tractions. Maximal voluntary contractions (MVC) were determined at the start of each experiment, and 20 minutes later the first of three successive hand-grips was made, at 30% MVC, to fatigue. The intervals between the contractions were 10 and three minutes respectively. Over the 10 days, there was no change in either the maximal strength or the duration of any of the three hand-grips held to fatigue. This failure to improve either the strength or duration of sustained contractions is consistent with several previous observations (unpublished) in our laboratory with either hand, with tensions up to 60% MVC, and over periods of up to three months. Furthermore, there was no change in the heart rates or blood pressures before and after training. These findings are obviously at variance with the observations of others. The hand-grip is a reasonably common activity, so that our subjects were presumably partially trained before starting these experiments, but in view of the findings reported in the literature (including the influence of training on hand-grips) it was, at first sight, surprising that none of our subjects showed an increase in muscular strength.

Large daily variations of the muscle strength of individuals are normally reported in experiments on training. This variation is most often attributed to daily differences in motivation. But it has also been suggested that "trick" anatomical learning procedures may play a part (an explanation that reflects on the design of the dynamometer). Such a learning procedure might be expected to improve the recorded muscle strength progressively through a training experiment and might, for instance, account for some of the dramatic changes in strength following astonishingly little daily muscular activity. In our experiments, the dynamometer was designed to eliminate the effects of stray bodily movements and trick anatomical maneuvers. The motivation of our subjects was high. Day-to-day variations in muscular effort were small (with a coefficient of variation of never more than 5%, and sometimes as low as 2%). Can it be that a proportion of the apparent improvement of muscular strength in training experiments reported in the literature may be due to simple anatomical learning in the use of the dynamometer? If so, what may be the dimensions of that proportion?

SESSION III: Paper 3

Psychological Changes with Physical Fitness Training

V. B. O. HAMMETT, M.D., *Philadelphia, Pa., U.S.A.*

EARLY STUDIES

MAN'S interest in physical-psychological relationships is traceable at least as far back as the times of Hippocrates, Aristotle and Plato several centuries B.C. Yet in the more than two millennia since, there has been relatively little specific gain in our knowledge of these relationships. Without doubt man's inquiring mind did not altogether overlook this field in all this time, but the inquiries were speculative and hypothetical rather than experimental, and psychological theories paid little attention to physiology and physical factors. This state of affairs caused Aldous Huxley[1] to criticize the science of psychology in these words: "What is, I suppose, the most serious, as it is certainly the most conspicuous, shortcoming of all—the absence of any mention of the body as a conditioning factor in the formation of a personality, or as a determinant of thoughts, feelings and behaviour." Although this criticism was fairly accurate at the time of its writing it is no longer valid. In this generation, and more particularly within the past decade or so, there has been a growing interest in the scientific investigation of physical-psychological relationships.

Some of the earlier studies seem, in retrospect, vulnerable to criticism on many counts; nonetheless they are efforts deserving of mention. Choosing various psychiatric syndromes as the psychological variables, these studies sought to determine the relationships between these syndromes and physical fitness. For example, one such study explored the relationships between physical fitness as measured by the Schneider

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method and various types of schizophrenia; a group of normal subjects were used as controls. The results were thought to demonstrate an inverse relation between physical fitness as thus measured, and mental illness: the schizophrenic subjects were less physically fit than the normal controls.[2] A similar study at about the same time included among the subjects not only schizophrenics, but also manic-depressives and psychoneurotics; mentally healthy persons and athletes were used as controls in this study. Differences considered to be of significant magnitude were found between the psychiatrically ill subjects and the controls, with respect to physical fitness as measured by the Schneider method.[3]

Although the method used for measuring physical fitness seems unsophisticated by more recent standards and although the psychological variables studied were somewhat unsatisfactory because of uncertainty as to their reliability, these studies are of some interest in showing correlations between physical fitness and psychic or psychological factors. They appeared to demonstrate that as physical fitness increases, psychic illness diminishes.

COMPOSITE FACTOR STUDIES

Several studies have demonstrated positive correlations between athletic ability and the general level of social adjustment, as determined by the use of sociometric techniques, teachers' ratings, and the California Test of Personality.[4-6] If athletic ability and achievement is accepted as a reliable and valid indicator of physical fitness—and this is somewhat uncertain—these studies show positive correlation between physical fitness and the rather complex psychological variable, identified as "social adjustment".

A somewhat similar study focussed upon the relationship to the academic index of college women to physical fitness.[7] Academic index was determined in the usual manner (A grade equals 4, B equals 3, C equals 2, etc.); thus it represents a rather complex, composite psychological factor. Physical fitness was determined by the physical fitness index prepared by the Springfield College Physical Education Tests and Measurements Laboratory. This study showed a statistically significant correlation between academic index and physical fitness.

DISCRETE AND MULTIPLE FACTOR STUDIES

A number of studies have investigated the relationship between various distinct psychological factors and personality traits, on the one hand, and physical fitness on the other. In the majority of these studies, the investigation of the psychological factors was based upon self-reporting questionnaires; a few used projective testing techniques.

Many studies focussed upon athletes of more-than-average ability, selecting only those who had won places as varsity athletes or the even more restricted category of champions. It is not certain that athletic prowess equates with general physical fitness: however, unless this is demonstrated to be invalid, it seems reasonable to assume that the two are more or less equivalent. Some interesting information bearing upon the relationships between physical fitness and discrete psychological factors, especially as these are revealed in specific personality traits, emerges from the study of athletes.

When 270 West Point cadets, who were letter winners in high school football, were compared to a control group of non-athlete cadets using Cattell's 16 Personality Factor Questionnaire[8] the athletes were more sociable, dominant, enthusiastic, adventurous, conventional, and group-dependent than the controls.[9] Another study of athletes of championship calibre found them to be more somatotonic than others, the controls being more viscerotonic or cerebrotonic.[10] This study used Scheldon's Scale of Temperament for measurement of the personality traits under investigation.

The psychological factor "tension-anxiety" has been studied in relation to athletic prowess. Using the anxiety factors in the Minnesota Multiphasic Personality Inventory as the method for measuring anxiety,[11] varsity athletes were found to have lower anxiety scores than non-athletes.[12] This study seemed to demonstrate that athletes, presumably physically fit, were less anxious than non-athletes, presumably less physically fit. However, in another part of the same study, it was shown that college freshmen athletes had higher anxiety scores. Since it might reasonably be assumed that freshmen athletes are approximately as physically fit as varsity athletes, the entire study yields ambiguous results, suggesting that some factor other than fitness must account for the lower anxiety scores of the varsity athletes.

Other research has used projective psychological tests to detect and appraise variable psychological factors. Twelve athletes of championship calibre, studied by means of the Rorschach and the "house-tree-person" tests,[13] had uniformly high scores for self-assurance, ambition, aggressiveness, and anxiety.[14]

High school girls at a high level of physical fitness showed a statistically significant correlation between enhanced body image and fitness when contrasted with girls at a lower level of fitness.[15] The tests used as measuring devices for

the psychological factor under study were the "draw-a-person" test[16] and the semantic differential test.[17]

These studies are fairly representative of this type of research. The findings are interesting and suggestive. However, there is little standardization of the measurement of physical fitness, and in most instances this is simply implied by athletic prowess. Nor is there any uniformity in the methods of testing for the various psychological factors; some are self-reporting symptom questionnaires, others are based upon the analysis of self-recorded personality factors, while others make use of projective techniques. The particular tests used in these studies are generally considered to have a fairly high degree of reliability. Their validity, when used as measurement devices for establishing correlates of physical fitness, is not yet determined. Commenting upon studies of this general type, Kroll and Petersen[18] urged caution in drawing definitive conclusions, and stated, "The confusing perplexity and conflicting definitions of personality traits, unreliable test instruments, inadequate statistical analysis, and the disconcerting carpriciousness of individual assessments have all contributed to the problem." They go on to say, however, that the advent of multivariate statistical analysis offers some promise in newer work on profile analysis in personality research.

It is not possible in a paper of this length to summarize, in any detail, a multivariate study because of the complexity of such research. However, a fairly representative example of this type of investigation will be described in barest outline.[19]

Eighty male college students were given a battery of physical fitness tests and a series of objective and questionnaire psychological tests. Thirty-eight variables were obtained from the various physical fitness tests. These 38 fitness variables were correlated with 35 psychological variables; the psychological variables included Cattell's 16 Personality Factor Questionnaire, anxiety ratings by two psychiatrists in personal interview, two questionnaire tests on friends, and 15 factors that had been obtained by factor analysis of a total of 113 different psychological variables obtained through a variety of tests. Analysis yielded 116 significant correlations between the physical fitness and the psychological variables. Obviously these cannot be repeated in this paper; however, two illustrative examples follow:

1. Dynamic strength, as measured by the number of "dips", correlates with: more friends, more adventurous, and more maturity; less anxiety and less tension.

2. A high score on the Schneider Index of Physical Fitness correlates with: more inhibition, more assertiveness, more sensitivity, and less overall anxiety.

BEFORE-AND-AFTER STUDIES

The studies cited thus far demonstrate a number of correlations between physical fitness, as measured or inferred by various methods, and a considerable range of psychological factors identified by a multiplicity of testing devices. Implicit in these correlations is the idea that the psychological factors will vary or change as physical fitness increases or diminishes. There is, however, no demonstration of the validity of this implication. In order to demonstrate that change in psychological factors accompanies change in physical fitness, longitudinal studies of the before-and-after type are necessary. There have been some studies of this type.

Sixteen children with various neuromotor problems were studied before and after an individualized physical development program which consisted of eight one-hour sessions. The psychological factors studied were body image and self-concept; the tests used were projective in type and consisted of the "draw-a-person" test, a semantic differential test and a projective-type sociometric test. In addition to these tests, the children's teachers made before and after ratings on a nine-point scale designed to measure performance. This study reported definite improvement in the body image and the self-concept after completion of the physical development program.[20]

However, another study employing a different method of testing body image and using many of the same children as subjects, obtained findings which were uniformly negative; there was no change in the body image as tested after the eight-week physical development program. Testing was done by an aniseikonic technique, which requires the subject to view his body or parts of it while wearing special lenses and to answer "yes or no" if he sees distortions.[21]

A somewhat similar study was done on 10 retarded males, but the experiment included a much more extensive program of physical fitness training totalling 48 hours over an eight-week period. The change in physical fitness was carefully measured by several tests, and showed significant improvement. The psychological variable studied was the body image, and the method of study was the "draw-a-person" test. The experiment demonstrated that there was significant improvement of the body image for all of the subjects after completion of the program of fitness training.[22]

Not all of the before-and-after studies employed body image as the psychological factor for investigation. Another experiment of interest employed a battery of three personality tests (Allport's A-S reaction study, Cattell's 16 personality factors, and the Kuder preference record, Form C), yielding a total of 28 personality-trait measurements. Body image was not included. The experimental subjects were 26 high school boys, with a control group of 24. The experimental group participated in a strenuous physical-fitness program over a period of nine months, whereas the control group engaged in only the regular physical-education class. The physical fitness of the experimental group improved significantly more than did the fitness of the control group: 21.7 percentiles gain in fitness as contrasted with only 3.9. Analysis of the results of the "before-and-after" psychological tests yielded strikingly negative findings: the experimental group changed significantly on only one of the 28 psychological factors measured. The factor showing significant change was the clerical score of the Kuder preference record. This experiment appears to indicate that psychological factors of the personality-trait type do not show significant change as physical fitness improves.[23]

An experiment of the "before-and-after" type which investigated another kind of psychological factor is of interest. Radiotelegraph operators were given two and one-half months of physical fitness training, consisting of four hours weekly. At the conclusion of this training, they showed improved performance at their jobs and improved general psychological functioning as measured by the digit-span test and the numerical problem-solving test.[24] These are sub-tests of the Wechsler adult intelligence scale. They reflect the subject's attention and concentration, and thus are considered to be indirect measures of the degree of anxiety.

DISCUSSION

There is a general assumption that physical fitness has psychological correlates. The concept of body-mind relationships is age-old. Psychosomatic research has indicated that physical changes result from continued psychological states; it seems logical to assume the reverse, that psychological changes result from physical states, such as fitness. Although there is a general assumption that this is so and considerable claims rather vaguely documented, there are surprisingly few firmly validated data.

The earlier studies, examples of which have been cited, are of historical interest, but they are of no substantial help in devising an experimental approach to the problem.

Correlation studies show relationships between many psychological factors and physical fitness. These findings are interesting and deserve scrutiny for possible leads into further research. However, they cannot be regarded as valid indications of psychological change related to increasing physical fitness; it is equally possible that they reflect predilections: i.e. persons with certain psychological characteristics may gravitate to physical-fitness programs.

The before-and-after type of experiment appears to be required to obtain valid data concerning psychological changes related to fitness training. To date there has not been sufficient research of this type to enable us to draw any firm conclusions. Of the studies reported, those concerned with psychological factors of the personality-trait type have yielded negative results. The most promising results thus far have been obtained with studies focussing upon body image as the psychological factor under investigation.

Body image is defined as "the way in which the body appears to ourselves",[25] or "the picture of one's own body in his mind".[26] Body image can be tested by the "draw-a-person" test and the Rorschach test. Both tests are considered to be reliable for determination of the *qualitative* factors related to body image. There is no general agreement that either test is reliable for determination of *quantitative* factors.

Description and measurement of psychological factors which change in relation to physical fitness require further research in the future.

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Commentaries

Commentary: A. PAIVIO, *London, Ontario*

FINDINGS from an experimental study carried out by an interdisciplinary research group from the Departments of Physical Education, Medicine, and Psychology at Western suggest that the psychological effects of exercise may depend upon the person's interpretation of the relevance of physical activity to a particular deficiency. Psychological tests designed to measure personality variables, emotional (or mood) states, and attitudes toward the self were completed by four groups: an experimental and a control group of postinfarction ("cardiac") patients, and clinically healthy ("normal") adult men before and after a 24-week program of graduated exercises. The normal controls were sedentary throughout the 24 weeks, but the cardiac controls participated in a weekly recreational swim. The most reliable specific change was a reduction in anxiety scores for the two exercising groups and the cardiac controls; in contrast, the normal controls showed an increase in anxiety after the 24 weeks. In terms of overall changes on a large number of rating scale items concerned with feelings of happiness, pleasantness, confidence, success, cheerfulness, and the like, the cardiac exercise and cardiac control groups showed comparable changes in a positive direction. This occurred despite a higher level of activity and greater improvement in physical fitness in the cardiac patients who were exercised. In comparison with the cardiac patients, the normal subjects who exercised experienced slight negative psychological changes. Thus beneficial psychological effects appeared to be related to the cardiac condition and to participation in a program appropriate to that condition, rather than to the level of activity *per se*.

Commentary: M. L. HOWELL, *Edmonton, Alberta**

THE term "motor educability" has commonly been used to describe the ease with which individuals learn motor skills. Single tests have been proposed to measure this factor on the supposition that there is a "general learning ability", and that individuals who learn one motor skill well will also learn another motor skill well.

Of course many factors affect the rate of motor learning, for example the difficulty of the task, the length of the task, the number of trials, the spacing of those trials, motivation, and drive level. Further, psychologists have now shown that there is a high degree of task-specificity in learning. Woodrow[1] found evidence of this with verbal material, and Heese[2] reported extremely low intercorrelations between individual differences in the learning of fine motor skills. Present evidence[3-6] suggests that motor learning tasks are so specific that the concept of a general learning ability is not tenable. This does not mean that there is no general or common variance or that some common factors do not exist. However, such general variance is always small even when acts are very similar. Typically such common variance is of little importance compared to the item-specific variance.

*Prepared in collaboration with R. B. Alderman, Fitness Research Unit, Edmonton.