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YEAR BOOK OF SPORTS MEDICINE® 1991

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The Year Book of SPORTS MEDICINE®

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Journals Represented

Mosby–Year Book subscribes to and surveys nearly 850 U.S. and foreign medical and allied health journals. From these journals, the Editors select the articles to be abstracted. Journals represented in this YEAR BOOK are listed below.

Acta Orthopaedica Scandinavica
Acta Radiologica
American Heart Journal
American Journal of Cardiology
American Journal of Clinical Nutrition
American Journal of Diseases of Children
American Journal of Emergency Medicine
American Journal of Epidemiology
American Journal of Medicine
American Journal of Obstetrics and Gynecology
American Journal of Occupational Therapy
American Journal of Physical Medicine & Rehabilitation
American Journal of Physiology
American Journal of Psychiatry
American Journal of Public Health
American Journal of Roentgenology
American Journal of Sports Medicine
American Review of Respiratory Disease
Annales de Chirurgia et Gynaecologiae
Annals of Allergy
Annals of Emergency Medicine
Annals of Internal Medicine
Annals of Thoracic Surgery
Archives of Physical Medicine and Rehabilitation
Arthroscopy
Athletic Training
British Heart Journal
British Journal of Sports Medicine
Canadian Family Physician
Canadian Journal of Sports Sciences
Cancer Research
Chest
Circulation
Clinical Endocrinology
Clinical Orthopaedics and Related Research
Clinical Pediatrics
Clinical Physiology
Clinical Sports Medicine
Contemporary Orthopedics
Digestive Diseases and Sciences
Endocrinology
European Heart Journal
European Journal of Applied Physiology and Occupational Physiology
Experimental Physiology
Fertility and Sterility
Foot and Ankle
Human Pathology
International Journal of Sports Medicine

Italian Journal of Orthopedics and Traumatology
Journal of Applied Physiology
Journal of Applied Sport Science Research
Journal of Biomechanics
Journal of Bone and Joint Surgery (American volume)
Journal of Bone and Joint Surgery (British volume)
Journal of Bone and Mineral Research
Journal of Cardiopulmonary Rehabilitation
Journal of Clinical Epidemiology
Journal of Clinical Investigation
Journal of Clinical Pharmacology
Journal of Orthopaedic Research
Journal of Orthopaedic and Sports Physical Therapy
Journal of Orthopaedic and Surgical Techniques
Journal of Orthopedic Trauma
Journal of Pediatric Orthopedics
Journal of Sports Medicine and Physical Fitness
Journal of the American College of Cardiology
Journal of the American Medical Association
Lancet
Life Sciences
Magnetic Resonance Imaging
Medecine du Sport
Medical and Biological Engineering and Computing
Medicine and Science in Sports and Exercise
Metabolism
Nature
Neurobiology of Aging
Neuropsychologia
New England Journal of Medicine
Orthopaedic Review
Physical Therapy
Physician and Sportsmedicine
Physiotherapy Canada
Postgraduate Medicine
Public Health Reports
Radiology
Research Quarterly for Exercise and Sport
S.A.M.J./S.A.M.T.–South African Medical Journal
Scandinavian Journal of Clinical Laboratory Investigation
Scandinavian Journal of Rehabilitation Medicine
Sports Medicine
Sports Training, Medicine, and Rehabilitation
Thorax

Standard Abbreviations

The following terms are abbreviated in this edition: acquired immunodeficiency syndrome (AIDS), the central nervous system (CNS), cerebrospinal fluid (CSF), computed tomography (CT), electrocardiography (ECG), human immunodeficiency virus (HIV), and magnetic resonance (MR) imaging (MRI).

Introduction

As always, the year has stimulated much fascinating new research of importance to the physician with an interest in sports medicine, and the YEAR BOOK's panel of expert editors has devoted much time to selecting and abstracting an appropriate and representative selection of this work.

The epidemiology of sports injuries is a growing area of interest, and the present volume includes papers not only on running and intercollegiate sports, but also on skating, sailboarding, horseback riding, and rodeo competition. As the causes of injury become delineated, preventive measures will be planned on a more rational basis. It is particularly encouraging to include the paper of Konradsen and associates, confirming the earlier observations of Panush that habitual joggers do not suffer an excess of osteoarthritic problems as they become older. Anatomical studies are also playing a growing role in injury prevention; approaches include not only the conventional cadaver dissections, but also new techniques of visualizing and/or assessing structures during life, such as MRI of the shoulder region and arthrometers to replace clinical evaluation of knee laxity (although Dr. Torg raises some important questions about the validity and cost-effectiveness of much of the new technology). Another topical issue for the surgeon is the use of frozen musculoskeletal allografts, with a small potential associated risk of HIV infection.

Medical doctors will be interested to see further data from some of the major epidemiologic studies of exercise and ischemic heart disease, as well as new evidence suggesting that regular physical activity protects against colon cancer. Many of the benefits of exercise are relatively small, and papers are presented on the statistical technique of meta-analysis, which is finding increasing application in the evaluation of such gains.

Both trainer and physician or surgeon are increasingly vulnerable to litigation, and Francis George discusses some helpful paper that may serve to protect all parties from such an unpleasant and costly experience. Other helpful papers in the training section continue to explore the controversy over the use of abdominal belts during weight lifting.

The growing involvement of women in sport and exercise programs is increasingly raising issues on how much activity the physician should allow during pregnancy. This volume also contains material on ovocation of uterine contractions by such activity. Exercise physiologists are becoming more interested in muscular strength assessment as opposed to making measurements of maximal oxygen intake ad nauseam, and a useful group of papers are included to show some of the critical variables that influence the results of isokinetic strength testing. Discussion also is offered on the appropriate use of terminology and on the choice between the several measurement systems now commercially available. The continued popularity of triathlon events has raised queries about potential adverse effects of such competitions on the myocardium; however, new evidence suggests that there is no damage to cardiac myocytes. The search for simple, reliable, and valid methods of measuring body composition continues, with the bio-impedance technique now coming under increasing attack. Another current interest of those treating obesity is the extent to which exercise stimulates postactivity metabolism.

Psychologists continue to explore possible methods of reaching those segments of the population who remain chronically inactive. Papers selected for this volume look at traveling distances and the attitudes of "hard to reach" client groups. Those who are concerned with the prevention of steroid abuse will be interested to see a new hazard—the development of a dependence on such drugs.

In all, the 1991 edition gives a fascinating overview of the high-quality research and clinical investigations now being conducted in sports medicine. The abstracts and the associated critical commentaries provide a rapid entrée into a vast, scattered, and rapidly growing literature. The information that is offered will be a major resource to both the research worker who wishes to keep abreast of the field and the sports physician who wishes to prepare for specialist certification in sports medicine, or who merely wants to remain up-to-date in an ever-expanding specialty.

Roy J. Shephard, M.D., Ph.D., D.P.E.

Current Standards of Obesity: Implications for Exericse Prescription *

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Introduction

Many patients consult their physicians with a desire to "lose weight." They hope to meet mythical standards imposed by "normal" weight-for-height tables or to match the yet more rigorous demands suggested by fashion models. After a few weeks or months of vigorous physical activity, the patients (and sometimes their medical advisers are disappointed because prescribed exercise has apparently yielded little or no weight loss. It is thus very important that the physician distinguish clearly between excess fat and a heavy body weight when advising such patients. Frequently, a large body mass is an indication of obesity and increased risk of chronic disease, but it can also signal strong muscles developed through a rigorous training program. Irrespective of causes, a heavy person must perform more work to displace body mass, putting them at a potential disadvantage when performing some tasks such as lifting. However, there is also a close association between total and lean body mass, and because of technical difficulties in measuring the latter accurately under field conditions, the total body mass has been suggested as a criterion to select those who are able to perform heavy physical work, both in the armed services (1) and in occupations such as mining (2). Indeed, Nottrodt and Celentano (3) suggested that simple weighing was one of the more reliable occupational discriminators. Weight-for-height ceilings occasionally have been imposed in the opposite sense, to exclude the obese (for instance, in the police force, as military personnel, and as flight attendants). There is then a danger that the personnel concerned will use highly undesirable self-chosen methods of achieving the imposed targets (cigarette smoking, dehydration, purging, crash dieting as the date of evaluation approaches, or operation of dangerous machinery while maintaining blood sugar with a food intake of 2 mJ or less per day).

This article considers the issues of obesity and body mass in the context of exercise prescription and the performance of vigorous physical activity. It examines the definition of obesity, looks at its impact on the performance of physical activity, and explores how effort tolerance is modified in extremes of heat and cold.

Definition of Obesity

It is first necessary to contrast the bimodal thinking of the clinician with the linear approach of the sports scientist and the ergonomist. Cli-

*Based in part on an invited presentation to the Military Nutrition Committee of the US National Academy of Sciences, Washington, DC.

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nicians have commonly defined obesity as a body mass that exceeds an actuarial "ideal" value (4, 5) by a specified margin such as 10 or 15 lbs (5–7 kg). The main difficulty with the adoption of such standards is that of sample selection—the tables are based on those who are wealthy enough to purchase life insurance, particularly those who do so at a young age. However, Andres (6) has accumulated evidence that the optimum mass for future longevity increases progressively with age. The curve of mortality against body mass seems J-shaped, and an unusually low body mass remains a disadvantage to health even after control of the data for current smoking habits. Possible explanations of this paradox include a cessation of smoking because of incipient disease, and complications of anorexia. Finally, any adverse health effects of excess body mass are no more than a statistical risk; there is no guarantee that problems will become manifest in the individual patient. One alternative standard, also widely used, is the body mass index [for instance, patients may be advised to conform to an ideal range of 20–25 kg/m^2, as proposed by Health & Welfare Canada (7)]. This standard suffers from most of the same problems found with following actuarial norms.

It is debatable how appropriate any ceiling of weight-for-height is from the veiwpoint of a clinical consultation. First, the goal of the physician is not to choose someone who is currently able to undertake a given physical task. Rather, "obesity" should be diagnosed and corrected only when body fat has reached a level where there is an increased vulnerability to chronic disease (Table 1). Vulnerability requires a substantial excess mass. One practical corollary of this is that the adverse health impact of smoking is much greater than the obesity that it prevents. Moreover, most of those who are seeking an exercise prescription, and many of those working in heavy occupation, are quite young, whereas any loss of health from obesity-related chronic disease tends to occur in later adult life. Moreover, effort tolerance is typically a continuous rather than a bimodal function of body mass, and heavy people perform many activities better than those who are lighter. The clinical approach draws no distinction between an accumulation of muscle and a build-up of fat, and in consequence a muscular person may be asked to lose an excessive amount of weight. From the viewpoint of exercise prescription, the energy cost of most physically demanding tasks depends not only on total body mass, but also on the proportion of fat and on its distribution (superficial or deep, central or peripheral).

Many athletes involved in events that require endurance have extremely low percentages of body fat, but it is probably undesirable for the ordinary patient to try to emulate them. One possible way of defining the fatness of an average patient more precisely is to compare hydrostatic, skinfold, or impedance estimates of the patient's body fat content with the average values observed in a patient of ideal body mass. Amor (8) used population-specific skinfold predictions, arbitrarily setting the desirable upper limit of body fat at 14% in male army recruits. Incidentally, Amor's data apparently suggested that 16.8% body fat would correspond with the 1959 actuarial ideal body mass. Taking the 14% figure

TABLE 1.—Mortality of Obese Subjects

Condition	Men		Women	
	+24kg	+33kg	+28kg	+37kg
Diabetes	179	385	270	242
Cer. Vasc. disease	136	183	143	142
Heart/circulation	131	155	175	178
Pneumonia/flu	128	193	148	110
Digestive diseases	147	197	140	200
Kidney diseases	146	230	93	122
Accident/homicide	109	126	85	98
Suicide	71	104	47	
Total	123	145	130	138

Mortality was classified by disease and expressed as a percentage of standard values for subjects of the same sex, aged 15–69 years.
(Courtesy of Society of Actuaries: *Build and Blood Pressure Study.* Chicago, 1959.)

for males and 18% for females, this would imply respective "ideal" fat masses of 10 kg and 11 kg in men and women of average body mass (70 kg and 60 kg, respectively). Applying the most conservative clinical criterion of obesity (a 5-kg excess of fat), the obese have at least a 50% increase over the desirable body fat content, with totals of more than 21% in males and 27% in females. Amor (8) noted that approximately 50% of male British soldiers exceeded the actuarial norm. The proportion of those who had more than 18% body fat increased with age (Table 2) but was unrelated to the physical demands of employment (Table 3). Those who were classified as "obese" also tended to have a poor maximal oxygen transport, particularly if this was expressed in mL/kg·minute (Table 4).

Skinfold thicknesses offer a second way to distinguish muscle from fat accumulation. The observed skinfold readings can again be compared with the average values observed in a person meeting actuarial standards of body mass (9). Ideal readings average about 10 mm in males and 14 mm in females. Assuming that a double fold of the skin per se accounts for 4 mm of the total skinfold reading, there would be a superficial layer of $.3 \times 18{,}000$ or 5,400 cm^3 of fat in a man with a body surface of 1.8m^2 (4.8 kg of fat, assuming a density of .9), while in a woman with a body surface

TABLE 2.—Influence of Age on Percentage of Obese Male Subjects

Age	Percent obese (>18% fat)
17-19yrs	32
20-24	39
25-29	46
30-34	56
35-39	62

Data of AMOR (1978) for British army.
(Courtesy of Allen C (ed): *A Survey of Physical Fitness in the British Army: Proceedings of the First RSG4 Physical Fitness Symposium With Special Reference to Military Forces.* Downsview, Ontario, Defense and Civil Institute of Environmental Medicine, AMOR, 1978.)

TABLE 3.—Influence of Job Intensity on Body Fatness

Intensity	Percent with >18% fat
Sedentary	53%
Light	42
Moderate	38
Heavy	51

Based on data of AMOR (1978) for British army.
(Courtesy of Allen C (ed): *A Survey of Physical Fitness in the British Army: Proceedings of the First RSG4 Physical Fitness Symposium With Special Reference to Military Forces.* Downsview, Ontario, Defense and Civil Institute of Environmental Medicine, AMOR, 1978.)

area of $1.6m^2$ there would be about $.5 \times 16{,}000$ or $8{,}000cm^3$ (7.2 kg of fat). Obesity is not necessarily distributed equally between deep and superficial depots, but assuming that there is at least a 50% increase of subcutaneous fat in a person who is clinically "obese," the threshold of clinical obesity would be reached with an average skinfold reading of at least 13 mm in males and 19 mm in females.

In field situations, some investigators prefer to measure circumferences rather than skinfolds, on the basis that the circumference measurements can be made with less experience (10, 11). Again, it is possible to develop norms by relating readings to those observed in patients of ideal body mass.

TABLE 4.—Influence of Body Fatness on Percentage of Subjects With Poor Fitness Level

Body fat, %	Percent with poor fitness
<10	2
10-14	5
14-18	9
18-22	21
22-26	32
>26	51

Predicted aerobic power < 35 mL/kg/min.
Based on data of AMOR (1978) for British army.
(Courtesy of Allen C (ed): *A Survey of Physical Fitness in the British Army: Proceedings of the First RSG4 Physical Fitness Symposium With Special Reference to Military Forces.* Downsview Ontario, Defense and Civil Institute of Environmental Medicine, AMOR, 1978.)

Performance in Comfortable Climates

Poor health and obesity.—What impact does moderate clinical obesity have on health? Minor sickness and absenteeism are common problems in all occupations (12). Government employees lose 10 of 220 working days each year through absenteeism, and an unpredictable need for well-trained replacements adds some 17.5 days of labor costs, about 8% of the total payroll (12). Is such minor illness and absenteeism more prevalent among the obese?

Bardsley (13) commented on the substantial economic cost of life-style diseases in the Canadian Armed Forces (Table 5). In 1973, $5.9 million was spent to replace those soldiers who died, $5.8 million was spent to replace those who were released, $12 million was spent on soldiers who were hospitalized, and $1.5 million was spent for those on sick leave. However, the prospects for a preventive exercise prescription are relatively limited. Much of the expense is related to smoking and alcohol abuse rather than obesity. A substantial excess body mass (20–30 kg) is needed to increase the risk of death from disease such as coronary atherosclerosis and diabetes (4). Moreover, the economic impact of any obesity-related chronic disease is most prevalent in older members of the labor force. Finally, much absenteeism is attributable to causes other than organic disease and would be unlikely to respond to the correction of clinical obesity or indeed to any other form of medical treatment (14). Nevertheless, we observed a 22% decrease in absenteeism among high adherents to a work-site fitness program, and such adherence was associated with a decrease in body fat.

Other occupational implications of obesity.—Obesity often has an adverse effect on a person's self-image and thus morale. Obese personnel

TABLE 5.—Estimated Cost of Diseases of Choice in the Canadian Forces in 1973 (1973 Dollars)

Replacement of the dead	$5.9 Million
Replacement of the released	5.8
Hospitalization + lost wages	12.4
Wages of those on sick leave	1.5
Total	25.6

This cost is spent on a labor force of about 80,000 military personnel.
(Courtesy of Bardsley JE: *The Canadian Forces Life Quality Improvement Program.* Downsview, Ontario, Defense and Civil Institute of Environmental Medicine, AMOR, 1978.)

also run contrary to the public image for jobs such as soldier, police officer, fire fighter, or even senior executive, and it seems logical that organizational effectiveness will be impaired if an individual is perceived as obese (12).

Notice that in this context, the quest has shifted from a threshold for disease to an appearance criterion. The ideal percentage of body fat from the appearance standpoint varies widely with the purpose of the examination. Yuhasz (15) suggested a figure as low as 14.3% fat when a panel of men judged the physical attractiveness of seminude female university students. Those selecting military personnel have accepted a much higher ceiling of fat (around 20% even in male recruits)—in part because the men are clothed, and in part because factors other than body fat contribute to a "military" appearance.

Baun et al. (16) further commented on an association between achievement orientation and personal fitness. They suggested that by selecting personnel that met specified standards of body composition and physical fitness, and insisting on the maintenance of those standards throughout the period of employment, a company recruited and retained premium personnel.

Effort tolerance.—The energy cost of prescribed and occupational activities often is taken from tables, but in fact values show a substantial interindividual variation, dependent in part on body mass and body composition. The total cost is the sum of resting metabolism plus the additional energy cost imposed by the activity in question. Physically demanding tasks may be classified simply into endurance activities, such as prolonged walking or jogging, and activities that involve lifting or carrying. The latter commonly limit the performance of heavy occupations [for example, the key task for front-line military personnel is an ability to lift a mass 36 kg from the ground to a height of 110 cm (3)].

Resting metabolism.—Resting metabolism is neither a linear nor a bimodal function of body mass. There is some reduction of metabolic responses to feeding in the grossly obese, but because of body surface effects, resting metabolism tends to be a power function of body mass M:

$$\dot{V}_{O2} = (M)^{.75}$$

A large part of each fat cell is metabolically inert stored triglyceride. Thus, the resting metabolism per unit of body mass is greater in a muscular individual than in a fat individual. On the other hand, obesity imposes a mass loading on the chest, increasing the work of breathing. There are decreases of lung volume and chest wall and lung compliance. In extreme cases, there is the classical Pickwickian syndrome of hypercapnia and hypoxia (17), sometimes with an increased sensitivity to hypoxia (18) and carbon dioxide (19, 20).

Endurance activities.—Many of the studies of walking and jogging have been based on results in young military recruits. Givoni and Goldman (21) and Pandolf et al. (22) have developed various equations to predict the energy cost of marching which seems to be a linear function of body mass and the mass of any backpack that is being carried. Thus, a heavier patient spends more energy in walking, jogging, and other forms of movement, whether their added body mass is attributable to muscle or fat. Given that a healthy young 70-kg adult can carry a 30-kg pack, a patient who is 10-kg heavier apparently faces a 10% handicap in walking speed (total mass to be displaced is 110 kg rather than 100 kg) or (if pace is to be maintained) a 33% reduction in the size of the backpack that can be carried.

If the added 10 kg of body mass is muscle, the actual penalty of endurance performance is less harsh. There is usually some compensatory increase in the patient's absolute maximal oxygen transport, measured in L/minute, and because the muscles are stronger, it also may be possible to operate at close to the maximal oxygen intake for a sustained period of time without developing an excessive oxygen debt. The tolerance of endurance activity in a heavy but muscular person may thus approach that of a lighter individual. However, if the extra mass is fat, there is no compensatory development of maximal oxygen intake, and often oxygen transport is poorer than in a lighter person. Endurance performance is thus limited by an amount corresponding to at least the theoretical prediction, based on excess body mass. There is no decrease of mechanical efficiency in the moderately obese individual, so that the oxygen cost of walking per kilogram of body mass remains unchanged. However, a combination of heavier limbs, awkward or impeded movements, and increased respiratory loading gives rise to a low mechanical efficiency in patients with pathologic obesity. The oxygen cost of a given speed of movement thus rises further, with a corresponding restriction of the individual's endurance performance (23).

The metabolism of an obese patient is characterized by insulin resistance and difficulty in mobilizing fatty acids (26, 27). There is thus a reliance on stored carbohydrates, therefore, an endurance activity is sustained for a long period of time, function may be impaired by a depletion of glycogen reserves.