DOCUMENT RESUME

ED 104 880 SP 009 121

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TITLE	Exercise and Fat Reduction.
INSTITUTION	President's Council on Physical Fitness and Sports, Washington, D.C.
PUB DATE	Apr 75
NOTE	28p.
JOURNAL CIT	Physical Fitness Research Digest; Series 5 n2 Apr 1975
EDRS PRICE	MF-$0.76 HC-$1.95 PLUS POSTAGE
DESCRIPTORS	*Body Weight; *Educational Research; *Exercise (Physiology); Human Body; Physical Activities; Physical Characteristics; *Physical Fitness; Physical Health

ABSTRACT

This document analyzes the problems encountered by the obese individual and the effects of regular exercise on weight loss and fat reduction. Part one compares the psychological traits of obese children with age groups of normal weight and discusses the organic disorders and social attitudes which plague the overweight individual. Part two states that caloric intake and genetic and environmental factors are the major causes of obesity. Part three offers several methods of determining obesity including the following: (a) Age-Height-Weight Tables; (b) Meredith's Age-Height-Weight Charts; (c) the Wetzel Grid; (d) Adipose Tissue Measurement; (e) Hydrostatic Weighing; and (f) use of a volumeter. Part four cites a variety of studies concerning the physical activity habits of the obese and compares these activities to those of nonobese individuals. Part five studies the relationships between exercise, excess fat, and weight. Part six analyzes several physical conditioning studies conducted with adult men from college age through middle age and older. Part seven traces the effect of exercise upon fat reduction in females from fifth grade through middle age. Part eight illustrates the effects of weight training experiments male and female physical conditions. Part nine evaluates spot reducing and its lack of significant effects. Part ten summarizes the article and offers suggestions for research. A list of references is included. (JS)

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ED104880

Physical Fitness Research Digest

Series 5, No. 2
April 1975

Published quarterly by the
President's Council on Physical Fitness and Sports
Washington, D.C.

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EXERCISE AND FAT REDUCTION

Excess fat on the body, commonly referred to as obesity, is a problem that concerns both children and adults. Frequently in today's society, fat reduction is undertaken for aesthetic reasons by those with such excesses. However, there are many vital reasons for doing so; complications associated with obesity are far-reaching, being associated with serious organic impairments and shortened life, with psychological maladjustments, with unfortunate peer relationships (especially among children); with inefficiency of physical movement, and with ineffectiveness in motor and athletic activities. Obesity is consistently encountered as a cause of physical unfitness among boys and girls, men and women; these individuals score low on physical and motor tests, a result encountered universally by school and college physical educators.

The President's Council on Physical Fitness and Sports has shown concern for weight control, as evidenced by the pamphlet, *Exercise and Weight Control*, produced by the Council and the Committee on Exercise and Physical Fitness of the American Medical Association in cooperation with the Lifetime Sports Foundation.

Disadvantages of Obesity

Organic Disorders

Excessive weight places an additional burden upon the circulation, respiration and kidneys, so that obese persons are prone to develop disorders of these organs and systems. Mayer (22, chap. 8) indicated that at least transitory abnormalities of almost every body function have been reported in obese persons. Important and frequent among these abnormalities are respiratory difficulties. Fat people have less exercise tolerance, greater difficulty in normal breathing, and a higher frequency of respiratory infections than do people of normal weight. Even more seriously, perhaps, obesity is related to the prevalence of high blood pressure and atherosclerosis (hardening of the arteries), generally closely related to high blood cholesterol.

Armstrong and associates (2) contrasted the mortality rate of overweight persons limited to substandard life insurance policies with persons accepted for standard insurance. The mortality rates were 79% for men markedly overweight and 42% for men moderately overweight above the standard risk group; comparable percentages for women were 61 and 42, respectively. The excess mortality rates were due to a greater number of deaths from degenerative diseases among obese people. From an analysis of 3,000 clinical records, Joslin and associates (18) found that 67% of females and 63% of males showed evidence of overweight at the outset of diabetes. From a survey of 74,000 industrial workers, Master and associates (20) found that average blood pressure increased with body weight for a given height for both sexes at every age.

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Social Attitudes

Fat boys and girls have been subjected to ridicule by their unthinking peers. "Tubby," "fatty," "fats," "fatso" and other unkind nicknames have accompanied them through their school years. Fat adults have been derided in literature and on the stage. Such comments, endlessly repeated, cannot but result in hurt feelings, inferiority complexes and social withdrawals by the recipients.

In a study of high school seniors in the Boston area, Mayer and associates (22, p. 91) found a strong discrimination against college admissions of obese boys and girls. Everything else being equal, including high school grades, intelligence quotients, entrance examination scores and teachers' recommendations, obese girls had only one-third of the chances of nonobese girls of being admitted to colleges; with obese boys, this chance was better, two-thirds, but the bias still existed. Mayer suggests that the obese girl is thus likely to fall in socioeconomic status; and, a decreased likelihood of advancing socially through marriage is a penalty which the obese girl has to pay.

Psychological Traits

Mayer and Monello (22, 119) contrasted the psychological traits of adolescent girls attending two summer camps on Cape Cod. One hundred girls were from a camp for obese girls, conducted to help them reduce their weights; 65 girls were from a camp of "normal" campers, i.e., not selective in regard to obesity. The mean weights were 169 pounds for girls from the obese and 118 pounds for those from the other camp. All girls were given three projective-type psychological tests: word association, sentence completion and picture story. Some of the findings follow.

Word association: The girls in both camps responded with three words to each of the following words: outdoors, sugar, time, boring, freedom, worry, picnic, flying, dates and camp. Contrasted with the nonobese girls, the obese girls indicated a larger number of words such as calories, diet, reducing, fattening, fat, heavy and overweight. The frequent and spontaneous mention of the weight references indicated a preoccupation with "overweight" similar to a heightened sensitivity toward status found among ethnic and racial minorities reported by others when applying the same test.

Sentence completion: For this test, the girls completed 10 incomplete sentences in any way they wished. Generally, the obese girls responded with "passive" and the nonobese girls with "active" expressions. Examples of responses to three of the incomplete sentences are given: "When things get too hard for me, I ________." "When I am feeling bad, I ________." and "When my mother left, I ________." More obese girls completed these sentences with such words as cry, sleep, sit and sulk, and feel lonely; whereas more of the nonobese subjects gave work harder, try my best, talk to someone, visit friends, do my homework and clean my room. These results show a greater dependency on their families by the obese girls, interpreted as an effect of social pressure on the obese.

Picture story: This test consisted of showing nine pictures about which the subjects were asked to write stories: four pictures were family scenes, two were peer groups, one was a man and a woman, and two were single figures. As for the sentence completion test, the responses generally were "passive" and "active" in nature, respectively, for the obese and nonobese girls. Some examples follow.

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When shown a picture of some girls walking while another girl walks behind them, all nonobese subjects said that the lone girl was catching up with her friends, but 60% of the obese wrote that the lone girl was being excluded from the group. Both obese and nonobese girls described a picture of a woman facing a boy whose arm pointed out a doorway as a boy leaving his mother or returning to her. But the obese pictured a passive boy asking permission or being scolded, ordered, or addressed by a dominant mother, whereas the nonobese pictured an assertive boy telling his mother what he was about to do or had just done.

In discussing the results of the psychological testing, Mayer (22, p. 123) stated: *"Clearly, it is not far-fetched to say that obese persons in the United States may form a minority group which suffers from prejudice and discrimination. The exact nature and extent of these prejudicial attitudes against obesity, the myriad effects they have on the nonobese as well as on the obese, and the possible role these attitudes may play on the perpetuation of obesity, are questions that remain to be answered. At the very least, the heavy burden of inferiority and self-blame imposed by society on obese adolescent girls (and to an only slightly lesser extent, boys) is a matter to be remembered."*

Causes of Obesity

Obesity occurs when the individual's diet produces more fuel than is needed to maintain body functions and to meet the energy requirements of daily activities, and this excess is stored as fatty tissues throughout the body, gradually increasing to an undesirable amount. It would seem from this definition that avoiding obesity is just a matter of controlling the diet to the point of balancing caloric intake with body requirements; and that fat reduction is merely to reduce this intake below such requirements so that existing fat is burned off in order to supply the full energy needs. Certainly, such dietary considerations are essential and they have been the focal point of efforts to control weight, especially the fat content of weight. However, the cause of obesity is not limited to improper diet; other causes exist, usually forming a complex of interacting factors with more than one operating on the organism for a given individual.

Obesity runs in families, which may be due to both genetic and environmental factors. In studies of Massachusetts children reported by Mayer (22, p. 124), only 10% of the children of normal weight parents were obese; the proportions rose to 40% if one parent was obese and to 80% if both parents were obese. A propensity toward such body fatness may be related to hereditary hormonal factors acting on the fat producing "mechanism." However, it could also be due, in part at least, to providing a festive board in the home and permitting high caloric between-meal snacks and the like. Further, lack of exercise in the family could be a vital contributing influence. The "battle of the bulge" seems to be a lifetime effort for those who are fat prone, while all sorts of dietary excesses do not seem to affect fat accumulation by those who are not so prone.

The concept that obesity is solely due to overindulgence in food has been refuted by such investigators as Mayer, Kraus, Raab and others. Repeated studies by such nutritionists and physicians have shown that the great majority of adolescents eat less than the nonobese adolescents of the same sex. The physical inactivity of the obese adolescent easily accounts for the calories which permit fat deposits. The purpose of this *Physical Fitness Research Digest* is to concentrate on studies pertaining to the effect of exercise on fat reduction. It is not intended to relegate dietary considerations to a minor role, to negate the need for medical treatment when glandular and other bodily malfunctions are causative factors, to ignore the presence of hereditary influences in the situation, or to disregard the possibilities of psychological and emotional involvements in the obese complex. As pointed out above, more than one causative factor may confront a given obese person who is desirous of reducing fat deposits throughout the body. Studies on humans only are included in this report, so no attempt was made to review relevant studies on animals.

Determination of Obesity

Determination of obesity is not solely a matter of identifying an overweight condition, since body weight consists of many components, especially the skeletal frame, the viscera, the musculature and the amount of fat. The proportions of these components varies among individuals. Thus, the determination of obesity is not a simple matter. The strengths and weaknesses of various methods for determining the presence and amount of obesity should be understood.

Age-Height-Weight Tables

For many years, age-height-weight tables have been used as an indicator of nutritional status. As early as 1900, life insurance companies prepared such tables to determine the weights of men and women who were acceptable for life insurance policies. The schools used such tables to identify children who were under ight and overweight. The usual policy has been to consider as undernourished those who were seven to 10% below the average weight for their sex, age and height; as obese, those who were 15 to 20% above the average. Recent researches, however, have cast considerable doubt on the reliance on this form of nutritional assessment, largely because body build and the proportions of bone, muscle and fat are not considered in making nutritional determinations. For example, for two boys of the same age, height and weight, one may be muscular with little fat, while the other may have a weak muscular development and generous amounts of adipose tissue; and, numerous combinations exist in between.

Expressing this situation differently, the respective physiques of three men may be endomorphic, mesomorphic and ectomorphic; certainly, they should not all be held to the same weight standards. William H. Sheldon, the originator of the somatotype system of physique typing, in his *Atlas of Men*, provided an age-height-weight table for each of 88 basic somatotypes, ages 18 to 65 years.

Behnke and Wilmore (3, p. 130) have discussed overweight when related primarily to well-developed musculatures. They show that the weight of a lean, muscular athlete may well exceed by 30% the average weight for stature in standard tables. Muscle is primarily responsible for the greater lean bulk, but bone may also be ancillary, as revealed by thickened cortices of long bones. Weightlifters show some remarkable examples of muscular hypertrophy. Wilhelm and Behnke (44) dramatized this situation during World War II by showing that, "*according to height-weight tables, the majority of football players could be unqualified for first-class insurance by reason of overweight.*" Obviously, overweight in these men is largely due to nonfat components of the body.

Some tables have been proposed based on "appropriate" weight for the individual's sex, age, body build and height. These weight tables are superior to those based on sex, age and height only. However, some difficulty may be encountered in differentiating body build. Two approaches to appropriate weights of boys and girls up to 18 years of age are based on growth; these tests are presented here.

Meredith's Age-Height-Weight Charts (24). Meredith developed charts of height and weight for boys and girls separately for the American Medical Association. Each chart contains growth curves of height and of weight for ages four to 18 years; the chart for each sex at all ages has five zones for height, short to tall, and five zones for weight, light to heavy. When a girl's or boy's height and weight points do not lie in corresponding zones, the discrepancy should be studied to determine if it is due to a normal slenderness or stockiness of build or reflects an undesirable state of health. For example, if a boy's scores fall in average height and moderately heavy weight zones, the dissimilarity may indicate ruggedness of build, or it may be related to obesity. Generally, the child's height and weight curves should follow the same zones during the growth period, unless otherwise cortraindicated; this procedure gives some idea as to whether he or she is growing and developing satisfactorily. These charts are available through the American Medical Association, 535 North Dearborn Street, Chicago, IL 60610.

Wetzel Grid (43). The Wetzel Grid was devised as a direct reading control chart on the quality of growth and development of individual boys and girls. It is divided into nine physique channels, designated as follows: A_4, obese; A_3 and A_2, stocky; A_1, M, and B_1, good; B_2, fair; B_3, borderline; and B_4, poor. The child's position on the grid is plotted from his or her age, height and weight. From this plotting, the developmental level and the age schedule of development are determined; repeated plottings indicate the direction of growth and development. If the child's growth is "normal," he will stay in the same channel as time goes on, moving upward progressively. A crucial point in this determination is need for assurance that an age-height-weight combination is an adequate index of physique when initially placing the child in his channel; if not correct, an improper growth channel may be perpetuated. The Wetzel grid has been widely used and has been the subject of considerable research. Grids may be obtained from: Newspaper Enterprise Association, 1200 West Third Street, Cleveland, OH 44113.

Adipose Tissue

Brožek (6) proposed that the individual's relative leanness-fatness may be obtained directly from adipose tissue measurements, inasmuch as a large proportion of total fat, placed at 50% by some investigators, is contained in the subcutaneous deposits. Amounts of adipose tissue may be measured either by the thickness of skinfolds externally with calipers, or by the actual fat layer internally with X-rays. The use of the skinfold-caliper approach is obviously the more practical for routine use; further, frequent X-ray exposure is considered undesirable.

Specifications for skinfold calipers have been established: amount of pressure applied to the skinfold, 10 grams per square millimeter; contact surface, varies from 20 to 40 square millimeters depending on the shape of the contact surface. (6, p. 10) The skinfold sites generally accepted for determination of body fat are at the back of the upper arm over triceps muscle and at the subscapular position on the back; a third site is also suggested in the abdominal region, on the mid-axillary line at the level of the umbillicus. Through his research and that of others, Mayer (22, p. 32) indicated that the triceps (back of arm) skinfold is most representative of the total body fat of obese individuals. Based on this belief, he and Selzer (37) developed minimum triceps thicknesses indicating obesity for males and females of different ages; these thicknesses appear in the accompanying table. Minimum thickness was placed at one standard deviation above mean skinfold at each age; thus, 16% of the population would be designated as obese. The standard for obesity over age 30 was taken at 30 years on the assumption that weight gain after adult size has been reached is usually excess fat.

The directions for the back of arm, or triceps, skinfold test follow: The skinfold is taken over the muscle at a point halfway between the tip of the shoulder and the tip of the elbow. The point is located with forearm flexed to 90 degrees; in making the measurement, however, the arm hangs free. The skinfold is lifted parallel to the long axis of the arm by pinching the skinfold between the thumb and index finger about 1 cm. from the site at which the caliper is to be applied. The amount of the skinfold should include two thicknesses of skin with intervening fat, but excluding muscle; to isolate this thickness, the subject may tense the underlying muscles. The caliper is applied above the fingers holding the skinfold; all measurements are made to the nearest millimeter.

Other Measures

More sophisticated methods for determination of body composition, especially for differentiation between lean and fat tissues, are available but require laboratory facilities and apparatus, so are not practical for routine use in schools and in offices of physicians. These methods range from the "relatively simple" measurement of body volume to the complex biochemical measurements of isotopic dilution or inert gas absorption. These methods are described and discussed by Behnke and Wilmore. (3, chap. 2) Two of the "simpler" methods, which have been used widely in research, will be mentioned here, so that they will be understood when encountered in studies cited later in this *Digest*.

Hydrostatic Weighing. A widely used method for assessing body volume is hydrostatic weighing, based on Archimedes' physical principle that a body immersed in fluid is acted on by a buoyancy force which is evidenced by a loss of weight equal to the weight of the displaced fluid. Thus, when an individual is weighed totally submerged under water, his total body volume is equal to his loss of weight in water, corrected for the density of the water corresponding to the water temperature at the time of the weighing. The equations used provide for measures of body volume and specific gravity; amount and percentage of fat and lean body weight may be determined. The actual weighing of the body under water is usually accomplished by having the subject sit in a chair, supported by a weight scale, which is lowered into a tank of water.

Body Volume. A second method of assessing body volume determines water displacement with a volumeter. The technique is the same as for hydrostatic weighing except that the volume of water displaced by the person is measured rather than loss of weight in water. The water displacement is determined by submerging the subject under water and then measuring the increase in the water level of the tank by using a fine bore burette connected to the tank; the burette is calibrated for the size of the tank used. It has been estimated that this technique is less precise than hydrostatic weighing because of the difficulties in distinguishing changes in the volume of the tank. However, the method does work especially well when the purpose is to assess separate segments of the body.

Minimum Triceps Thickness Indicating Obesity

(Millimeters)

Age in Years	Males	Females
5	12	14
6	12	15
7	13	16
8	14	17
9	15	18
10	16	20
11	17	21
12	18	22
13	18	23
14	17	23
15	16	24
16	15	25
17	14	26
18	15	27
19	15	27
20	16	28
21	17	28
22	18	28
23	18	28
24	19	28
25	20	29
26	20	29
27	21	29
28	22	29
29	22	29
30-50	23	30

From: Selzer, C. C., and J. Mayer, "A Simple Criterion of Obesity," *Postgraduate Medicine*, 38, No. 2 (1965), A-101.

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Physical Activity of the Obese

Mayer has pointed out that in recent years the role of exercise in weight control has been minimized, if not ridiculed by a number of health and physical educators and some physicians. As an investigator of international repute, he has successfully refuted this concept. Furthermore, he effectively supported the contention that physical inactivity is the single most important factor explaining the increasing frequency of overweight people in modern Western societies. He states: *"Natural selection, operating for hundreds of thousands of years, made men physically active, resourceful creatures, well-prepared as hunters, fishermen and agriculturists. The regulation of food intake was never designed to adapt to the highly mechanized sedentary conditions of modern life, any more than animals were made to be caged."* (21). Kraus and Raab (19) also maintain that lack of exercise is the most common cause of overweight and that prescription of exercise is important in its medical treatment. Many studies support these assumptions, several of which will be mentioned here.

Over 20 years ago, Mayer and Johnson (22, p. 76) determined the caloric intake and physical activity of two groups of high school girls. One group was overweight and the other was normal weight but matched for age and height. Generally, the obese girls ate less than the normal-weight girls; yet, they also exercised considerably less. "Sitting" activities were emphasized much more than walking and sports. Watching television consumed four times as many hours for the obese as for the nonobese group.

A more recent study by Mayer, Bullen and Reid (22, p. 126) demonstrated that during periods of exercise, obese children spent far less time in motion than did nonobese youngsters of the same age and social background. Motion pictures of obese and nonobese children swimming or playing tennis or volleyball revealed that the obese were actually physically active for much less time than were the nonobese. For girls in summer camps, overweight girls were essentially motionless for 65% of the time in tennis, 80% in volleyball, and for an even higher percentage in swimming.

Bruch (7) studied the activity habits of 140 obese boys and girls ages two to 14 years, most being between six and 12 years: 66% of the boys and 68% of the girls were physically inactive. Few of the obese children in school made use of the opportunities for exercise provided by the school. Marked delay in ability and willingness to take care of themselves in early life was observed in 77% of obese children. Further, 50% were both inactive and without playmates; 74% did not take part in active games; and 65% had marked difficulties in social contacts.

Chirico and Stunkard (9) compared the physical activities of 15 obese and 15 nonobese women and [illegible] obese a[illegible] nonobese men; the women and men groups, respectively, were matched [illegible] occupation and socioeconomic status. The women were housewives, secretaries, [illegible], typists and scrub women; the men were medical students, painters, clerks, teachers and unemployed persons. Physical activity was the distance the body was moved as measured by means of a pedometer for one week by the women and two weeks for the men. The mean distances per day by the women were 2.0 miles for the obese and 4.9 miles for the nonobese. For the men, the mean distances per day were 3.7 and 6.0 miles by the obese and nonobese groups, respectively. When a coefficient of activity, which takes into account the body weight moved, was calculated in order to allow a rough comparison of caloric expenditure, the difference between matched pairs of obese and nonobese women remained significant at the .01 level. For the men, however, the difference was not significant.

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Reviews

A 1962 article by Wells, Parizkova and Jokl (42) discussed the relationships between exercise, excess fat and weight; their studies and those by others were reviewed. Among their conclusions were the following:

a. Body weight measures give no indication of tissue composition. Specific gravity or weight of tissue per unit volume provides a truer index of proper weight through measures of lean tissue and excess fat.

b. Intensive physical training causes a depletion of excess fat and an increase of specific gravity; inactivity has the opposite effect.

In the reference, the nature of the statistical relationship between skinfold measurements and specific gravity is detailed and an amount is presented of the theoretical bases for the computation thus rendered possible, of excess fat and lean tissue.

In the Behnke-Wilmore research monograph (3, chap. 9), a chapter is devoted to alterations in body composition with physical activity. They reported that exercise does mediate a basic change in body composition. Increase in lean body weight was attributed to muscular hypertrophy, which is possibly the consequence of an increase in the level of serum-human growth-hormone, since it has been shown to rise during exercise. This substance is considered a protein anabolic hormone; in animals receiving growth hormone, the increased deposition of protein is accompanied by a loss of carcass fat. This latter finding could be related to the loss of fat which was a consistent finding in the studies reviewed. The loss of body fat is associated with an increased expenditure of calories. However, the caloric equivalent of the amount of exercise actually performed is less than that necessary to account for the fat loss in some studies. The authors suggested that this result could be due to a concomitant decrease in caloric intake with exercise, which results in a caloric imbalance of the magnitude necessary to explain the fat loss. They supported this concept from the work of Mayer, which showed that exercise up to one hour in duration tends to suppress the appetite.

A recent research review of various aspects of the role of exercise in weight control was reported by Oscai (28). Four broad topics were presented: effects of exercise on appetite, body growth and composition; factors which control body fat; the role of exercise in the possible prevention and therapy of obesity; and the role of exercise in maintaining normal weight. Some conclusions that may be drawn from this review relative to exercise and fat reduction are:

a. Exercise can affect the body composition of young, growing humans by lowering or preventing an increase in body fat and by increasing lean tissue.

b. Similar results may be obtained with adults, which, of course, is desirable since their increase in body fat usually accounts for their gains in body weight.

c. Exercise does have favorable effects on body composition with or without a change in body weight.

d. It is possible to increase caloric expenditure sufficiently by means of regularly performed exercise alone to produce a marked decrease in body weight; as much as 78% of weight loss occurring in exercising obese rats has been due to loss of fat.

e. Exercise combined with food restriction may be the sensible approach to weight reduction for obese individuals who desire to lose weight at a fairly rapid rate but cannot tolerate severe caloric restriction or prolonged, strenuous exercise.

f. Demonstrated in animals and observed in human beings, the grossly obese are considerably less physically active than the nonobese; furthermore, although caloric intake is often greater in a grossly obese than in a nonobese person, obesity often can be traced directly to physical inactivity without an abnormal increase in food intake.

Adult Men

Quite a number of physical conditioning studies have been conducted with adult men from college age through middle age and older, in which measures of body composition are included. Several of the studies presented here were reported in the July 1974 *Physical Fitness Research Digest*, since they were primarily concerned with the use of exercise in the improvement of circulatory-respiratory endurance. These studies also included body composition and skinfold measures; emphasis in this *Digest* is directed toward the effects of the conditioning programs on fat reduction. Dietary controls were not employed in the studies unless indicated.

Pollock's Studies

Pollock, Cureton and Grueninger (30) formed two experimental groups and a control group of men between 28 and 39 years of age. For the experimental groups, Group I exercised two days a week and Group II exercised four days a week for 20 weeks. The training program was the same for both groups, consisting of approximately 30 minutes of continuous running, jogging and walking with increasing intensity as exercise tolerance improved. Body composition assessment consisted of body weight and the sum of six skinfold measures obtained over chest, axilla, triceps, abdomen, supra-iliac and front thigh. The results in terms of the sum of the six skinfold tests showed that: the control group became fatter (122 to 135 mm.); the twice-a-week group remained about the same; and the four-times-a-week group lost appreciably (131 to 108 mm.). Body weight also significantly decreased for the four-day-a-week group (79.7 kg. to 76.8 kg.).

In order to further study twice-a-week conditioning programs, a control and two experimental groups of middle-aged men between 30 and 45 years of age, 11 to 12 men in each group, were formed by Pollock and associates (31). The experimental groups trained at 90% and 80% of maximum heart rate, respectively, for 20 weeks. Exercise sessions were monitored on a quarter-mile track with total distance being equal for both groups; the two groups averaged 4.2 miles and 509 kilocalories per exercise session. Group I trained 44.4 minutes per day at 92% maximum heart rate (173 beats/min.) and Group II trained 47 minutes at 80% maximum heart rate (161 beats/min.). As for the previous study, body weight and the sum of the same six skinfolds were used for evaluation of body composition; the anthropometric measures of chest expansion and abdominal, gluteal and thigh girths were also applied. The 90% group recorded

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a significant reduction in skinfold fat (149 to 138 mm.), which was also significantly greater than for the 80% group. Changes in the other measures, including body weight, were not significant.

Recently, Pollock and co-workers (33) conducted a third study in the above sequence; this time, a further investigation of the four-day-a-week jogging-running program. In the initial study, the intensity was at a high level, 90 to 95% of maximum heart rate, which may not be practical (or desirable) for many adults. The subjects in this study were nine healthy sedentary men, 28 to 47 years of age; a control group of 10 men was also employed. The conditioning was 30 minutes each session, four times a week for 20 weeks. Initially, the subjects walked and jogged equal 110-yard segments and progressed gradually to a continuous run. The walking segment of training was held constant at 3.75 mph; the jogging varied from 5.6 to 7.5 mph, depending on each subject's condition. The body composition measures were weight, sum of six skinfolds, and abdominal, gluteal and thigh girths. The control group did not change significantly on any of the measures. The experimental group showed significant reductions on all measures when compared to the control group. The gluteal and thigh girth differences, however, were due more to an increase on these tests by the control group, rather than an appreciable loss by the experimental group.

Sixteen sedentary men between 40 and 56 years of age trained by walking four times per week for 20 weeks in a study by Pollock and others (32). The walking was vigorous; by the last week, the men averaged 4.7 miles per hour (3.23 miles for a session of 40 minutes). Significant reductions in body weight and the sum of six skinfolds resulted. Inasmuch as circulatory-respiratory endurance measures also improved, it was demonstrated that vigorous walking can be an effective adult training activity. Further, the investigators observed that walking seemed to elicit a lower incidence of leg problems and less general discomfort during exercise than does running, especially for those who are beginning exercise regimens after years of sedentary living.

Studies by Others

Tooshi (40) formed one control and three experimental groups, each containing eight to nine men, 27 to 45 years of age. The experimental groups participated five days a week for 20 weeks in a progressive training program consisting of running, jogging and walking. For the three groups, the programs differed only in time of participation each day: 15, 30 and 45 minutes. The 45-minute training regimen produced a significant reduction in serum cholesterol level and total body fat, while the others did not. The investigator concluded that expenditures of less than 600 calories during exercise sessions were insufficient to cause significant changes in the measures used, which also included cardiovascular tests.

Cureton and Phillips (12) studied physical fitness of men as a result of two 8-week training programs separated by eight weeks of nontraining. Six volunteer participants were contrasted with four nonparticipants (controls); the ages of the men ranged from 28 through 47 years, all of whom had led sedentary lives for several years. The conditioning periods, conducted six days per week, were gradually progressive in nature, and consisted of approximately 15 minutes of calisthenics, 30 to 40 minutes of cross-country running, and 30 minutes of handball or squash. Significant changes occurred in reducing abdominal girth, surface area and total fat.

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Total fat was measured by skinfolds and by specific gravity through hydrostatic weighing. The greatest reductions occurred during the second training period, the last eight weeks.

Skinner, Holloszy and Cureton (38) studied the effects of a program of endurance exercises on physical work capacity and on fat reductions of 15 middle-aged men, all of whom had been sedentary for at least three years. The exercise program was conducted at noon, six days a week for six months; average attendance was 3.35 times per week. On three days each week, the program consisted of Cureton's progressive rhythmic endurance training regimen, of rhythmic calisthenics interspersed with walking, running and stretching, and accompanied by deep breathing. On the other three days, the men ran on an indoor dirt track. For the first month the exercise sessions lasted 30 minutes; subsequently they increased to three-quarters of an hour. Mean specific gravity of the body by hydrostatic weighing increased significantly; abdominal, chest and buttocks girths decreased significantly, as did the sum of six skinfold measures. Among the conclusions of the investigators: *"A vigorous exercise program is feasible for actively employed, middle-aged professional men, and such a program produces changes in functional capacity and body composition that run counter to the trend usually seen with aging."*

Elder (15) studied the effects upon cardiovascular fitness, flexibility and fat reduction from participation in conditioning exercises, 35-45 minutes per day, three days per week for three months. The subjects were men between the ages of 25 and 73 years. The conditioning program followed the continuous rhythmic procedures proposed by Cureton, except for shorter workouts, greater emphasis on jogging, and fewer performances of rhythmic exercises. In general the jogging progressed so that a large majority of the men could jog one mile in 12 minutes or less at the end of the eighth week and two miles in 20 minutes or less by the end of the program. Fat reduction was determined by use of skinfold tests at the following six sites: cheeks, abdomen, hips, gluteals, front thigh and rear thigh. The only skinfold measure that did not show a significant reduction was at the gluteal site. The t ratio for the sum of the six skinfolds was 3.48, significant beyond the .01 level.

Wilmore and co-workers (46) determined body composition changes of 55 men between the ages of 17 and 59 years as a result of a 10-week jogging program. At each session, the subjects were encouraged either to increase the distance each day or to decrease the time for a given distance. No subject jogged more than 24 minutes a day or more than three times a week. Over the 10-week period the mean rate of jogging was 7.5 mph; the mean overall distance covered during the study was 51.75 miles in a mean time of 6.9 hours.

The body composition tests were body density by hydrostatic weighing, seven skinfolds, and two girths. Small but significant alterations in body composition occurred from this moderate jogging program. The significant changes were: (a) Body weight decreased about 1 kg, while lean body weight remained essentially unchanged, indicating a loss in total body fat; (b) body density increased and the percentage of body fat decreased; (c) four of the seven skinfolds decreased, at the following sites: inferior angle of the scapula, the chest just above and medial to the axilla, midaxillary at level of fifth rib, and front of thigh; and (d) decreases of abdominal girth, made laterally midway between the lowest lateral portion of the rib cage and the iliac crest and anteriarly, between the xiphoid process of the sternum and the umbilicus.

The changes in the various skinfold and circumference measurements were not highly correlated to changes in body fat and body density. Consequently, the authors questioned the validity of using single skinfolds to estimate alterations in body composition; the sum of several skinfolds was recommended instead.

College-Age Men

With sedentary college men as subjects, Boileau (4) formed two groups based on their relative fatness, as follows: obese, 25-46% fatness (N = 8); lean, 10-20% fatness (N = 15). All subjects walked or ran on a motor-driven treadmill, 60 minutes per day, five days per week for nine weeks. The approximate energy expenditure prescribed was 600 kilocalories per day of physical conditioning. During the physical conditioning program, significant decrements in body fat and increments in fat-free body weight were found for both groups by anthropometric, densitometric and hydrometric analysis of body composition. The sum of 10 skinfolds decreased; body density increased. Relative total body water increased while extracellular water remained fairly constant, suggesting an increase in the intracellular water compartment. Total blood volume and plasma volume did not significantly change. While changes in the various measures were generally significant for both groups, they were greater for the obese subjects.

In a study by Dempsey (13), seven men 18 to 28 years of age, who differed markedly in their initial degree of obesity, underwent daily training for eight weeks, followed by normal activity for five weeks and then five additional weeks of daily training. The training sessions were one hour in length and consisted of "maximum movement" exercises (calisthenics, interval running, circuit training), progressive resistance exercises (weight training, isometrics), and individual and dual sports (swimming, squash, handball). Selected aspects of body composition were appraised through measurements of body density, subcutaneous tissue and fat-corrected limb circumferences. All subjects who were initially fat experienced losses in body weight and in subcutaneous and total body fat and increases in fat-free body weight and muscular mass. Gains in fat-free weight, however, showed some relation to the amount of excess fat being carried.

In a second study, Dempsey (14) subjected 35 healthy but inactive young men to measures of gross body weight, relative body weight (percentage of standard from height-weight tables), height, percentage of body fat, fat-free body weight, and the Balke test of treadmill performance. A multiple regression analysis of the data indicated that 52.2% of the total interpersonal variance in treadmill performance was accounted for by the anthropometrical variables employed. Body fat, fat-free body weight and relative body weight accounted for 38.9, 9.7 and 1.7%, respectively, of the total variance. A decline in these relationships for seven subjects undergoing training indicated that treadmill performance had improved somewhat independently of changes in body composition or body mass.

Anderson (1) equally divided 86 college men into control and experimental groups. The experimental group participated in a vigorous program of calisthenics, isometric exercises, weight training, sports and running, three days a week for nine weeks. The tests administered were body weight and skinfolds at three sites. Body density was estimated from the three skinfolds, using a formula by Brozek and Keys. The experimental group experienced significant decreases in fat for all three tests and increases in body density; the control group did not change significantly on any test. Both groups lost weight, but not significantly.

Girls and Women

For males, most studies on the effect of exercise upon fat reduction were conducted with middle-aged and older subjects. For women, the preponderance of such studies was with college women.

Middle-Aged Women

An especially interesting study pertaining to fat reduction by middle-aged women was conducted by Zuti (47) over a period of 16 weeks. Three experimental groups of 11 women each were formed; the subjects were between the ages of 25 and 45 years, premenopausal, in general good health, and from 16 to 40 pounds overweight. The tests given were body weight, 13 skinfolds, 15 trunk and limb girths, somatotype assessments, body density by hydrostatic weighing, predicted working capacity at a heart rate of at least 170 beats/minute on a bicycle ergometer (PWC_{170}), and blood limpid determinations. Programs for the three groups were designed to achieve a reduction of 500 calories per day over normal activities, as follows: Diet Group, diet reduction only; Exercise Group, exercise requiring 500 calories, no change in regular diet; Diet-Exercise Group, 250 caloric reduction in diet and 250 caloric loss through exercise. The exercise regimen consisted of walking, jogging-running, bench stepping and calisthenics.

In the Zuti study, all groups lost weight, but the differences between the groups were not significant. However, significant changes in body composition did occur, as shown in the following tabulation, given in pounds:

	Body Weight	Body Fat	Lean Body Tissue
Diet Group	-11.7	- 9.3	-2.4
Exercise Group	-10.6	-12.6	+2.0
Exercise-Diet Group	-12.0	-13.0	+1.0

Both exercise groups showed greater body fat reduction than did the Diet Group. The loss in lean body tissue by the Diet Group is undesirable, as it involves muscle tissue. All trunk and limb girth measures showed significant reductions as a result of weight loss, but were unaffected by the method used to create weight loss. Both exercise groups increased their circulatory-endurance PWC_{170} scores, while the Diet Group did not. Cholesterol and phospholipids were significantly reduced as a result of weight loss; the differences between the groups, however, were not significant.

College Women

The effects of a moderate exercise program on body weight and skinfold thickness of 11 obese college women was reported by Moody, Kollias and Buskirk (25); the program was conducted six days per week for eight weeks. Five walk-jog patterns were formulated, each equaling a 500-kcal expenditure, ranging from 50% of the distance walked at three mph and 50% jogged at five mph, to 100% jogged at five mph. The actual selection of the run-walk combination each day was left to the participant. The average subject completed 70% of the planned program. The measures applied were weight and the sum of 12 skinfolds. Over the period of eight weeks, body weight and skinfolds decreased significantly. According to calculations based on loss in body weight and skinfold thickness, total body fat decreased and fat-free weight increased.

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The effect of diet and physical activity upon 15 obese college women enrolled in a weight control class, which met for 35 minutes three times a week for a semester, was investigated by Tufts (41). The diet applied was the "1000-Calorie Exchange Plan" established by the American Dietetic Association. The physical activities were varied from day to day, but consisted of calisthenics, rhythmics, folk dancing, badminton, basketball, hiking, jogging, bicycling and circuit training. Among the tests employed were body weight, 11 skinfolds, arm girth, volumetric displacement in water of each arm, strengths of elbow flexors and extensors, and the "Q Test for Body Image and Movement Concept." Significant improvements of this semester of diet, weight control instruction and exercise were: reduction of body weight and 10 skinfolds; increase in strength of elbow extensor muscles of both arms; and improvement in body image. Arm volume did not change, which may be attributed to a balancing of fat loss and muscle enlargement.

Zwiren (48) formed an experimental group of 10 and a control group of four overweight college women. The experimental group participated in an 8-week physical education course one hour a day, five days a week. The exercise consisted of a walk-jog program of 500 kcal energy expenditure daily, as adapted to each subject. Both the exercise and control groups lost significant amounts of weight. However, only the experimental group had a significant loss in the total of 13 skinfolds: the pre- and postexercise amounts were 381.8 and 340.2 mm, a loss of 41.6 mm or 11%. The experimental group also had a significant decrease in percentage of body fat, while the control group did not. The investigator cautioned about making comparisons between the two groups, since the control group was considerably heavier than the experimental group at the start of the study (100.70 kg and 78.88 kg, respectively), and the control group also lost weight, the reason for which was not known.

Prentiss (34) conditioned 21 obese college women on a program of exercise utilizing a bicycle-type exerciser during the winter and spring quarters of the same year. The exercise regimen each day consisted of a 15-minute ride with three 30-second work periods evenly spaced during the ride. As each individual progressed and a plateau of work accomplished was reached, the number of work periods for the 15-minute ride was gradually increased. Work accomplished for each 30-second work period and for total work from the three 30-second periods were recorded in metrocycle units. Among the pre- and post-tests administered were: body weight; arm, forearm, waist, hip, thigh and calf girths; abdominal, subscapular, back of arm, and hip skinfolds; modified Harvard Step Test; and a control ride on the exercycle. The significant results were: reduction in body weight, seven pounds; loss in fat, especially at back of arm and hips; reduced girth measures, especially at waist and hips; gains in endurance, as measured by the Harvard Step Test and by the exercycle control ride. For the control ride, the heart rate on the final ride was less than on the ride at the start of the experiment in spite of a highly significant increase in total work.

With 172 college freshman women, Throneberry (39) studied their weight loss during a semester of physical education as related to the courses they chose. The greatest average weight losses were: 4.15 pounds in slimnastics and 2.00 pounds in balance and posture classes. Weight gains were recorded for the following classes: tennis, 2.95 pounds; archery and badminton, 2.48 pounds; and volleyball, 1.55 pounds. No appreciable mean weight changes were recorded in basketball and gymnastics classes and for a nonactivity group. It is not clear from this report whether significant differences in mean weights among the groups were present at the start of the study. Stated more pointedly: did the heavier girls choose the slimnastics and posture classes and the leaner girls the sports classes?

With college women as subjects, 20 in an experimental and 24 in a control group, Bowes (5) studied the effects of specific exercises on body weight, skinfolds and girths. The following skinfold sites on the right side and the girths at these sites were: posterior surface of upper arm, iliac crest on the midaxillary line, and medial side of thigh opposite superior ridge of the patella. The experimental subjects were enrolled in a physical education class for women which met for three 1-hour periods per week for 10 weeks. Thirty minutes per period were devoted to exercises, which consisted of body mechanics exercises for the first five weeks and modern dance techniques, composition, and lectures for the second five weeks. The differences between the experimental and control groups on all tests were not significant at the start of the study. For the experimental group, significant losses of arm skinfold and arm and knee girths occurred, mostly during the second five weeks (modern dance activity). Change in body weight was not significant. The investigator suggested that the results of her study should be considered with some caution due to some uncontrolled conditions.

Gulyas (16) reported on the effect of a body conditioning program upon the body composition of 70 college women. Body composition was measured by hydrostatic weighing with subsequent calculations of body fat and body density. Details on the conditioning program in which the subjects participated are not given in the report; nor is it clear whether the subjects were obese or nonobese. However, significant differences did occur in body composition, as evidenced by decreases in percent and total body fat and increases in total body density and lean body mass.

High School Girls

Body composition changes in 40 normal and obese high school girls were assessed by Moody and associates (26) following participation in a jogging program four days a week. Of the total sample, 12 girls were classified as normal and 28 as obese, using 30% body fat as an arbitrary division between the two groups. All subjects participated in the program for one semester (15 weeks) of walking and jogging; of the obese girls, 19 elected to continue for a second semester (total of 29 weeks). The program started with the girls jogging and walking one mile in equal proportion and was gradually increased until the daily distance was between three and three and one-half miles with at least 75% of the distance jogged. The body composition tests were: body density, lean body weight, and fat percentage, by hydrostatic weighing; sum of 12 skinfolds; and sum of eight girths. The obese girls demonstrated significant reductions in body weight and percentage of fat and increases in body density and lean body weights; subcutaneous fat, as measured by the skinfolds, decreased markedly. For the obese girls in the program for 29 weeks, a significant decrease in the girth measures also occurred; the greatest changes on all measures for these girls occurred during the first 15 weeks. The only significant change in the normal group was a reduction in skinfolds.

Elementary School Children

Although a study by Corbin and Pletcher (11) does not show the effect of exercise on fat reduction, it does provide information about the activity patterns of obese and nonobese fifth grade children (boys and girls combined). The subjects were divided into four groups on the basis of triceps skinfolds. Those with a skinfold of 17 mm or more were classified as obese (N = 11); the remaining pupils were divided into three groups of about the same size in accordance with skinfold amounts. Seven-day diet records for each child were obtained from parents. Activity patterns were studied by filming the children during games of high and low organization and during free play; indices of duration and intensity of activity were derived from these analyses.

The obese group was significantly less active than at least one of the nonobese groups in all activity situations. The intensity of the activity of obese children more nearly approximated that of nonobese children when the activity was more highly organized. In unorganized activity, all three nonobese groups were significantly more active than the obese group. Also, the obese group was active a significantly lesser percentage of time than the nonobese. The obese group consumed fewer calories of food than any of the three nonobese groups; however, the differences between the groups were not significant. Further, the differences between the four groups were not significant for amounts of proteins and carbohydrates consumed. The correlations between skinfold measures and various activity indexes for all groups combined were negative, significant at the .01 level and beyond. The correlations between calories and activity were not significant. The authors' conclusion agreed with Mayer, as reported earlier in this *Digest*: inactivity may be as important or more important than excessive caloric intake in the development and maintenance of childhood obesity.

Eighth Grade Pupils

Johnson (17) compared the effects of participating daily in physical education, and participating two or three days a week, on the fitness, skill, adipose tissue and growth of eighth grade boys and girls over a period of two years. Of the 743 pupils included in the study, 284 (151 boys, 133 girls) had physical education daily and 460 (221 boys, 239 girls) had physical education two or three times per week. The program was identical for all subjects in terms of the number of weeks spent in the various physical education activities. Near the end of the second year, a motor fitness test battery of six items for boys and four for girls, a skill test battery of four items for boys and two for girls, and the triceps skinfold were given. Longitudinal growth curves were based on biannual height and weight measures from grades one through eight. The results indicated that the 5-day subjects were significantly superior in motor fitness and activity skills and had significantly less fat than did the 2- and 3-day-a-week subjects. Body density was obtained from the triceps skinfold using the formulas for boys and for girls developed by Parizkova; the differences in lean body mass heavily favored the 5-day pupils. No significant difference in growth curves was found.

Weight Training

As can be seen so far in this *Digest*, the bulk of studies on the effects of exercise on fat reduction have employed various walk-jog-run regimens of physical activity. As reported here, some investigators have used progressive weight training as the means of inducing exercise. In these studies, the amount of weight for weight training regimens is designated usually as the amount that can just be lifted a given number of times. Thus, 10- RM is the weight possible for 10 repetitions.

In an experiment by Wilmore (45), 47 women and 26 men volunteered to participate in a 10-week period of intensive weight training; the average attendance was two days per week, 40 minutes per session. After five minutes of general warmup exercises, each subject completed two sets each of the following lifts: half squats or leg presses, toe raises, two arm underhand curls, standing press, bench press, bent arm pull-overs, bent rowing and side bends. Each exercise was performed with a starting weight of 7-9-RM; when this weight could be lifted 14-16 times, weight was added to reduce the number of repetitions back to the initial number.

The body composition measures used were lean body weight and absolute and relative body fat by hydrostatic weighing, seven skinfolds, and 17 and 15 girths respectively for the men and women. Both men and women substantially increased their lean body weight and decreased their absolute and relative body fat. Significant reductions in five of the seven skinfolds occurred for the women, but only in one skinfold for the men. Significant gains were found for both sexes in shoulder, chest, deltoid, biceps flexed and extended, and forearm girths, although the gains exhibited by the men were substantially greater. The author noted, however, that the girth gains, while statistically significant, were small; the greatest such gains were .25 and .40 inches for women and men respectively.

From 105 college male volunteers, Pencek (29) formed an experimental group of 68 and a control group of 37. The control group attended a sports lecture class, which did not involve physical activity; this group was found to have greater body density and amounts of fat than did the experimental group at the start of the study. The experimental group participated in progressive weight training for 35 minutes three times per week for six weeks; 35 of these men continued weight training for another seven weeks. Weight training consisted of seven barbell exercises and three exercises with body weight as the resistance media (floor pushups, situps and pullups). For barbell exercise, the loads started 6-RM; when 12 repetitions were reached, weight was added to force a return to the initial number of repetitions.

The body composition measures were: girths of the upper arm relaxed and flexed-tensed, waist and chest; skinfolds at hips, two locations on chest, and back of upper arm; body density, estimated from skinfolds by use of the equation by Pascale and co-workers. Both groups showed significant reductions in the arm skinfold, while only the experimental group had significant fat reductions at the hip and chest locations; the weight training group also had significant increases in the chest and both arm girths and in body density. During the additional seven weeks, the experimental group continued significantly to lose body fat and increase body density and arm girth.

Earlier at the same university, Clements (10) conducted a study with essentially the same experimental design as the preceding one by Pencek. Three skinfolds were administered. Percentage of body fat was estimated from the skinfolds by use of an equation proposed by Keys and Brozek. A significant decrease in body fat occurred as a result of the weight training. When further analyzed, a fat-plus subgroup lost 3.6% of body fat in 14 weeks of weight training; a fat-minus subgroup gained six pounds during the same period. The investigator observed that fatter men lose very little weight although the amount of fat seems to change. The thin boys gained weight. Any expected gain in the fat-plus subgroup's body weight because of muscle development does little more than equal their weight loss due to fat decrease in six weeks. In 14 weeks, the weight gain in the fat-plus subgroup seemed to compensate for the poundage of fat loss.

Mayhew and Gross (23) evaluated the effects of high resistance weight training on the body composition of 17 college women; 10 others served as nontraining controls. Body composition was assessed by seven skinfolds, eight muscular girths, four skeletal diameters, and total body potassium (^{40}K scintillation). From the potassium test,

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measures of lean body mass, fat weight and fat percentage were computed. The weight training group exercised 40 minutes per session, three times weekly for nine weeks, employing a circuit weight training routine. Exercises were modified to employ the Universal Gym Machine; two sets of the following exercises were performed each session: biceps curl, military press, supine bench press, latissimus pull, situps, forearm curl, bent-over rowing, bent-arm pull-over, wrist roll, seated leg press and heel raise. Each subject employed the 10-RM technique; when able to complete 15 lifts with a given weight, the weight was increased to establish a new 10-RM.

Significant increases in total body potassium, lean body mass, flexed biceps and forearm girths, and shoulder width occurred. Relative fat and chest depth were significantly decreased. Skinfold thickness and body weight were unaffected. Over the 9-week period, the sedentary control group did not show a significant change on any test. The authors concluded that high resistance weight training can enhance feminine body composition without concomitant masculinizing effects or marked changes in body weight.

Spot Reducing

A claim made by some exercise device manufacturers, exercise leaders and diet book promoters is that a particular program will help the individual "spot reduce." That is, the device, a specific exercise, or diet, can help burn off fat from practically any area of the body and that area only. Research has cast doubt on the validity of these claims. This section of the *Digest* will present studies on spot reducing as affected by exercise.

Schade, Hellebrandt, Westerland and Carns (36) divided 22 overweight university women into two groups; one group received spot reducing and the other participated in general exercise designed for weight reduction. Exercise programs were conducted for 45 minutes, three times a week for six weeks. Exercise for the spot reduction group concentrated on the hip and abdominal areas; for the generalized group, the concentration was on the musculatures of the upper back, shoulder girdle and extremities. A set of nine exercises was planned for each group; three of the exercises were common for both groups; they emphasized stretch, contraction and compression. The same nutritionally balanced diet was served to all subjects in the university's student union.

For evaluation, standardized photographs in the rear and profile positions were taken; with a planimeter, the surface areas were determined for the leg, thigh, combined hip and abdominal region, and the upper trunk, the latter including the upper arms. Small but significant losses in weight occurred for both groups, but the difference between the groups was not significant. In every instance, except the leg, greater decreases in surface area were found for the spot reducing group; however, the differences were not significant. The investigators concluded that reductions in body segments are most significant where fat accumulations are most conspicuous, regardless of the type of exercise.

In an earlier study, Carns and coworkers (8) compared general and localized exercise effects on segmental volume of 33 women who engaged in exercise three times a week for eight weeks. Segmental volumes were determined by water displacement. Both groups lost in body weight and in volume from the twelfth rib to the greater trochanter of the femur. However, no noticeable differential effect was attributed to spot reduction.

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With 15 college men as subjects, Roby (35) investigated changes in skinfold thickness over an exercising muscle; the triceps muscle of one arm was exercised, while the skinfold over the other, unexercised, triceps served as a control. Each exercise session for this purpose was 10 minutes in length, conducted three times a week for 10 weeks. A dumbbell was used with a 10-RM load; three sets of this exercise were completed during each exercise session. When a subject was able to complete 15 repetitions, the weight of the dumbbell was increased again to 10-RM. Skinfolds were taken over both triceps muscles. Skinfolds significantly decreased over both the active and inactive triceps; the difference between the two triceps, however, was not significant. The investigator attributed the skinfold losses to some weight reductions by both groups during the period of the study. In addition, the exercised triceps gained significantly in strength, while the unexercised triceps did not. The investigator concluded that the findings did not support the postulate that subcutaneous fat is reduced in localities where muscles are active and in proportion to their activity.

Olson and Edelstein (27) employed 32 high school boys to determine if triceps skinfolds taken over an exercised arm would decrease more than skinfolds on the opposite arm after a 6-week period of weight training. The exercises consisted of three sets of 1-arm curls and 1-arm triceps extensions with a dumbbell; three minutes rest was allowed between sets. The starting load for each exercise was 7-RM on the first set; when seven repetitions could be performed on all three sets, the load was increased, again to a 7-RM on the first set. The tests administered were triceps skinfold, flexed-tensed upper arm girth, and elbow flexion and extension strengths.

The triceps skinfold for the exercised arm decreased significantly during the 6-week training period, while the skinfold for the unexercised arm increased, but not significantly. The mean skinfold on the nonexercised arm was significantly less (.05 level) than the mean of the exercised arm prior to the training period; at the end, the order was reversed (.01 level of significance). Both the exercised and unexercised arms increased in girth. The only significant increase in strength was for elbow extension of the exercised arm. The authors concluded that hard exercise in a specific area of the arm will result in a reduction of subcutaneous tissue in that area.

Summary and Implications

The purpose of this issue of the *Physical Fitness Research Digest* is to present the value of exercise in fat reduction and to indicate the forms of exercise and their applications in numerous research studies. In concentrating on exercise, it is not intended to present exercise as a panacea, or cure-all. Other essential factors are obviously involved in weight control, including dietary considerations, medical treatment when glandular and other bodily malfunctions are causative factors, hereditary influences, and psychological and emotional involvements. More than one causative factor may confront a given obese person who is desirous of reducing fat deposits throughout the body. Studies on humans only are included in this report, so no attempt was made to review relevant studies on animals. Summarizations of the results from the studies reviewed follow, with some implications for physical fitness practices that may be drawn from them.

1. For this report, obesity occurs when the individual's diet produces more fuel than is needed to maintain body functions and to meet the energy requirements of daily activities, and this excess is stored as fatty tissue throughout the body, gradually increasing to an undesirable amount.

2. The disadvantages of obesity were presented as contributing to aesthetic disfigurement, organic disorders, social rejection, psychological maladjustments and emotional problems.

3. The causes of obesity were considered as: fuel intake through the diet in excess of daily needs, lack of exercise, hereditary and other familial considerations, glandular and other bodily malfunctions, and psychological, social and emotional problems. Certainly, an effective approach to fat reduction for a given individual may well involve any or various combinations of these causative factors.

4. The determination of obesity is not confined solely to the identification of an overweight condition based on sex, age and height, since body weight consists of many components, especially the skeleton, viscera, musculature and fat. Thus, the glaring weaknesses of the common age-height-weight tables were shown. Weight tables on growth considerations were presented, with special reference to Meredith's Age-Height-Weight Charts and the Wetzel Grid.

5. Adipose tissue measurement by skinfold caliper was presented as a more acceptable means of determining obesity. The triceps (back of upper arm) measure was considered the single best skinfold for this purpose, although the evidence suggests that the sum of several skinfolds is more desirable. However, obesity standards for the tricepts skinfold are available and presented in this *Digest*, so this test deserves attention in identifying obese persons under field conditions. Other measures of assessing body composition were considered, especially hydrostatic weighing and body volume; these measures, however, are confined to the research laboratory.

6. While weight has been included in studies of exercise and fat reduction, the significant measures relate to body composition. The prevalent measures are the sum of several skinfolds and hydrostatic weighing. From these measures, formulae are available to compute lean body weight (mostly muscular tissue), total fat and percentage of fat.

7. The most frequent physical activity utilized in studies on the effect of exercise in fat reduction is some regimen of walk-jog-run. This form of activity, too, as seen in the July 1974 *Physical Fitness Research Digest*, is commonly used in research on the improvement of circulatory-respiratory endurance; in fact, several of the studies reported here were designed primarily to evaluate C-R improvement, but also included body composition items. However, weight training was also utilized in fat reduction investigations, as were Cureton's progressive rhythmic endurance training regimen, circuit training arrangements and others.

8. For males, the bulk of fat reduction studies were conducted with middle-aged and older men as subjects. For females, the preponderance of studies were with college women.

9. Intensive physical conditioning causes a depletion of excess fat and an increase in lean body weight. In fact, some studies resulted in no appreciable change in body weight, but body composition did change with a decrease in body fat and a balancing increase in muscular tissue.

10. Caloric intake was not controlled in most of the fat reduction studies reported; commonly, the subjects were admonished to continue with their usual dietary practices. Still, obese persons without caloric restriction did significantly decrease fat and, as a bonus, increased lean body mass through exercise. Usually, control groups were employed in the studies; generally, these groups remained essentially constant on the body composition measures employed. Thus, it is possible to increase caloric expenditure sufficiently by means of regular exercise alone to produce a marked decrease in fat. However, exercise combined with dietary regulation is the more desirable approach to fat reduction.

11. Demonstrated in animals and observed in humans, the grossly obese are more sedentary than the nonobese. Furthermore, although caloric intake is often greater in a grossly obese than in a normal person, obesity can often be traced to a lack of physical activity without an abnormal increase in food intake.

12. Fat reduction results achieved from exercise regimens not only depend on the nature of the exercise but upon the manner a given regimen is applied. How a regimen is conducted is dependent upon its frequency, duration and intensity, all of which are explained in the studies reported. To illustrate: In one series of studies adult men participating in the same walk-jog-run program lost fat significantly when participating four times a week, but did not change on a two-day-a-week program. However, when the exercise program was intensified, significant improvements did occur with a twice weekly group. In another study, three groups of middle-aged men participated in the same walk-jog-run regimen for 15, 30 and 45 minutes, respectively. The 45-minute training group produced a significant reduction in total body fat and in serum cholesterol level, while the others did not. This investigator concluded that expenditures of less than 600 calories during exercise sessions were insufficient to cause significant changes in the measures employed.

13. In one study, vigorous walking produced the usual desirable body composition changes in adult men. The intensity of the walking may be judged by the fact that the average rate was 4.7 miles per hour after training four days a week for 20 weeks.

14. In a study of middle-aged women, diet, exercise, and diet-exercise groups, all geared to achieve a reduction of 500 calories a day, lost between 10.6 and 12.0 pounds of weight over a 20-week period; the differences between the groups were not significant. However, both groups engaging in exercise had greater average losses in fat and gains in lean body tissue as contrasted with the diet only group. The two exercise groups had about the same loss in body fat, but the exercise only group gained more in lean body weight; the gains were 2.0 and 1.0 pounds.

15. A bicycle-type exerciser proved effective in reducing body weight, fat, and the girths of waist and hips, and in improving the circulatory-respiratory endurance of college women. The exercise regimen consisted of a 15-minute ride interspersed with 30-second work periods.

16. Intensive progressive weight training programs resulted in desirable changes of body composition in six to 10 weeks of time. These changes were reflected in skinfold reductions, in decreases in absolute and relative fat, in increases in arm, shoulder and chest girths, and in increased lean body weight.

17. Most fat reduction studies have been conducted with sedentary individuals. As a consequence, all investigators have used a progressive approach in applying exercise, starting gradually and increasing systematically as each individual's condition improved. This approach is essential, as conditioning programs should be regulated to each individual's physical status. Three basic concepts in conditioning sedentary men and women, boys and girls, are:

   a. Exercise tolerance. The exercise tolerance of an individual is his or her ability to execute a given series of exercises or activities involving endurance in accordance with a specific dosage without undue discomfort or fatigue. With unfit persons, the tolerance will be low; they should not be pushed into competitive situations, whether it be with others or against scoring charts, until their condition warrants.

   b. Overload. In overloading, the individual's exercise is increased in intensity or extended for a longer time than normally. Thus, the participant should be encouraged to perform beyond his customary performance, but still within his exercise tolerance.

   c. Progression. Progression is intimately involved with the first two principles: overload progressively, keeping pace with increased exercise tolerance.

18. The possibility of spot reduction through exercise is not clear from findings of the limited research so far conducted, as these studies have produced conflicting results. Perhaps the following statements are presently justified as at least a partial answer: Reduction of fat in body areas is most likely where fat deposits are most conspicuous regardless of the exercise format used. Thus, both general and localized exercise of the muscles underlying pronounced fat locations will result in fat reduction of these deposits. However, a different reason for recommending general rather than localized (spot reduction) exercise, which is warranted from the studies reviewed, stems from the fact that exercise improves muscular tissue as well as reducing fat. Thus, general, overall exercise would logically spread this benefit throughout the musculature of the body, certainly a desirable result.

A CORRECTION: An error in the January 1975 *Physical Fitness Research Digest* appears on page 14, fourth line under "Motor Fitness Tests": the last word should be "skill," not "speed."

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