AN ANALYSIS OF FINGER SIZE AND PERFORMANCE ON THE PURDUE PEGBOARD DEXTERITY TEST

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To the Graduate Council:

I am submitting herewith a thesis written by Gwendolyn Sue Housman entitled "An Analysis of Finger Size and Performance on the Purdue Pegboard Dexterity Test." I have examined the final copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Health and Human Performance.

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AN ANALYSIS OF FINGER SIZE AND PERFORMANCE ON THE PURDUE PEGBOARD DEXTERITY TEST

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ABSTRACT

The objective of the study was to identify a relationship between finger size and performance on the Purdue Pegboard dexterity tool. Twenty-six right-handed subjects, thirteen females and thirteen males, were tested. A negative correlation between performance and finger size was observed in both females and males. Females, however, had significantly smaller fingers and performed better than males on all sub-tasks. When finger size was used as a covariate of performance, all significant gender difference in performance disappeared.

The results of the study lend support to a previous study done with college students (Peters, Servos, & Day 1989), evidencing that finger size affects dexterity test performance. The larger the finger size, the poorer the performance. The results of the study also evidenced that gender difference in performance may be a result of finger size difference in males and females. The accepted belief that females are naturally more skilled in fine manipulative tasks is not supported. Changes in dexterity tools and established norms may be warranted, thus further study of these factors would be beneficial.

TABLE OF CONTENTS

Chapter 1

INTRODUCTION

Dexterity tests, developed over the last several decades, measure the ability to move the fingers and manipulate small objects rapidly and accurately (Bear-Lehman & Abreau, 1989). Examples of these tests include the Grooved Pegboard, the Nine Hole Peg Test, the Purdue Pegboard, the Jebsen Test of Hand Function, and the O'Connor's Tweezer Dexterity Test. Studies, using these tests and others, evidence that females perform better than males (Tiffin & Asher, 1948; Gordon, O'Dell, & Bozeman, 1981; Synk, 1983; Mathiowetz, Rogers, Dowe-Keval, Donahoe, & Rennells, 1986; Peters, Servos, & Day, 1990; Ruff & Parker, 1993). As a result, there exists an accepted belief that females are innately superior in performing tasks requiring fine motor skills. However, in studies of finger tasks that do not require manipulation of small objects, such as finger tapping, males perform better than females (Morrison, Gregory, & Paul, 1979; Peters & Durding, 1979; Synk, 1983; Ruff & Parker, 1993).

Differences between male and female performances may be due to a factor not considered in previous studies. As males are usually larger than females, finger size could affect performance on dexterity tests. Peter, Servos, and Day (1990) examined this relationship between finger size and dexterity performance using the Purdue Pegboard

dexterity tool. A high negative correlation between finger size and performance was observed. In addition, all significant gender difference disappeared when finger size was used as a covariate of performance. Although the sample population was small, the results of this study warrant further investigation.

Statement of the Problem

Previous studies of dexterity performance evidence that females perform better than males when manipulating small objects. However, little research has been done to determine factors that influence gender difference in performance. Specifically, there has been little study into anatomical factors that may affect dexterity performance. The purpose of this study was to identify a relationship between finger size and performance on the Purdue Pegboard dexterity test, and to determine if finger size is a factor in gender difference in dexterity performance.

Justification for the Study

Dexterity tests and tools are used in a variety of ways. Two of the most common are in the areas of employment and rehabilitation. Pre-employment screenings, including a variety of aptitude tests, are designed to match employee skills to specific job duties. Dexterity testing frequently is included. One of the most widely used and accepted

systems for classifying and measuring job related abilities has been developed by the United States Department of Labor (Synk, 1983). The Department uses a battery of nine aptitude tests in a program administered by the Employment Service. Finger dexterity and manual dexterity are integral components of this battery. In rehabilitation, dexterity tests are used to establish the presence and degree of disability, as well as establish benchmarks for treatment progress following injury or disease.

With the pervasive use of dexterity tests in the critical areas of employment and rehabilitation, the need to assess factors affecting performance becomes essential. The literature includes several studies concerning the effects of age (Hackal, Wolfe, Bang, & Canfield, 1992; Ruff & Parker, 1993), educational level (Ruff & Parker, 1993), stimulant use such as caffeine (Jacobson, Winter-Roberts, & Gemmell, 1991) and alcohol (Breckenridge & Berger, 1990), practice (Lee, Swanson, & Hall, 1991; Maring, 1990) and mental retardation (Broadhead & Church, 1993; Serr, Lavay, Young, & Green, 1994) on dexterity test performance. One study (Peters, Servos, & Day, 1990) addressed the effect of finger size on dexterity. In this study, gender difference in performance on the Purdue Pegboard vanished when finger size was used as a covariate. The sample size was less than 100 subjects and the study has not been repeated. Further study is needed to validate and reinforce the results.

Identification of a relationship between finger size and dexterity could affect significantly the use of dexterity tests. Dexterity tests may need to be redesigned, norms modified, and results of testing more closely scrutinized. Tool design in the work place also could be affected. The common belief that females naturally possess superior fine motor skills would need to be reassessed.

Design of the Study

Twenty-six male and female hospital employees, ranging from 21 to 39 years of age, participated in the study. All subjects were screened for a history of injury or disease process that might affect performance. The investigator assumed that the sample population represented a normal distribution with regards to dexterity.

The Purdue Pegboard was selected as the testing tool. The test consists of a board with two vertical rows of holes into which pins, washers, and collars can be placed. The tool is reliable and valid for measuring manipulation of small objects (Tiffin & Asher, 1948; Fleishman & Ellison, 1962; Mathiowetz et al. 1986). All tasks of the Purdue Pegboard were administered by the investigator.

A finger circumference gauge was used to measure finger size. Finger size was defined as the combined circumference of the distal phalanx of the index finger and thumb. The crease at the distal interphalangeal joint was used as a

proximal border to provide consistency in measuring finger size from subject to subject.

Data analysis was performed using the Statistics with Finesse program. A Pearson r correlation was used to compare finger size and performance on the Purdue Pegboard. Gender difference was assessed using an analysis of covariance, with finger size used as a covariate. An alpha level of .05 was set for significance.

The study had limitations. The sample population was small (N = 26). The small non-randomized population was employed by the same hospital facility as the investigator and were known by the investigator prior to the study. The study was further limited by the use of only one dexterity tool to determine dexterity skills.

Hypotheses

The study was designed to test the following null hypotheses:

1. Finger size does not affect performance on dexterity tests.

2. Gender difference in dexterity performance are not related to finger size.

Chapter 2

REVIEW OF THE RELATED LITERATURE

The Purdue Pegboard was developed in 1948 and its basic design has remained unchanged. The testing tool originally was designed to assist in selecting applicants for industrial jobs requiring assembly, packing, and other manual tasks (Mathiowetz et al. 1986). It has been used extensively in the areas of job placement and vocational assessment, with published norms for college students, veterans, and industrial applicants (Tiffin, 1968). Studies of reliability and validity have been done with intercorrelations ranging from .50 to .91 and validity coefficients ranging from .07 to .76 (Tiffin & Asher, 1948; Fleishman & Ellison, 1962; Mathiowetz et al. 1986). The variation of the validity coefficients serves to emphasize the fact that the validity of any dexterity tool should be determined for each specific job for which it is to be used.

Numerous factors affecting dexterity performance have been studied. Age has a significant effect on dexterity. There is a decrease in performance of the dominant and nondominant hands as age increases (Ruff and Parker, 1993), particularly in subjects 60 to 89 years of age (Hackel, Wolfe, Bang, & Canfield, 1992). Both accuracy and speed diminish with age. Educational levels also have a significant effect (Ruff and Parker, 1993). Participants with higher levels of education perform faster than

participants with lower levels of education. In addition, those individuals classified as mentally retarded perform slower than those persons with normal IQ levels (Serr, Lavay, Young, & Green, 1994). These results evidence a higher level of executive functioning may be a factor in dexterity testing. Using a strategy, rather than a trial and error method, may enhance performance. Results of studies on stimulant use indicate that both excessive caffeine (Jacobson, Winter-Roberts, & Gemmell, 1991) and alcohol (Breckenridge & Berger, 1990) intake have a detrimental effect on dexterity skills. Practice, however, improves dexterity skills (Lee, Swanson, & Hall, 1991). Mental practice combined with physical practice is more effective in improving dexterity skills than physical practice alone (Maring, 1990).

In all the studies, where gender difference was noted, females performed significantly better than males on tasks requiring manipulation of small objects (Tiffin & Asher, 1948; Gordon, O'Dell, & Bozeman, 1981; Synk, 1983; Mathiowetz, Rogers, Dowe-Keval, Donahoe, & Rennells, 1986; Peters, Servos, & Day, 1990; Ruff & Parker, 1993). These results are reinforced by investigators who specifically investigated gender differences in dexterity performance. A meta-analysis of scores on the General Aptitude Test Battery (Synk, 1983) indicate females performed significantly better than males on fine dexterity tasks. However, no gender

difference was noted on manual dexterity tasks. Ruff and Parker (1993) discovered that females perform better on the grooved pegboard task, while males performed better on finger tapping tasks. Finger manipulation of small objects appears to be a significant factor in gender performance.

The anatomical aspects of the hand rarely have been considered in dexterity performance and yet certainly have an influence. In a study of dental hygiene students (Macdonald, Wilson, & Waldman, 1991), twelve hand measurements were compared to clinical skills development using three dental instruments. Wrist width and finger span measurements were discovered to have a significant effect on early clinical skills development with two of the instruments. Finger size, specifically length of the finger, was reported to be a factor in performance on the finger tapping test (Gordon et al., 1981). Investigators concluded that males performed better than females because of greater strength and longer finger size. In another study, investigators postulated that males performed better on finger tapping tests because the mechanical counting device more easily accommodated the larger hand size of the males (Morrison et al., 1979). Peter, Servos, and Day (1990) studied the effect of finger size on dexterity performance using the Purdue Pegboard. A high negative correlation was observed in both males and females. In addition, when finger size was used as a covariate, all significant gender

difference in performance disappeared. Both studies used small sample sizes and have not been repeated.

Summary

The Purdue Pegboard has been used widely since 1948 in a variety of settings. Numerous studies of reliability and validity have been done, establishing it as a reliable tool with varying validity. Likewise, factors affecting dexterity performance have been studied, especially factors of gender, age, education level, and stimulant use. However, little research has been done to examine the effect of anatomy, and specifically finger size, on dexterity performance. With the extensive use of dexterity scores in the critical areas of employment and rehabilitation, these factors need further study. The purpose of this study was to identify a relationship between finger size and performance on the Purdue Pegboard dexterity test, and to determine if finger size is a factor in gender difference in dexterity performance.

Chapter 3

METHODOLOGY

The purpose of the study was to identify a relationship between finger size and performance on a specific dexterity tool. A descriptive research design was used to determine if finger size affects performance on the Purdue Pegboard dexterity tool. Gender difference in performance, with finger size factored out, also was evaluated.

Participants

Twenty-six hospital employees, thirteen males and thirteen females, volunteered to participate in the study. The ages of the participants ranged from 21 to 39 years of age, with a mean age of 30.23 $\pm$ 5.86. All participants were right-hand dominant. This occurred solely by chance, as no effort was made to limit the study to right-handed individuals. The participants were screened for any injury or disease process that might have affected dexterity test performance. Any individual reporting pain, decreased sensation, or decreased function of the hand was eliminated. All participants signed a document of informed consent.

Instrumentation

A finger circumference gauge, calibrated in centimeters, was used to measure the circumference of the

distal phalanx of the right and left index fingers and the right and left thumbs. The Purdue Pegboard, a test of manipulative dexterity, was selected as the dexterity testing tool. The test has been demonstrated to be a reliable tool with varying validity. Published norms for college men and women, veterans, and industrial applicants are extensive. The Purdue Pegboard consists of a board with two vertical rows of holes into which pins, washers, and collars can be placed. These pins, washers, and collars are stored in one of four cups across the top of the board. The test yields five separate scores. These include the right-hand task score, the left-hand task score, the both-hands task score, and the assembly task score. All four sub-task scores are added to get a total performance score.

Procedure

The participants were tested in the Rehabilitation Services department of Clarksville Memorial Hospital. All participants were seated at a table, 30 inches in height. The circumference of the distal phalanx of the right and left index fingers and the right and left thumbs were measured, using the distal interphalangeal joint line as a proximal border. Finger size was calculated by adding all four circumference measurements. The Purdue Pegboard was administered by following standard instructions as given in the procedures manual (Tiffin, 1968). All four sub-tasks

were given, to include the right-hand task, the left-hand task, the both-hands task, and the assembly task. In the right-hand task, participants were instructed to pick up one pin at a time, with the right hand, from the right-hand cup and place it in the right-hand row, starting with the top hole. The participants worked as rapidly as possible for 30 seconds. The left-hand task was the same as the right-hand task, except the subjects used the left hand, taking pins from the left-hand cup and placing them in the left-hand row. The both-hands task required the participants to use both hands at the same time. The participants took a pin from the right-hand cup with the right hand, and a pin from the left-hand cup with the left hand, and placed pins down the rows simultaneously for 30 seconds. For the assembly task, the participants were instructed to assemble pins, washers, and collars, with an assembly consisting of a pin-washer-collar-washer. Both hands operated at the same time, one picking up a pin, one a washer, then a collar, and so on. The assembly task was timed for 60 seconds. In the first three sub-tasks, scores were calculated by adding the number of pegs or pair of pegs placed. The number of parts assembled were counted to calculate the assembly score. In addition, all four sub-task scores were added to get a total performance score.

Design and Data Analysis

The investigator administered all tests, in the same place, using the same equipment. The participants were given identical instructions and each performed the tasks in the same order. Data analysis was performed using the Statistics With Finesse program. A Pearson r correlation was used to compare finger size and performance on the Purdue Pegboard. An analysis of covariance was used to assess gender differences, with finger size used as a covariate. An alpha level of .05 was set for significance.

Chapter 4

RESULTS

The mean calculations for finger size are presented in Table 1. Females, with a mean of 18.946 ± .804, had

Table 1. MEAN AND STANDARD DEVIATION OF FINGER SIZE.

POPULATION	MEAN (centimeters)	STANDARD DEVIATION
Males	21.615	1.228
Females	18.946	.804
Total Population	20.281	1.699

N = 26

smaller fingers than males, with a mean of 21.615 ± 1.228. Performance on the Purdue Pegboard by the participants is summarized in Table 2. The female participants performed

Table 2. MEAN AND STANDARD DEVIATION OF PERFORMANCE SCORES ON THE PURDUE PEGBOARD.

POPULATION	RIGHT HAND (30 sec.)	LEFT HAND (30 sec.)	BOTH HANDS (30 sec.)	ASSEMBLY (60 sec.)	TOTAL PERFORMANCE
Males	14.54±1.27	13.69±1.32	11.23±1.01	39.31±3.71	78.77±5.73
Females	15.85±1.07	15.31±1.65	12.26±1.71	41.77±4.62	85.54±6.98
Total Pop.	15.19±1.33	14.50±1.68	11.92±1.55	40.54±4.29	82.12±7.13

Note. Scores are the number of parts placed or assembled.

N = 26

better than the male participants on all sub-tasks. The greatest difference in task performance occurred in the assembly task, with a mean of 41.77 ± 4.62 for females and a mean of 39.31 ± 3.71 for males. The least difference

occurred in the right-hand task, with a mean of 15.85 ± 1.07 for females and a mean of 14.54 ± 1.27 for males. Females had a mean total performance score of 85.54 ± 6.98, while males had a mean score of 78.77 ± 5.73.

A Pearson r correlation was calculated between each sub-task score, including the total performance score, and finger size. The results are illustrated in Table 3. A

Table 3. PEARSON PRODUCT-MOMENT CORRELATION COEFFICIENTS BETWEEN FINGER SIZE AND PERFORMANCE SCORES.

TASK	CORRELATION (*r*)	PROBABILITY
Right Hand	-.5813	.0018
Left Hand	-.4194	.0330
Both Hands	-.4455	.0225
Assembly	-.5131	.0073
Total Performance	-.6549	.0003

N = 26

negative correlation between finger size and performance was present with all sub-tasks. The total performance score had the highest correlation of -.6549, with a -.5813 correlation on the right-hand task. The left-hand task had the lowest correlation of -.4194.

An analysis of covariance was used to compare the total performance scores of males and females, with finger size as a covariate. By eliminating the effect of finger size, there was no significant difference between genders (F = .1184, P = .7339).

Chapter 5

DISCUSSION

This study lends support to previous work (Peters, Servos, & Day 1989), indicating that finger size has an effect on dexterity test performance. As finger size increases, performance decreases. Based on a moderately high correlation ($r = -.66$) between finger size and performance scores, the larger hand size does handicap an individual on the Purdue Pegboard tasks. In addition, if finger size is used as a covariate of dexterity performance, gender difference is no longer significant.

The establishment of a relationship between finger size and dexterity may alter the way dexterity tests are used in the work place. Components of these tests may need to be modified and new, stratified norms established. Tools in the work place could be redesigned to accommodate larger finger and hand sizes. The belief that females possess superior fine motor skills as a result of gender is not supported by these test results.

The lack of studies into anatomical factors affecting dexterity is surprising, considering the wide use of dexterity testing. The conclusions of this study evidence the need for additional studies with larger sample sizes. In addition, the development of a battery of tests that would include anatomical factors relative to finger size are needed.

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APPENDIX

INFORMED CONSENT STATEMENT

The Effect of Finger Size on Dexterity Test Performance

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Phone: 615-551-1716

PURPOSE

The purpose of this study is to establish a relationship between finger size and performance on a specific dexterity test. In addition, the study will establish that gender differences in dexterity performance are related to finger size.

PROCEDURE

The study will include twenty-six (26) subjects, male and female health care professionals, between the ages of 21 and 39. The circumference of the index finger and thumb on both hands will be measured with a tape measure. The subject's dexterity skills will be measured using the Purdue Pegboard, which consists of a board with two rows of holes into which pins, washers, and collars can be placed. Subjects perform the dexterity tasks in a sitting position. There are four tasks the subjects will be asked to complete. The right-hand task involves placing pins in holes with the right hand. The left-hand task involves placing pin in holes with the left hand. The both-hands task involves placing pins in the holes with the right and left hand simultaneously. These three tests are timed for a period of 30 seconds. The final task is an assembly task, in which the subject assembles a pin-washer-collar-washer combination using both the right and left hands together. This is a 60 second test. Subjects will be given the opportunity to practice each task prior to the test.

POSSIBLE RISKS

Participating in this study poses no risk to the subject.

POSSIBLE BENEFITS

Dexterity tests are used a great deal in the employment and rehabilitation areas. Job placement may depend on how well an individual performs on a dexterity test. The presence and degree of disability may depend partially on dexterity test scores. These scores are also used to establish benchmarks for treatment progress, following injury or disease. With the pervasive use of dexterity tests in the critical areas of employment and rehabilitation, the need to assess factors effecting performance becomes essential. The establishment of a relationship between finger size and dexterity could effect a great many things, from the way in which norms are presented and used, to an actual redesign of dexterity tests. Job placement and tool design in the work place could also be effected. The prevailing belief that females possess superior fine motor skills would need to be reassessed.

ASSURANCE OF CONFIDENTIALITY

Information obtained from you in this study will be treated confidentially. Your name will not be used and only group data will be reported. No one, other than the investigator, will have access to your responses.

VOLUNTARY PARTICIPATION AND WITHDRAWAL

You are free to decide not to participate in this study or to withdraw at any time without adversely affecting your relationship with the investigator or with Austin Peay State University. Your decision will not result in loss of benefits to which you are otherwise entitled. If any information develops or changes occur during the course of this study that may affect your willingness to continue participating you will be informed immediately.

The scope of the project will be explained fully upon completion.

I agree to participate in the present study being conducted under the supervision of a faculty member of the Department of Health and Physical Education at Austin Peay State University. My signature certifies that the content and meaning of the information on this consent form have been fully explained to me and I have decided to participate having read and understood the information presented. My signature also certifies that I have had all my questions answered to my satisfaction. I understands that I will be given a copy of this consent form to keep.

_____ _____
Signature of Subject Date

_____ _____
Signature of Witness Date

_____ _____
Signature of Investigator Date

VITA

Gwendolyn Sue Housman was born in Arkansas City, Kansas on September 29, 1950. She attended the University of Oklahoma, receiving a Bachelor of Science in Physical Therapy in August 1972. In 1991, she was credentialed as a Certified Hand Therapist by the American Hand Therapy Commission. She presently is attending Austin Peay State University, working toward a Master of Science in Health and Human Performance, with an emphasis in Community and Public Health.

She has worked in a variety of rehabilitation settings, as both a clinician and manager. She is currently the Director of Rehabilitation Services at Clarksville Memorial Hospital, Clarksville, Tennessee.