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ABSTRACT

In this presentation on exercise and aging, the following explanations are made: the nature of physical fitness, physical fitness values, the importance of recognizing individual differences, physiological changes occurring with age through the adult years, physical fitness studies pertaining to middle-aged persons, the trainability of older people, and suggestions for an adult fitness program. The suggestions emphasize proper principles of exercise and procedures for the improvement and maintenance of circulatory-respiratory endurance and muscular strength and endurance, basic physical fitness components, and body flexibility. The studies presented show that (1) older people are trainable in respect to physical fitness components even though many have been sedentary for many years; (2) exercise, when properly applied, can retard the aging process and add vigor throughout life; (3) improvements in the physical fitness components are slower for older people than for younger; and (4) the older person cannot hope to regain his or her youthful performance level. Some case studies are provided; many older persons have phenomenal performance records and engage in championship events into their seventies and beyond. A list of references is included. (MM)

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EXERCISE AND AGING

The last two *Physical Fitness Research Digests* were devoted to topics of current concern to the President's Council on Physical Fitness and Sports, as indicated by the Executive Director, C. Carson Conrad. The topics were: "Physical Fitness Practices and Programs in Elementary and Secondary Schools," October 1976; and "Jogging," January 1977. This issue is intended to contribute to a third such concern, "Exercise and Aging." Efforts are made to show the need for and values of exercise by older Americans and to provide advice and suggestions for initiating and maintaining exercise regimens, especially for those who have been sedentary for several years and longer. Research evidence is utilized to justify and support the proposals and suggestions made insofar as such evidence is available. Considerable physical fitness research has been reported with adults. As would be expected, however, most subjects were in the middle ages with a much smaller number in the older ages of 60 years and over. As appropriate, references are made to findings reported in former *Physical Fitness Research Digests* in order to make this a self-contained account.

In 1972, the Opinion Research Corporation, Princeton, N.J., conducted a National Adult Fitness Survey for the PCPFS in which national representative samples of approximately 2,000 men and women each were interviewed. Summaries of the survey results appear in the May 1973 *Newsletter* of the PCPFS and the April 1974 *Physical Fitness Research Digest*. According to the survey, only 39% of Americans aged 60 and over get any systematic exercise. The favorite form of exercise for this age group is walking, which is practiced by 46% of the men and 33% of the women who exercise. Few older people engage in more vigorous forms of activity: 6%, calisthenics; 4%, swimming; 3%, bicycling; 1%, jogging; and 1%, men only, weight training. From their responses to survey questions, these individuals did not have good physical education and athletic experiences when young and are not informed about the contributions that physical fitness can make to their personal health, performance, and appearance.

Because of the extremely low level of physical fitness practices by United States adults revealed by the survey, the President's Council on Physical Fitness and Sports is taking action to improve this situation. Basic to the problem are the attitudes toward exercise and fitness of most older citizens. Conrad (13) has characterized these attitudes, as follows:

a. They believe their need for exercise diminishes and eventually disappears as they grow older.

b. They vastly exaggerate the risks involved in vigorous exercise after middle age.

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c. They overrate the benefits of light, sporadic exercise.

d. They underrate their own abilities and capacities.

As stated by Conrad: *"The challenge is one we cannot fail to meet. The stakes are too high. What we are talking about is, quite simply, more years of life and a more abundant way of living for 30 million of our fellow citizens."*

The Federal government, per se, has shown concern for the improvement of the physical fitness of the aging. On April 22, 1975, the Subcommittee on Aging of the Senate's Committee on Labor and Public Welfare heard testimonies on this subject from representatives of relevant associations, Federal agencies, and the fields of cardiology, psychiatry, geriatrics, and exercise physiology (33,52). The weight of the testimonies moved Congress to amend the Older Americans Act by directing the Administration on Aging (AOA) to encourage the development of services designed to enable older Americans to attain and maintain well-being through programs of regular physical activity and exercise. Through a grant from the AOA, the National Association for Human Development and the President's Council on Physical Fitness and Sports are cosponsoring a pilot project to train physical fitness leaders for the elderly and to educate, motivate, and enlist the support and participation of older persons in physical activities in order to enhance their general health. Workshops have been held in three widely separated cities representing four states. They featured older people themselves, with representatives of state and local agencies, physical educators, community and college officials, and community leaders (13, 55). The statewide workshops have generated regional and local workshops in their respective areas. The model project created so much interest that plans are projected to expand the program nationwide.

THE NATURE OF PHYSICAL FITNESS

Physical fitness is defined as the ability to carry out daily tasks with vigor and alertness, without undue fatigue, and with ample energy to enjoy leisure-time pursuits and to meet unusual situations and unforeseen emergencies. The definition implies that physical fitness is more than "not being sick" or merely "being well." As expressed by Richard Keelor, Director of Program Development for the PCPFS (33): *"Physical fitness really implies more than the ability to do a day's work without running out of gas or surviving the emergency of snow shoveling or grass cutting. It is also a state of well-being that breeds confidence, poise, posture, physical ability, and an exhilarating feeling of buoyancy."*

Inasmuch as this physical fitness definition is so general, a breakdown into its underlying components is essential for its adequate understanding and, subsequently, for a determination of the types of exercise to be employed in its improvement and maintenance. Assuming a body which is organically sound and free from disease, the components of basic concern are:

Muscular strength: strength of muscles in a single maximum contraction. Example: maximum amount of weight raised in a single lift.

Muscular endurance: ability of muscles to perform work. Examples: number of situps; maintenance of an isometric contraction.

Circulatory-respiratory endurance: moderate contractions of large muscle groups over long periods, during which pronounced adjustment of the circulatory-respiratory complex are necessary. Example: jogging.

For those with inadequate trunk-hip flexibility and marked posture deviations, appropriate steps should be taken for their amelioration.

PHYSICAL FITNESS VALUES

The values of physical fitness and exercise are not circumscribed by age; they are general and apply in some degree to all ages. Certainly an individual's physical fitness problems may vary with age and some problems may be more acute in old age than during youth. This section is devoted to a general statement of the values of exercise and physical fitness.

Several *Physical Fitness Research Digests* have been devoted to the importance of physical fitness in the total effectiveness of the individual and of physical activity for continued well-being. These reviews demonstrate that the individual acts and reacts as an integral whole, rather than as separate physical, mental, social, and psychological entities. Further, the need for exercise is shown in maintaining organic soundness, in fat reduction, and in motor performances. While such relationships are significant, they are not sufficiently high for predictive purposes, which is to be expected. Separately and in combination these entities are affected functionally by a host of factors, including the individual's interests, motivations, opportunities, cultural and social backgrounds, economic status, and the influences of associates.

Former *Digests* dealing with physical fitness values are: "The Totality of Man" (mental), October 1971; "The Totality of Man" (personal-social), January 1972; "Physical Activity and Coronary Heart Disease," April 1972; "Exercise and Blood Cholesterol," July 1972; "Exercise and Other Risk Factors Associated with Coronary Heart Disease," October 1972; "Exercise and Fat Reduction," April 1975; and "Health Practices and Physical Health Status and Diet and Exercise Relation to Peripheral Vascular Disease," April 1976. Certain of the salient conclusions and implications that are at least reasonably well supported by the research evidence follow.

Mental Achievement. More studies produced positive relationships between physical-motor traits and mental achievements than resulted in nil or negative results. It may be contended that a person's general learning potential for a given level of intelligence is increased or decreased in accordance with his degree of physical fitness.

Personal-Social Status. Positive relationships have been shown between physical and motor traits and personal-social characteristics, as evaluated by psychological inventories, peer status indicators, teachers' assessments, and self-concept instruments.

Coronary Heart Disease. An overwhelming majority of studies on adults from several countries supports an inverse relationship between the amount of physical activity in their daily lives and the incidence of coronary heart disease. Regular physical activity does not invariably prevent a heart attack but will make its occurrence much less likely; further, in the event of an attack, it tends to be less severe and the likelihood of survival is greater.

Risk Factors Associated with Coronary Heart Disease. Utilizing circulatory-respiratory endurance regimens of exercise, with appropriate intensity and dosage continued regularly over a period of time, the following results have been achieved with adults: reduction in serum cholesterol and triglyceride levels; development of collateral circulation around coronary artery restrictions; improvement in myocardial vascularization; increase in red blood cells and blood volume; improved fibrinolytic capability; and reduction in blood perssure.

Peripheral Vascular Disease. As reported by Pritikin and associates (44), the Longevity Research Institute of Santa Barbara and the Veterans Administration Hospital of Long Beach, California, studied the treatment of peripheral vascular disease through diet and walking over a period of six months (80% of the patients had had arterial reconstruction surgery). Nineteen patients with this disease were assigned to each of two groups. Both groups walked daily as much as they could. The experimental factor was the diet consumed: the control group had the conventional diet for cardiac patients, consisting of 20% protein, 40% fat, 40% carbohydrates, and 300 mg. cholesterol; the diet for the experimental group was 10% protein, 10% fat, 80% carbohydrates (simple and unrefined), and no cholesterol. On a treadmill walking test, the control group improved 302%; the experimental group's improvement was 5,820%. Coexisting diseases in the experimental group (but not in the control group) improved as follows: 100% of patients with angina, diabetes treated by oral hypoglycemics, gout, arthritis, and elevated blood lipids; 75% of those with hypertension and diet-controlled diabetes; 50% or more of insulin-dependent diabetics and those with congestive heart failure; and some plaque reversals in the arteries.

Other Organic Conditions. Kraus and Raab (35) extensively developed the concept of "hypokenetic disease," defined as the *"whole spectrum of inactivity-induced somatic and mental derangements."* In addition to coronary heart attacks, they indicated that other diseases more frequent in the sedentary than in the active are diabetes, ulcers, and other internal conditions. Eighty percent of low back pain is due to lack of adequate physical activity; lack of physical exercise parallels emotional difficulties; the physically active show better adaptability to stress, less neuromuscular tension, and less fatigability; active persons age later, do not tend toward obesity, have lower blood pressure, are stronger and more flexible, and have greater breathing capacity.

Fat Reduction. Mayer (37) has effectively supported the concept that physical inactivity is the single most important factor explaining the increasing frequency of overweight people in modern western societies. Studies reviewed demonstrated that intensive physical conditioning causes a depletion of excess fat and an increase in lean body weight. 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.

Tensions. In their clinical practice, Jacobson and others have demonstrated that muscular tension reflects emotional states. Usually, such states have been treated by drugs, which, typically, have undesirable side effects. deVries and Adams (27) contrasted the tranquilizing effect of exercise with the ingestion of 400 mg. of meprobamate upon 10 tense ("anxious") men and women between 52 and 70 years of age. Muscular tension was measured by electromyography using surface electrodes. The results showed that 15 minutes of walking at a heart rate of 100 beats per minute lowered electrical activity in the musculature about 20%. Neither meprobamate nor placebo treatments were significantly different from controls. Thus, in single doses, at least, exercise had significantly greater effect upon reducing tension, and without any undesirable side effects, than did the tranquilizer drug.

Mortality. Based upon epidemiologic data obtained from 6,928 adults in Alameda County, California, Breslow (6), Belloc (4), and associates studied health practices as related to physical health and mortality. Based on the World Health Organization's definition of health as *"physical, mental, and social well-being, not merely the absence of disease and infirmity,"* a 7-point Physical Health Spectrum was developed, ranging from severe and lesser disabilities through chronic and symptomatic conditions to a high energy level. Seven health practices were identified which had significant relationships to the spectrum and to mortality. The health practices were: usually sleep 7-8 hours; regularly eat breakfast; rarely or never eat between meals; roughly, weight between 10% under and 20% over desirable amounts; regular exercise; no or moderate drinking; and never smoke cigarettes. Deaths in the sample were determined five years after the survey was made.

All health practices were positively related to mortality for both men and women. Death frequencies decreased with the number of practices observed. The following tabulation shows the average lifetime expectation at older ages in accordance with the number of health practices observed.

	Number of Health Practices			
Age	0-3	4-5	6-7	California*
		Men		
45	21.6	28.2	33.1	27.6
55	13.8	20.2	25.0	19.7
65	10.6	13.7	17.4	13.3
75	7.4	10.2	11.2	8.3
		Women		
45	28.6	34.1	35.8	33.1
55	20.0	25.1	27.8	24.6
65	12.4	17.3	19.9	16.7
75	8.6	11.7	12.5	10.0

State Department of Public Health, Abridged Life Tables, California, 1959-61, September 1963.

A statement attributed to Breslow in the September 21, 1975, *Washington Post* ("Clean Living Payoff," by Stuart Auerbach) is: *"A man at age 55 who follows all seven good health habits has the same physical status as a person 25 to 30 years younger who follows less than two of the health practices."* And, further: *"The daily habits of people have a great deal more to do with what makes them sick and when they die than all the influences of medicine."* This statement is similar to one made by former President Gerald R. Ford: *"It's a tragic fact that many of our most serious ailments are self-inflicted, or at least are within our power to minimize or avoid* (13)."

Singling out exercise: The respondents were asked whether they participated often, sometimes, or never in the following five physical activities: active sports, swimming or taking long walks, working in the garden, doing physical exercises, and hunting or fishing. The only activity category that failed to differentiate persons along the Physical Health Spectrum was hunting and fishing. For the other activities, those who participated often had the best physical health, followed in order by those who participated sometimes and by those who did not participate at all. For mortality rates: the lowest was for "often active" in sports (.038 for men; too few women to report); the highest rates were for "no special exercise" (.114 for men and .067 for women); "sometimes gardened or performed exercises," rates of .080 for men and .043 for women. Quite obviously, the mortality rates differed with age. The following tabulation shows the mortality rates for men and women in the 65-74 age bracket:

Men	Women	Activity
.143	-	Often active in sports
.154	.150	Sometimes sports or walk/swim
.221	.110	Often walk/swim, garden, exercise
.303	.184	Sometimes garden or exercise
.483	.224	Never any of above

Growth Hormone. Shephard and Sidney (46) reviewed 135 references pertaining to studies on the effects of physical exercise on human growth hormone (HGH) and cortisol levels of human subjects. In summary they indicated that plasma concentrations of HGH are generally increased by exercise, often with a latent period of up to 20 minutes. At any given intensity of effort a response is more likely in the elderly, in women, and in subjects who are unfit. With very prolonged effort a secondary fall in HGH may occur. Training apparently diminishes the response in young subjects but has the opposite effect in the elderly. Changes in cortisol level during effort are more variable. With light to moderate effort there may be no change, or a small decrease, but if the effort is sustained to stressful exhaustion an increase may be seen. In the review the influences of such variables as age, sex, fitness, obesity, core temperature, drug administration, and hormone abnormalities are discussed, and possible roles of HGH and cortisol level in exercise metabolism are considered. By way of explanation: the most important role of HGH in the body seems to be the regulation of anabolism (food changed into living tissue); the principal effect of cortisol is the reverse (catabolism).

INDIVIDUAL DIFFERENCES

No doubt exists that many physical, mental, and psychological changes take place as people become older. Actually, change goes on throughout life. Physiological aging, for example, is the constant change in physical powers and capacities: a gradual improvement occurs to about age 17 years; relatively minor changes occur until around 26 years; then, a decline usually occurs during the balance of the life span. While the use of chronological age, as above, is a convenient point of reference, it can also be fallacious. Great individual differences are present around any given chronological age in respect to all human traits.

The October 1973 *Physical Fitness Research Digest* was devoted to "Individual Differences, Their Nature, Extent, and Significance." While that account was confined to school and college ages, nevertheless, it demonstrated tremendous physical differences that exist for single chronological ages; and these differences had pronounced significance for human performances of many kinds. Some traits are improvable through the right kind and amount of exercise, while others are not. Yet, those traits not subject to appreciable improvement through exercise, such as maturity, physique type, and body size, underly the individual's total effectiveness. As general examples for boys of the same chronological age: (a) The more mature boys are larger, stronger, and have a greater potential for success in athletics; they are also prone to higher levels of aspiration and better psychological adjustment. (b) High mesomorphic boys have advantages related to greater muscular strength, muscular endurance, and successful athletic experiences; high endomorphic boys are handicapped by excessive body bulk, by low strength relative to body weight, and by inability to make and be successful on athletic teams. (c) Similar striking manifestations can be shown for differences in body size, muscular strength, and motor abilities. (See ref. 11.) Thus, chronological age is a faulty criterion to apply to physical and motor fitness and performances of boys and girls during their growth years.

While the nature, extent, and significance of physical and motor differences have been demonstrated for younger ages, the same situation is found at older ages throughout the life span. This may be belaboring the obvious. Observe any group of elderly persons: some are tall, some are short; some are skinny, some are obese; some are strong, some are weak; some are erect, some are stooped; some are endomorphs, some are mesomorphs, some are ectomorphs, some are various combinations of these physique components; some are mentally alert, some are mentally sluggish; some are aggressive, some are vacillating; some are extroverts, some are introverts; and on and on. Yet, despite the obvious, society clings to chronological age as a criterion for many things, the most obvious of which for older people is the age of retirement, usually 65 years.

Just what does elderly mean? It certainly should mean different things to different people. Older Americans should be discouraged from equating infirmity with chronological age. Examples abound. "Four Tough Jobs for Elder Statesmen" appeared in *U.S. News and World Report* for March 24, 1975: at age 80, Ellsworth Bunker was assigned the task of negotiating a new treaty with Panama on ownership, operation, and defense of the Panama Canal; at age 77, David Bruce became U.S. Ambassador to the North Atlantic Treaty Organization; at age 75, Kenneth Keating became Ambassador to Israel; at age 73, John Cooper opened the first American Embassy in East Germany.

In the *NRTA Journal* for March-April 1975, the famous biographer, Catherine Drinker Bowen, told how "Five Salty Old Men" coped with age by starting over: Edward Coke challenged James I's authority at age 76; Francis Bacon had his most productive years after age 60; Benjamin Franklin quieted passions threatening the Constitutional Convention at age 81; John Adams left the White House at age 65 and devoted another quarter century to the study of history and philosophy; and Oliver Wendell Holmes sat on the Supreme Court in his 90's. This country has had great elder statesmen in all walks of life: jurists, philosophers, educators, scientists, physicians, authors, poets, historians, artists, musicians, humanists, industrialists, inventors, and many more. Let us recognize then that age alone should never be a deterrent to worthwhile accomplishments in accordance with the individual's inherent and acquired capabilities. It should not "put him on the shelf" physically or in any other way.

CHANGES WITH AGE

No doubt exists that physical, motor, physiological, and psychological changes go on throughout the life span of men and women. These changes reflect greater development and effectiveness during the growth period, until maturity is reached. For a few years, these gains may be maintained. Then a gradual deterioration takes place through the middle years and into old age; the activities of the body and its physiological processes are slowed. It is difficult, however, to distinguish between the actual process of aging and such environmental influences as the condition of the vital organs, amount of exercise, dietary and other health practices, tensions, human associations, mental attitudes, and the like. As will be seen later, the aging process is slowed when the individual exercises as a way of life; and the process is speeded when the individual is sedentary.

In fact, at any age, enforced inactivity, as in bed rest for a period of time, will induce many of the physiological deteriorations found in aging. Only one example is given. Taylor and associates (51) studied the effects of bed rest for a 4-week period on cardiovascular functions and work performances of healthy young men. The results showed a 17% decrease in heart volume and an 8% decrease in the transverse diameter of the heart. The average pulse increased one beat per minute for each two days in bed. The pulse rate at the end of a half-hour treadmill walk at 3.5 miles per hour up a 10% grade increased 40 beats per minute after the bed rest. The oxygen intake during a 90-second run at seven miles per hour up a 15% grade was reduced by 730 cc., or 16%; this was accompanied by increases in oxygen debt and blood lactate. The rate of recovery of the various functions was roughly proportional to the extent of deterioration during the rest when normal activity is resumed. An additional note could be in regard to the well-publicized deteriorating effects of weightlessness and inactivity of astronauts on moon flights of many days; in the later flights instruments for exercising were installed in spacecraft and exercise regimens were prescribed for the occupants.

All physiological processes of the body are involved in aging and these processes are affected by exercise. No attempt is made here to include all the various processes that are affected or to present involved explanations of the processes mentioned. For readers who wish greater detail with supporting evidence, the following sources are mentioned: Brunner and Jokl (7), deVries (25), Lamb (36), Montoye (38), Norris and Shock (40), and Shephard (45). The comments below apply to Canadian and United States samples, so are not applicable to those countries, such as those in Scandinavia, where people generally continue physically active as adults. The descriptions apply to both men and women, although in some instances the averages of men are higher than for women.

Heart Rate. Unless affected by exercise, little change in resting heart rate occurs during adult life; similar results are shown for heart rates minutes after a submaximal bench-stepping exercise, except for a decline after age 55. However, maximal heart rate decreases regularly throughout adult life; Clarke (10) presented a table showing this decrease to be six beats per minute for each five years after age 25, from 200 at 25 to 153 at 65 years of age.

Blood Pressure. The upper limits of normal blood pressure for persons under age 20 is 133/83 (133, systolic; 83, diastolic) for males and 128/83 for females; the mean at this age is approximately 120/72 for men and slightly lower for women. Both systolic and diastolic pressures increase by 10 to 15 mm. Hg. over the span of adult life.

Cardiac Output. By right heart catheterization, Granath, Jonsson, and Strandell (30) compared cardiovascular pressures and cardiac outputs at rest and during exercise for young men and men from ages 61 to 83. The resistance indices of the pulmonary and systemic circulations were higher for the elderly men, both at rest and during exercise. The mean cardiac output was less for the older group, but the increase in blood flow to working muscles was approximately equal for both groups. Stroke volume was consistently lower for the older men, which was thought to be the major factor in cardiac output differences.

Respiratory Efficiency. A decline in respiratory efficiency occurs as adults become older, as indicated by: decreased elasticity of the lungs, insufficient emptying of the lungs, and less flexibility of the thorax; and decreases in vital capacity, maximal oxygen intake, forced expiratory volume, maximal ventilation, and residual volume. The loss for several of these conditions is between 20 and 25%. Residual lung volume is about 22% of total lung capacity in children and young adults, but increases to as much as 60% at age 60. Maximum pulmonary ventilation declines with age, being 20 to 25% less in the 60's as compared with younger ages. A similar situation exists for maximum exercise ventilation.

Aerobic Power. Aerobic power, as expressed in ml/kg min., for young boys is around 48-50. A progressive loss occurs after age 20 until at age 60 between 40 and 50% of this power is lost. This change is due partly to a reduction in absolute aerobic power and partly to an increase in body weight that commonly occurs between the ages of 30 and 40 years.

Anaerobic Power. Some evidence exists that old men, even though healthy, cannot accumulate much lactate in the blood stream. Consequently, the capacity for anaerobic work falls off with increasing age.

Protein Synthesis. Protein synthesis is promoted by pituitary growth hormone and by androgen (male sex hormone). Therefore, a training regimen should be most successful in inducing hypertrophy of cardiac and skeletal muscles if conducted during adolescence when these substances are present in highest concentration. This phenomenon may be a reason for slower conditioning effects from exercise at older ages.

Cellular Aging. Cellular aging takes place when active tissue, such as muscle, is replaced by metabolically less active fat and connective tissue fibers. Basal metabolic activity declines about 25% from youth to old age. Loss of cell protoplasm is an important factor in age decrements of performance capacities.

Bones. Generally, bones become less resilient, more brittle and porous, and increasingly fragile, especially at the older ages. Cartilage calcifies, leading to decreased elasticity throughout the skeleton. The capacity of the bone marrow to produce red blood cells is also affected by age.

Muscular Strength. Based on grip strength tests, the average man reaches his strength peak at age 17, maintains this level to about age 45, and then declines about 15% over the next 20 years. A similar pattern is found for women, except the strength peak occurs with the onset of puberty. It has been suggested that strength loss is due to such factors as decreased androgen production and deposition of collagen and elastic fibers in the muscles; these latter materials are not functional and tend to reduce the power of the muscle.

Arm strength and manual cranking ability were measured in 218 men between 20 and 89 years of age by Shock and Norris (47). The strength score was the composite of

four movements of the arm and shoulder muscles; the cranking movement was also for the arm and shoulder area with the subjects recumbent on a bed. The average composite strength score was 150 for men 20 through 69 years old and declined to 130 and 105 in the 70's and 80's, respectively. In contrast, cranking ability defined as maximum power output declined steadily for successive groups of participants older than 39 years. The authors concluded that reduced coordination ability was the most likely cause of the deficit of power output relative to static strength in the older participants in their study.

It would be improper to assume that older men and women are incapable of high physical and motor performances. There are instances, for example, of a 52-year-old woman running a marathon (26 miles, 385 yards) in 3 hours and 45 minutes; she ran 8-minute miles for each of the first 13 miles. Another woman at age 85, and again at age 86, won gold medals in the half-mile and mile runs in "Senior Olympic" competition. In his lifetime Clarence DeMar, a premier distance runner, ran 1,000 distance races, including 100 marathons of 25 miles or more; his last race was for 15 kilometers at age 69, one year before his death from cancer. He entered 34 Boston marathons, winning seven of them in his remarkable career. For 94 of his 106 years Larry Lewis, a San Francisco hotel waiter, practiced an undeviating regimen of daily running. He ran six miles through Golden Gate Park almost every day of his adult life.

Generally, however, older people cannot achieve performance levels equal to those which they could attain when younger. As has been mentioned, all physiological deteriorations mentioned can be slowed through a life style that includes regular exercise. Further, as will be shown, older people are trainable and some deteriorating processes are reversible for long-time sedentary men and women.

To illustrate the retarding effect of exercise on physiological aging, Kasch and Wallace (31) observed that normally the physical work capacity of men declines from 9-15% during the ages of 45 and 55 years. To examine whether vigorous physical activity would protect against this decline, they studied the effects of circulatory-respiratory exercise on such capacity of 16 middle-aged men during a 10-year span. The ages of the men ranged from 32 to 56 years, average of 44.6 years, at the start. The group averaged three days of training per week, 12 months per year, for 10 years. The training consisted mostly of running, although one man swam, and two men combined running and swimming. The average duration of exercise sessions was 57 minutes; the intensity of exercise was 86% of maximal heart rate; the average distance run per week was about 15 miles.

The results of the Kasch-Wallace study over the 10-year span included the following: (a) No changes were found in body weight, resting heart rate, and resting blood pressure. (b) Maximal heart rate declined seven beats per minute. (c) Pulmonary ventilation increased approximately 18%. (d) Mean max VO_2 was essentially unchanged whether measured as l/min or ml/kg min. The investigators concluded that the usual 9-15% decline in physical capacity from age 45 to 55 can be forestalled by regular endurance exercise. These subjects maintained a relatively constant body weight, resting heart rate, blood pressure, and maximum oxygen uptake; further, they improved in pulmonary ventilation.

In another longitudinal study Dill, Robinson, and Ross (28) determined the physiological changes in 16 champion distance runners 20 years after their competition was terminated. Although the regular aging effects occurred on heart rate, blood pressure, and metabolic and respiratory measures in both the basal and resting states,

these effects were less than for "normal" people over the same period. The variability of the athletes was great due in part at least to their exercise and health practices during the 20-year period. The five rated most fit exercised regularly and did not smoke cigarettes. Three of the four rated least fit did not exercise much and smoked cigarettes; two of these subjects had gained the most weight.

MIDDLE-AGED PEOPLE

A substantial amount of research has been done on the physical fitness improvement of adults through various forms of regulated exercise. A sizeable number of these studies concentrated on men, although some were on women, of middle age; however, some studies have been done with men and women 60 years of age and over as subjects. In this section, exercise results with middle-aged people are briefly summarized from existing research reviews; in the next section, reports of studies on older subjects are presented.

Cureton's Work

Thomas K. Cureton, Director of the Physical Fitness Institute, University of Illinois, is a world-famed investigator and practitioner of ways by which adult physical fitness can be improved and sustained. With his graduate students for over a quarter century, he conducted and sponsored numerous investigations on exercise regimens for adults. Many of his former students have carried out related studies since receiving their degrees. Well recognized among such individuals are: B. Don Franks, Lawrence A. Golding, William L. Haskell, Paul A. Hunsicker, Ernest D. Michael, Henry J. Montoye, Michael L. Pollock, Sharon A. Plowman, Paul M. Ribisl, and James S. Skinner.

Cureton has summarized much of this work. One report (18) is upon the evaluation of 20 types of fitness programs, including his continuous, rhythmical endurance process, jogging, Canadian 5BX, various sports, swimming, calisthenics, weight training, and isometrics. The conclusion was reached that his progressive rhythmic type of exercise is superior in obtaining improvements in various circulatory elements with adults. Time devoted to exercising emerged as an important factor: programs of an hour a day, five to six days a week, were superior to programs of one, two, and three times per week; also, regimens of one hour per day were better than one-half hour or less.

Cureton's book (22) on the physiological effects of exercise on adults documents 200 related studies; practical field tests are elaborated; the effects of such programs are presented in much greater detail than in the previously mentioned report. Among the significant conclusions reached are the following:

a. Men--even young men--are not doing enough vigorous exercise to keep the blood flowing through the muscles in adequate amounts, an important key to physical fitness. Thus, physiological aging comes upon modern man with astonishing rapidity, especially those who are sedentary.

b. In the trained state the nervous system is prepared for action rather than inaction. In general the individual is trained away from persistent sedentary tendencies and toward a higher sympathetic and vagus tone leading toward a desire for physical activity.

c. Strength per pound of body weight increases from force and speed exercises of the power type. Strength is vital, as it is required to move the body about continuously in walking, running, swimming, climbing, hiking with a pack, pedalling a bicycle uphill, and in doing activities which make life useful and practical.

d. He[illegible]e, nutrition, and general well-being are all dependent upon a common [illegible]rculatory fitness. The only way to gain and maintain this fitness [illegible]ystematic exercise that re[illegible]s a primary adjustment of the cir[illegible]latory complex of the body t[illegible]ctivity.

e. Bodily movement trains the heart and improves circulation. In movement a stimulation of the sympathetic branches of the autonomic nervous system occurs. Lack of movement leads to deterioration of the circulation, as demonstrated from the results of enforced bed rest mentioned earlier.

f. The heart is not a vacuum pump and cannot suck the blood up from the feet and legs to the heart when the body is upright. There are muscular movements, involuntary contractions, and wave pulsation which help the blood to lift itself against gravity. The use of the legs in exercise significantly expedites the efficient return flow of blood to the heart, which is a strong reason for utilizing such activities as leg exercises, jogging, and swimming in the physical fitness program.

g. Exercise opens up capillaries which are not otherwise open. The muscles, heart, spinal cord, brain, lungs, nerves, and organs in general are permeated by a countless number of capillaries. No matter how small, these vessels are controlled by microscopic nerves. Exercise affects these nerves and causes them to produce dilation in the capillaries. Thus, the capillaries are not fixed in size; some may not be in use, but expand according to need. Exercise is necessary for their continuing effectiveness.

Former Digests

Several issues of the *Physical Fitness Research Digest* have been devoted to various activities utilized in the improvement and maintenance of physical fitness components. These issues are: January 1973, "Toward a Better Understanding of Muscular Strength"; January 1974, "Development of Muscular Strength and Endurance"; July 1973, "Circulatory-Respiratory Endurance"; July 1974, "Circulatory-Respiratory Endurance Improvement"; January 1977, "Jogging."

Values to the human organism that may be realized from regular jogging, as well as other forms of C-R endurance activity, include: improvement of the fitness of the cardiovascular and blood transport system; reduction in the likelihood of coronary heart attacks; an effective modality in postcoronary care and rehabilitation; strengthening of muscles, bones, ligaments, and tendons, especially in lower part of the body; improvement in the regulation of anabolism and catabolism through the human growth hormone and cortisol processes; aid in fat reduction and increase in lean body tissue; protection against the decline in work capacity normally evident with increasing age (retardation of the aging process); and enhancement of such psychological traits as self-concept, intellectual inclinations, emotional stability, easy-going and adventurous attitudes, dominance and aggressiveness, extroversion, self-sufficiency, and social poise.

Improvements in the following physiological manifestations resulting from jogging were found in one or more studies: lowered resting and exercising heart rate for the same work, and more rapid heart rate recovery after exercise; increase in

cardiac output and blood volume; decrease in capillary blood hemoglobin; increased score on Schneider cardiovascular test; lactic acid tolerance enhanced; improvement in R and T waves of the electrocardiogram; improved brachial pulse wave; increased oxygen intake, oxygen pulse, carbon dioxide production, maximum lung ventilation, forced expiration volume, and respiratory-exchange ratio; better mechanism for contracting oxygen debt and more rapid oxygen debt repayment; greater utilization of anaerobic energy reserves; and reduced time in the 1- and 2-mile runs and increased time jogged on a standardized treadmill run; and reduction in diastolic blood pressure.

TRAINABILITY OF OLDER PEOPLE

In this section, studies pertaining to the trainability of older people through exercise are presented. Associated with a greatly increased elderly population is an increasing concern in recent years with geriatric problems; attention is being given by scientists to the role of exercise in the well-being and longevity of men and women in the over-60 age category.

Physiological Studies

In a study by deVries (24), 112 men aged 52 to 88 (mean age of 69.5) years participated in a training program consisting of calisthenics, jogging, and either stretching exercises or aquatics for one hour, three days per week. The walk-run regimen was regulated at a heart rate of 145 beats per minute. The subjects were pretested; subgroups were retested at 6, 18, and 42 weeks of exercise. The most significant findings were related to the oxygen transport system: oxygen pulse and minute ventilation at heart rate 145 improved by 29.4 and 35.2%, respectively; vital capacity increased by 19.6%. Significant improvements were also found for percentages of body fat, physical work capacity, and both systolic and diastolic blood pressures. Controls did not improve on any of these measures.

In this same study seven men were placed in a modified exercise program because of various cardiovascular problems. This group exercised in the same manner as above except they substituted a progressive walking program for the jogging and were restricted to a maximum heart rate of 120 instead of 145 which prevailed for the normal group. This group was exercised for six weeks, at which time their improvement showed a similar pattern to that of the harder working normal subjects at six weeks.

Barry and associates (2) formed two groups of elderly subjects, average ages 70 and 72: an experimental group of five men and three women and a control group of five. The experimental group trained on bicycle ergometers followed by brief conditioning exercises three times a week for three months; the bicycling was interspersed with rest periods. When retested with the initial workload, a significant reduction in circulatory stress was evident, as indicated by decreases in work pulse, systolic blood pressure, and blood lactate concentration. Other changes occurring during the training period were an increase in workload limit of 76% and increases in oxygen uptake and pulmonary ventilation. In a second report from this same experiment (3), improvements were reported in muscular endurance, agility, hand-movement speed, visual discrimination, and imaging. From an analysis of the pattern of training effects and the characteristics of the test items, the authors suggested that physical conditioning is associated with the adaptation of the neural regulatory mechanism to a higher level of functioning. The control group did not change in any item of both parts of the study.

In the first of two studies Stamford (49) formed exercise and control groups each of 8-9 geriatric patients in ambulatory wards of a state hospital. The exercise group worked out daily on a treadmill at 70% maximum heart rate, five days a week for 12 weeks; length of the exercise sessions gradually increased from six to 20 minutes. Although the level of training was not high, significant decreases in heart rate and blood pressure occurred, with these training effects taking place in the later weeks of training.

In Stamford's second study (48), geriatric patients were grouped as chronically institutionalized (minimum of 20 years), recently hospitalized (less than one year), and control. Except for the control group, the subjects exercised five days a week on a treadmill for 18 weeks, as follows: first six weeks, intensity 50% of maximum heart rate for 15 minutes; second six weeks, intensity the same but duration 30 minutes; last six weeks, intensity 60% of maximum heart rate for 15 minutes. After 18 weeks of training the chronically institutionalized patients showed a significant training effect, as shown by reduced heart rate for a given exercise load and by reduction in systolic blood pressure and oxygen pulse. The recently admitted group showed no training effects for the first 12 weeks. With increased training intensity during the last six weeks, both exercise groups made significant physical fitness improvements. The control group showed no improvements throughout the study.

Vittorio (54) studied the rate of development and the effects of double work periods on the endurance of three age groups: 9 boys, 12-14; 15 college men, 18-19; and 10 older men, 24-70. The subjects trained on a bicycle ergometer against a constant resistance and at a prescribed pedalling rate. The resistance and wheel revolutions per minute were: boys, 22½ pounds, 72 revolutions; college and older men, 32½ pounds, 80 revolutions. The training period was twice weekly for eight weeks; a subgroup of college and older subjects rode two bouts per session. For each subject at each session, pedalling continued until he could not maintain the prescribed rate of wheel revolutions. Significant results included the following: (a) From the mid-twenties on, much greater time was necessary to develop endurance; four to seven weeks elapsed before appreciable gains occurred for the older men. (b) The percentage improvement of the older group varied, but seemed to decrease with each decade of life. (c) In comparing the college subgroups employing single and double bouts per session, the single-bout group improved 53% and the double-bout group improved 90%.

In one of the few studies involving older women, Adams and deVries (1) had 17 subjects, aged 52-79 (average age, 65.9), participate in a vigorous 3-month exercise program for one hour, three times a week. The exercise program consisted of calisthenics, jogging, and stretching movements; the jogging intensity was regulated by a heart rate of 145 beats per minute, which represents about 60% of maximum. Six controls were also pre- and posttested. The trainability of the cardiovascular system was demonstrated by the improvement in physical work capacity and resting heart rate. The improvements were of a similar order of magnitude as those commonly reported for young females, but not of the magnitude for men.

Blucker (5) formed two groups each of exercising and nonexercising young and older women; the mean ages were around 20 for the young and 61 for the older women; each of the four groups contained 42-44 subjects. The young exercising subjects were participants in a college women's conditioning course; the older women had been engaged in an exercise class at least four days a week for two months. From contrasting these groups on four tests, the following significant results were obtained: (a) The young were superior to the older women in reaction time, grip strength, and maximum oxygen uptake. (b) The older women had a greater percentage of body fat

than did the young. (c) The only significant difference between exercising and nonexercising groups was for older women; the exercisers had faster reaction time than the nonexercisers.

Brunner and Meshulam (8) examined 45 male members of a health club; age groupings were 13 between 55-59, 15 between 60-64, and 17 between 65-71. The daily occupations of these men ranged from sedentary to moderately active. The results indicated a high grade of physical fitness considering their age. Nevertheless, a gradient with age was evident. Fitness performances were in order of their ages with the youngest group best, although there was an overlapping in fitness levels among the age groups.

In a study in Finland by Suominen and associates (50), 26 men and women 69 years of age participated in 1-hour exercise periods a week for eight weeks; the exercise consisted of walking, jogging, swimming, gymnastics, and ball games. The mean maximal oxygen uptake of the men increased from 28.9 to 32.0 ml/kg min after training; the increase for the women was 27.9 to 31.3 ml/kg min. Muscle malate dehydrogenase activity was increased while that for lactate dehydrogenase decreased or remained the same. Prolyl hydroxylase activity was decreased after training especially in the female subjects. The authors concluded that their results show that endurance-type training leads to an enhanced capacity for aerobic metabolism in older subjects and that collagen metabolism in skeletal muscles is affected by physical training.

Case Studies of Older Adults

Some adults have participated for many years in the exercise program conducted at the University of Illinois and others have followed similar programs elsewhere. Cureton has presented three longitudinal case studies of older men who participated in regular physical fitness activities during the sixth decade of life. "E.D.W." (17), an agriculture professor, entered the Illinois program at the age of 58; at age 74 he was continuing with his exercises. His body at age 74 was "remarkably" lean, trim, and in good posture. Most cardiovascular and motor measures had maintained levels comparable to those achieved 12 years earlier. Some negative changes were noted: some loss in strength, breath holding ability, vigor of the resting brachial pulse wave, and expiratory force; blood pressure had risen but was still low for his age.

Sydney Meadows (16), a second case study, had been practicing weightlifting at the Cleveland Y.M.C.A. for several years prior to the age of 62. Upon being tested by Cureton at that time he was found to be exceptionally strong but had marked deficiencies on cardiovascular tests, including shortness of breath when running, depressed brachial pulse wave after running in place for one minute, an extremely rapid heartbeat, and high blood pressure. Upon examination a cardiologist reported that he had had a heart attack, estimated to have occurred four years earlier. Meadows substituted aerobic exercise, including running and Cureton's rhythmic endurance exercises, for weightlifting. Within three years he had eliminated all of the original cardiovascular weaknesses. On his 65th birthday he ran 10 miles in one hour, 17 minutes and repeated the run a few days later in one hour, 11 minutes.

The third case study (19) was reported on Joie Ray, a top distance runner years ago, 1914-1933; the report was for his age period 60-70 years. This case study is of a man who had continued training for the mile run throughout his lifetime. Several mile times, run mostly on his birthdays, were: age 60, 6:36; age 62, 6:24; age 64, 5:50; age 66, 6:32; age 68, 6:18; age 69, 6:11.5. The outstanding improvement in his mile run time from 6:36 to 6:11.5 despite advancing years, from 60-69, was paralleled by considerable increase in oxygen intake capacity; further, improvements were made on

many physical, motor, cardiovascular, and respiratory tests; and heart size was reduced. This case study depicts one determined and highly motivated individual's ability to maintain and even improve his cardiovascular system and his circulatory-respiratory endurance performances well into older ages.

Masters' Competition

The 1975 World Masters' Championships for adults, held in Toronto, Canada, attracted many international class competitors. Masters' competition is within five categories: MS, submasters, aged 30-40; M-I, category I, aged 40-50; M-II, category II, aged 50-60; M-III, category III, aged 60-70; and M-IV, category IV, aged 70-90. In a contrasting study of the competitors in these categories, Kavanagh and Shephard (32) reported the following results: (a) The MS and M-I competitors were of average height and weight; older groups showed progressive height diminution. (b) Lean tissue was well preserved except in the oldest category. (c) Body fat was very constant, 14% of body weight in all categories except M-IV (11.1%). (d) Aerobic power showed the rate of aging anticipated in a sedentary population: MS, 49.6 ml/kg/min; M-I, 49.9; M-II, 46.0; M-III, 41.6; M-IV, 29.0. (e) Women contestants were fairly tall (5'6") and were not particularly slim (22.8% fat). (f) Electrographic abnormalities were less frequent than in the general population.

Psychological Benefits

Many studies have been reported on the relationships of personal-social characteristics and physical-motor traits for school and college age boys and girls. The January 1972 *Physical Fitness Research Digest* was devoted to this topic: Generally, from that review, boys high on physical-motor tests tended to be extroverted, dominant, sociable, dependable, tolerant, active, and competitive; they were prone to be leaders and popular with their peers. Boys low on such tests tended to have feelings of inferiority, insecurity, and inadequacy, and had difficulties in social relationships; they were inclined to be rebellious, emotionally unstable, and defensive, and to have negative feelings about themselves.

Fewer studies pertaining to psychological benefits have been reported for adults, especially for the older ages. In a 1963 article Cureton (20) reviewed studies on the improvement of psychological states by means of exercise programs. In a study of 500 adults a large proportion of those checking five of Sheldon's viscerotonic traits were relatively unfit; the adults who checked more than five cerebrotonic responses were "almost always" nervous and tense. In another study mentioned, eight of Cattell's Sixteen Personality Factors correlated positively and significantly with an all-out treadmill run. As implications from his review, Cureton listed the following factors as physical correlates of personality deterioration in adults: accumulation of fat, reduction in metabolic rate, loss of muscular strength, slowing of reaction time, reduction in work capacity, loss of motor fitness, reduction in visual efficiency, reduction in ventilation capacity, and increase in blood pressure. He suggested that personality deterioration and physical deterioration parallel each other, and it follows that improvement of physical fitness should minimize both types of deterioration.

Young and Ismail (57) studied personality differences among young and old high-fit and low-fit groups of seven men each between the ages of 21 and 61 years. All four groups participated in a fitness program consisting of calisthenics, progressive running, and recreational activities for three 90-minute sessions per week for four months. The Cattell 16 Personality Factor Questionnaire, the Eysenck Personality

Inventory, and the Anxiety Scale of the Multiple Effect Adjective Check List were used to assess personality characteristics. The results showed that both high-fit groups were more intellectually inclined, emotionally stable, unconventional, composed, secure, easy going, and adventurous than were the low-fit groups. The young high-fit group was more dominant and aggressive than the old high-fit group. At the end of the 4-month program the high-fit men were more self-sufficient and all subjects were more socially precise, persistent, and controlled

The physiological and psychological effects of a 14-week, 3-day-a-week jogging and cycling program on older men, 60-79 years, were studied by Buccola and Stone (9). Two groups were formed: one group of 16 men participated in walking and jogging; the other group of 20 men engaged in a cycling program. The significant physiological results were: both groups decreased in weight and systolic and diastolic blood pressures and increased in estimated max VO_2; the cyclists decreased in percentage of body fat; and the joggers improved in trunk flexibility. Based on the Cattell 16 Personality Factor Questionnaire, the cyclists did not show any significant changes during the 14-week training period; the walk-jog group became more sober and self-sufficient.

In order to study the effect of four years of exercise on personality characteristics, Young (56) formed three groups of 16 adult men each, as follows: (a) regularly exercised before and after 1971; (b) inactive before 1971, participated one semester in an adult fitness class and then became inactive again; (c) inactive before 1971, took the adult fitness program, and subsequently continued regular exercise for four years. Personality traits were assessed by use of the Cattell 16 Personality Factor Questionnaire. Only the regularly active groups increased significantly in physical fitness over the 4-year period. On both pre- and posttests the regularly active group was more confident than the other groups, indicating a stable relationship between physical fitness and self-confidence.

SUGGESTIONS FOR THE ADULT PHYSICAL FITNESS PROGRAM

In the final section of this *Digest* suggestions are made for the participation of older adults in physical fitness regimens. Some suggestions are general, so apply to physical fitness programs at all ages: other suggestions are specific for older people. Support for some proposals is drawn from conclusions reached in former *Physical Fitness Research Digests*; new research is introduced when it applies to older men and women. Program emphases are directed toward the improvement and maintenance of muscular strength, muscular endurance, and circulatory-respiratory (C-R) endurance, the basic physical fitness components indicated at the start of this report. Some comments also are included relative to body flexibility.

General Principles of Exercise

Sensible principles of exercise should be observed by all, but especially by sedentary people who embark on physical fitness programs. Five such principles of essential import for older people are presented here.

1. Exercise should be adapted to the individual's exercise tolerance. Exercise tolerance refers to the ability of the individual to execute a given exercise, series of exercises, or activities involving exercise in accordance with a specified dosage

without undue discomfort or fatigue. An exercise regimen which is easy for the person falls short of exercise tolerance; on the other hand, an exercise which is either impossible to perform or leaves him or her in distress exceeds a reasonable interpretation of exercise tolerance.

2. Overloading should be applied to induce a higher level of performance. In overloading the individual's exercise is increased in intensity or is extended for a longer time than normally. Overload is a relative term: a slight overload exceeds usual activity to a small degree, while the greatest overload equals the person's exercise tolerance at the moment.

3. The exercise plan should provide for [illegible] progression to [illegible] involved with the first two principles. The exercise plan starts with an understanding of the individual's exercise tolerance; then, within this tolerance level, an exercise regimen is provided for overloading the muscles to develop strength or for increasing the demands on the C-R system to improve endurance. If the exercise regimen stopped at this point, some improvement in fitness components would result, but it would soon cease as the body accommodated to the new requirements in output; both normal and exercise tolerance levels have risen. Progression must now be applied by increasing exercise in a logical way, thus keeping its demands ahead of the improvement made. Progression may be accomplished by increasing the intensity and duration of exercise.

4. Individuals must desire to improve. The desire to be fit and stay that way is essential for any individual to adopt exercise as a way of life. A realization of the importance of physical fitness in the person's daily and future life is vital.

. Advance the unfit individual's psychological limits of effort. For many unaccustomed to strenuous physical exertion, psychological tolerance for exercise may be reached well before physiological limits are attained. Also, psychological limits may be conditioned by habit, boredom, slight aches, breathlessness, and by such mental factors as anxiety and fear of physical harm. Such mildly distressful feelings halt exercise before appreciable overloading has occurred; consequently, only minimal increases in strength and endurance result. Here some judgment must be used, since certain of the factors related to psychological limits also serve as safeguards in the prevention of overstrain. A progressive approach to exercise dosage should solve this problem, as the individual gradually learns to accept strenuous exercise and to realize his or her true limits.

It should be added that sedentary older persons should check against any abnormalities of the cardiovascular system before embarking on a vigorous exercise regimen which places stress on that system. Such a check is the province of the physician. Stress testing may also be desirable, especially for those with symptoms of cardiovascular abnormalities or with family histories of coronary events. Such testing involves electrocardiographic monitoring of workloads of increasing intensity. Sound advice for the sedentary man or woman is to approach exercise gradually and determine tolerance by internal feelings of fatigue or distress.

Muscular Strength and Endurance

Three previous issues of the *Physical Fitness Research Digest* gave major attention to factors related to strength, as follows: July 1971, "Isometric Versus Isotonic Exercise"; January 1973, "Toward a Better Understanding of Muscular Strength"; and January 1974, "Development of Muscular Strength and Endurance." The fitness

components of muscular strength and endurance are combined, inasmuch as the resistance type of activity, although differently applied, develops both. To develop these components, physical activities which offer strong resistance to the muscles must be selected.

1. In developing the strength of the total musculature, a systematic involvement of all large-muscle groups is required, since pronounced specificity of strength among the muscle groups of the body exists.

2. The isotonic is [illegible] metric form of muscular conditioning. Further, motivation is greater, since the participant can observe what he is accomplishing and specific goals can be set.

3. The use of progressive resistance exercise (PRE), especially training with weights or comparable arrangement, has much to commend it. For strength development of muscles, use heavy weights with few repetitions; for endurance, use lighter weights with many repetitions.

4. In weight training the amount of exercise can be precisely prescribed through specification of the amount of weight lifted, the number of repetitions, and the cadence of the movements. Exercises can be designed to include all the muscle groups as desired. Further, the principles of exercise can be effectively applied, especially the determination of exercise tolerance and the progressive application of overload.

5. Various PRE regimens, all of which improved muscular strength, have been shown to be approximately equal in effectiveness over periods of six to 10 weeks. However, some recommendations for effective practice in strength development utilizing PRE can be made from the studies reviewed: (a) weight loadings should be based on RM (repetition maximum), the amount of weight that can just be lifted a specified number of times; (b) although RM's may differ, one investigator found that 6-RM was superior to 2-RM or 10-RM for three sets, although 2-RM for six sets was equally effective; (c) the number of bouts, or sets, of PRE per session may vary, but several investigators suggested three; (d) training sessions should not be less than two weekly and may be as many as five, although positive results are obtained with three; (e) progression in the amount of weight lifted should be applied by increasing the amount of weight for a given exercise when the pupil can exceed the number specified, keeping the number of repetitions constant.

6. In one study, college women participating in progressive weight training improved their body contous, as indicated by reductions in five skinfold and four girth measures, much more than did women participating in calisthenic-type exercises.

7. The studies reported have mostly used weight training in the improvement of muscular strength and endurance, not only because it is effective, but, as mentioned, it can be accurately applied. Other activities, of course, can be used for this purpose, the most common being calisthenics, as such exercises may be performed almost anywhere. Also, various types of apparatus are available, including peg boards, chinning and dipping bars, traveling bars and rings, and various commercial devices.

Circulatory - Respiratory Endurance

Three previous *Physical Fitness Research Digests* gave primary attention to aspects of circulatory-respiratory endurance, as follows: July 1973, "Circulatory-

Respiratory Endurance"; July 1974, "Circulatory - Respiratory Endurance Improvement"; and January 1977, "Jogging." As indicated earlier, C-R activities require adjustments of the circulatory-respiratory system for their performance. This physical fitness component is most complex, as the evidence indicates various affected elements of the system are [illegible]. These include the heart and lungs, the vessels serving [illegible] parts of the body, the blood and carbon dioxide carrying capacity of that blood, and the capillary system dispensing the blood to the tissues. Other body systems are also affected by such exercise, including the muscles, the digestive-absorption-elimination processes, the various internal secretion glands, the bones the bone marrow's production of red blood corpuscles, and the brain (for the brain, too, has arteries, as oft expressed by President Dwight D. Eisenhower's cardiologist Paul Dudley White).

Activities. Particularly desirable forms of C-R endurance activities, expecially for previously sedentary adults, are the walk-jog-run continuum and swimming, since these exercises can be reasonably well controlled. Thus, distance, speed, and duration can be specified in accordance with the exercise tolerance of the individual. Other activities, such as bench-stepping, bicycling, rope-skipping, skiing, and skating have similar values. Many sports have high endurance potentials, including soccer, basketball, handball, tennis, and other sports requiring sustained walking, running, or swimming. For the unfit adult, however, some caution should be observed in sports participation to be sure that the competitive element does not lead to overexertion.

Method. A number of exercise systems have been proposed for and have proven effective in physical fitness improvement. Two prominent systems that apply the principles of exercise proposed above are: (a) Cureton's *Progressive Rhythmical Non-stop Exercises*, which combines jogging and calisthenics: 22 progressively arranged lessons are presented divided into low, middle, and high gears (21). Cooper's [illegible] for men (14) and for women (15), which is based on an age- and sex-adjusted graduated system: the participant should average 30 points per week chosen from several forms of exercise; the forms are walking, running, cycling, swimming, stationary running, and handball/basketball/squash for men and walking, running, rope-skipping, stair-climbing, swimming, and cycling for women.

Interval Training has been advocated by many authorities as an effective way to utilize jogging in the development and maintenance of C-R endurance. A variety of such training regimens have been employed, including in order of intensity: jog-rest, jog-walk, slow jog-fast jog, and jog-sprint. For the beginning jogger, interval training is especially valuable, as it provides some "rest" between jogs, thus increasing the total work done without undue stress while permitting the jogger to work gradually into more vigorous regimens.

Intensity. Exercising heart rate has been found to be an effective means of regulating the intensity of jogging and running regimens; rates have been expressed both as beats per minute and percentage of maximum heart rate elicited during running. Normally, maximum heart rate declines one stroke per year, at least among the sedentary, so heart rate percentages for sedentary older men and women would be best when initiating jogging programs. Morehouse and Gross (39, p. 138) proposed the formula, 220-minus age, as a means of approximating the maximum heart rates for sedentary older people; these amounts show a decrease of one beat per year of age, which coincides within two beats with those heart rates indicated by Clarke (10, p. 271). Based on the Morehouse-Gross formula, the following chart shows maximum heart rates and percentages for older ages.

% of Maximum Heart Rates	Training Heart Rates by Ages						
	60	65	70	75	80	85	90
50	80	78	75	73	70	68	65
60	96	93	90	87	84	81	78
70	112	109	105	102	98	95	91
80	128	124	120	116	112	109	104
90	144	140	135	131	126	122	117
100 (Max)	160	155	150	145	140	135	130

deVries (22) studied the exercise intensity threshold level for improvement of the circulatory-respiratory function in men between 60 and 70 years of age; the men participated in a 6-week jogging program. The Astrand bicycle ergometer test was utilized for the prediction of maximal oxygen consumption. The significant results included the following: (a) Improvement in the Astrand score varied directly with the intensity of work as indicated by percentage of maximal heart rate. (b) Improvement on the Astrand test varied inversely with the physical fitness level of the men at the start of the program. (c) The exercise intensity threshold for older men appears to be about 40% of maximum heart rate. (d) Men in the 60's and 70's of "average" physical fitness may improve their fitness by raising their heart rates above 98 and 95, respectively. According to the chart above, the corresponding percentages of maximum heart rate are 61 and 63. It should be emphasized that the results indicated in this study are minimal, so they do not represent optimal improvement in cardiovascular-circulatory function.

DURATION. Some duration studies have been done with adults; the results of these studies may be useful as a guide in determining the individual's exercise regimen. Tooshi (53) formed a control and three experimental groups of men 27 to 45 years of age. The experimental groups participated in the same run-jog-walk program five days per week for 20 weeks; the time of participation per day varied: 15, 30, and 45 minutes, respectively. Endurance training of 30 and 45 minutes a day increased the cardiovascular and running tests more than did training for 15 minutes. Changes were in proportion to the duration of the training session, i.e., in the order of 45, 30, and 15 minutes. Only the 45-minute group produced a significant reduction in serum cholesterol level and in total body fat. The only improvements shown by the men in the 15-minute group were in a 2-mile and all-out treadmill runs.

FREQUENCY. In considering the frequency that jogs should be performed each week, Pollock, Cureton, and Greninger (43) demonstrated that four days were superior to two days per week in obtaining significant improvements in working capacity, cardiovascular fitness, and body composition of middle-aged men. Two days per week, however, did produce significant gains over pretest scores.

INTENSITY - DURATION. Obviously, the length of training sessions depends in no small degree upon the intensity applied: the greater the intensity, the shorter the training session that can be tolerated. To show this relationship, Gettman, Melisis, and Pollock (29) applied various combinations of intensity and duration during a 20-week period with inmates from a state prison and a county jail as subjects. The men

were randomly assigned to an exercise or control group at each location (27-31 in each group). The inmates at the state prison trained 15, 30, or 45 minutes, three times weekly; those at the county jail exercised 30 minutes for one, three, and five days weekly. The conditioning regimen consisted of alternate bouts of running and walking; training intensity was approximately 90% of maximum heart rate for all exercise groups. Results showed that circulatory-respiratory fitness as measured by maximum oxygen intake, treadmill performance time, and resting heart rate improved in proportion to the duration and frequency of training. Improvements in VO_2 max were 9%, 16%, and 17% for the 15-, 30-, and 45-minute duration groups and 8%, 13%, and 15% for the 1-, 3-, and 5-day groups, respectively. Body weight and fat reductions occurred only in the groups training at least three days a week and 30 minutes duration. The control groups remained unchanged on all variables.

MAINTENANCE. Pollock and associates (42) studied the maintenance of circulatory-respiratory endurance through an exercise regimen of decreased intensity and increased duration. Fifteen sedentary men aged 30 to 40 years participated as follows: Phase I, 30 minutes daily for 20 weeks at a high intensity level (94% of maximum heart rate); Phase II, an additional six weeks at a moderate intensity level (84% of maximum heart rate) with duration of training extended to equal the energy cost for both phases. In Phase II, five subjects stopped exercising to serve as a control group for this phase. During Phase I the exercisers increased in VO_2 max and V_E max and decreased in resting and maximum heart rates, body weight, and fat percentage; the control group did not change. During Phase II the exercising group maintained its improved level on the tests applied, while the controls (five dropouts) showed significant decreases. The implication of these findings is that high intensity efforts are not necessary to maintain circulatory-respiratory endurance.

Flexibility

In this report body flexibility is presented as a corrective measure, rather than a continuum test of a basic physical fitness component. Thus, adults who are not flexible in the trunk-hip area would benefit from special stretching exercises to increase mobility in this stem area. The *Physical Fitness Research Digest* for October 1975 was devoted to "Joint and Body Range of Movement."

A simple test of hip-trunk flexibility is the floor-touch test included in the Kraus-Weber Minimum Muscular Fitness Test (34). This test is performed as follows: Subject stands in stocking or bare feet, hands at sides, feet together; lean down slowly and touch floor with finger tips without bending knees, hold position for three seconds (bouncing not permitted). To pass, the floor touch is held for three seconds. Scoring may be applied by giving 10 points for passing test; deduct one point for each inch reached away from floor.

Kraus has indicated that poor hip-trunk flexibility is associated with functional low back pain and has urged the use of exercises to alleviate the situation. Studies and clinical practice have demonstrated that pronounced improvement has occurred from appropriate exercises. Kraus provides details pertaining to the use of exercise in improving body flexibility as well as muscular deficiencies in the hip and trunk areas of the body.

IN CONCLUSION

In presenting "Exercise and Aging" in this issue of the *Physical Fitness Research Digest*, the following explanations were made: the nature of physical fitness, physical

fitness values, the importance of individual differences, physiological changes occurring with age through the adult years, physical fitness studies pertaining to middle-aged persons, the trainability of older people, and suggestions for the adult fitness program. The suggestions for the program emphasized proper principles of exercise and procedures for the improvement and maintenance of muscular strength, and endurance and circulatory-respiratory endurance, basic physical fitness components; some comments were also made relative to body flexibility. The necessary space restrictions of the *Digest* did not permit a detailed account of the day-by-day application of specific activities to the physical fitness program. For those who may wish to pursue program detail, reference is made to a publication by deVries (26), *Vigor Regained*. The books by Cureton (21) and the Coopers (14,15) were mentioned earlier. An article by Pollock (41) gives an overview of an aerobic fitness program. Clarke and Clarke (12) have presented specifics for the improvement and maintenance of the physical fitness components.

The studies presented show clearly that older people are trainable in respect to physical fitness components, even though having been sedentary for many years. Exercise, of course, cannot stop a person from getting older, but, when properly applied, can retard the aging process; it also adds vigor to living throughout life. Improvements in the physical fitness components are slower than for younger people, and the older person cannot hope to regain his or her performances as a youth. Even Joie Ray, whose case study was presented above, did not duplicate his mile time as a young man at the age of 70. Older people have had phenomenal performance records and many engage in championship events for older people, even into the seventh and ensuing decades of life.

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