

## PERSONNEL SELECTION FOR PHYSICALLY DEMANDING JOBS: REVIEW AND RECOMMENDATIONS

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Improvement in personnel selection systems for physically demanding jobs is needed due to equal employment opportunity (EEO) considerations, concern for worker physical well-being, and the lack of alternative procedures. After addressing the special EEO sensitivities of physical abilities selection, the literature is reviewed from a variety of disciplines on: (1) the physiological background underlying the selection strategies, (2) the assessment of human physical abilities, (3) the measurement of physical requirements of jobs, and (4) the physical abilities personnel selection studies reported in the literature. Conclusions are provided in the form of recommendations for future research.

THERE is a need for increasing sophistication in the selection of personnel for physically demanding jobs for at least three reasons. First, equal employment opportunity (EEO) legislation has resulted in greater numbers of females and handicapped individuals seeking employment in occupations requiring high levels of physical capability. Improved screening devices are needed to both insure that job performance requirements are met and to protect the well-being of prospective employees. Second, it is becoming more widely recognized that physically unfit workers have higher incidences of lower-back injuries, and that properly developed strength testing selection programs can reduce the occurrence of these injuries (e.g., Chaffin, 1974; Chaffin, Herrin, and Keyserling, 1978; Kemp, 1981; Keyser-

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ling, Herrin, and Chaffin, 1980). Third, preemployment medical evaluations used alone are inadequate for personnel selection for physically demanding jobs. Although they are useful for detecting preexisting ailments that may create excessive health risks on the job (Hogan and Bernacki, 1981), they have not been shown to reduce the incidence of lower-back injuries (Chaffin, 1974; Kemp, 1981; Redfield, 1971) or to predict job performance or absenteeism (Alexander, Maida, and Walker, 1975). Furthermore, medical evaluations are usually not given until after the person has been hired, thus serving more for placement decisions rather than for selection decisions (Miner and Miner, 1979).

Unfortunately, the topic of selection systems for physically demanding jobs does not fall exclusively within the auspices of one profession or body of literature. For example, work physiologists are astute in the measurement of the physiological costs of work, but are typically not well versed in personnel selection; conversely, industrial psychologists are thoroughly familiar with the intricacies of selection, but know little of the physiological determinants of work performance. The purpose of this paper is to survey and integrate knowledge from the diversity of fields that bear upon this problem including work physiology, occupational medicine, industrial engineering, biomechanics, and industrial psychology.

This paper is divided into five main sections. The first provides a brief overview of some of the physiological background and logic underlying the physical abilities selection strategies. The second section discusses the various methods of assessing physical abilities; while the third section addresses the issue of measuring the physical requirements of jobs. The fourth section reviews the physical abilities selection efforts that have been reported in the literature. Finally, the fifth section concludes by offering some recommendations as to future research on systems for selecting personnel into physically demanding jobs.

Before this review, however, the special EEO implications of physical abilities selection procedures should be considered.

### *EEO Sensitivities of Physical Abilities Selection*

The risk with physical ability selection criteria is that they are likely to exhibit adverse impact against females and some ethnic groups. As such, they may violate Title VII of the Civil Rights Act of 1964 unless they are demonstrated to be job related. Furthermore, physical abilities selection may discriminate against individuals with certain handicaps and thus may violate the Vocational Rehabilitation Act of 1973.

Traditionally, some organizations have used minimum height and weight requirements as surrogates for strength. Unfortunately, these standards are usually set arbitrarily, and their relationship to job performance is not demonstrated. Many of these selection standards have been ruled illegal (e.g., *Blake v. City of Los Angeles*, 1979; *Dothard v. Rawlinson*, 1977). It is only under rare circumstances that these types of standards have withstood legal scrutiny, such as when a minimum height is necessary of a pilot in order to see properly and reach all the controls in an airplane cockpit (*Boyd v. Ozark Airlines*, 1977).

Even selection systems that measure physical abilities directly have frequently not fared well in the courts (e.g., *Harless v. Duck*, 1980; *Officers for Justice v. Civil Service Commission*, 1975). These systems are usually criticized for inadequate job analyses or excessive judgment in test selection or standard setting. Moreover, the *Blake* court suggests that merely showing some rational relationship between the selection device and job performance is not enough, but the practice must be shown to be *necessary* to safe and efficient job performance.

In short, physical abilities selection procedures should be validated against job performance like any other selection procedures, especially given their expected adverse impact against females (Hogan, 1980). Guidance as to the proper evidence to demonstrate job relatedness can be gained from government regulations (Equal Employment Opportunity Commission, Civil Service Commission, Department of Labor, and Department of Justice, 1978) and from professional guidelines (American Psychological Association, Division of Industrial-Organizational Psychology, 1980). Further guidance as to the legal considerations relevant to employee selection can be obtained from Miner and Miner (1979) and Arvey (1979). Hogan and Bernacki (1981) and Sherman and Robinson (1982) can be consulted for discussion as to the special problems of testing handicapped people. Finally, developers of selection procedures for government contractors should be aware of the affirmative action obligations for females, minorities, and handicapped persons (Employment Standards Administration, Department of Labor, 1974; Office of Federal Contract Compliance Programs, Department of Labor, 1978).

### *Physiological Background*

The ability to perform physical work depends on the ability of the muscle cells to transform chemically bound energy in food into mechanical energy for muscular work. This depends in turn on the

capacity of the service functions that deliver fuel and oxygen to the muscles, including both oxygen uptake and cardiac output (Astrand and Rodahl, 1977). Additionally, other factors affecting physical performance capacity include the nature of the work itself such as intensity and duration, somatic factors such as sex and health, psychological factors such as attitude and motivation, environmental factors such as altitude and temperature, and other factors such as training and adaptation levels.

In most types of gross muscular exercise, oxygen uptake increases roughly linearly with increases in work load (Astrand and Rodahl, 1977). Consequently, an individual's maximum oxygen uptake (i.e., maximum aerobic power) is usually used as a direct index of the individual's physical work capacity (Astrand and Ryhming, 1954). One approach in selecting for physically demanding jobs is to measure the work load, and then to only select people whose maximum aerobic power is great enough so that they can perform the job without excessive physiological fatigue. It is generally believed that a job should not require more than 30 to 40 percent of an individual's maximum aerobic power on a continuous basis during a normal 8-hour shift with usual breaks and rest pauses (e.g., Astrand and Rodahl, 1977; Garg, Chaffin, and Herrin, 1978; Konz, 1979; Michael, Hutton, and Horvath, 1961). Therefore, this suggests a selection strategy of hiring only those individuals whose maximum aerobic power is two and one-half times greater than the continuous work load required on the job. Of course, most jobs require varying levels of aerobic power at different times during the work day. Thus, much judgment is usually required in the establishment of this standard. Both the levels of aerobic power required and the intermittent versus continuous nature of the work must be considered.

Another major approach to the selection of personnel for physically demanding jobs focuses on strength requirements. Much of the work in this area has been spearheaded by Chaffin and his associates (Chaffin, 1974; Chaffin, et al., 1978; Chaffin, Herrin, Keyserling, and Garg, 1977; Herrin and Chaffin, 1978; Keyserling, et al., 1980; Park and Chaffin, 1975). Their approach is based on two assumptions. First, the relationship between the strength requirements of the job and the physical strength of the workers has an impact on the incidence of lower-back (and other) injuries. In other words, injuries are more likely to result to the extent that the jobs require physical strength at or above the capabilities of the workers. The second assumption is that selecting employees with physical strength meeting or exceeding the requirements of the job will result in fewer injuries, less physiological fatigue, and higher levels of job perform-

ance. The usual procedure is to determine the strength requirements of the job, either through direct measurement or biomechanical analysis, and then simulate the muscle movements required in the strength-demanding tasks in a preemployment screening program. Although it is advisable that the strength as measured in the screening test is similar to that as required on the job, strength in one muscle group can show high correlations with strength in other muscle groups (Fleishman, 1964). Cut-off scores are often used on these strength tests, and they are usually set to approximate the maximum or near maximum requirements of the job.

### *Assessing Physical Abilities*

This section reviews some of the methods of assessing physical abilities or work capacities of individuals. Space does not permit a delineation of the specific procedures, but the interested reader could consult the references cited. The goal here is only to highlight the approaches available. Three types of physical abilities will be addressed: endurance or maximum aerobic power, strength, and omnibus physical fitness. Finally, the influence of sex and age will also be briefly discussed.

A variety of different procedures and instruments have been used to assess maximum aerobic power. Three distinctions clarify the differences between the approaches. The first distinction is between direct versus indirect determinations. Direct measures involve collecting the actual expired air during exercise and analyzing the oxygen content. Typically, the Douglas bag method is used (see Astrand and Rodahl, 1977, for details). Indirect measures usually use heart rate to predict oxygen consumption, because they are linearly related within an individual (Astrand and Ryhming, 1954). Although direct measures are the most accurate, they are cumbersome to administer and require expensive instrumentation and trained personnel.

The second distinction is whether the test is maximal or submaximal. That is, the test could either require the individual to exhibit maximum aerobic performance, or only submaximal performance may be required. With the latter approach the maximum aerobic power is predicted, rather than measured. Again, maximal measures may be the most accurate, but they are more time consuming to administer, are more strenuous on the subjects, and may involve safety risks due to the high exertion required.

The third distinction involves the mode of exercise used. The most frequent choices are the bicycle ergometer, the treadmill, and

the step test. The bicycle ergometer and treadmill are more standardized and have a wider range of adjustability, but they are more expensive and cumbersome to work with than the step test.

As might be expected, there has been considerable effort in trying to develop valid indirect measures of maximum aerobic power from submaximal tests, especially using the step test. The first such effort was by Astrand and Ryhming (1954). They developed a nomogram for calculating aerobic power from heart rate during submaximal work on a bicycle ergometer or step test. Their method exhibits reasonable accuracy, with errors typically in the  $\pm 5$  to 10% range. Others have tried to improve on the accuracy of the nomogram approach by measuring heart rate at four different known work load levels (Maritz, Morrison, Peter, Strydom, and Wyndham, 1961), or by measuring heart rate at two known work load levels and correcting for body weight (Margaria, Aghemo, and Rovelli, 1965). Others have tried to improve on the exercises used to measure aerobic power. For example, Shephard (1967) has proposed the use of a progressive step test. Finally, Datta and Ramanathan (1969) have explored pulmonary ventilation as a predictor of oxygen uptake.

A variety of methods are also available for the assessment of human strength. The techniques utilize one of three categories of muscle contractions: isometric, isotonic, or isokinetic. Isometric muscle contractions are static and involve no movement. Isotonic muscle contractions are dynamic and do involve movement of the limb. Isokinetic exercise also involves movement, but the speed and sometimes the displacement of the movement is controlled or held constant.

Many efforts at assessing human strength focus on the measurement of static (isometric) strength. This is because the measurement of dynamic (isotonic) strength is more complicated. The body movements are difficult to control or assess, and thus there is a greater potential for error. Therefore, some argue that it may be better to focus only on static strength, because it can more easily be measured by practical standardized methods (e.g., Chaffin, 1975). In terms of specific methodology, the techniques proposed by Chaffin (1975) in his ergonomics guide for the assessment of static strength may be useful. He reviews four factors that are known to influence a given strength assessment: (1) the instructions given, (2) the duration of the measurement, (3) the posture of the individual during the test, and (4) the rest allowed between trials. In his guide, Chaffin makes recommendations concerning each of these factors and discusses many of the available measurement techniques.

Unfortunately, static strength is not perfectly correlated with dynamic strength, and much care must be taken when using tests of static strength to determine dynamic strength (Garg, Mital, and Asfour, 1980). As a result, even with the difficulties in controlling or assessing movement, many people do use dynamic strength assessment techniques (e.g., using dynamometers or lifting tote boxes) or isokinetic devices (e.g., see Pytel and Kamon, 1981) in order to measure strength. It might also be argued that dynamic muscle movements more closely approximate the types of movements required on most jobs. Hogan (1980) contains a list of sources of both dynamic and static strength tests for various muscle groups.

The variety of assessment techniques available for the measurement of human strength have created many problems. For example, Kroemer (1970) has pointed out that problems such as scoring differences (e.g., peak versus average), no controls for motivation, and poor measuring devices make comparisons across studies difficult. This, of course, increases the care that must be taken in order to demonstrate the content validity of selection procedures based on strength measurement.

Another frequently heard criticism of strength testing is that it might expose the subject to safety risks such as pulled muscles or lower-back injuries. However, strength testing rarely results in injury to the subjects. Park and Chaffin (1975) explain this by suggesting that the receptors in the musculoskeletal system sense the degree of strain and notify the central nervous system when strain is occurring. When the strain is above learned limits, the voluntary action is stopped before injury. These learned limits provide a check on maximum exertions. They also note that there are situations in which the learned limits are not effective in preventing injury such as when the person moves rapidly or jerks, is overly motivated to exceed limits, or exhausts muscles to a degree that coordination is lost.

The third approach to the measurement of physical abilities for the purpose of selection into physically demanding jobs derives from the work of Fleishman (1964, 1975, 1979). Based on programmatic experimental-correlational studies of actual performance of subjects on a wide range of physical tests, nine physical fitness factors that can be measured via ten physical fitness tests were identified. There are two unique aspects about this approach. First, this assessment approach attempts to measure a wide variety of physical abilities including endurance, many types of strength, and measures of flexibility, coordination, and balance. Second, the tests that measure these abilities require little instrumentation or administration

training. These features may make Fleishman's approach potentially useful in applied settings.

It might be noted that some research effort has been devoted to predicting physical abilities based on other information. For example, Mital and Ayoub (1980) predicted strength and lifting capacity from anthropometric characteristics such as weight, shoulder height, and chest depth. Gunderson, Rahe, and Arthur (1972) explored biographical and health status measures along with fitness to predict stressful physical performance. As a final example, body fat has been used to predict gross motor proficiency by Brady, Knight, and Berghage (1977). Although these measures may correlate with physical abilities, it may be more logical and legally defensible to measure the actual physical abilities directly.

Before leaving this section, a few rules-of-thumb can be offered regarding the effect of sex differences, age, and training on physical abilities. Although it is realized that wide individual differences exist, the following generalizations are offered to give a feel for the magnitudes of the average differences. From puberty onward, females' aerobic power averages 70 to 75% of that of males (Astrand and Rodahl, 1977). Depending on the muscles involved, females also have about two-thirds the strength of males of the same age (Hogan, 1980; Konz, 1979; Laubach, 1976) and will select lighter lifting work loads in a materials handling task (Snook and Ciriello, 1974). After the twenties, maximum aerobic power and strength decrease steadily with age to about 70% for aerobic power (Astrand and Rodahl, 1977) and about 80% for strength (Konz, 1979) at age 65. However, at submaximal work loads, continuous-work capacity is not grossly age-dependent (Henschel, 1970; Snook, 1971). Finally, regular training can increase maximal oxygen uptake by no more than 10 to 20% in previously trained persons, but possibly more in untrained persons; the influence of training on strength depends primarily on the muscles involved (Astrand and Rodahl, 1977; Konz, 1979).

### *Measuring Physical Requirements of Jobs*

Most of this section is also divided into three areas: measures of metabolic (i.e., oxygen uptake or energy cost) requirements of jobs, measures of strength requirements, and measures of multiple physical abilities based on Fleishman's work. Some other approaches to measuring physical requirements of jobs are noted as well. Again, the purpose here is to briefly review the methods available and not to discuss specific procedures in detail.

There are three general types of approaches to the measurement



of metabolic costs of work. The first approach is to assess the oxygen consumption on the job through either direct or indirect means. The classical, and most direct, method is to collect and analyze the expired air in Douglas bags carried on the worker's back while on the job. Unfortunately, this method is so intrusive that the test situation becomes atypical of on-the-job behavior. The bulky equipment not only affects heart rate and ventilation, but it may interfere with the actual work operation.

A more applicable method of determining metabolic work load is indirectly through the assessment of heart rate during work. This technique is well known and is described by a variety of sources (Astrand and Rodahl, 1977; *Ergonomics Guide to Assessment of Metabolic and Cardiac Costs of Physical Work*, 1971; Poulsen and Asmussen, 1962). This technique is based on the fact that, within a particular person, there is a linear relationship between oxygen uptake and heart rate. Consequently, heart rate can be used to estimate work load, if the work load—heart rate relationship has been established for the individual in question, if approximately the same muscle groups are used, and if environmental conditions, etc., are the same. The work load—heart rate relationship for an individual can be established using a bicycle ergometer or treadmill and measuring the heart rate at certain known work loads (e.g., for a given number of revolutions per minute on a bicycle ergometer, at a known tension level, for a specified duration, etc.). Once the relationship is established, the work load on the job can be estimated from the heart rate recorded during the work situation. In other words, the individual is calibrated on standardized tasks and then used as a meter to measure the metabolic costs of the job. The recording of the heart rate in the field is usually accomplished using portable, miniature, battery operated recorders which are readily available.

Three points must be made regarding the measurement of metabolic costs via the above techniques. First, the researcher should be cognizant of the intermittent versus continuous nature of the work. Measurement of only high demand, but infrequent, job tasks would yield an unrealistic picture of the requirements of the job. One must be careful to select tasks for detailed study that truly reflect an accurate profile of the job. This problem can be compounded if physiological measures are recorded on the job for only a short period of time. Second, ideally the same large muscle groups should be involved in the job tasks in question as was involved in the work load—heart rate calibration. For example, the heart rate from arm work is higher than that resulting from leg work. However, because

most physically demanding jobs require dynamic, rhythmic alternations of large muscles, the use of heart rate (e.g., based on bicycle ergometer calibration) will usually yield a fairly accurate estimate of work load regardless of which large muscle groups are used on the job (Astrand and Rodahl, 1977). Third, rather than try to take metabolic measures while the worker performs actual job tasks, some researchers opt to use simulated job tasks performed in the lab. This approach may be a viable alternative when actual measures on the job are prohibited, but special care must be taken to insure the fidelity of the simulated tasks.

The other two types of approaches to the measurement of metabolic costs are the use of tables and micro-studies. Tables are available which list the metabolic energy estimates for a wide variety of activities (e.g., Durnin and Passmore, 1967). These tabled values are only very rough approximations, however. They reflect the energy expenditure by average people under average conditions, and thus do not take into account the unique characteristics of particular situations and do not reflect important individual differences and task parameters.

The micro-studies approach tries to predict metabolic energy expenditures from various physical measurements of manual activity. Typically, regression analysis is used to determine the functional relationship between metabolic costs and physical parameters of the job. Examples of this approach include systems to predict energy expenditures for specific activities such as walking and running (e.g., Givoni and Goldman, 1971), as well as more generic systems that involve the use of multiple measures such as posture, weights lifted, and time and motion indices to predict metabolic costs on a variety of tasks (e.g., Aberg, Elgstrand, Magnus, and Lindholm, 1968; Garg, et al., 1978). Unfortunately, some investigators have found only low relationships between work study indices and physiological measures in field settings (Tomlinson and Manenica, 1977).

The measurement of the strength requirements of jobs range from quite simplistic to very complex. At the most simple level, one could merely weigh or rate the materials or equipment that the worker must lift. Along with recordings of heights lifted, transport distances, frequencies, etc., this approach can result in a reasonable picture of the strength requirements of the job.

On a more sophisticated level, Chaffin and his associates (Chaffin, 1974; Chaffin, et al., 1977) have developed a lifting strength rating (LSR) system. This system takes into account not only the weight of the load, but also the load location effect. That is, this system

recognizes that if the load is held away from the body, the stress effect of the load is much greater. Each task is given an LSR rating which reflects the load lifted on the job compared to an estimated maximum human strength in the same position. In other words, each task is rated in terms of the proportion of a large, strong man's strength required to perform it.

On an even more sophisticated level, Chaffin and his associates (Chaffin, et al., 1977) have developed a computerized biomechanical strength model. Inputted into this model are body angles, weights, load locations, and normative population strength statistics. The model is then used to predict the proportion of men or women who could be expected to be able to perform the task.

All of these methods can be used to classify jobs in terms of strength requirements. Ayoub and his associates (Ayoub, Mital, Asfour, and Bethea, 1980; Ayoub, Mital, Bakken, Asfour, and Bethea, 1980) have provided an extensive review of models and norms for strength and lifting capacity. However, as gross rules-of-thumb, Snook and Irvine (1967) conclude that 50 pounds is the maximum weight that a compact object should be lifted by an unselected, adult male population, while Herrin and Chaffin (1978) suggest that 35 pounds held close to the body (or its equivalent) is the limit for lifting tasks before entering a zone that may be too stressful for some people. In other words, frequent lifting requirements at these levels or greater may indicate the need for some strength hiring standards.

Fleishman's work on developing taxonomies and measures of human physical abilities has also resulted in a system for measuring the physical requirements of jobs (Fleishman, 1975, Note 1, 1979; Fleishman and Hogan, Note 2; Gebhardt, Jennings, and Fleishman, Note 3; Theologus, Romashko, and Fleishman, 1973). With this approach, called Physical Abilities Analysis, one uses behaviorally anchored rating scales which are specifically constructed to assess the nine physical fitness abilities identified in the taxonomic research. More recent advances in this taxonomy have added scales for strength factors specific to the lower and upper body (Myers, Gebhardt, and Fleishman, Note 4). The advantages of using this approach for the measurement of physical requirements of jobs are that the scales are easy to use in a field setting, they cover a wide spectrum of physical abilities, they link physical abilities to job tasks, they relate to known abilities that can be tapped by specific tests, and they are supported by research and a solid theoretical background. However, one should not rely exclusively on ratings by incumbents, supervisors, or analysts. These job expert opinions

should be combined with some of the more direct methods of assessing the physical requirements of jobs as discussed above.

In terms of other approaches to measuring physical requirements of jobs, there has been considerable interest in developing perceived effort rating scales that actually relate to physiological work load. Most prominent in this area is the work of Borg (1962). He has developed a 15-point rating scale of perceived effort (RPE) specifically designed for use during bicycle ergometer work. This scale has shown high relationships to various metabolic indices such as heart rate. Recent work by Hogan, Fleishman, and others has shown that trained and untrained analyst ratings of written task statements on a Borg-type scale can be reliable and correlate well with actual metabolic costs of such tasks (Hogan and Fleishman, 1979), and such ratings can be used by subjects performing tasks to predict actual physical work (Hogan, Ogden, Gebhardt, and Fleishman, 1980). They also showed that such task ratings can be used to classify diverse jobs according to physical effort requirements. The relationship between physical work and perceived effort has attracted the attention of researchers from a variety of disciplines (see Borg, 1977).

Before leaving this section, two final additions should be made. First, Nylander and Nelson (Note 5, Note 6) present results of a long term project to develop comprehensive job related medical screening programs. Along with reviewing medical considerations relevant to various bodily systems, they describe a standardized instrument for assessing the entire range of physical requirements of jobs including working conditions such as temperature, humidity, noise, toxic substances, etc., and physical abilities such as strength, effort, body movements, vision, and hearing. Second, Sparks (1982) provides an overall review of the topic of job analysis including definitions, uses, methods, instruments, research, and EEO sensitivities. He suggests that no one system can meet all the needs of a proper job analysis. This may be good advice for physical abilities analysis; probably multiple methods and approaches should always be used.

### *Physical Abilities Selection Studies in the Literature*

Chaffin (1974) argues that the ultimate solution to excessive physically demanding and strenuous jobs is job redesign to make them easier. But in the meantime, personnel selection based on physical abilities is a viable alternative. Review of the literature reveals, however, that relatively few selection studies exist in this

area. The present literature review resulted in 16 studies being identified: eight criterion-related (empirical) validity studies, two unpublished content-oriented validity studies, and six others that are too incomplete to be considered validation studies, but do address the issue of physical abilities selection systems. Finally, the existence of a number of large scale, but unpublished, studies will be recognized.

Five of the criterion-related studies were based at least in part on the physical fitness measures developed by Fleishman. In an early study by Gunderson, et al. (1972), underwater demolition team training completion was predicted using biographical, physical fitness, and health status measures. Physical fitness tests (e.g., squat-jumps, sit-ups) tended to be the best predictors of training success in the sample of 293 enlisted men and 94 male officers, but physical and emotional health indices measured via questionnaires also aided prediction.

Bernauer and Bonanno's (1975) study began with the assumption that using job samples may be too risky for selection into some physically demanding jobs, thus assessing physical abilities may be a good alternative. They evaluated the factor composition of 40 physical measures, including anthropometric measures and measures of strength and endurance, in a sample of 241 job applicants. A field battery of 6 tests was selected to represent the factorial composition of the 40 physical measures: reaction time, grip strength, percentage fat, step test, balance, and sit-ups. In a subsequent, but very small, sample of students (15 males, 15 females) in pole climbing training, the step test and balance performance were found to significantly differentiate ( $p < .05$ ) the successful from the unsuccessful students. Although these relationships held regardless of sex, mean sex differences were observed on most of the tests in the field battery.

A study by Jones and Prien (1978) used Fleishman's procedures more directly. They analyzed a set of jobs (e.g., materials handler) based on Fleishman's (1964) physical fitness taxonomy by rating the physical ability requirements using the behaviorally anchored scales (Theologus, et al., 1973). They then tested the physical abilities of 114 male and 98 female applicants using the physical fitness battery (Fleishman, 1964) and thus determined reliability, sex differences, and norms. Not only does their study demonstrate a potentially useful methodology for documenting content validity, but they also collected some predictive validity evidence on a small sample of hires ( $n = 61$ ) against a supervisory rating criteria. As expected, however, large sex differences did occur in the applicant sample,

especially on the strength measures. The authors recommended a minimum cutting score to minimize adverse impact.

Another study utilizing many of Fleishman's procedures was conducted by Reilly, Zedeck, and Tenopyr (1979). This research involved two predictive validation studies on outdoor telephone craft jobs. Both studies used the physical ability requirements rating scales as part of the job analysis and the physical fitness battery as the predictor. The first study used 83 male and 45 female hires into a craft training program. Six job samples taken during training and training survival served as the criteria. Results showed many significant validity coefficients. For example, reaction time and dynamic arm strength adequately predicted the job sample criteria (shrunken  $R = .36$ ). The second study used a new sample of 132 male and 78 female subjects and four criteria (e.g., time-to-complete training, field observations). Again, a number of significant validity coefficients were found. For instance, a composite of body density, balance, and static strength yielded valid predictions of the time-to-complete criterion ( $R = .45$ ). Both studies also found mean differences in both predictor and criterion performance between the sexes, but analyses revealed no evidence of test unfairness.

A very recent validation study for physically demanding jobs was conducted by Arnold, Rauschenberger, Soubel, and Guion (1982). They developed a physical ability testing program for entry into a steelworker labor pool. Subjects were 168 men and 81 women from three work sites. Criteria consisted of approximately 12 work samples for each site. Abstracting the general abilities required by the work samples resulted in the choice of 10 physical ability measures, most of which were strength tests borrowed from the work of Fleishman. Analyses revealed that 82 percent of the zero-order correlations between the predictors and criteria were .40 or larger. Arm strength was the best single predictor with an average correlation of .84 with the work sample composites. Within-sex validities were also significant, but smaller in magnitude. Although mean sex differences existed on most of the predictors and criteria, the use of a common regression line would result in only a small bias against men. Finally, estimates of test utility indicated the substantial dollar value of the strength testing system.

An observation can be made regarding the above studies. With the exception of the Jones and Prien (1978) study which used a small sample, the criteria used in these studies were either work samples or training completion. That is, maximum performance physical abilities measures were used to predict maximum performance work sample measures or completion of difficult training programs. The issue remains whether these physical ability measures can predict

*typical* on-the-job performance. In other words, is the relationship between physical abilities and actual performance on the job linear, as it is with cognitive abilities? It is likely that the correlations between physical abilities and typical job performance will be lower than those between physical abilities and maximum performance job samples.

Three studies have been conducted by Chaffin and his associates on the use of strength testing for personnel selection. These studies differ in that they used strength tests to predict the incidence rate of lower-back injuries. The first study (Chaffin, 1974) involved 410 current employees in 103 jobs. The jobs were analyzed in terms of strength requirements and each employee was assessed with two maximum lifting strength tests. Results showed that a ratio of strength required on the job compared to the individual's strength was significantly correlated ( $r = .38$ ) with the incidence of lower-back injury during the one year of the investigation.

In a similar study (Chaffin, et al., 1978), 551 employees from 6 plants were administered arm strength, leg strength, and torso strength tests. Again, the strength requirements of their jobs were analyzed and compared to the employee's exhibited strength. Over the 18 months in which medical records were examined, it was found that the workers' likelihood of sustaining back injuries increased as the strength requirements of the jobs approached or exceeded the strength capacities of the individuals.

The third study (Keyserling, et al., 1980) compared one year follow-up medical records of 20 employees hired with strength testing standards versus 51 employees hired without such standards in 21 entry-level production jobs. The strength of the hires was measured with 4 tests, and the cut-offs were based on the job requirements. Positive results were obtained, but they were only marginally significant due to the small sample size.

Researchers of strength testing suggest that there are a number of advantages of strength testing programs (e.g., Keyserling, et al., 1980): they show a relationship to job requirements, they can be reliably administered, they are predictive of injury rates, they are safe to use, they are easy to administer, and they are inexpensive. However, these researchers fail to mention that strength tests, as well as most other physical ability measures, will probably show significant sex differences and adverse impact.

Most of the above studies found that one or two physical ability measures (e.g., arm strength) could adequately predict the criteria. However, an argument can be made to include additional predictors even if they do not add substantially to the validity. One reason is that multiple predictors may result in a more reliable battery. But

perhaps a more important reason is that using multiple predictors may enhance the content validity of the selection system. Most physically demanding jobs probably require some amount of both strength and endurance, thus measures of both should be included in the predictor set. Documenting both content and criterion-related validity may be a wise strategy, especially given the potential adverse impact of physical abilities selection systems.

The author is aware of two unpublished content-oriented validity studies on the development of selection systems for physically demanding jobs. They will be briefly discussed here because it is felt that they illustrate some positive approaches and some potential weaknesses of current work in this area. However, they will not be directly referenced because of the criticisms to be made and the fact that they are proprietary. There are a number of similarities between the two studies. Both involve strength and endurance measures; both attempt to measure the metabolic requirements of the jobs, one with direct oxygen uptake measures and the other with indirect estimates from heart rate; both conclude by recommending a step test and some type of strength test; and both suffer two potential weaknesses, one methodological and one conceptual. Methodologically, the sampling of job tasks for physiological measurement in both studies was rather arbitrary and short term. From the descriptions in the reports there is no way of knowing whether the tasks used were representative and frequently occurring on the job, or whether they were simply selected on the bases of convenience and presumption. Further, the time intervals in which work load was measured per subject was very short, 5 minutes in one study and 15 minutes in the other study. This may not be sufficient time to adequately gauge the entire job.

From a conceptual point of view, there is a weakness in the logical link between the job analysis information and the selection standards or cut-off scores on the tests used in both studies. These cut-offs appear to be set somewhat arbitrarily, without a clear and consistent rule for relating them to the job requirements. Although it is recognized that much judgment is usually needed in establishing the cut-off scores when some of the tasks are intermittent, this may be legally risky. If females score lower on the tests, the cut-off scores will directly determine the amount of adverse impact against females. As such, a strong and consistent logic for the establishment of the cut-off scores is essential.

There are six additional studies that are relevant to personnel selection for physically demanding jobs. These studies are too incomplete in their published accounts to be called validation studies, but they are reviewed briefly here to add perspective and



completeness. Most of the studies deal with the development of systems to help select police and fire fighters. In one study on fire fighters (Considine, Misner, Boileau, Pounian, Cole, and Abbatello, 1976), three types of measures were collected: biological measures such as age, weight, and body fat; physical fitness measures such as grip strength, broad jump, and 880-yard run; and functional performance tests such as climbing stairs, hose coupling, and carrying dummies. Data were collected on over 250 fire fighters and the results were analyzed in terms of race differences, intercorrelations, and factor structure. Although fair correlations were found between the physical fitness measures and the functional performance tests, the researchers curiously decided to implement a battery that contained some items of both.

A highly similar study was reported by Wilmore and Davis (1979) on state traffic officers. They also administered a battery of measures to a group of over 200 officers. They then examined the interrelationships among these three types of measures, found that the biological and physical fitness measures related fairly well to the job samples, and then decided to use the job samples for selection. The reason given is that the job samples showed more face validity. Both this study and the previous one are puzzling. If viable job samples are available to be used for selection, then why bother to examine relationships with physical abilities? Or else, if physical abilities measures are used for selection due to costs, safety, or other considerations, then why continue to use the job samples once their relationships with the physical abilities measures have been established?

A third study is discussed by Guyor (1974). He administered six physical fitness tests to 107 police officer candidates. The article is of the "let me describe our program" variety, but the article does not describe efforts to document the relationship between the tests and job performance.

A fourth study on police and fire department personnel selection was reported by Hubbard, Hunt, and Krause (1975). Although they present no data, they do describe a common-sense method of developing job related strength and agility tests based on a content validity strategy. Their procedure consists of five basic steps: (1) task identification, (2) rating of tasks for strength and agility factors, (3) review of possible tests to be recommended, (4) preliminary choice and try-out of the battery of tests, and (5) preparation of a job relatedness analysis of the recommended tests.

Two final studies were concerned with the validation of a step test to predict working capacity. One study utilized 114 state patrol officers (Davis and Wilmore, 1979) and the other utilized 45 Iranian

steel workers (Tuxworth and Shahnawaz, 1977). Both attempted to validate recovery heart rate count on a step test against measured oxygen uptake. One study concluded that the step test was a good predictor (Tuxworth and Shahnawaz, 1977) and the other concluded that it was a poor predictor (Davis and Wilmore, 1979). Neither study addressed the actual requirements of the jobs.

Before concluding, the existence of a number of large scale, unpublished studies should be recognized. A comprehensive program of selection tests based on physical abilities has been carried out at the Advanced Research Resources Organization (ARRO) by Fleishman, Hogan, and their colleagues. The approach involves determining the critical job tasks, evaluating the physical abilities required of these tasks through behaviorally anchored ratings, and the selection and validation of physical tests linked to these requirements. General ability or work sample tests may be utilized. For example, Cooper, Schemmer, Gebhardt, Marshall-Mies, and Fleishman (Note 7) examined 27 jobs in a nationwide study of the electric power industry; a criterion-related validation found four general physical ability tests (tests of static and dynamic strength, flexibility, and balance) valid predictors across jobs and various sub-groups. Gebhardt and Weldon (Note 8) used a similar strategy for the development of physical tests to select for a law enforcement position. Other ARRO studies have examined physical abilities selection for jobs in a variety of organizations including grocery stores (Hogan, Ogden, and Fleishman, Note 9), the military (Hogan, Ogden, Gebhardt, and Fleishman, Note 10), and the petroleum industry (Hogan, Jennings, Ogden, and Fleishman, Note 11, Note 12; Hogan, Zonderman, and Pederson, Note 13). Petroleum industry jobs have also been studied by Wunder (Note 14, Note 15; Coverdale and Wunder, Note 16), Osburn (Note 17), and Laughery and others (Laughery, Jackson, Sanborn, and Davis, Note 18; Laughery and Bigby, Note 19; Laughery and Jackson, Note 20). Physically demanding jobs in the forest products industry have been assessed by Spurlin, Scontrino, and Doolittle (Note 21). Finally, Scheffers (Note 22) has examined physical hiring standards in the steel industry. This list is not meant to be exhaustive of the unpublished work in the area, but only illustrative.

### *Recommendations*

By way of conclusions, the following recommendations are offered for future research on personnel selection systems for physically demanding jobs.

1. A detailed job analysis is a critical minimum prerequisite to the development of a valid physical abilities selection system. One cannot merely presume that a job is physically demanding and then arbitrarily establish standards of fitness for employment.

2. Analyses of job requirements and subsequent selection of tests should probably not be limited to just one aspect of fitness. Most jobs are multidimensional. A selection system should consider both endurance and strength requirements at a minimum, and possibly other abilities as well. This is especially important if validity evidence is based on a content-oriented strategy.

3. For the non-physiologist, the instrumentation and technical support needed for the direct methods of assessing work load and aerobic power may be prohibitive. However, the indirect techniques (e.g., estimates from heart rates) seem to be well established, sufficiently accurate for most purposes, and technically feasible in most situations. Astrand and Rodahl (1977) is probably the best source of information for anyone interested in this area.

4. Regarding the measurement of the strength requirements of jobs and the assessment of the strength of individuals, the work by Chaffin and his associates may be the best guide available for anyone setting up a program.

5. Fleishman's work holds much promise for a truly integrated approach to selection for physically demanding jobs. His work provides useful measures of physical abilities, methods of determining the requirements of jobs, and a strong empirical and theoretical base. Further, his approach requires the least amount of training in biomechanics and work physiology.

6. More attention needs to be paid to the sampling and representativeness of tasks chosen for detailed physiological or biomechanical analysis. The arbitrary selection of tasks, and data collection on only a few minutes of on-the-job behavior, are unlikely to yield an accurate profile of the true requirements of the job. On the other hand, relying solely on incumbent and supervisor interviews and ratings may be insufficient. Techniques for more direct assessment of physical work load are available and should also be used.

7. The conceptual link between the job requirements and the cut-off scores chosen for the selection tests must be made explicit, and it must be documented and defensible. Physical abilities tests do have adverse impact against females; they probably will be legally challenged; and the cut-off scores determine the degree of adverse impact.

8. More good empirical research is needed in this area. For example, although the relationship between maximum performance

physical ability measures and maximum performance job samples seems to be strong, the relationship between physical ability measures and typical on-the-job performance has not been established. Given possible adverse impact, future applied research should evaluate both content and criterion-related validity and begin to explore for physical ability predictors with lesser adverse impact. Finally, future research must be more interdisciplinary so that we can tie together accurate measures of the physical requirements of jobs, the reliable assessment of physical abilities, and the realities of the organizational and societal milieu in which these selection systems must operate.

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