EXAMINATION OF DEXTERITY AS A FUNCTION OF HAND SIZE AND OCCUPATION USING THE PURDUE PEGBOARD

by

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ABSTRACT

The purpose of this study was to examine potential differences in the level of dexterity between large handed individuals and small handed individuals. Each subject's hand size was determined by measuring palmar girth. Palmar girth measurements greater than one standard deviation from the mean palmar girth were classified as large and the palmar girth measurements at least one standard deviation below the mean palmar girth were classified as small hand size. The subjects included males from an agrarian population and from an industrial population. The Purdue Pegboard was used to test bilateral hand dexterity. Each subject performed the Purdue Pegboard test according to established testing procedures. Results were examined to determine if any differences in performance were evident between occupations and between larger sized hands versus smaller sized hands. Additionally, results were examined in terms of whether there was a particular occupation that comprised the larger hand size group. Although a difference was found in performance between groups (agrarian and industrial), no difference in performance was found as a function of hand size. Also, the agrarian population was not identified as having predominantly large hands as compared with the industrial population.

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CHAPTER I

INTRODUCTION

The human hand is an important anatomical structure that allows for the direct manipulation of the environment (Norkin & Levangie, 1992). The hands, due to location and usage, are subject to frequent injury with varying degrees of severity (Hebert, 1990). For example, a paper cut is a minor injury that causes discomfort and may affect performance of tasks requiring the use of the injured hand. However, trauma caused by repetitive movements of the hands can lead to major injury (Hebert, 1990; Hunter, Schneider, Mackin & Callahan, 1990; Norkin & Levangie, 1992). The capacity of the hand to move is dictated by the muscular, nervous and bony systems of the upper extremity. Any trauma to the anatomical, physiological or neurological systems of the hand can disrupt function (Hunter et al., 1990). The importance of the hand in performance of a variety of tasks makes it necessary to understand its composition and function (Hebert, 1990).

The importance of the hands in the performance of a variety of agricultural tasks makes it necessary to understand the impact of hand injuries on an agrarian population. There are more than 3.5 million workers in the agricultural industry (Jackson, 1983). In 1994, the National Safety Council reported 140,000 disabling injuries for farm residents. Agriculture is the third most hazardous occupation in the United States (Jackson, 1983). In the state of Texas, the Department of Health has a trauma registry that is responsible for receiving and tabulating death and injury data from hospitals. Until September of 1996 hospitals voluntarily submitted data to the Department of Health. As of September 1, 1996, it is mandatory for hospitals to report injuries to the Department of Health. Mandatory reporting will be useful in tracking the prevalence and severity of hand injuries by various populations of individuals.

Prior to 1996, reports in Texas of farm-related injuries had been provided by a few hospitals on a voluntary basis. There are approximately 482 hospitals in the state of Texas. In 1994, 18 hospitals provided injury reports on 6155 people, of those injuries 164 were farm related. In 1995, 51 hospitals provided injury reports on 13,656 people, of those 322 were farm related. In 1996, 96 hospitals reported injuries prior to mandatory reporting. For the first 8 months of 1996, 184 farm injuries were reported from only 20 percent of the hospitals operating in the state of Texas.

Agrarian populations participate in a variety of tasks that involve lifting, carrying, pushing, pulling and the manipulation of tools and equipment. A hand injury can be a great detriment to any individual that relies on the use of their hands for their livelihood. Appropriate assessment of limitations following a hand injury is important to determining the functional outcome or coordination and dexterity of the patient. Standards currently available may or may not represent a patient accurately. Before an individual is compared to established standards, it should be determined that the standards represent the population being tested. Agrarian workers participate primarily in gross grasp tasks. Coordination and dexterity required for agricultural tasks may differ from the coordination and dexterity required by an industrial population that performs assembly line or repetitive type tasks. The human hand is capable of numerous movements. How an individual uses their hands to work or play determines the movements important to that individual.

The hand is composed of nineteen bones and nineteen joints distal to the eight carpal bones of the wrist. Muscles on the volar and dorsal surfaces of the forearm primarily create flexion and extension of the wrist and digits. Muscles originating in the hand contribute to the flexion, extension, abduction and adduction of the digits as well as opposition of the thumb and fifth digit. Muscles of the hand produce contractile forces that contribute to gross and fine manipulation patterns of the hand/digits (Norkin & Levangie,1992). The amount of strength, endurance and motor skill of the hands is influenced by muscular properties such as the number of motor units within the skeletal muscle.

Skeletal muscle can be described in terms of a hierarchy of components. Skeletal muscle is comprised of muscle fascicles or bundles of muscle fibers encircled by connective tissue (Lieber, 1992). Muscle fibers are bundles of myofibrils and myofibrils are made up of contractile filaments. Contractile filaments are arranged in such a manner as to produce sarcomeres in series. Sarcomeres are composed of thick and thin filaments called myofilaments or more specifically, actin and myosin filaments (Lieber, 1992; Norkin & Levangie, 1992). An increase in the size and number of sarcomeres, which are the contractile units of muscle tissue, leads to improved contractile capabilities, while the decrease in sarcomeres contributes to muscle stiffening (Norkin & Levangie,1992). When there is increased utilization of a muscle in an activity it can increase in size (Vander, Sherman, & Luciano, 1994). Increase in the size of a muscle is referred to as hypertrophy (Cormack, 1987; Goldspink, 1980).

Hypertrophy may occur with heavy resistance training, such as weight lifting. As a result of increased tension in the muscle, myofibrils increase in size and number. Acceleration of protein synthesis and the reduction of protein breakdown results in the increase of sarcomeres (McArdle, Katch & Katch, 1991). Heavy resistance training or tension overload may also stimulate an increase in bone mineral content, as well as connective tissue and satellite cells that surround the individual muscle fibers (McArdle et al., 1991). Muscle can also have an increase in elemental structures such as mitochondria depending on the activity producing the modification of the muscle (McArdle et al., 1991; Vander et al., 1994). An activity, such as long distance running, that emphasizes endurance can lead to an increase in the production of mitochondria rather than myofibrillar material (Goldspink, 1980). Aerobic or endurance training leads to an increase in oxygen uptake in the mitochondria which results in an increase in both size and number of mitochondria. This increase in mitochondria size, as well as number, increases the capacity of the muscle to generate energy (McArdle et al., 1991). When the muscle increases in the number and size of contractile filaments or the number and size of mitochondria, muscle response can be affected by increasing the capacity for contraction (McArdle et al., 1991; Norkin & Levangie, 1992; Tortora & Anagnostakos, 1990). Considering that the muscular structure can be influenced, it is beneficial to know how the change in muscle structure affects digit coordination.

Coordination of the hand is important to an individual's interaction within the environment. There are various degrees of hand coordination required for daily activities, occupations and self-care (Kroemer, 1986). Using a computer requires a different composition of muscular responses than operating a forklift. The amount of coordination available to perform an activity determines functional use. Functional use of the hand is demonstrated by the ability of the individual to perform required daily tasks (Pedretti & Pasquinelli, 1990). For an agrarian population, fine motor dexterity/coordination of the hand is not required at the same level or degree as perhaps persons involved in small piece assembly work. For example, circuit board assembly requires more fine motor manipulation than operating farm equipment. Holding a pair of tweezers requires a pincer grasp as compared to a more gross grasp used for driving a tractor or moving pipe. However, the difference in performance of fine motor skills does not indicate dysfunction. If an injury does occur, appropriate evaluation tools are needed to accurately identify the level of functional use of the hand.

An important aspect of rehabilitation of the hand involves an individual's occupation and recovery expectations. It is valuable to the therapeutic process to have appropriate standards and norms available to the therapist. A number of evaluation tools for fine motor dexterity testing are described in the literature (Mathiowetz & Haugen, 1995). However, the standard of performance used to determine "functional use" may not be appropriate for all populations (Lafayette Instrument Company [LIC]). Standards need to be established that are appropriate for the individual being examined.

The Purdue Pegboard has been selected as an evaluation tool due to the test's popularity in a variety of settings, such as hand rehabilitation and work hardening settings, as well as general use in inpatient and outpatient rehabilitation facilities. The examination of hand size and whether it has an effect on the level of dexterity may assist the therapeutic process by providing a scale of performance indicative of functional use of the hand.

Purpose of the Study

In a clinical setting, such as a hand therapy program, the Purdue Pegboard is used to test bilateral hand dexterity. However, the published norms available may not be appropriate for all populations. As a result, many persons that demonstrate functional use of their hands, may score poorly on the test because the test norms are established for "average" hand size. The goal of this study is to examine the effects of hand size on hand dexterity. Another purpose of this study is to determine whether there is a difference in hand size as a function of occupation (agrarian compared to an industrial assembly line population).

Definition of Terms

Agrarian--persons involved in farming and ranching occupations.

Functional use--the capacity to perform activities of self-care, work and play.

Industrial Assembly line--a type of production line where individuals perform specific tasks repetitively.

Purdue Pegboard--dexterity test which measures gross movements of the upper extremity and fine movements of the digits.

Work hardening--an area of industrial rehabilitation where the focus of treatment is on the evaluation and improvement of an injured worker for return to work.

Assumptions

The assumptions of this study are: (1) the subjects will respond to the questionnaire honestly; (2) the population of Lubbock and surrounding rural communities will be representative of the hand sizes expected in the average human population; (3) the population of the industrial subjects in West Memphis, Arkansas will be representative of the hand sizes expected in the average human population; (4) the Purdue Pegboard is a good measure of hand dexterity.

Statement of Hypotheses

The subjects identified as agrarian will demonstrate significantly lower performance scores as compared to subjects from an industrial population. The subjects with large hands will demonstrate significantly lower performance scores on the Purdue Pegboard tests as compared with subjects with small hands. The subjects from an agrarian population will exhibit a significantly larger hand size as compared to subjects from an industrial population.

Delimitations

This study was limited to population sampling in the Lubbock area and surrounding rural communities for the agrarian subjects and West Memphis, Arkansas for the industrial subjects.

Significance of the Study

This type of study can be of great benefit in the evaluation and treatment of patients with hand injuries. Information on the effects of hand size in regards to dexterity can help in the assessment of the patient's hand function capabilities. If patients with large hands cannot perform at the level dictated by current standards of the Purdue pegboard, those standards should not be used to determine the level of function for those individuals. This study also examined whether an agrarian population exhibited larger hand size as compared to an industrial population. This study can promote the proper assessment of hand function by providing information on factors, such as hand size, that contribute to the dexterity of the hand.

CHAPTER II

REVIEW OF LITERATURE

Introduction

The hand is a complex structure that allows an individual to manipulate the environment. Hand design and function is dependent on the bone and joint formation, muscle and tendon composition, nerve innervation and the interdependent capabilities of these elements (Hunter et al., 1990; Norkin & Levangie, 1992). How a person moves or is able to move is influenced by the coordination of muscles (Kreighbaum & Barthels, 1990; Norkin & Levangie, 1992). Muscle composition can be influenced by the activities required from the muscle (Goldspink, 1980; Norkin & Levangie, 1992; Salmons, 1980; Wells, 1966). Thus, differences in how a person moves or uses the hand can affect and be affected by muscle composition and its relationship to the other structures in the hand.

Muscular Design and Function

Muscular design affects function and the degree to which a muscle is utilized affects its structure. Muscles can be categorized in many ways, such as mobility versus stability, tonic versus phasic, shunt or spurt (Norkin & Levangie, 1992). Within these categories, muscles may perform different roles depending on the motion being produced. For example, the triceps brachii muscle is considered a stabilizing muscle of the elbow complex and demonstrates this function when the elbow is in full extension (closed kinematic chain). However, this does not mean the muscle acts only to lock the elbow, it can also mobilize the elbow from a fully flexed position. Ultimately, the primary function of a muscle often dictates its classification (Norkin & Levangie, 1992). In regards to tonic and phasic classification, the muscle's proportion of energy producing fibers (metabolic characteristics) and fiber arrangement (penniform) contribute to the categorization of the muscle. For example, a muscle with a high proportion of slow-oxidative fibers (slow-twitch) to fast glycolytic fibers (fast-twitch) may be classified as a tonic muscle (McArdle et al., 1991; Norkin & Levangie, 1992; Tortora & Anagnostakos, 1990). While tonic and phasic categories are influenced by the fiber arrangement and composition of energy producing fiber types, spurt and shunt refers to the location (origin and insertion) of a muscle in relation to the joint(s) upon which it acts (Norkin & Levangie, 1992). Both of these groupings also take into consideration the speed at which a muscle can respond or produce a motion (due to location or metabolic characteristics).

It has been shown that fast-twitch and slow-twitch muscle fibers can be reprogrammed by changing neural input into the muscle fiber (Salmons & Sreter, 1976). Muscle fiber adaptation occurs in response to cross-innervation of the muscle fiber types. For example, if a slow muscle previously innervated by a slow nerve is cross-innervated by a fast nerve it will become fast contracting (Salmons, 1980). In addition to the adaptation of contractile characteristics, corresponding changes in the metabolism of the muscle have been shown to result from cross-innervation (Salmons, 1980). The neural information, muscle action and metabolic process can dictate fiber type, speed, duration (endurance) and size of the muscle. Therefore, how the muscle is used can affect the composition of the muscle.

Effects of exercise or occupational activity on muscle fiber can involve the increase in the myofibrillar material size and number, the number and size of mitochondria and the amount of oxidative enzymes (Goldspink, 1980; Salmons, 1980). Hypertrophy refers to the increase in muscle fiber size and usually results in the increase of myofibrillar material. The increase in myofibrils results in an increase in contractile units, therefore, contractility of the muscle fibers involved (McArdle et al., 1991; Norkin & Levangie, 1992). There can also be an increase in the size and number of mitochondria rather than myofibrillar material if the activity emphasizes endurance. The hand is unique in that there are five appendages that can work independently or collectively to manipulate objects. Muscle fiber size and metabolism can affect the motion produced in regard to the quality of movement, speed, and duration of the muscles of the hand (Norkin & Levangie, 1992). For example, an increase in myofibrillar material can increase contractility of the muscle while an increase in metabolism will increase the energy forming capacity of the muscle.

In addition to individual muscle activity affecting dexterity, muscle group activity also plays a role. For example, flexors and extensors act together (co-contract) to perform a stabilizing function (Kreighbaum & Barthels, 1990; Norkin & Levangie, 1992; Wells, 1966). This is demonstrated when the wrist is held in a neutral position while the digits are allowed to grasp an object, such as a writing utensil. The coordination of the wrist and hand for fine motor as well as gross motor manipulation is dependent on the ability of particular muscles to stabilize as well as mobilize bony levers (Wells, 1966). Ultimately the structure, efficiency and appropriate functioning of each muscle determines the coordination of the muscle groups and the overall coordination of the system (in this case, the upper extremity with an emphasis on the hand).

For coordination to exist, movement must exist and to create movement, muscles must have the capacity to respond to stimuli by producing contractile activity. A muscle's ability to produce contractile forces is influenced by the presence of such elemental structures as the sarcoplasmic reticulum, mitochondria and energy supplying substances such as ATP which affect sarcomere activity (Norkin & Levangie, 1992; Tortora & Anagnostakos, 1990; Vander et al., 1994). In a larger view of these microscopic processes one must be able to test the presence or absence of a muscle's ability to produce motion as well as the amount or speed of the motion in order to identify any movement limitations. Coordinated movement is dependent on many variables. How much coordination is required for functional use of the hand depends on the activities of each individual.

The Role of Occupational Therapy

In 1979, the Representative Assembly (a governing body in the American Occupational Therapy Association) adopted a philosophical statement of Occupational Therapy. The premise accepted for Occupational Therapy is that mankind can be affected through purposeful activity (Pedretti & Pasquinelli, 1990). The hands play an important role in how an individual interacts within the environment and performs "purposeful activities." The hands can be viewed as the tools providing humans power over the environment. The hand is of great interest to therapists working specifically with hand patients in how it functions and its structure (Hunter et al., 1990; Norkin & Levangie, 1992). Therapeutic intervention attempts to facilitate optimal performance based on the limitations and capabilities of an individual (Pedretti & Pasquinelli, 1990).

Research has been performed in evaluating task design, work environment as well as tool use in relation to the capabilities of the worker/individual (Mital & Sanghavi, 1986; Rahimi & Malzahn, 1984). Industry leaders have become very interested in how an individual's abilities can be accurately tested in order to provide information on appropriate job placement (Rahimi & Malzahn, 1984). Occupational therapy is involved in the process of work or any daily activity deemed important to the individual. Taking into consideration the extreme importance of the upper extremity (especially the hands) in daily activities, the evaluation of strength and dexterity are a significant part of the therapeutic process (Hunter et al., 1990; Kellor, Frost, Silberberg, Iversen & Cummings, 1971).

In 1985, the Representative Assembly, addressed the role of occupational therapy in hand rehabilitation. Based on the overall premise of occupational therapy, the focus remains on purposeful activity as a therapeutic approach to the prevention of dysfunction, restoration of functional ability and the facilitation of adaptation to impairment (Melvin, 1985). The occupational therapy role is based on anatomical, physiological, neurological, kinesiological and psychological concepts (Bear-Lehman & Flinn-Wagner, 1988; Melvin, 1985). Assessment of hand function involves the evaluation of sensibility, amount and type of movement as well as vocational and avocational requirements of the hand.

Vocational requirements of the hand may include activities requiring speed of movement such as typing or computer use to larger hand movements such as lifting and moving boxes. Avocational requirements can include anything required for self-care, such as dressing, to home care or possibly hobbies, such as playing the guitar. Avocational requirements of the hand can be as varied as vocational requirements.

Occupational therapy must consider a holistic approach in the treatment as well as assessment of the hand (Bear-Lehman & Flinn-Wagner, 1988; Melvin, 1985). Treatment approaches should utilize activities deemed appropriate by the therapist as a result of the information gathered through assessment. As the patient progresses, occupational and leisure components should become a greater part of the hand rehabilitation. The success of hand treatment depends on the overall performance of the patient in producing movement appropriate for a task and whether the patient perceives the movement produced as acceptable.

Assessment tools play a vital role in the evaluation of the initial performance of a patient, upon entrance into a therapy setting. Assessment tools also provide information as to the improvement made during the process of therapy. Due to the importance of factors such as occupational and leisure uses of the hand, assessment tools should reflect these factors (Melvin, 1985). Evaluation of hand function should involve assessment tools that are appropriate for the anatomical, physiological and neurological limitations of the hand as well as vocational and avocational aspects of the patient.

Historical View of the Purdue Pegboard

The Purdue Pegboard was established in 1948 by Joseph Tiffin, Ph.D. The test focus is concerned with gross motor performance of the upper extremity as well as fine motor skills of the hands. The Purdue Pegboard has been tested for reliability and validity by Tiffin and Asher (1948). Validity of the Purdue Pegboard has been established by several researchers (Costa, Searola & Rapin, 1964; Fleishman & Ellison, 1962; Gardner & Broman, 1979; Hamm & Curtis,1980; Kane & Gill, 1972; Leslie, Davidson & Batey, 1985). Normative data for the Purdue pegboard is available on various jobs including: male and female applicants for assembly jobs, general factory work, production work, female applicants for electronics production work, female hourly production workers, male hourly production workers, male utility and service workers, and female sewing machine operator applicants (Lafayette Instrument Company). However, norms have not been established for an agrarian population.

Many agrarian patients have large callused hands and may be unable to score within a range indicative of normal hand function, however the patient may be capable of functional activity within the realm of the patient's own work level. The Purdue Pegboard is widely used in rehabilitation facilities, therefore, appropriate norms for an agrarian population would be extremely useful in performing functional capacity evaluations. Appropriate norms would benefit the evaluation of hand function in a hand therapy setting that treats patients who work in heavy labor settings or agrarian type work. The Purdue Pegboard has been tested for validity with focus on specific populations. There is a need for the Purdue Pegboard to be utilized in the determination of norms concerned with an agrarian population.

CHAPTER III

METHODOLOGY

The purpose of this experiment was to determine whether there was a significant difference in the level of performance between large handed individuals and small handed individuals on the Purdue Pegboard. The Purdue Pegboard was used to evaluate the bilateral dexterity of the subjects. Subjects completed a consent form and questionnaire prior to testing (see Appendices A and B). The purpose of the questionnaire was to obtain information on each subject regarding occupation and hand size, as well as age, height and weight. Hand size was used to examine performance level differences while occupation was examined to determine whether an agrarian population had predominantly large hands as compared to an industrial population.

Subjects

Subjects included 48 males from an agrarian population in the Lubbock and surrounding rural areas with no past history of hand injury requiring medical care. The subjects also included an industrial population that consisted of 21 males in West Memphis, Arkansas with no past history of hand injury requiring medical care. The industrial subjects were composed of workers in a steel pipe assembly line production factory.

Apparatus

The Purdue Pegboard was used to test bilateral hand dexterity. The Purdue Pegboard consisted of four cups with pins, collars, and washers at the top of the board and two rows of holes down the middle of the board (see Appendix C).

Procedure

Subjects were tested in a classroom setting. Prior to dexterity testing a tape measure was used to measure the girth at the level of the distal palmar crease (DPC) of both the right and left hand. This DPC score was used as a measure of hand size for each subject. Subjects with hand size greater than one standard deviation above the mean palmar girth of the dominant hand were classified as large hand and subjects with hand size greater than one standard deviation below the mean palmar girth were classified as small hand. Other studies have determined hand size by measuring the length from the tip of the middle finger to the distal wrist crease or have determined hand size by measuring the area of the palm (McCabe & Smeltzer,1993; O'Driscoll et al., 1992; Oh & Radwin, 1993). Length of the fingers and palm provide information on grip span. Girth measurements provide information on the thickness or bulkiness of the hand.

The Purdue Pegboard was placed on a table approximately 30 inches in height directly in front of the subject. The testing procedure included four tests; however, five scores were derived from the four tests. Each subject was told to perform each test as quickly and accurately as possible. Before each exam, the test was demonstrated and the participant was allowed to practice by placing 3 to 4 pins.

The first test involved the **right hand**. Subjects were instructed, "With the right hand pick up one pin at a time from the right-hand cup. Starting with the top hole place each pin in the right-hand row." Three trials were performed. The subject had 30 seconds for each trial. The average number of pins successfully placed in the 3 trials was scored. For the second test, this procedure was repeated with the **left hand**. The third test required the subject to place the pins with **both hands** simultaneously. Again subjects were given 3 trials of 30 seconds. The number of pairs successfully placed, not individual pins, at the end of each trial was the score. A fourth score was derived from the first three tests. This score was a combination of right hand placing plus left hand placing plus bilateral placing average scores. The fourth test, which comprised and fifth score was an **assembly** test. The subject was asked to pick up a pin with the right hand and while it was being placed, pick up a washer with the left hand and put it on the pin, subjects continued with the right hand by placing a collar on the pin, followed by another washer placed on the pin with the left hand. The activity was timed for one minute and each subject was given 3 trials. The number of pieces successfully placed was the score. The fifth score is the average of the three assembly trials of the fourth test.

Design and Analysis

Five scores were obtained from each subject: (1) right hand, (2) left hand, (3) both hands, (4) right + left + both, (5) assembly. An initial t-test was performed to determine if a difference existed between the agrarian population and industrial population as a function of the dominant hand size. An additional t-test was performed to analyze non-dominant hand size to determine if there was a significant difference between the agrarian and industrial population. To determine if there was a significant difference between agrarian versus an industrial population scores were analyzed in a 2 (group) X 5 (Purdue Pegboard scores) ANOVA with repeated measures on the last factor. An additional analysis examined large hands versus small hands in a 2 (hand size) X 5 (Purdue Pegboard scores) ANOVA with repeated measures on the last factor.

CHAPTER IV

RESULTS AND DISCUSSION

Results

For each subject in both the agrarian and industrial groups, ten dependent measures were collected. The dependent measures were age, weight, height, distal palmar crease girth for the dominant hand, distal palmar crease girth for the non-dominant hand, right hand placing, left hand placing score, bilateral placing score, combined score (R+L+B), and an assembly score (see Table 1 for average scores). From the information collected, an initial t-test was performed to examine differences between the agrarian and industrial populations for the dominant hand size (using distal palmar crease as a measure of hand size). An additional t-test examined differences in the same population for non-dominant hand size. No significant differences were found for either the distal palmar crease of the dominant hand or the non-dominant hand (see Table 2). This analysis indicated that there were no differences in hand size between the two groups.

To examine differences between groups as a function of the Purdue pegboard scores, a 2 (group) X 5 (Purdue Pegboard scores) ANOVA with repeated measures on the last factor was performed. Results indicated a significant main effect for group, $F\ (1,67) = 4.49$, $p < .05$. The agrarian group

TABLE 1

Means from dependent measure scores
for the agrarian and industrial groups

	AGRARIAN	INDUSTRIAL
Age	44.8 years	38.3 years
Weight	190 lbs.	182 lbs.
Height	70.2 in.	70.3 in.
DPCDH	23.1 cm	23.1 cm
DPCNDH	22.8 cm	22.9 cm
X1	13.1	14.0
X2	12.8	13.6
X3	10.2	10.8
X4	35.4	38.4
X5	30.3	32

Note: DPCDH=distal palmar crease of the dominant hand; DPCNDH=distal palmar crease of the non-dominant hand; X1=right hand placing; X2=left hand placing; X3=bilateral placing; X4=combined scores of right+left+bilateral placing; X5=assembly score.

TABLE 2

Summary of t-test result for group effects as a function of hand

Source of variance	df	Standard Error	t	p
Group				
(DH)	67	.271	.133	.89
Group				
(NDH)	67	.270	-.43	.67

Note: DH = dominant hand
NDH = non-dominant hand

performed the five Purdue Pegboard tests with an average score of 20.32 as compared to the industrial group with an average score of 21.76. Results also indicated a main effect for scores, $F (4,268) = 1341.59$, $p < .001$. This main effect was due to the fact that the five Purdue Pegboard scores differed from one another which is expected since the scores were measuring different capabilities. The interaction between group X scores was not significant (see Table 3 for a summary of ANOVA results).

Since results of the present experiment did not find differences between groups as a function of hand size, an additional analysis was performed using hand size as the independent variable. For this analysis hand size was separated into small and large using the mean score for the distal palmar crease of the dominant hand and taking one standard deviation above and below this mean. For example, the mean distal palmar crease of the dominant hand across groups was 23.1 cm, the standard deviation was 1.3 cm, the small hand size was determined to be less than 21.8 cm, similarly large hand size was determined to be greater than 24.4 cm. A 2(hand size) X 5(Purdue Pegboard scores) ANOVA was performed on this data. Results of this analysis indicated no significant main effects or interaction.

TABLE 3

Summary of 2 (Group) X 5 (Score) ANOVA

Source of Variance	df	Mean Square	F-Ratio	p
Group	1	145.48	4.49	.03
error	67	32.38		
Scores	4	9744.29	1341.59	.0001
error	268	7.26		
Group X score	4	14.21	1.96	.10
error	268	7.26		

Note: Group = Agrarian and Industrial
Score = Five Purdue pegboard scores

Discussion

The hands allow humans to manipulate and affect their own environment. The anatomical, physiological and neurological components of the hand produce movements such as grasp, and allow for sensations such as pain, to promote interaction and understanding of the world. The function of the hand to appropriately identify and manipulate objects is vital to the many jobs and everyday tasks performed by humans. The ability to carry and transport pipe is as important as the ability to type on a computer for some individuals. It is the occupation and interests of each individual that determines the hand movements necessary for successful interaction in the environment. When the systems of the hand are disrupted to the degree that interaction and manipulation using the hand are hindered, medical assistance and functional evaluation may be required.

Appropriate assessment of hand injuries is important to the treatment and rehabilitation process. Understanding how the individual uses their hands for work as well as leisure is as pertinent to the evaluation process as the assessment of actual anatomical, physiological and neurological systems that may be compromised by the injury. Standardized tests of coordination and dexterity provide helpful information on the abilities of a hand injured patient. It is critical that the test standards represent the population being tested to appropriately identify limitations. Agrarian populations are often not represented in the standards provided by coordination and dexterity assessments (i.e., Purdue Pegboard test).

The purpose of this study was to examine the coordination and dexterity of two different populations based upon occupation and hand size. The Purdue Pegboard was used due to is popularity as a fine-motor coordination test and availability of standards. The two different populations examined were agrarian and industrial participants. The agrarian population was selected due to the lack of standards available specifically targeting this group. There was also a concern that available standards were not appropriate or valid in the assessment of function for an agrarian population. Individuals involved in agrarian occupations predominantly perform gross grasp activities. An industrial population was selected for contrast due to the standards available for the assembly line type of workforce. An assembly line industrial population was also selected due to the propensity for highly specialized, fine-motor and repetitive job tasks performed in industrial settings.

It was hypothesized that the agrarian population would have significantly lower scores in performance on the Purdue Pegboard than the industrial population. This hypothesis was supported with the results indicating that the two populations, agrarian and industrial, differed in performance on the five Purdue Pegboard tests. The agrarian population performed worse than the industrial population on the Purdue Pegboard. A second hypothesis stated that there would be a significant difference for performance due to hand size, large handed individuals would demonstrate lower performances on the Purdue Pegboard test as compared to small handed individuals. This hypothesis was not supported. Results of the present study found that the two populations (agrarian and industrial) did not differ from one another as a function of hand size. A possible reason for the similarities in hand size may be that the job tasks performed by the industrial population more closely resembles that of the agrarian population (i.e., gross grasp assembly, rather than fine motor assembly). A final hypothesis stated that of the two populations tested, the agrarian group would be comprised of predominantly large handed individuals while the industrial group would be comprised of predominantly small handed individuals. This hypothesis was not supported as results indicated the agrarian and industrial population had similar hand size. In fact, the mean hand size of the dominant hand of each occupational group was not different.

Although the industrial subjects perform repetitive movements of the hands, the movements may be dominantly gross grasp versus fine-motor movement. To perform an examination of hand size effects on dexterity performance, an agrarian population may need to be viewed in contrast to a fine-motor assembly population in order to more accurately determine if hand size plays a role in coordination and dexterity. If the industrial population in this study performs gross grasp repetitive movements, the coordination required to perform the assembly line tasks may not differ enough from the everyday tasks of an agrarian worker to create a difference in hand size or be influenced by hand size. The performance of circuit board assemblers on the Purdue Pegboard test may provide greater difference in coordination skills as compared with an agrarian population. The greater disparity in hand tasks performed by occupational groups may provide more information on the influence of hand size on hand coordination performance.

Aside from the fact that neither group differed in performance based upon hand size, both groups scored well below the fiftieth percentile on any of the standards established for the Purdue Pegboard. Yet, the participants were able to function and perform the job duties assigned to them without having had any previous hand injury. If evaluation tools are used on an injured individual on which an uninjured individuals scores low, the performance of the injured participant may not be classified as a valid representation of limitations. It is of great concern to this researcher as to why so many of the subjects are performing low on the overall scale.

Tiffin and Asher(1948) admittedly note that the validity of any test depends on the situation. If an individual who is tested with the Purdue Pegboard does not perform a job represented by the standards provided by the Purdue Pegboard manual, that individual cannot be ranked or scored with any validity. There are no norms or standards established for an agrarian population. Therefore, these persons can be compared only to their own performance over time to examine improvement. The industrial participants also scored low based on the Purdue Pegboard standards. This again raises the concern as to whether the Purdue is appropriate for testing individuals who perform fine-motor work tasks only and whether the standards can be used only for those groups specifically identified in the Purdue Pegboard test manual.

Future studies in this area should consider increasing the number of subjects to allow for the examination of hand size two standard deviations from the mean above and below. Another consideration could involve the examination of gender differences in coordination and dexterity performance as well as hand size. An additional consideration, as previously mentioned is the examination of a fine-motor assembly population in comparison with an agrarian population.

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APPENDIX A

INFORMED CONSENT

I hereby give my consent for my participation in the project entitled: "A comparison of hand size with dexterity performance using the Purdue Pegboard" I understand that the persons responsible for this project are Adrienne Pearce-Lambert (telephone 784-1255) and Dr. L. Dornier (telephone 742-3371). Ms. Pearce-Lambert has explained that these studies are part of a project seeking to examine the effect of hand size on dexterity performance using the Purdue pegboard

Ms. Pearce-Lambert has (1) explained the procedures to be followed and identified those which are experimental; (2) described the attendant discomforts and risks; (3) described the benefits to be expected: and (4) described appropriate alternative procedures.

There are no known expected discomforts or risks involved in my participation in this study. It has been explained to me that the total duration of my participation will be less than 20 minutes; that only Ms. Pearce-Lambert and Dr. L. Dornier will have access to the identity of the subjects volunteering for this study; and that all data associated with this study will remain strictly confidential. The data gathered from the timing tasks will be used to determine if hand size effects performance using the Purdue pegboard.

Ms. Pearce-Lambert has agreed to answer any inquires I may have concerning the procedures and has informed me that I may contact the Texas Tech University Institutional Review Board for the Protection of Human Subjects by Writing them in care of the Office of Research Services, Texas Tech University, Lubbock, Texas, 79409, or by calling 742-3884.

If this research project causes any physical injury to participants in this project, treatment is not necessarily available at Texas Tech University or the Student Health Center, nor is there necessarily any insurance carried by the University or its personnel applicable to cover any such injury. Financial compensation for any such injury must be provided through the participant's own insurance program. Further information about these matters may be obtained from Dr. Donald R. Haragan, Vice President for Academic Affairs and Research, 742-2184, Room 108 Administration Building, Texas Tech University, Lubbock, Texas 79409.

I understand that I may not derive therapeutic treatment from participation in this study. I understand that I may discontinue this study at any time I choose without penalty.

Signature of subject ______________________________ Date ________

APPENDIX B

PURDUE PROJECT QUESTIONNAIRE

Note: Subjects should **NOT** have any history of previous hand injury that required medical intervention.

Information sheet

Name (optional): ________________ **Subject #:** ________

Hand dominance: ________

Verify No previous injury: ________

Age: ________ **Weight:** ________ **Height:** ________

Occupation:

 # hours/week of manual labor work:

Types of jobs typically performed in a day:

Girth measurements: (hand)

	dominant	non-dominant
DPC (distal palmer crease)		

Purdue pegboard scores: (recorded in seconds) Percentile

Right hand: _____, _____, _____ = _____ _____

Left hand: _____, _____, _____ = _____ _____

Both hands: _____, _____, _____ = _____ _____

Right + Left + Both: _____ _____ _____
(add the final scores)

Assembly: _____, _____, _____ = _____ _____

APPENDIX C

DIAGRAM OF PURDUE PEGBOARD

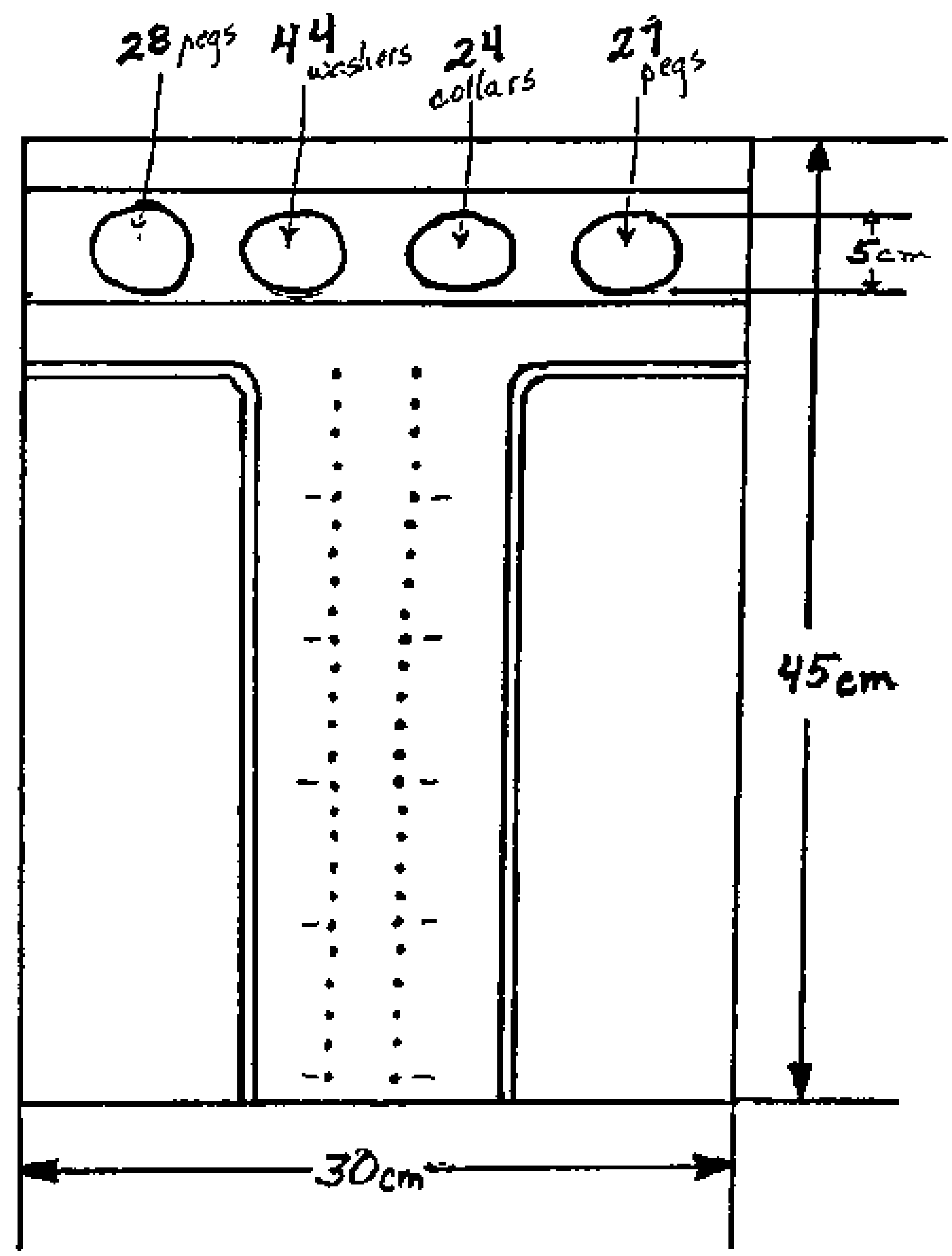

Figure 1. Diagram of Purdue Pegboard.

APPENDIX D

RAW DATA FOR THE AGRARIAN POPULATION

Table 4. Raw data for the agrarian population

SUB	AGE	WT	HT	HD	DPCDH	DPCNDH	X1	X2	X3	X4	X5
1	53	160	70	r	23.0	23.1	13.00	11.67	10.33	35.00	27.67
2	39	188	68	r	24.7	24.0	15.00	15.33	12.67	43.00	36.67
3	50	180	66	r	21.3	21.7	11.00	11.33	8.33	30.67	21.00
4	50	175	72	r	22.6	22.7	15.00	13.67	11.67	40.33	36.00
5	57	190	69	r	23.7	23.2	14.33	13.33	11.33	39.00	33.33
6	55	200	71	r	23.0	23.4	13.67	15.67	11.00	40.33	27.67
7	44	165	68	r	22.5	21.3	11.67	13.00	8.67	11.11	20.67
8	52	212	72	r	24.8	23.8	12.33	11.00	8.33	31.67	31.67
9	34	175	73	r	24.7	23.4	11.00	12.67	10.00	33.67	28.33
10	49	176	72	r	24.1	23.7	14.33	14.00	10.00	38.33	34.33
11	33	185	71	l	23.9	23.9	14.67	12.33	9.67	36.67	33.00
12	43	140	67	r	20.5	21.1	13.00	12.00	10.33	35.33	32.00
13	34	125	66	r	21.0	20.4	14.00	12.67	9.67	36.33	31.00
14	23	150	73	r	23.1	22.4	13.67	12.33	11.00	37.00	27.33
15	44	175	72	r	23.5	22.8	14.00	14.00	10.67	38.67	28.67
16	43	175	71	l	23.6	23.0	14.00	14.00	11.67	39.67	30.33
17	50	210	72	r	24.5	25.0	14.67	15.00	12.00	41.67	37.33
18	45	320	74	r	25.7	25.6	10.33	11.33	8.00	29.66	27.67
19	36	225	70	r	25.0	23.5	13.33	14.33	9.33	37.00	42.33
20	40	245	76	r	25.7	25.6	13.67	14.33	10.33	38.33	34.00
21	26	235	68	r	23.4	22.8	13.67	13.67	12.00	39.34	35.33
22	41	200	66	r	24.4	24.1	15.00	14.67	11.67	41.34	29.33
23	45	169	71	r	22.9	22.9	14.33	14.00	10.33	38.66	32.33
24	49	200	66	r	23.1	21.7	11.67	10.67	10.00	32.34	22.67
25	51	180	76	r	23.8	23.5	11.00	12.00	8.00	31.00	29.67
26	58	140	69	r	22.3	21.4	16.00	13.00	11.67	40.67	27.67
27	57	180	68	r	23.1	22.7	11.33	11.33	8.67	31.33	30.33
28	37	170	68	r	22.2	22.3	16.00	13.67	11.67	41.34	31.33
29	62	250	68	r	23.6	22.2	7.67	10.00	5.00	22.67	18.67
30	34	230	73	r	24.5	23.7	12.33	12.00	9.33	33.66	35.33
31	60	180	71	r	23.0	22.8	13.00	11.67	9.67	34.34	23.00
32	25	250	72	r	24.3	23.5	15.67	15.00	12.00	42.67	35.67
33	36	230	65	r	24.2	22.5	12.00	11.33	8.67	32.00	28.00
34	26	160	69	r	21.5	22.0	13.00	15.00	13.00	41.00	36.33

Table 4. CONTINUED

SUB	AGE	WT	HT	HD	DPCDH	DPCNDH	X1	X2	X3	X4	X5
35	41	185	71	r	22.1	21.8	13.00	12.33	10.00	35.33	29.33
36	35	145	67	r	21.5	20.8	15.00	14.33	12.00	31.33	38.33
37	58	175	73	r	22.2	22.1	13.00	12.67	10.00	35.67	26.00
38	54	205	71	r	24.5	23.8	11.00	11.67	10.33	33.00	32.33
39	50	205	69	r	23.0	22.5	11.33	10.67	9.33	31.33	29.00
40	55	180	71	r	22.0	22.1	11.33	11.33	8.67	31.33	26.33
41	55	195	74	r	23.0	23.1	11.33	12.00	9.33	32.66	31.67
42	49	220	71	r	23.9	23.3	11.33	12.00	8.67	32.00	28.67
43	37	150	72	r	21.5	21.6	13.67	12.67	10.33	36.67	26.67
44	46	156	71	r	21.6	21.3	12.67	11.33	9.33	33.33	26.67
45	61	175	68	r	22.5	22.5	13.67	13.33	10.00	37.00	32.67
46	52	225	71	r	24.9	24.9	13.67	13.33	10.67	37.67	25.33
47	43	218	77	r	23.8	22.8	12.00	11.33	10.00	33.33	23.67
48	34	140	61	r	19.8	19.6	16.67	14.67	12.67	43.67	39.33

WT = weight (lbs)
HT = height (inches)
HD = hand dominance (r=right, l=left)
DPCDH = distal palmar crease dominant hand
DPCNDH = distal palmar crease non-dominant hand
X1 = Right hand placing score
X2 = Left hand placing score
X3 = Bilateral placing score
X4 = Right + Left + Bilateral score
X5 = Assembly score

APPENDIX E

RAW DATA FOR THE INDUSTRIAL POPULATION

Table 5. Raw data for the industrial population

SUB	AGE	WT	HT	HD	DPCDH	DPCNDH	X1	X2	X3	X4	X5
1	42	180	70	r	22.1	21.9	15.33	15.33	12.33	42.99	43.00
2	42	178	71	r	23.9	23.9	14.33	13.33	10.33	37.99	27.33
3	26	180	64	r	23.3	23.2	11.67	13.00	8.67	33.34	34.33
4	33	140	68	r	22.3	22.5	14.67	14.00	12.67	41.34	35.67
5	19	130	70	r	20.0	19.8	15.67	14.33	11.00	41.00	39.67
6	48	187	76	r	22.2	22.3	14.67	14.00	11.67	40.34	32.67
7	35	175	70	r	23.2	23.0	13.67	11.33	9.33	34.33	29.33
8	31	200	73	r	23.8	23.9	12.00	13.00	9.67	34.67	30.00
9	37	196	71	r	24.2	23.9	13.67	13.67	10.00	37.34	29.00
10	39	140	65	r	21.7	21.4	15.00	13.33	11.67	40.00	34.33
11	53	190	69	r	24.8	24.4	14.33	13.33	9.33	36.99	25.33
12	23	165	71	r	22.5	22.1	15.33	13.67	11.67	40.67	39.33
13	50	210	70	r	23.4	23.4	13.33	14.00	9.00	36.33	31.00
14	47	190	72	r	25.5	24.5	14.33	12.33	10.33	36.99	24.33
15	32	160	72	r	21.6	20.9	16.67	15.33	12.33	44.33	43.00
16	46	210	74	r	24.0	23.5	13.33	12.67	10.33	36.33	22.33
17	32	205	69	r	23.6	23.6	13.33	15.00	11.33	39.66	25.67
18	51	145	71	l	23.0	22.5	14.00	14.67	12.33	41.00	41.33
19	34	205	68	r	23.1	22.5	14.33	13.00	11.67	39.00	29.33
20	46	235	70	r	24.5	24.5	13.33	13.33	11.33	37.99	31.67
21	38	200	72	r	23.5	23.8	11.67	12.33	10.33	34.33	23.00

WT = weight (lbs)
HT = height (inches)
HD = hand dominance (r=right, l=left)
DPCDH = distal palmar crease dominant hand
DPCNDH = distal palmar crease non-dominant hand
X1 = Right hand placing score
X2 = Left hand placing score
X3 = Bilateral placing score
X4 = Right + Left + Bilateral score
X5 = Assembly score