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Computer Technology to Evaluate Body Composition, Nutrition, and Exercise[1]

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The use of computer technology has made it possible to make accurate determinations of body composition, nutrition, and exercise. With the FITCOMP computer assessment system, detailed measurements of physique status have been made on a variety of world-class athletes, including professional football and baseball players, as well as on diverse groups of young and older men and women throughout the United States. The FITCOMP measurement system allows the user a choice of measurement techniques: fatfolds, girths, bone diameters, and hydrostatic weighing. Combined with body composition assessment is a nutrition and exercise plan. The nutrition plan is based on guidelines formulated by the American Dietetic Association. This application of computer technology is unique, because individuals can select the foods they will eat from a list of preferred choices from the basic food groups. Individual menu plans for breakfast, lunch, and dinner are generated to provide an optimal blend of nutrients aimed at achieving ideal body mass and fat percentage. This is coupled with an aerobic exercise program that is selected by the individual from nine different forms, including walking, jogging, running, swimming, cycling, and various sport activities. The caloric output is designed to reduce total body fat through reductions in body weight of 1.4 to 2.5 pounds per week, depending on the exercise selected and total weight loss necessary to achieve a weight goal (and ideal fat percentage). The aerobic exercise plan is based on the method of overload, where intensity and duration are periodically increased dependent on individual capabilities. The use of fitness-oriented computer technology makes it possible to prepare detailed reports about current status and progress as well as to systematize record keeping.

INTRODUCTION

The measurement and evaluation of body composition permit accurate quantification of the major structural components of the body—fat, muscle, and bone. Although height–weight tables are still used to assess optimal weight based on age and body frame size, such tables do not permit an assessment of the relative composition of the body. A person may weigh much more than the average weight for height standards based on insurance company standards, yet still be underfat in terms of the body's total quantity of fat. The so called "excess weight" could simply be additional muscle mass. A more desirable alternative to the height–weight tables is to determine the body composition by reliable and valid indirect measurement procedures. It has been our experience that practitioners, in their search for a simple way to measure body composition, sacrifice validity in favor of expediency.

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The purposes of the present paper are threefold: (1) to present indirect procedures for assessment of body composition, (2) to illustrate how these assessments are combined with the FITCOMP computer nutrition and exercise plan, and (3) to show how body composition evaluation can serve as the cornerstone for interfacing computer technology with important aspects of physical fitness.

I. TECHNIQUES OF MEASUREMENT

Three indirect procedures for assessment of body composition will be described. The first applies Archimedes' principle of hydrostatic weighing. With this method, percentage body fat is computed from body density (ratio of body mass to volume). The other procedures involve the prediction of body fat from fatfolds and girths. The girth technique provides a more sophisticated opportunity for incorporation with computerized outputs.

Body Density Determined by Hydrostatic Weighing

According to Archimedes' principle, if an object weighs 75 kg in air and 3 kg when submerged in water, the loss of weight in water is equal to the weight of the displaced water. Because the density of water at any temperature is known, the volume of water displaced can easily be computed. In the example, 72 kg of water is equal to 72 liters (1 kg of water = 1 liter in volume). The density of the person, computed as weight/volume, would be 75/72 or 1.0417 kg $\cdot$ liter^{-1}. In our laboratories, the following procedure is used routinely to determine body density.

The subject's body weight first is determined in air on a balance scale accurate to ± 50 g. A diver's belt is usually secured around the waist of fatter-appearing subjects to ensure that they do not float upward during submersion. The underwater weight of this belt and chair weight are determined beforehand and are subtracted from the subject's total weight under water. The subject, who wears a thin nylon swim suit, sits in a lightweight, plastic tubular chair suspended from the scale and submerged beneath the surface of the water. A swimming pool can serve the same purpose as the tank, and the scale and chair assembly can be suspended from a support at the side of the pool. In the tank, water temperature is maintained at about 35°C, which is close to the subject's body temperature. Water temperature is recorded to correct for the density of water at the weighing temperature. Figure 1 illustrates a "field" test of hydrostatic weighing for a former, All-Pro quarterback.

The subject makes a forced maximal exhalation as the head is lowered under water. The breath is held for about 5 sec while underwater weight is recorded on a sensitive scale accurate to at least ± 10 g or on a force transducer system with digital readout. The underwater weighing procedure is repeated 8 to 12 times because subjects learn to expel more air from their lungs with each additional underwater trial. An average of the last two or three weighings is used to minimize intraindividual variation. Although some researchers select the highest score in the series of weighings, we would like to emphasize that this procedure does not yield the most dependable or reliable score, since it may contain a variable and unknown error source. Reproducibility of body volume scores measured several

FIG. 1. Measurement of body volume by hydrostatic weighing.

times on the same day or on consecutive days is high, with the test–retest reliability coefficient usually above $r = 0.94$.

The formula for calculating the density of the body (D_b) is

Eq. 1 $$D_b = \frac{\text{mass}}{\text{volume}} = \frac{M_a}{(M_a - M_w)/D_w - \text{RV}} . \quad [1]$$

For ease in computation, the formula can be rewritten as

$$D_b = M_a \times D_w/(M_a - M_w - \text{RV} \times D_w), \quad [2]$$

where M_a = weight (kg); M_w = net underwater weight (kg); D_w = correction factor for water density at the weighing temperature, and RV = residual volume = (L).

Computing Percentage Body Fat. The percentage of fat in the body can be determined from a simple equation that incorporates density. The simplified "Siri equation" is obtained by substituting 0.90 and 1.10 kg · liter^{-1} for the densities of fat (F) and lean (L) tissue, respectively. Hence,

$$D = \frac{F + L}{(F/f) + (L/1)} \qquad [3]$$

where f and l are observed values for fat and lean, respectively. Because the density of the whole system equals the sum of its parts,
$F + L = 1$, and

$$D = \frac{1}{(F/f) + (L/1)}. \qquad [4]$$

By rearranging terms, the proportional contribution of F becomes

$$F = \frac{1}{D} \times \frac{f \times 1}{(1 - f)} - \frac{f}{(1 - f)}. \qquad [5]$$

With substitution, the derivation becomes

$$\text{percentage body fat} = \frac{495}{\text{density}} - 450. \qquad [6]$$

This equation was derived from a two-compartment model of the body consisting of fat and lean tissues. Fat extracted from adipose tissue has a density of 0.90 kg · liter^{-1} at 36°C, whereas fat-free tissue has a density of approximately 1.10 kg · liter^{-1}. Each of these densities remains relatively constant even with large individual variations in total body fat.

The measurement of body density by hydrostatic weighing and conversion to percentage body fat is highly recommended for the clinic and hospital environment, physical fitness center, and sports medicine facility. The use of this procedure to assess body fat should serve as the "gold standard"; it is preferable to the use of various combinations of the ponderal index, and avoids the ambiguities and uncertainties of popular field assessment procedures.

Measurement of Subcutaneous Fatfolds

The rationale for fatfold measurements is based on the assumption that approximately one-half of the body's total fat content is located in the fat deposits directly beneath the skin. The procedure for measuring fatfold thickness is to grasp firmly a fold of skin and subcutaneous fat with the thumb and forefinger, pulling it away from the underlying muscular tissue following the natural contour of the fatfold. Constant tension is exerted by the pincer arms of calipers at their point of contact with the skin. The thickness of the double layer of skin and subcutaneous tissues is then read directly from the caliper dial.

All measurements are made on the right side of the body with the subject standing. A minimum of two or three measurements are taken at each site and the average value is used as the criterion score. The anatomical locations for the five most frequently measured fatfold sites are (a) triceps—vertical fold measured at the midline of the upper arm halfway between the tip of the shoulder and the tip of the elbow; (b) subscapula—oblique fold measured just below the bottom tip of the scapula; (c) supra-iliac—oblique fold measured just above the hip bone (the fold is lifted to follow the natural diagonal line at this point); (d) abdomen—

vertical fold measured 1 in. to the right of the umbilicus; and (e) thigh—vertical fold measured at the midline of the thigh, two-thirds of the distance from the mid-knee cap to the hip joint.

Although the use of fatfolds to predict percentage body fat is widely used, a major drawback is that the person taking the measurements must have considerable experience in order to obtain consistent fatfold values. Because there are no standards by which to compare the results between different investigators from diverse geographic regions, it is almost impossible to determine which sets of data are in fact "correct." Thus, prediction equations developed by any particular researcher (which may be highly valid for the sample measured) may be almost useless to predict body fat for an individual when another person makes the measurements.

Even when an approach that incorporates measurement of surface area with fatfolds is used, there is still the basic limitation imposed by technique. Despite this, the theoretical rationale for the surface area formulation is sound, and the approach may provide an adequate estimate of body fat for different populations, especially in athletes. The basic equation is

$$\text{percentage fat} = \frac{\Sigma \text{ fatfolds}}{3F \times k(\text{sf})}, \qquad [7]$$

where Σ fatfolds is the sum of 3, 4, or 5 fatfolds, usually triceps, subscapular, supra-iliac, abdomen, or thigh; $3F = 3\sqrt{\text{weight, kg/height, dm}}$; and $k(\text{sf}) = \Sigma$ fatfolds/ $3F \times$ percentage fat. To calculate k(sf), the value for percentage fat is based on a criterion method such as underwater weighing to express the observed average (mean) for the general group or population (of a particular age, sex, state of training, or sport). Thus, different k(sf) constants are required for diverse populations. For example, consider the mean values for a population representing relatively sedentary young men: height = 18.42 dm; weight = 72.16 kg; fatfolds = 67.3 mm; fat = 15.3%. The k(sf) constant is calculated as

$$k(\text{sf}) = \frac{67.3}{3\sqrt{3.9175} \times 15.3} = 0.741.$$

By knowing the k(sf) constant, the percentage body fat for any similar individual can now be computed with basic equation [7]. If weight = 74.0 kg, height = 17.52 dm, and the sum of five fatfolds = 57.5 mm, then percentage fat for this particular young man is computed as follows:

$$\begin{aligned} \text{percentage fat} &= \frac{\Sigma \text{ fatfolds}}{3F \times k(\text{sf})} \\ &= \frac{57.5}{6.166 \times 0.741} \\ &= 12.6\%. \end{aligned}$$

This method of computing percentage body fat warrants further study, especially in athletes where estimates of body composition are desirable as part of a screening profile.

Measurement of Girths

Girths are measured by lightly applying a cloth or plastic measuring tape to the skin surface so the tape is taut, but not tight. This procedure avoids skin compression, which could produce lower girth scores. Duplicate measurements should be taken at each site and the average used as the criterion circumference score. The anatomic landmarks for the various girth measurements are as follows:

(a) Shoulders—maximal protrusion of the bi-deltoid muscles and the prominence of the sternum at the junction of the second rib.

(b) Chest—for men about 1 in. above the nipple line; for women at the axillary level. Note: in men and women, the tape is placed in position with the arms held horizontally; the arms are then lowered and the measurement recorded at the midtidal level of respiration.

(c) Abdomen—take the average of the following two circumferences: (i) the conventional circumference of the waist just below the rib cage at the minimal width, (ii) level of the iliac crests at the umbilicus (omphalion).

(d) Buttocks—maximal protrusion and, anteriorly, the symphysis pubis. Keep heels together.

(e) Thighs—crotch level at the gluteal fold.

(f) Biceps—maximal circumference with the upper arm fully flexed (not 90°) and fist clenched.

(g) Forearms—maximal circumference when the arm is extended with palm up.

(h) Wrists—the circumference distal to the styloid processes of the radius and ulna with the palm down.

(i) Knees—the middle of the patella with the knee relaxed in slight flexion.

(j) Calves—maximal circumference.

(k) Ankles—minimal circumference, usually just above the malleoli.

Application of Girth Measurements: The Behnke Anthropometric System

Table 1 displays the essential details of the Behnke anthropometric system, a method that has played a very important role in the evaluation of physique status. Data are presented for the basic matrix of 11 girths, including head and neck. These data are useful for inter- and intragroup comparisons, for the derivation of ponderal equivalents, fractional weights, and segment volume analysis based on routine anthropometry.

Table 2 illustrates the utility of the girth analysis system for quantifying changes in body configuration with aging. From 1955 to 1983, the subject was measured on 10 occasions by seven different investigators, each proficient with anthropometric techniques of measurement. What is remarkable is the close agreement between actual body weight and body weight calculated from the girth measurements. The basic formula for calculation of weight based on girth dimensions is

$$\text{Calc } W = D^2 \times \text{ht(dm)} \times 0.111, \qquad [8]$$

where D is the sum of 11 girths divided by 100.

By age 79, the highest values were recorded for the waist and omphalion, wrist

TABLE 1

BEHNKE ANTHROPOMETRIC SYSTEM FOR A REFERENCE MAN AND WOMAN

Reference man	Variable	Reference woman (cm)	Reference man (cm)	k^a	Girth site	Reference woman (cm)	k
20–24	Age group (years)	20–24	110.8	18.47	Shoulder	97.4	17.51
174.0	Stature (cm)	163.8	91.8	15.30	Chest	82.5	14.85
70	Weight (kg)	56.8	77.0	12.84	Waist	65.6	11.80
69.6	Median weight (kg)	56.2	79.8	13.30	Omphalion	77.8	13.99
6.00	$3F^b$	5.56	78.4	13.07	Abd-avg	71.7	12.90
6.00	D^c	5.56	93.4	15.57	Buttocks	94.2	16.93
61.8	LBW[d]	43.0	54.8	9.13	Thigh	55.8	10.03
60	Fat-free weight (kg)	42	31.7	5.29	Biceps	26.7	4.80
—	Minimal weight (kg)	48.4	26.9	4.47	Forearm	23.1	4.15
			17.3	2.88	Wrist	15.2	2.73
			36.6	6.10	Knee	34.9	6.27
			35.8	5.97	Calf	34.1	6.13
			22.5	3.75	Ankle	20.6	3.70
			600.0	100	Total	556.0	100

[a] k = proportionality constant computed as the mean of the given measurement in relation to the sum of the 11 girths. Example: $k = 18.47$ (shoulders) is $110.8/600 \times 100$.

[b] $3F = 3\sqrt{\text{weight, kg/stature, dm}}$

[c] D = sum of 11 girths/100, for the 11 girths, the Abd-avg girth is used (not waist or omphalion).

[d] LBW = Body weight minus fat weight.

TABLE 2

CHANGES IN BODY SIZE AND GIRTH DIMENSIONS OVER A PERIOD OF 28 YEARS[a]

Year	1955	1956	1960	1962	1964	1964	1967	1971	1977	1983
Age	52	53	57	59	60	60	63	67	74	79
Stature (cm)	178.8	178.8	178.8	178.8	178.8	178.8	178.4	178.4	178.4	177.3
Weight (kg)	100.0	83.6	94.8	96.4	98.0	93.0	95.6	84.3	88.2	95.2
Calc W^b (kg)	99.2	84.6	94.2	96.1	98.6	93.7	95.9	85.0	87.6	95.3
Girths (cm)										
Shoulder	125.7	120.6	121.1	122.5	122.8	122.0	123.2	116.6	120.0	117.5
Chest	108.0	97.8	104.5	108.3	109.3	105.6	108.0	102.6	101.3	108.6
Waist	101.2	84.7	99.6	101.0	100.6	97.4	101.4	86.7	94.1	105.2
Omphalion	100.5	90.8	103.5	103.0	99.9	98.5	103.3	93.5	96.7	108.0
Abd-avg	100.8	87.0	101.6	102.0	100.3	98.0	102.4	90.1	95.4	106.6
Buttocks	108.0	99.5	104.7	106.3	107.9	106.1	106.7	100.8	102.9	106.5
Thigh	64.2	57.8	63.2	61.8	63.2	60.8	61.4	55.6	56.8	59.5
Biceps (flex)	41.3	37.7	39.0	39.6	40.5	38.6	38.5	36.3	37.5	38.5
Forearm	31.9	29.8	31.1	31.2	32.4	30.7	30.8	29.3	29.2	30.0
Wrist	19.4	19.2	19.1	19.6	20.1	19.7	20.3	19.1	19.0	20.2
Knee	43.3	41.4	42.3	41.8	44.0	41.2	42.1	41.4	41.2	45.1
Calf	40.4	38.8	38.3	38.9	40.2	39.8	39.4	39.5	38.3	39.8
Ankle	23.8	23.3	24.2	23.5	24.0	24.0	23.5	23.3	23.1	24.1
Sum[c]	706.8	652.9	689.1	695.5	704.7	686.5	696.3	654.6	664.7	696.4
D	7.07	6.53	6.89	6.96	7.05	6.87	6.96	6.55	6.65	6.96

[a] Data courtesy of Albert R. Behnke, M.D., based on measurements of him over a 28-year span.

[b] Weight calculated as $D^2 \times$ stature (dm) $\times$ 0.111. An average of waist and omphalion girths (Abd-avg) was used to compute D.

[c] Sum = 11 girths, excludes waist and omphalion; uses Abd-avg. Measurements for 1967–1983 taken by one of us (F.I.K.).

and ankle. Because the sum of the bone diameters remained essentially unchanged from age 59 to 79, the increase in girth size reflects accretion of fat in adipose tissue, particularly in the midtrunk region.

The calculation of body weight by the girth technique serves as an index of the accuracy of the girth measures. If weight cannot be predicted to within 1 kg, the girths are remeasured. With practice, reliability coefficients based on test–retest (same day or different days) exceeds $r = 0.94$. When using a cloth tape, frequent calibrations should be made against a meter stick.

II. COMPUTER TECHNOLOGY: THE FITCOMP SYSTEM

FITCOMP (acronym for fitness by computer) grew from the need to provide a rapid system of data analysis for various professional sport teams measured in the early 1970s. We have devised an interactive computer system for input, analysis, and output to provide individualized reports to athletes and coaches on a timely basis. The computerized approach also enabled us to assemble and compile a vast amount of anthropometric data for later quantitative analysis of basic relationships. What impressed us at the time was the need to integrate information about body composition (chiefly recommendations concerning weight loss and an optimal playing-weight range) with nutritional recommendations and various parameters of physical fitness (muscular strength and endurance, cardiovascular capacity, and flexibility).

Early on, we decided against assessment of nutrient intake from daily recall of foods consumed or 3- to 7-day food diaries; instead, we took the position that a computer could be programmed to plan daily menus based on food preferences selected by the individual. It was our firm belief, and still is, that individuals respond more favorably with regard to weight loss when they are allowed to make choices about food consumption and exercise. Instead of selecting specific calorie menus from cookbooks, we devised a computer program that constructs nutritionally balanced breakfasts, lunches, and dinners from a basic list of foods selected by the individual. Preselection of foods is the major distinguishing characteristic between the FITCOMP meal plan and all other computer-based nutrition programs.

The food list is essentially that devised by the American Dietetic Association and incorporated into their food exchange plan. The essence of the FITCOMP approach is to combine body composition, nutrition, and exercise into one computer program, either separately or in combination, so the individual receives a comprehensive plan to achieve an ideal body fat percentage and to improve aerobic fitness.

Body Composition Computer Report

Four different versions of the computer report are available, depending on the level of sophistication required. In the simplest form, a desired weight loss is requested by the individual, and the output is adjusted so body weight can be reduced by at least 1.2 pounds per week, but no more than 2.4 pounds, depending on the option selected for exercise. Figure 2 shows an example of a weight loss

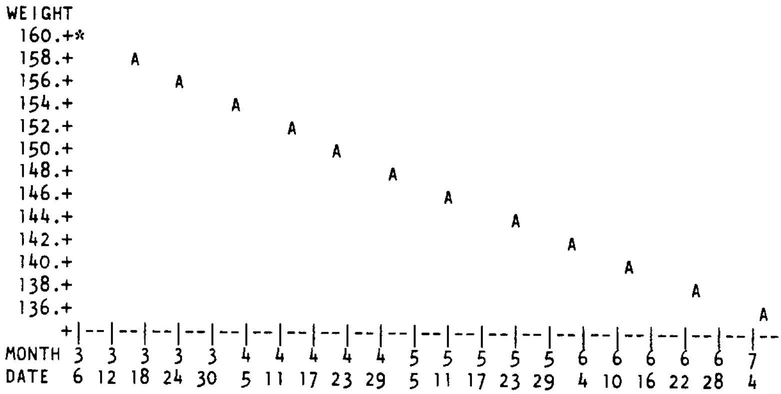

FIG. 2. Computer-generated 25-pound weight loss curve to accompany a 1,421-calorie meal plan. It is possible to draw up to three weight loss curves on the same printout, each geared for a different rate of weight loss depending on caloric level and intensity of the exercise prescription.

curve for a 25.0-pound decrease in weight. The algorithm takes into account the magnitude of weight loss, an estimate of changes in resting metabolic rate, change in status of physical activity (e.g., inactive to vigorous), as well as duration and intensity of exercise participation. If the individual adheres to the dietary and exercise prescription, then the theoretical endpoint or target "goal" weight can reasonably be expected to occur during a given week and month. A specific date is assigned as a target so individuals can work toward their goals realistically.

If body density data are available, then the individual's current level of body fat, independent of weight, is used to generate the weight loss curve. Data from the world literature are used to provide guidelines for theoretical vs expected alterations in body composition. Because dietary plans are never generated without concomitant exercise regimens, weight loss by diet restriction alone is not allowed. In this way, initial weight loss, chiefly by dehydration, is avoided and lean mass is spared. Preservation of lean mass is a common occurrence when diet is accompanied by exercise—preferably large muscle exercise performed at an intensity that elevates pulse rate to between 60 and 85% of maximum.

If fatfolds or girths are available, then age-, sex-, or fitness-specific regression equations can be used to predict percentage body fat. The data base includes mean values from the pertinent literature and unpublished data on approximately 6,600 individuals, including several thousand "high caliber" football, baseball, basketball, volleyball, and soccer players, as well as body builders, weight lifters, gymnasts, rowers, and combat sport and track and field participants. For all subjects, measurements include body density by hydrostatic weighing with correction for residual air volume, and duplicate or triplicate measures of 5 fatfolds and the 11 basic girths. Combined with height, weight, and age information, regression equations to predict body fat have been generated that yield multiple r values above 0.90 with standard errors of estimate for body fat in the range of ± 1.1 to 2.0.

Nutrition Meal Plan Report

Figure 3 is an example of the first 2 days of a 1,258-calorie food plan. The usual procedure is to generate a 14-day plan; because foods are arranged as exchanges within a given food category (breads, dairy products, fruits, meats, fats, vegetables, alcohol, and "treats"), each exchange is assigned a specific calorie value. Therefore, one can exchange any one food within a food category with any other food in that category. One-half cup of cooked grits, for example (70 calories), can be exchanged for one-half cup of cooked cereal, bran flakes, cooked barley or spagetti, lima beans, or one ear of corn-on-the-cob, one small baked potato, and so on. In addition, any one complete breakfast, lunch, or dinner can be interchanged for any other breakfast, lunch, or dinner. This makes the number of food combinations for a given day equal to 14 factorial. There is also an override function, so hundreds of consecutive meal plans could be generated. In practice, however, up to 35 consecutive days of meals have been generated for individuals enrolled in supervised weight loss experiments; thereafter, individual food items are reviewed and new menus generated. The basic food list includes 11 food choices from the milk category, 35 each from breads and fruits, 42 from meats,

	Breakfast	Lunch	Dinner
Day 1	Cooked grits 1 cup Non-fat milk 1 cup Swiss cheese 1 ounce Apricot juice 1/2 cup	Soda crackers 8 Hot Dog 1 small Avocado 1/6 Plum 4 medium	Cupcake-icing 1 small Milk - 2% 2/3 cup Veal - chops 3 ounce Artichokes 1 1/2 cup Radishes no limit Walnuts 2 Tangarines 1 medium

	Breakfast	Lunch	Dinner
Day 2	Cooked cereal 1 cup Milk, skim 1 cup American cheese 1 ounce Prune juice 1/4 cup	Matzo 1 Turkey 1 ounce Diet Margarine 4 tsp Pear 2 small	Wine red/white 3 1/2 ounce Non-fat milk 1 cup Veal - cutlets 3 ounce String beans 1 1/2 cup Lettuce no limit Peanuts-dryroast 20 Pineapple 1/2 cup

FIG. 3. Sample breakfast, lunch, and dinner computer-generated menus. These are reproductions of actual outputs from the page printer.

17 from fats, 28 from vegetables, 7 from low-calorie vegetables, 12 from treats, and a choice from 7 common alcoholic beverages. The current list of 194 foods was based on those most frequently chosen by approximately 13,000 individuals throughout the United States who responded to a questionnaire which included 234 food items. Examples of foods not included are goat's milk, powdered milk, bratwurst, wheat germ, and apricot juice.

Aerobic Exercise Report

The FITCOMP aerobic exercise program is designed so individuals will eventually expend approximately 300–500 kilocalories per exercise session. There are three basic exercise plans geared for the beginner, intermediate, or advanced participant. The appropriate level is assigned based on age and sex, and the response to questions concerning physical activity from the questionnaire (Table 3).

The three main activities are walking, jogging or running, and swimming or cycling. A person can also select activities from nine other popular choices: racquetball, circuit training, squash, badminton, basketball, downhill skiing, tennis, golf, and aerobic dancing. Figure 4 outlines step 17 of a 21-step exercise program for the person whose weight loss curve and sample menus were shown in Fig. 2 and 3.

In this example, all activities are listed together to show the approximate equivalency in terms of caloric expenditure for either a beginner, intermediate, or advanced level of participation. This kind of computer-generated output gives the person freedom to exchange activities for any given workout; it offers flexibility and variety in planning workouts to meet individual preferences. The major advantage, however, is the maintenance of caloric equivalency between the different

TABLE 3
ASSESSMENT OF CURRENT LEVEL OF DAILY PHYSICAL ACTIVITY[a]

Place an X next to the one section which best describes your current level of daily physical activity:

a. ___ **Inactive:** You have a sit-down job and no regular physical activity.

b. ___ **Relatively Inactive:** Three to four hours of walking or standing per day are usual. You have no regular organized physical activity during leisure time.

c. ___ **Light Physical Activity:** You are sporadically involved in recreational activities such as weekend golf or tennis, occasional jogging, swimming, or cycling.

d. ___ **Moderate Physical Activity:** Usual job activities might include lifting or stair climbing, or you participate regularly in recreational/fitness activities such as jogging, swimming, or cycling at least three times per week for 30 to 60 min each time.

e. ___ **Very Vigorous Physical Activity:** You participate in extensive physical activity for 60 min or more at least 4 days per week.

[a] This question is from the questionnaire that includes name, address, age, sex, weight, height, desired weight, preference for exercise, and food preference list.

```
--------------------------------------------------------------------------
STEP Jog for 4 1/2 miles in 51 minutes 15 seconds(11 min 23 sec/mile)
 17  This exercise burns 512 calories.

     Cycle 5 3/4 miles in 22 minutes 59 seconds(15.01 miles/hour)
     Repeat this 2 times. This exercise burns 459 calories.

     Swim 500 yards in 12 minutes 55 seconds(38.70 yards/min)
     Repeat this 4 times. This exercise burns 516 calories.

     The following alternate activites will expend approximately the
     same number of calories as the aerobic activities above expend.
               Racquetball        for      92. minutes
               Circuit Training   for      39. minutes
               Squash             for      69. minutes
               Badminton          for     166. minutes
               Basketball         for      62. minutes
               Downhill Skiing    for      72. minutes
               Tennis             for     148. minutes
               Golf               for      85. minutes
               Aerobic dancing    for      50. minutes
--------------------------------------------------------------------------
```

FIG. 4. Computer-generated exercise prescription. This example shows the approximate caloric equivalency for the three main activities, walking, cycling, and swimming, and nine other activities.

activities that is linked with caloric input from the menus. If inclement weather prohibits jogging or cycling, then swimming or racquetball, for example, can be substituted without altering either the required calorie output (activity) or the required calorie input (food) side of the energy balance equation. In this way, the individual stays in phase with his or her tailor-made weight loss curve. The exercise prescription is sensitive to individual differences because it considers age, sex, current level of physical activity (relative fitness status), and body size (height and weight) and body composition (percentage fat and lean body weight).

Practicality of Computer-Generated Reports

The most obvious advantage of computed-generated reports is that exercise and menu planning are based on individual preferences, rather than requiring adherence to standard workouts and set meal plans as occurs typically in popular books on exercise or diet. It is unnecessary to spend time performing tedious calculations and trying to individualize a particular exercise and nutrition plan; the speed in which the final report can be obtained is only limited by the speed of the output device (printer) since the computations can be done in a fraction of a second. In our own work, we utilize a large main-frame computer with a high-speed page printer. A typical 16-page computer report is printed in less than 10 sec. In the future, we hope to make the FITCOMP program interactive with the new generation of powerful, but relatively inexpensive, home minicomputers.

In summary, interactive, computer-based technology can provide individualized reports that take into account body size, body composition, age, sex, current fitness status, and activity preference. Such reports can greatly enhance the quality of health services.