THE EFFECTS OF WORK RATE SCHEDULES ON TOTAL WORK OUTPUT

A Thesis

Presented to

the Faculty of the Department of Psychology

University of Houston

In Partial Fulfillment

of the Requirements for the Degree

Master of Arts

By

John D. Stout

May, 1984

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Tests are used in industrial settings as a means of predicting those job applicants who will make successful employees. A recent focus has turned to tests that are intended to measure the physical abilities required on a job as determined by a formal job analysis. Development of a physical ability selection test draws on data and concepts from both industrial psychology and work physiology. This study was conducted in order to reevaluate an existing physical ability test in light of physiology literature which bears upon it.

The purpose of this study was to determine what the effects would be if subjects were allowed to rest for brief periods during completion of a test which is usually administered in a continuous manner with no rest pauses. Eighteen female physical education majors were subjects in a repeated measures design experiment with three test conditions; continuous exertion, intermittent exertion with one revolution every three seconds, and intermittent exertion with one revolution every four seconds.

Results indicate that the amount of work per unit time was the critical factor in determining performance, not whether or not the subject was allowed rest pauses.

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CHAPTER I

INTRODUCTION

The use of tests to help select employees has become a standard business practice in many organizations. The purpose of testing is to accurately predict future job performance from tests given to the applicant before hiring. Many different types of tests have been used for this purpose including aptitude and ability tests, achievement tests, personality inventories, interest inventories and physical ability tests. In recent years there has been a noteworthy increase in research on and use of preemployment physical ability testing (Campion, 1983).

This increased interest in physical ability testing has been influenced by several factors. First, equal employment opportunity (EEO) legislation has resulted in increased numbers of women entering jobs with physical requirements traditionally designed for men. Second, Chaffin and his collegues (Chaffin, 1974; Chaffin, Herrin, and Keyserling, 1978; Keyserling, Herrin, and Chaffin, 1980) have indicated that physically unfit workers have higher incidences of lower back injuries, and that through the use of physical strength testing the occurrence of these injuries can be reduced. Third, preemployment medical examinations have been inadequate for the purpose of screening applicants in order to reduce the incidence of lower back injuries (Chaffin, 1974; Snook, Campanelli, and Hart, 1978) or to predict performance or absenteeism (Alexander, Maida, and Walker, 1975).

The physical abilities that are required or demanded in a job are identified through formal job analysis. Measurement of job applicants on these same physical abilities requires expertice in two disciplines, both industrial psychology which is concerned with the various psychometric, and legal aspects of selection, as well as work physiology which lends important information concerning the physiological costs of work and the appropriate methodologies for test development.

The purpose of this study was to reevaluate an existing physical ability selection test in light of some recent physiology literature that bears upon it. The selection program under investigation involves a continuous exertion test performed in a continuous, repetitive manner (without stopping to rest). Evidence from the physiology literature (Margaria, Oliva, diPrampero, & Cerretelli, 1969 ; Essen, 1978) suggests that performance under continuous exertion is much poorer than under intermittent exertion. Job analysis data used in the development of this continuous exertion physical ability test indicates that the task should be completed within a set period of time, and does not indicate the rate at which the task should be performed. Therefore the performance measures obtained from this continuous exertion test may not be representative of actual job requirements.

Physical Ability Testing

Perhaps the most comprehensive work in the area of physical ability testing was done by Fleishman (1964). He identified nine specific areas of physical abilities using factor analytic techniques. These factors include dynamic strength, static strength, explosive strength, gross body equilibrium, extent flexibility, dynamic flexibility, speed of limb movement, gross body coordination, and trunk strength. Dynamic strength refers to the power of arm and leg muscles to repeatedly or continuously support or move one's own body weight. Static strength refers to the extent of muscular force exerted against some fairly immovable external object, and can include lifting, pushing or pulling, among other movements. Explosive strength requires a mobilization of energy for a burst of muscular effort rather than the continuous exertion of the muscles. Gross body equilibrium is simply body balance. Extent flexibility involves the ability to move or stretch the body as far as possible in various directions. Dynamic flexibility requires repeated flexing or stretching movements. Speed of limb movement represents the ability to move the arms or legs as rapidly as possible where skill is not involved. Gross body coordination involves gross activity of the whole body necessitating what some have called "agility". Finally, trunk strength is dynamic strength specific to the trunk muscles, especially the abdominal muscles.

One important point raised by Fleishman (1964) is that these distinct ability factors do not generally correlate highly with each other. If a person possesses a great deal of static strength it does not mean he will also possess a great deal of explosive strength, gross body equilibrium, etc. Therefore it is important that one define specifically the task being performed and what corresponding physical factor or factors are being used. The test which is developed must measure these same factors. In a later paper, Fleishman (1979) discusses these factors as they should be applied when developing a physical ability test. One should, through proper job analysis techniques, determine what the tasks of a job are and which of these basic abilities are relevant for performing those tasks. Others, such as Jones and Prien, (1978), have adopted this approach in the development of other physical ability tests.

Chaffin and his colleagues (Chaffin, 1969; Garg & Chaffin, 1975 ; Keyserling, Herrin & Chaffin, 1980) have developed a more elaborate method of determining the physical requirements of a job. The biomechanical strength requirements were evaluated by a computerized three-dimensional biomechanical strength prediction model. During the job analysis, each job was systematically broken down into a set of strength demanding tasks. For each of these tasks the following variables were recorded: 1) a basic description of the task (eg. lift, push, or pull); 2) a description of the body posture maintained while performing the task (eg. stand, sit or squat); 3) the force (in pounds) which must be exerted in order to perform the task; and 4) the location of the hands in space (with respect to the feet). These data were used to develop a set of four strength tests which simulate the actual lifting and handling requirements of the job under study.

Physical ability tests have been utilized for other purposes besides the prediction of job performance. Several authors (eg. Chaffin, 1974; Chaffin & Park, 1979; Holts & Keyes, 1974; Keyserling, Herrin & Chaffin, 1980; Snook, Campanelli & Hart, 1978) have used various forms of physical ability tests to reduce the incidence of lower back injury in industry. Keyserling, et al. (1980) found the medical incidence rate of employees who were selected using isometric strength tests were approximately one-third that of employees selected using traditional medical criteria. It thus appears that preemployment strength tests are not only useful in selecting workers who possess adequate strength, but also in selecting those who can do the job without unnecessary risk or harm to themselves, or others.

Physiological Determinants of Muscle Fatigue

Fatigue, as used here, will be defined as the transient decrease in performance capacity of muscles when they have been active for a certain period of time. This is usually evidenced by failure to maintain or develop a certain expected force or power (Asmussen, 1976). There may be two basic mechanisms of fatigue: a centeral (proximal to the motor neurons) and a peripheral (motor neurons, peripheral nerves, and muscle fibers themselves) mechanism. Asmussen (1976) speaks of central fatigue in terms of human motivation. If the subject under study has no volition to continue, even though his muscular system is not fatigued, he will stop performing. Peripheral fatigue is characterized as being caused by either failures in the transmission mechanisms and/or the contractile mechanisms. The failure of these mechanisms are most likely caused by a depletion of some necessary substance(s) and/or the accumulation of catabolites or other substances set free by the muscle activity (Asmussen, 1976). The exact substances responsible for fatigue are still in question and a detailed analysis of this area is beyond the scope of the present paper. Let it suffice to say that fatigue is most likely due to: 1) glycogen depletion; 2) oxygen depletion; 3) lactic acid buildup; 4) alactic acid buildup; and/or 5) more efficient lipid utilization.

Intermittent versus Continuous Exertion

Intermittent exertion as defined in the physiology literature is comprised of brief periods of intense muscular activity alternating with brief periods of recovery. Margaria, et al. (1969) studied subjects' physiological responses to intermittent exercise and found that:

> ...if a period of supramaximal exercise does not last long enough to reach the lactacid phase, lactic acid production does not begin, and only an alactic oxygen debt is contracted; if time is allowed for this alactic oxygen debt to be paid,

> the exercise can be resumed very soon after, for the same time as before, and cycles of work and rest can be repeated indefinitely (Margaria et al. 1969).

It thus appears that by allowing the subject to rest briefly between periods of supramaximal exertion, he/she is able to overcome the causes of peripheral muscle fatigue. Others (Essen, 1978; Essen & Kaijser, 1978; Essen, Hagenfelt & Kayser, 1976; Astrand, Astrand, Christensen & Hedman, 1960) have also noted this phenomenon:

> When work of an equally high workload (compared to continuous exertion) is performed as intermittent exercise in short bouts interrupted by short rest periods it can be sustained for an extensive period of time and energy demands will fluctuate from a high to a low level between the work and rest periods. Metabolic response will be more similar to continuous moderate than to intense exercise with lower glycogen depletion, smaller lactic acid accumulation and significant utilization of lipids. Consequently, if intermittent and continuous work of equal loads are compared, the metabolic response is seen to be different (Essen, 1978).

It therefore appears that the results obtained from the use of a continuous exertion test would be dissimilar to an intermittent exertion test. It is the purpose of the present study to re-evaluate the criterion used on a continuous exertion test. More specifically, a Simulated Valve Turning Test, used to select operators at an oil refinery, will be reexamined (Osburn, Note 1).

The Simulated Valve Turning Test

It was concluded from Osburn's (Note 1) formal job analysis that: 1) a force of 30 lb. was sufficient to rotate 75 percent of the emergency valves sampled; 2) 21,000 ft.-lbs. of work was required to open or close 75 percent of the emergency valves tested; 3) 224 revolutions of a 12 inch handwheel under 30 lbs. resistance equals 21,000 ft.-lbs. of work; and 4) 15 minutes was estimated by unit managers as a relatively safe time interval to fully open or close 75 percent of emergency valves. It was concluded from the above information that one revolution every four seconds (which represents a rate of work equal to 23.56 ft.-lbs./sec) was sufficient to fully open or close 75 percent of the emergency valves in fifteen minutes or less without stopping (a total of 21,000 ft.-lbs. of work).

Test performance criteria were set so that the applicant had to perform at this rate of one revolution every four seconds for a period of two minutes without stopping. This criterion was established from data obtained from a pilot study where subjects performed the simulated valve turning test for a total of fifteen minutes. However, the subjects were instructed to keep pace with a metronome set at a pace of one revolution every four seconds; subjects who fell behind this pace were stopped. It was the purpose of the present study to reevaluate these criteria in view of the relevant physiology literature on intermittent exertion. Performance (number of turns completed within fifteen minutes) was examined under continuous and intermittent exertion conditions. If it were found that performance under these two conditions was disparate, then new testing procedures and performance criteria would be established and implemented. The specific research hypothesis was that performance measured as the number of revolutions completed on the simulated valve turning test will be greater under the intermittent exertion condition, than under the continuous exertion condition of equivilant workload.

Another issue will also be analyzed in greater detail. The fifteen minute time interval was established by managers as being a relatively safe time interval to fully open or close 75 percent of the emergency valves. Because this interval was derived subjectively, it is important to analyze alternative intervals to determine if this parameter has any influence on test performance. If subjects are given a longer interval in which to complete the SVT task, would there be a differential ranking ? In other words, would the rank order for subjects differ as a function of the workload intensity?

CHAPTER II

METHODOLOGY

Sample

Subjects were physical education majors and/or intercollegiate athletes. All were students at the University of Houston and were recruited from classes and variuos athletic groups. A physically select group was recruited for two reasons. First, a previous study (Jackson and Osburn, Note 2) has shown that applicants for physically demanding jobs were not representative of the typical adult population. Thus this group of physically select subjects was chosen to more closely resemble applicants for operator jobs. Secondly, the testing schedule was physically demanding, and the tests required subject motivation and cooperation. The subjects selected were interested in the tests and, were highly motivated to do their best.

Subjects, after volunteering to participate, were given a human subjects consent form (see Appendix A). A total of 20 female subjects participated in the study and completed the first day of testing. Two subjects were not able to complete the enire three days of testing. Consequently the final sample consisted of 18 females. Subjects were paid $15.00

for participating in this study.

Measures

The dependent variable, performance, was measured as the total number of revolutions completed on the simulated valve turning test within the allotted time period. The independent variable , exertion condition, had three levels: 1) continuous; 2) intermittent with one revolution every three seconds (intermittent-3); and, 3) intermittent with one revolution every four seconds (intermittent-4). For the continuous exertion condition, the subjects were required to turn the handwheel at a constant rate of one revolution every four seconds without pausing to rest. During the intermittent-3 exertion condition , subjects were required to turn the handwheel at an intermittent rate of one revolution every three seconds for fifteen seconds, followed by five seconds of rest. Both of these conditions therefore had an equivalent workload of fifteen revolutions per minute. The third exertion condition, intermittent-4 , required subjects to turn the handwheel at a rate of one revolution every four seconds for sixteen seconds, followed by fourteen seconds of rest. Subjects performed the continuous and intermittent-3 exertion conditions for a total of 15 minutes or until they voluntarily withdrew.

Subjects performed the intermittent-4 exertion condition for a total of twenty-eight minutes or until they voluntarily withdrew.

Subjects height and weight were measured using standard anthropometric techniques. Weight was measured (without shoes, but wearing gym clothes) to the nearest one-half pound using a medical-type weight scale. Height was measured (with shoes off) to the nearest quarter-inch using a standard BMP Swiss-made anthropometer. Several other anthropometric measures were also collected at that time, including; bicromion diameter and, lean body weight. Bicromion, which is essentially a measure of shoulder breadth, was measured using a BPM Swiss-made anthropometer. Technically it is the distance between the outside of the acromion process. Body composition was measured using the sum of skinfold method (Jackson, Pollock & Ward, 1980). Three skinfold measures were taken in order to estimate body density. A Lange skinfold fat caliper was employed. These measures along with the subject's age were entered into a multiple regression equations to obtain body density. The equations used to estimate body density are:

Adult Female

$$BD = 1.0902369 - 0.0009379\ (X1) + 0.0000026\ (X1)^2 -$$

0.0001087 (X2)

where X1 is the sum of the triceps, abdomen and suprailium skinfolds (mm); and X2 is age (in years).

Percent body fat was then calculated by Siri's (1961) method using densities:

% fat = (495/density) - 450

Given percent fat, body weight can then by subdivided into fat weight and lean body weight.

In addition to these anthropometric measures, several strength measures were collected. Upper body strength was assessed using an isokinetic Cybex arm tests. In an isokinetic test force is applied through a range of movement. The velocity of the movement is constant and independent of the force. The test is described in more detail in Appendix B.

Isometric strength measures included grip strength which was measured using a standard hand dynamometer manufactured by the Lafayette Instrument Company. While standing, the dynamometer is held in the dominant hand with the elbow at the side , at a 90 degree flexion. From this starting position, the subject fully extends the arm and exerts a maximum contraction (squezes on the hand grip). This effort typically lasts for 1-2 seconds. The force exerted is indicated on the scale in kilograms.

Two other isometric strength tests that individually assess arm strength and back strength were also administered. For a detailed description of these tests and how they were administered, see Appendix C.

A repeated measures design was employed to more accurately assess any differences that might occur across the three exertion conditions. A latin square design was utilized so that any minor effects due to treatment presentation could be avoided. Once the subjects general size and strength had been measured they were randomly assigned to one of the six treatment schedules and then instructed on how to performed the first simulated valve turning (SVT) test condition. The SVT task was designed in such a way that measurements of applicants could be related to actual performance in the field (content validity).

The SVT apparatus consisted of a disk brake mechanism that was turned by a 12 inch handwheel. The brake mechanism was welded to a gear that was driven by a pinion gear on the handwheel shaft. Brake resistance, which was regulated by a setscrew in the hydraulic oil system, (with oil pressure read on the pressure guage) was set at 30 lbs. The apparatus was enclosed in a metal box measuring 12 by 18 by 24. The box was bolted to a heavy table in such a way that the handwheel could be operated in a horizontal plane, 43 inches above the platform on which the examinee stood. The apparatus was fitted with a counter that registered the number of revolutions of the handwheel that had been completed. After the SVT test was completed, the grip strength and arm strength measures were again taken in order to determine the percent decrease in functioning, which would be used as a motivation manipulation check. After this, subjects were asked to estimate the amount of effort required to perform the task using the Borg Perceived Exertion Scale (Borg, 1978; See Figure 1). Subjects rated the amount of effort involved on a scale from 1 (very light) to 10 (extremely heavy, maximum). Upon completion of the first day of testing subjects were scheduled to return after at least two days of rest to complete the second testing session, followed by at least two more days of rest to complete the final testing session.

Figure 1

Borg Perceived Exertion Scale

0	Nothing at all
0.5	Extremely light (just noticeable)
1	Very light
2	Light
3	Moderate
4	Somewhat heavy
5	Heavy
6	
7	Very heavy
8	
9	
10	Extremely heavy (almost max)
•	Maximal

Analyses

In order to test the null hypothesis that exertion conditions of equilvilant workload would have no effect on performance, a a t-test between the treatment means will be performed.

Spearman rank-order correlation coefficients will be used to test the null hypothesis that varying workload intensity would not change the rank order of the applicants in the population.

CHAPTER III

RESULTS

Subject Measures

Presented in Table 1 are the descriptive statistics, means and standard deviations, for the total sample. The average age of the females in this sample was 23.9 years old, ranging from 18 to 33 years old. These subjects tended to be similar in size with subjects used in previous studies of physical capacity (Laughery, Jackson, Sanborn & Davis, Note 3; Laughery & Bigby, Note 4; Laughery & Jackson, Note 5). The most noticeable difference between the subjects of this study and previous groups was found in their percent body fat. The mean percent body fat levels of 18.2 was quite low for college women, but typical for highly conditioned female athletes. This percent body fat level confirmed that the sample consisted of physically fit subjects. The intercorrelations among the demographic and physical characteristics are given in table 2.

The means and standard deviations for the isometric and isokinetic strength measures are listed in table 3, and their corresponding intercorrelations in table 4. Composite strength is defined as the sum of the three isometric strength measures (grip, arm, and back). This sample of female athletes tended to have greater isometric and isokinetic arm strength when compared with subjects from other studies (Osburn, Note 1; Laughery, Jackson, Sanborn & Davis, Note 3; Laughery & Bigby, Note 4; Laughery & Jackson, Note 5). Table 5 shows the reliability estimates for the strength measures. All reliability estimates exceed 0.90, indicating that the measures were highly reliable.

Table 1

Means and Standard Deviations

for Demographic Variables and Physical Characteristics

	Mean (n=18)	SD
Age	23.9	3.9
Height	64.7	2.8
Weight	127.7	16.1
Percent Fat	18.2	3.4
Lean Weight	104.2	10.9
Bicromion	36.6	1.7

Table 2

Intercorrelations Among Demographic Variables and Physical Characteristics

	1.	2.	3.	4.	5.	6.
1. Age	1.00					
2. Height	-.09	1.00				
3. Weight	-.21	.57**	1.00			
4. Percent Fat	-.07	.28	.59**	1.00		
5. Lean Weight	-.21	.91**	.95**	.30	1.00	
6. Bicromion	-.23	.55*	.67**	.31	.65**	1.00

* $p < .05$

** $p < .01$

Table 3

Means and Standard Deviations for

Isometric and Isokinetic Strength Measures

	Mean (n=18)	SD
Isometric Strength		
Grip	61.13	10.4
Arm	49.25	7.3
Back	129.53	26.4
Composite	239.90	38.8
Isokinetic Strength		
Cybex Arm	193.39	68.3

Table 4

Intercorrelations Among the Isometric and Isokinetic Strength Measures

	1.	2.	3.	4.	5.
Isometric Strength					
1. Grip	1.00				
2. Arm	.74**	1.00			
3. Back	.49*	.69**	1.00		
4. Composite	.74**	.86**	.94**	1.00	
Isokinetic Strength					
5. Cybex Arm	.69**	.73**	.62**	.74**	1.00

* $p < .05$

** $p < .01$

Table 5

Coefficient Alpha Reliability Estimates

for Strength Measures

	Alpha
Isometric Strength	
Grip	0.97
Arm	0.96
Back	0.94
Isokinetic Strength	
Cybex Arm	.

Table 6 presents the Pearson product moment correlations between the strength measures and selected physical characteristics. These results showed that body size was highly related to strength. The highest relationship was found between weight and back strength, while height tended not to correlate strongly with subjects grip strength.

Performance on the Simulated Valve Turning Test Conditions

Table 7 contains the descriptive statistics for the three exertion conditions. Subjects turned the valve wheel fewer revolutions (134.6) in the continuous exertion condition compared with either of the intermittent exertion conditions (135.4, 196.9).

Table 8 shows the t-ratios for the differences between the treatment means. In order to control for the type I error rate per family of comparisons, Bonferroni's t statistic was employed. Setting the error rate per family at 0.05 and given that we had four comparisons to perform, our error rate per comparison was 0.01. That is, in order for the difference between treatment means to be significant the probability valve must be less than or equal to 0.01. There was no significant difference between the continuous and intermittent-3 test conditions. The mean difference between continuous and intermittent-4 as well as intermittent-3 and intermittent-4 were significant. This indicates that subjects were able to complete significantly more revolutions of the valve handwheel in the intermittent-4 condition compared to either the intermittent-3 or continuous conditions.

Table 6

Pearson Correlation Coefficients between

Strength Measures and Selected Physical Characteristics

	Height	Weight	Lean Weight	Bicromion
Isometric Strength				
Grip	.36	.49*	.49*	.39
Arm	.51*	.52*	.57**	.45
Back	.78**	.78**	.81**	.52*
Composite	.73**	.76**	.79**	.54*
Isokinetic Strength				
Cybex Arm	.60**	.54*	.56*	.46*

* $p < .05$

** $p < .01$

Table 7

Means and Standard Deviations for

the Simulated Valve Turning Test Conditions

	Mean (n=18)	SD
Continuous	134.6	93.2
Intermittent-3	135.4	90.9
Intermittent-4	196.9	50.3

Table 8

t-ratios and Significance Levels for the

Difference between Treatment Conditions

	Mean Difference	t-ratio	p
Continuous vs Intermittent-3	-0.83	-0.06	.96
Continuous vs Intermittent-4	-62.33	-3.34	.004
Intermittent-3 vs Intermittent-4	-61.50	-3.33	.004
Continuous, Intermittent-3 vs Intermittent-4	-61.92	-3.64	.002

Table 9 presents the Borg perceived exertion scale means and standard deviations within each of the treatment conditions. The intermittent-4 condition was perceived to be slightly easier (6.78) than either of the other two conditions (8.06, 7.83). These values indicate that subjects perceived all three test conditions to be very hard.

Table 10 contains the t-ratios and significance levels for the mean difference in perceived exertion across the treatment conditions. Since none of these values are significant one cannot reject the hypothesis that subjects perceived the continuous, intermittent-3, and intermittent-4 conditions to be of equal difficulty.

Presented in table 11 are the Spearman correlation coefficients among the three treatment conditions. Spearman corelation coefficients were used because the scores on these variables were skewed negatively. These results indicate that the rank order for any one condition is highly related to the rank order on either of the other two conditions.

Spearman correlation coefficients between the physical characteristics and the three test conditions are given in table 12. Body size was only moderately related to performance in the intermittent-4 condition, while not being highly correlated with performance in the other two conditions.

Table 13 contains the Spearman correlations between various strength measures and performance on the SVT test conditions. Composite strength was significantly related with performance in all three test conditions.

Table 9

Means ans Standard Deviations

for Borg Perceived Exertion Scale

within Treatment Condition

	Mean (n=18)	SD
Continuous	8.06	2.73
Intermittent-3	7.83	1.95
Intermittent-4	6.78	2.28

Table 10

Borg Perceived Exertion Scale

t-ratios and Significance Levels for the

Difference between Treatment Conditions

	Mean Difference	t-ratio	*p*
Continuous vs Intermittent-3	0.22	0.61	.55
Continuous vs Intermittent-4	1.28	1.73	.10
Intermittent-3 vs Intermittent-4	1.06	1.47	.16
Continuous, Intermittent-3 vs Intermittent-4	1.67	1.66	.12

Table 11

Spearman Correlation Coefficients

Among the Simulated Valve Turning Test Conditions

	1.	2.	3.
1. Continuous	1.00		
2. Intermittent-3	.77**	1.00	
3. Intermittent-4	.58**	.62**	1.00

** $p < .01$

Table 12

Spearman Correlation Coefficients Between
the Simulated Valve Turning Test Conditions
and Selected Physical Characteristics

	Height	Weight	Percent Fat	Lean Weight	Bicromion
Continuous	.13	.12	-.11	.10	.14
Intermittent-3	.17	.26	.18	.23	.07
Intermittent-4	.35	.49*	.16	.47*	.23

* $p < .05$

Table 13

Spearman Correlation Coefficients Between

the Simulated Valve Turning Test Conditions

and Strenght Measures

	Grip	Arm	Back	Composite	Cybex
Continuous	.37	.45*	.40	.45*	.20
Intermittent-3	.50*	.53*	.47*	.59**	.37
Intermittent-4	.39	.28	.54*	.55*	.32

* $p < .05$

** $p < .01$

Manipulation Check

In order to determine whether the subjects stopped the SVT tests because they were fatigued or because they lacked sufficient motivation, mean differences between pretest and posttest isometric strength measures were analyzed. As indicated in table 14, there was a significant decrease in grip strength under all three treatment conditions, while arm strength only significantly decreased under the intermittent-4 test condition.

Table 14

Pretest minus Posttest Mean Decrease

in Isometric Strength Measures

	Mean Difference	t-ratio	p
Continuous			
Grip	3.11	4.39	0.00
Arm	0.75	0.84	0.41
Intermittent-3			
Grip	2.47	3.30	0.00
Arm	1.14	1.02	0.32
Intermittent-4			
Grip	3.81	4.61	0.00
Arm	2.42	2.51	0.02

CHAPTER IV

DISCUSSION

The results of this study are somewhat suprising. Prior to conducting this research it was felt that performing a task under an intermittent exertion condition would greatly facilitate performance. It was our contention that if one were to perform the SVT test under intermittent and continuous exertion conditions of equivilant workloads, performance in the intermittent condition would be significantly greater. The t ratio between the two treatment conditions ($t = -0.06$, $p < .96$) was nonsignificant, as was the subjects perception of how difficult it was to perform both of these tests ($t = 0.61$, $p < .55$). The results from our analyses revealed that the null hypothesis could not be rejected, therefore regardless of exertion condition (with equivilant workloads) performance on the two SVT test conditions was not statistically significant. Considering the present sample size, N=18, these results should be interpreted with caution. The power of the t-test to detect a mean difference of this magnitude with a large standard deviation, using a repeated measures design, N=18, and alpha=.01 is quite low (power < .10). In designing this study we were interested in detecting mean differences that would be of practical significance and therefore had based our sample size, power, and alpha to detect only moderate to large mean differences (Cohen, 1977). With an increased sample size (N=473) our power would have been 0.80 and this mean difference might have been statistically significant, but differences of this size would not have been of practical significance.

One possible explanation for these results is that the rest time periods were not of sufficient duration to allow the alactic oxygen debt to be paid before the next bout of exercise began. Although the work/rest cycle time was based on that of Margaria, et al. (1969), their tasks involved the leg muscles which was a different muscle group than was used in the present investigation. It is possible that the physiological response to exertion has a slower lag time in the smaller muscle groups of the arm and hand than in the large muscle groups of the legs.

Another possible explanation could be that previous physiology studies failed to make the intermittent and continuous workload conditions equivilant. Margaria, et al. (1969), and Essen and his collegues (Essen, 1978; Essen, et al., 1977; Essen, et al., 1978) set the intermittent exertion condition <u>pace</u> at an equivalant or greater rate, but failed to set the amoumt of work completed per unit time equally in both conditions. Our results indicate that it is the amount of work completed per unit time that is the important factor, not whether or not one performs the task in an intermittent or continuous fashion.

Subjects perceived all three test conditions to be from 7 to 8 (very heavy) on Borg Perceived Exertion Scale. This indicates that subjects were working hard, within the level of work intensity defined to be aerobic. There was a significant decrease in performance between the two equivalant workload conditions (continuous-4, intermittent-3) and the intermittent-4 test condition. The continuous-4 and intermittent-3 test conditions had workloads of 23.56 ft.-lbs./sec, while the intermittent-4 condition had a workload of one half this intensity. Therefore subjects, while working under the continuous-4 and intermittent-3 test conditions, were working at a much higher intensity relative to their physiological maximum. This would explain the sixty revolution difference in performance between these conditions.

Another interesting finding was that the rank order did not vary greatly across the various treatment conditions. The Spearman rank order correlation coefficients all exceeded 0.58 and were all significant at $p < .01$. This indicates that if one were to choose a work rate of a different intensity the rank order would not be substantially different.

Conclusions

In light of our findings some tentative conclusions may be drawn. First it appears that allowing an applicant to rest during the testing session (while at the same time holding workload per unit time constant) does not influence their performance on the task. It seems that the most influential determinant of performance is the rate of work per unit time. The more time someone is given to complete a physically demanding task, the greater is the probability that they will finish more of it. Second, if the rate of work per unit time is varied it does not substantially alter the rank order of the applicants. In other words, the top performers under one rate of work will be the top performers under a higher rate of work.

Reference Notes

Reference Notes

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Appendicies

Appendix A

Informed Consent Form

UNIVERSITY OF HOUSTON
INFORMED CONSENT

The tests you are being asked to take will be used to modify a Shell Oil Co. physical performance test that will be used to determine if a potential job applicant will be able to perform the tasks required by certain jobs. This is a pilot study designed to judge the quality of these proposed modifications. Physical risk is minimal, although some tests may be tiring.

You will be required to attend three testing sessions which will be at the Department of HPER Research Laboratory. You will be paid $15.00 for your participation in this study. Each session will last for about 30 minutes. Thessions will be mutually arranged by appointment.

During these sessions you will be tested for maximum strength three different ways. Your general physical characteristics will be determined by standard anthropometric measures. All data will be kept confidential, but you will be given a copy of your scores upon request. The major benefit of this research will be the development of objective methods for selecting potential employees in industry.

Prior to taking a test, the investigator will demonstrate the test and you will be given a chance to try the test at your own rate. If you are not capable of doing the test, you will not be required to do so. Once the testing starts, you will be free to withdraw from the study at any time.

If additional information is needed, contact Mr. John D. Stout, Department of Psychology (phone).

DATE________________________________

I have read the above document and am satisfied with its terms.

____
Signature of Subject

Mr. John D. Stout
____
Investigator

____
Witness

This project has been reviewed by the University of Houston Committee for the protection of Human Subjects (phone).

Appendix B

Description of Cybex Arm Strength Test

Test: Isometric (Cybex) Arm Strength

Test Objective : To provide a measure of general arm strength.

Test Equipment : The Cybex bench press device is used to measure isokinetic arm strength. The system is manufactured by the Lumex Corporation, Bay Shore, New York. The test provides a continuous measure of strength through a range of motion.

Test Procedures : The subject assumes the supine position. From this position he/she exerts a maximum force and pushes the bench press handle upward. The muscular force is exerted primarily with the elbow extension and shoulder flexor muscle groups. A practice/warm up trial is administered, followed by two trials with maximum effort.

Scoring : The Cybex system includes a recording unit that registers the torque generated during the trial. The peak torque of the trial is used as the strength measure.

Appendix C

Description of Isometric Strength Tests

Test: Isometric Two-Arm Lift Test

Test Objective : To measure the maximim sustained lifting force that can be exerted with both arms at elbow height position. This test is basically an upper body strength measure.

Testing Equipment : The apparatus consists of a 4 ft. by 4 ft. plywood base with a steel hook attached to the base. The strain guage is attached to the hook at the base and to a chain which is fastened to a 2 in. by 4 in. board. The board is held with the hands at elbow height. The lifting force is recorded on the physiograph recorder.

Testing Procedures : The applicant stands on the plywood base with the arms at the side and the elbows at 90 degrees flexion. The legs are straight. The board is held by the hands and the chain length is adjusted to be consistent with the 90 degree elbow flexion. In this position, a maximum sustained contraction (lifting) force is exerted with the arms for a period of four seconds. The force is generated by the arms, not the legs or by leaning back. A trial starts with the command lift and ends four seconds later with the command stop. Following a demonstration of the test position, the individual is given a practice/warm up trail and two trials at maximum effort.

Scoring : A continuous record of the force exerted during the four second trial is provided by the recording system. The sustained strength score is based on two measures from each trial. These measures are the height of the curve from the baseline at two different points. The points are approximately 1.5 and 3.0 seconds after the start of the trial.

Test: Isometric Back Lift Test

Test Objective : To measure the maximum sustained lifting force that can be exerted with both arms at ankle height position. This test is basically a lower back strength measure.

Testing Equipment : The appartus consists of a 4 ft. by 4 ft. plywood base with a steel hook attached tothe base. The strain guage is attached to the hook at the base and to the chain which is fastened to a 2 in. by 4 in. board. The board is held with the hands at ankle height. The lift force is recorded on the physiograph recorder.

Testing Procedures : The applicant stands on the plywood base, bent over with arms at ankle level. The legs are straight. The board is held by the hands and the chain length is adjusted. In this position, a maximum sustained contraction (lifting) force is exerted with the back for a period of four seconds. The force is generated by the lower back, not by the legs or by arms. A trial starts with the command Lift and ends four seconds later with the command

Stop. Following a demonstration of the test position, the individual is given a practice/warmup trail and two trials at maximum effort.

Scoring : A continuous record of the force exerted during the four seconds trials is provided by the recording system. The sustained strength score is based on two measures from each trial. These measures are the height of the curve from the baseline at two different points. The points are approximately 1.5 and 3.0 seconds after the start of the trial.