0	24.1	35.3
1	3	2	1789	52.7	15.1	34.3	0.0	23.2	33.9
1	3	3	1548	76.2	9.5	17.7	0.0	20.1	29.4
1	3	4	2608	57.6	12.9	29.4	0.0	33.8	49.5
1	3	5	2631	53.3	15.4	34.3	0.0	34.1	49.9
1	3	6	1359	51.5	15.8	35.7	0.0	17.6	25.8
1	3	7	1949	38.0	13.9	48.9	0.0	25.3	37.0
1	4	1	1675	54.4	20.4	26.1	0.0	32.7	50.6
1	4	2	1867	48.6	15.3	37.7	0.0	36.5	56.4

Table 13. (cont'd)

Group	Subject	Day	Total calories	% of total calories Carbohydrate	Protein	Fat	Alcohol	Kcal/ kg BW	Kcal/ kg LBW
1	4	3	2378	57.3	15.7	28.7	0.0	46.5	71.8
1	4	4	800	18.1	15.1	67.2	0.0	15.6	24.2
1	4	5	1772	50.7	14.4	36.8	0.0	34.6	53.5
1	4	6	2232	52.6	15.5	32.5	0.0	43.6	67.4
1	4	7	1998	46.1	16.4	39.5	0.0	39.0	60.4
1	5	1	945	56.4	16.7	21.7	0.0	17.9	26.3
1	5	2	1978	50.3	14.3	27.9	10.1	37.4	55.1
1	5	3	1980	54.5	9.9	32.7	4.0	37.4	55.2
1	5	4	1663	53.7	13.1	24.9	0.0	31.4	46.3
1	5	5	883	51.2	12.3	29.6	0.0	16.7	24.6
1	5	6	1384	54.4	14.8	33.8	0.0	26.2	38.6
1	5	7	1786	43.1	20.9	37.5	0.0	33.8	49.8
1	6	1	1760	56.9	13.1	31.2	0.0	28.8	47.7
1	6	2	1916	55.4	10.4	32.2	3.0	31.4	51.9
1	6	3	1475	54.9	6.8	40.3	0.0	24.1	40.0
1	6	4	3560	47.3	12.5	34.0	6.5	58.3	96.5
1	6	5	2301	51.9	10.6	38.4	0.0	37.7	62.4
1	6	6	1654	56.0	14.2	31.1	0.0	27.1	44.8
1	6	7	1905	56.9	7.5	27.9	0.0	31.2	51.6
1	7	1	931	54.7	18.2	29.6	0.0	15.9	22.7
1	7	2	1860	49.4	13.3	38.5	0.0	31.8	45.3
1	7	3	1563	30.1	16.5	53.1	0.0	26.7	38.0
1	7	4	1246	61.3	10.7	30.5	0.0	21.3	30.3
1	7	5	1764	42.0	12.0	47.6	0.0	30.2	42.9
1	7	6	1833	52.2	15.7	34.6	0.0	31.3	44.6

Table 13. (cont'd)

Group	Subject	Day	Total calories	% of total calories: Carbohy-drate	Protein	Fat	Alcohol	Kcal/ kg BW	Kcal/ kg LBW
1	7	7	1629	36.8	12.5	52.0	0.0	27.9	39.6
1	8	1	1711	52.0	13.3	37.7	0.0	29.1	39.7
1	8	2	2202	46.9	18.8	35.1	0.0	37.4	51.1
1	8	3	1680	54.3	14.8	26.2	5.3	28.5	39.0
1	8	4	1837	47.6	16.2	31.4	4.9	31.2	42.6
1	8	5	1780	45.7	17.4	32.0	5.0	30.2	41.3
1	8	6	2100	42.6	16.4	42.1	0.0	35.7	48.7
1	8	7	1751	61.8	13.8	24.8	0.0	29.7	40.6
1	9	1	1274	37.9	17.4	46.1	0.0	17.5	28.2
1	9	2	1390	41.7	14.0	45.7	0.0	19.0	30.8
1	9	3	1240	62.7	17.8	22.6	0.0	17.0	27.5
1	9	4	1221	57.4	12.9	31.4	0.0	16.7	27.1
1	9	5	1977	41.5	12.5	47.8	0.0	27.1	43.8
1	9	6	1992	40.4	10.2	54.2	0.0	27.3	44.2
1	9	7	1724	36.1	20.2	44.4	0.0	23.6	38.2
1	10	1	1734	60.9	11.9	28.9	0.0	27.4	38.4
1	10	2	2174	42.1	19.6	39.3	0.0	34.4	48.1
1	10	3	581	21.0	14.7	66.3	0.0	9.2	12.9
1	10	4	1982	47.6	12.1	44.5	0.0	31.4	43.9
1	10	5	1035	59.5	6.2	36.1	0.0	16.4	22.9
1	10	6	1629	45.1	12.2	45.0	0.0	25.8	36.0
1	10	7	1040	40.5	14.1	47.2	0.0	16.5	23.0
2	1	1	1727	50 .2	17.5	34.6	0.0	26.7	34.4
2	1	2	2103	45.9	12.5	44.3	0.0	32.6	41.9

Table 13. (cont'd)

				% of total calories					
Group	Subject	Day	Total calories	Carbohy-drate	Protein	Fat	Alcohol	Kcal/ kg BW	Kcal/ kg LBW
2	1	3	1833	51.6	16.9	35.2	0.0	28.4	36.5
2	1	4	2201	48.8	12.5	33.5	6.1	34.1	43.8
2	1	5	1732	23.6	26.4	49.9	0.0	26.8	34.5
2	1	6	1300	53.1	14.8	38.3	0.0	20.1	25.9
2	1	7	2370	32.3	18.3	49.7	0.0	36.7	47.2
2	2	1	1499	38.2	17.5	41.7	3.9	29.5	38.3
2	2	2	1102	53.4	11.6	36.4	0.0	21.7	28.2
2	2	3	1699	28.5	13.3	44.8	13.6	33.4	43.5
2	2	4	1683	39.5	15.8	45.8	0.0	33.1	43.0
2	2	5	1879	38.4	14.0	48.4	0.0	37.0	48.1
2	2	6	1370	35.6	23.8	40.3	0.0	27.0	35.0
2	2	7	1616	32.7	15.7	51.2	0.0	31.8	41.3
2	3	1	1518	52.6	15.3	35.5	0.0	33.4	41.0
2	3	2	1678	49.2	13.5	39.1	0.0	37.0	45.4
2	3	3	1337	39.7	17.5	39.0	4.5	29.5	36.1
2	3	4	1882	43.6	9.7	48.4	0.0	41.5	50.9
2	3	5	1649	54.6	9.2	39.4	0.0	36.3	44.6
2	3	6	1458	54.3	15.0	35.0	0.0	32.1	39.4
2	3	7	1545	47.6	9.9	43.5	0.0	34.0	41.8
2	4	1	1880	56.3	14.4	32.6	0.0	40.3	51.9
2	4	2	1530	60.1	14.5	28.8	0.0	32.8	42.3
2	4	3	1433	48.2	14.8	40.1	0.0	30.7	39.6
2	4	4	1163	63.7	15.5	24.1	0.0	24.9	32.1
2	4	5	2148	46.3	17.9	31.4	5.5	46.0	59.3

Table 13. (cont'd)

Group	Subject	Day	Total calories	% of total calories Carbohydrate	Protein	Fat	Alcohol	Kcal/ kg BW	Kcal/ kg LBW
2	4	6	1867	45.8	22.0	27.8	4.8	40.0	51.6
2	4	7	1994	52.2	15.2	37.1	0.0	42.7	55.1
2	5	1	1580	33.5	21.2	46.1	0.0	27.9	34.9
2	5	2	845	27.8	15.7	57.5	10.5	14.9	18.7
2	5	3	973	25.1	17.1	59.4	4.0	17.2	21.5
2	5	4	1068	42.0	13.2	46.3	0.0	18.8	23.6
2	5	5	1224	18.7	18.7	63.2	0.0	21.6	27.0
2	5	6	452	49.0	16.5	35.7	0.0	8.0	10.0
2	5	7	1389	56.0	23.9	20.2	0.0	24.5	30.7
2	6	1	1879	63.9	14.8	25.2	0.0	36.5	49.4
2	6	2	882	83.0	12.2	10.3	0.0	17.1	23.2
2	6	3	1038	71.5	19.3	15.9	0.0	20.2	27.3
2	6	4	1236	73.9	16.0	15.7	0.0	24.0	32.5
2	6	5	1441	68.1	22.4	14.1	0.0	28.0	37.9
2	6	6	2003	62.7	18.7	18.9	0.0	38.9	52.7
2	6	7	1188	62.1	22.1	20.7	0.0	23.1	31.1
2	7	1	1009	56.7	17.9	30.7	0.0	19.8	25.6
2	7	2	2150	42.5	17.4	37.5	0.0	42.2	54.6
2	7	3	1593	68.0	13.8	28.6	0.0	31.2	40.4
2	7	4	2077	43.8	23.8	31.9	1.4	40.7	52.7
2	7	5	1458	69.7	12.7	17.3	0.0	28.6	37.0
2	7	6	798	49.3	11.2	42.6	0.0	15.7	20.3
2	7	7	955	64.9	15.7	23.1	0.0	18.7	24.2
2	8	1	1527	68.0	13.2	23.7	0.0	25.7	34.9

Table 13. (cont'd)

Group	Subject	Day	Total calories	% of total calories: Carbohy-drate	Protein	Fat	Alcohol	Kcal/ kg BW	Kcal/ kg LBW
2	8	2	2615	44.6	12.7	47.2	0.0	44.0	59.8
2	8	3	2006	42.3	18.5	43.1	0.0	33.8	45.9
2	8	4	1183	45.0	16.5	39.6	0.0	19.9	27.1
2	8	5	1343	57.3	14.7	29.8	0.0	22.6	30.7
2	8	6	1270	69.9	11.5	24.7	0.0	21.4	29.1
2	8	7	1554	54.3	14.6	36.0	0.0	26.2	35.6
2	9	1	1691	63.9	13.7	25.2	0.0	29.6	35.8
2	9	2	2700	46.8	12.7	42.7	0.0	47.3	57.1
2	9	3	3464	44.9	10.0	45.6	0.0	60.7	73.2
2	9	4	1599	46.7	15.1	39.3	0.0	28.0	33.8
2	9	5	1833	51.0	14.4	35.0	0.0	32.1	38.8
2	9	6	2321	44.5	15.0	44.6	0.0	40.7	49.1
2	9	7	2249	32.6	12.4	58.6	0.0	39.4	47.5
2	10	1	1663	70.1	11.4	24.9	0.0	30.1	37.4
2	10	2	2372	40.5	11.7	51.4	0.0	42.9	53.3
2	10	3	1738	48.1	15.7	40.0	0.0	31.4	39.1
2	10	4	1273	52.2	15.6	33.6	0.0	23.0	28.6
2	10	5	1771	61.1	12.3	27.9	0.0	32.0	39.8
2	10	6	1351	74.1	10.8	21.7	0.0	24.4	30.4
2	10	7	1699	68.7	11.1	25.6	0.0	30.7	38.2
3	1	1	1250	55.5	13.0	34.8	0.0	24.4	30.6
3	1	2	969	62.1	21.9	16.5	0.0	18.9	23.8
3	1	3	1230	58.7	20.9	23.1	0.0	24.0	30.1
3	1	4	1609	66.5	11.1	26.2	0.0	31.4	39.4

Table 13. (cont'd)

Group	Subject	Day	Total calories	% of total calories: Carbohy-drate	Protein	Fat	Alcohol	Kcal/ kg BW	Kcal/ kg LBW
3	1	5	1179	46.4	17.0	39.9	0.0	23.0	28.9
3	1	6	1532	51.9	15.1	34.6	0.0	29.9	37.5
3	1	7	1656	42.6	15.7	42.1	0.0	32.3	40.6
3	2	1	1281	41.7	15.5	41.7	0.0	23.2	28.6
3	2	2	590	37.0	2.9	0.0	58.9	10.7	13.2
3	2	3	1082	48.9	16.5	35.5	0.0	19.6	24.2
3	2	4	1146	33.5	10.7	44.6	12.4	20.7	25.6
3	2	5	1446	38.9	26.0	35.1	0.0	26.2	32.3
3	2	6	831	34.0	19.1	48.4	0.0	15.0	18.5
3	2	7	649	29.1	24.7	47.3	0.0	11.7	14.5
3	3	1	3040	38.5	26.2	35.5	0.0	54.8	65.0
3	3	2	3578	22.0	23.7	54.3	0.0	64.5	76.4
3	3	3	4377	16.7	26.3	54.3	2.5	78.9	93.5
3	3	4	2926	15.6	25.9	53.5	4.0	52.7	62.5
3	3	5	3017	24.9	22.6	39.0	12.4	54.4	64.5
3	3	6	2869	35.2	24.8	40.2	0.0	51.7	61.3
3	3	7	3698	32.0	22.0	45.1	0.0	66.6	79.0
3	4	1	1737	61.8	16.7	24.9	0.0	30.6	37.1
3	4	2	2626	61.5	11.5	23.6	7.6	46.3	56.1
3	4	3	1608	70.3	11.8	14.9	7.2	28.4	34.4
3	4	4	1344	68.7	14.2	20.5	0.0	23.7	28.7
3	4	5	1823	65.0	20.8	18.2	0.0	32.2	39.0
3	4	6	2188	53.8	18.3	31.5	0.0	38.6	46.8
3	4	7	1945	62.7	21.3	20.1	0.0	34.3	41.6

Table 13. (cont'd)

Group	Subject	Day	Total calories	% of total calories: Carbohy- drate	Protein	Fat	Alcohol	Kcal/ kg BW	Kcal/ kg LBW
3	5	1	2384	61.0	12.0	31.6	0.0	44.6	55.4
3	5	2	3534	58.5	15.1	19.4	11.3	66.1	82.2
3	5	3	2183	62.3	17.6	21.2	4.1	40.8	50.8
3	5	4	979	66.5	18.0	19.8	0.0	18.3	22.8
3	5	5	1928	61.7	15.0	26.2	0.0	36.0	44.8
3	5	6	2723	56.4	12.4	31.2	3.3	50.9	63.3
3	5	7	2429	61.9	16.4	25.5	0.0	45.4	56.5
3	6	1	1789	50.6	16.1	35.8	0.0	37.4	47.0
3	6	2	1404	52.8	13.3	38.0	0.0	29.4	36.9
3	6	3	1279	56.0	18.4	27.0	0.0	26.8	33.6
3	6	4	1197	54.4	32.3	16.8	0.0	25.0	31.4
3	6	5	1630	32.4	14.0	46.4	6.0	34.1	42.8
3	6	6	869	56.6	25.3	21.1	0.0	18.2	22.8
3	6	7	1156	58.9	15.8	26.4	0.0	24.2	30.3

* Groups: 1, Control; 2, Low Mileage; 3, High Mileage

Table 14. Calories expended/min, calories expended/mile and running pace for running groups.

Subject	Low mileage group			High mileage group		
	Kcal/min	Kcal/mile	running pace (mph)	Kcal/min	Kcal/mile	running pace (mph)
1	12.7	109	7.0	9.8	81	7.3
2	9.8	94	6.3	13.1	112	7.0
3	11.5	86	8.0	14.9	112	8.0
4	7.9	86	5.5	11.6	92	7.5
5*				12.0	93	7.8
6	7.9	87	5.5	8.4	75	6.8
7	7.9	86	5.5			
8	13.5	125	6.5			
9	11.2	89	7.5			
10	12.1	100	7.3			

* Data was not obtained.

Table 15. Calories expended per day during 7 days using kcal expended/min and kcal expended/mile for running groups.

		Low mileage group		High mileage group	
Subject	Day	Kcal expended/ min	Kcal expended/ mile	Kcal expended/ min	Kcal expended/ mile
1	1	489	444	783	729
1	2	468	412	734	729
1	3	435	400	783	729
1	4	0	0	783	729
1	5	544	482	539	567
1	6	446	406	588	648
1	7	468	419	548	648
2	1	375	378	875	895
2	2	0	0	626	672
2	3	375	406	0	0
2	4	375	404	993	1007
2	5	375	391	470	448
2	6	375	407	1071	1119
2	7	375	393	758	839
3	1	259	265	879	894
3	2	346	369	738	727
3	3	0	0	689	727
3	4	648	692	707	727
3	5	303	323	701	727
3	6	259	277	693	727
3	7	259	277	688	704
4	1	474	516	659	647
4	2	355	344	0	0
4	3	355	344	462	416

Table 15. (cont'd)

Subject	Day	Low mileage group Kcal expended/ min	Low mileage group Kcal expended/ mile	High mileage group Kcal expended/ min	High mileage group Kcal expended/ mile
4	4	0	0	543	573
4	5	316	387	0	0
4	6	276	344	693	647
4	7	0	0	578	555
5*	1			0	0
5	2			1322	1303
5	3			974	838
5	4			385	372
5	5			2356	2234
5	6			0	0
5	7			866	838
6	1	476	606	634	676
6	2	397	476	507	450
6	3	0	0	423	375
6	4	0	0	397	465
6	5	397	476	642	676
6	6	397	476	423	375
6	7	287	346	507	450
7	1	363	387		
7	2	394	430		
7	3	434	542		
7	4	355	387		
7	5	394	473		
7	6	276	301		

Table 15. (cont'd)

		Low mileage group		High mileage group	
Subject	Day	Kcal expended/ min	Kcal expended/ mile	Kcal expended/ min	Kcal expended/ mile
7	7	355	387		
8	1	437	436		
8	2	405	399		
8	3	405	374		
8	4	850	747		
8	5	375	374		
8	6	364	374		
8	7	0	0		
9	1	467	537		
9	2	263	259		
9	3	0	0		
9	4	490	554		
9	5	614	554		
9	6	0	0		
9	7	333	313		
10	1	0	0		
10	2	505	502		
10	3	285	331		
10	4	799	802		
10	5	337	301		
10	6	329	301		
10	7	0	0		

* Data was not obtained.

THE EFFECTS OF A RUNNING LIFESTYLE ON BODY COMPOSITION AND CALORIC INTAKE IN FEMALE DISTANCE RUNNERS

by

KRISTEN JANE WILLIAMS

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KANSAS STATE UNIVERSITY
Manhattan, Kansas

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The effects of a consistent running program on caloric intake and body composition were studied in women aged 20 to 32. The subjects were divided into three groups: 10 sedentary controls, 10 low mileage runners, who ran 20-30 miles/wk and 6 high mileage runners, who ran 40 or more miles/wk. Body composition was determined by underwater weighing and anthropometric measurements. Body density was determined by hydrostatic weighing and then coverted to percent body fat. Skinfold thickness was measured at the triceps, subscapula, abdomen, suprailiac and thigh sites to describe fat distribution. The caloric cost of running was calculated by steady-state treadmill running and determination of the respiratory quotient by calculating the ratio of the volume of CO_2 expired to the volume of O_2 consumed. Seven-day food records were kept by all subjects. The runners also recorded time spent running and estimated mileage for the same 7-day period. Items from the food records were computer coded and analyzed for calories, carbohydrate, protein, fat and alcohol, using U.S.D.A. food composition tables.

There were no significant differences in percent body fat and skinfold measurements between the two running groups. Both running groups had significantly lower ($P \leq 0.05$) values for percent body fat and all skinfold measurements than the control group, except the thigh skinfolds were not significantly different between the low mileage runners and the controls. The skinfold measurements were not strongly correlated with percent body fat in either of the two running groups, but suprailiac ($r = .62$, $P \leq .05$) and abdominal ($r = .75$, $P \leq .01$) skinfolds were significantly correlated with percent body fat in the control group. There was a difference ($P \leq 0.05$) in the weight/height index only between the controls and high mileage runners. The triceps skinfold was most highly correlated with the weight/height index ($r = .56$, $P \leq .09$) in the control group, while the suprailiac ($r = .66$, $P \leq .04$) and abdominal ($r = .62$, $P \leq .06$) skinfolds were correlated with it in the low mileage group. No skinfold measurements were significantly correlated with weight/height index in the high mileage group.

There were no significant differences in mean total calories, kcal/kg body weight or kcal/kg LBW among the three groups. A negative, though nonsignificant, correlation was found between kcal/kg body weight and percent body fat in both the high mileage and low mileage groups. Thus, runners who had the highest caloric intake/kg tended to have the lowest body fat.

There was no significant difference in percentage of total calories as carbohydrate among the three groups. Percentage of protein tended to increase as exercise increased, but was significant only between the controls and the high mileage group. Percentage of calories as fat tended to decrease as exercise increased, however, there were no significant differences among the groups. The high mileage group consumed more ($P \leq 0.05$) calories as alcohol than did either of the other two groups.

Runners in the low mileage group ran an average of 5.8 days and 25.6 miles/wk, while the high mileage group ran an average of 6.2 days and 47.9 miles/wk. The low mileage and high mileage groups expended approximately 1216 and 4439 kcal/wk, respectively, during running. By using the estimated values of 329 calories expended in running/d for the low mileage group and 643 calories expended in running/d for the high mileage group, and subtracting these values from average caloric intake (1624 and 1874, respectively), these runners existed on 1295 (low mileage) and 1231 (high mileage) kcal/d.

Only 19% of the subjects consumed 3 regular meals on each day of the 7-day period. There were no significant differences in the frequency of meals or snacks consumed by the three groups, even though the high mileage group tended to consume more snacks and slightly fewer meals than the other groups.

This study indicated that a consistent running program in young females resulted in significantly smaller skinfold measurements and lower percent body fat than in sedentary individuals. However, total caloric intake, percentages of total calories from carbohydrate, protein and fat and frequency of eating were not significantly influenced by running.