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Impact of Finger Position on Pinch Strength

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Impact of Finger Position on Pinch Strength

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A Research Project Submitted to the Graduate Faculty of the
Department of Occupational Therapy

GRAND VALLEY STATE UNIVERSITY

In

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Masters of Science

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Abstract

The purpose of this study was to assess for differences in the amount of tip, lateral, and three-jaw-chuck pinch force generated when fingers are placed on the groove or bridge of a B&L pinch gauge. Thirty-six healthy volunteers (9 males, 27 females), ages 19-49, participated in the study. Using a quantitative crossover design, each participant pinched six times: one for each type of pinch with fingers placed on the groove and bridge. Although no significant differences were found, results revealed slightly higher three-jaw-chuck and lateral pinch strength when fingers were placed on the groove, whereas tip pinch strength was slightly higher on the bridge. This study found that pinching on the bridge or groove may result in similar pinch strength measurements on a B&L pinch gauge. Based on these results, clinicians may guide clients to place fingers on either the bridge or groove during pinch strength assessment.

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Chapter One

Introduction

Functioning in society can be difficult with a disability, especially when the disability affects the hands. Functional use of the hand is essential for completing tasks in everyday life such as dressing, eating, and writing. Arthritis, which affects 49.9 million adults in the United States (Cheng, Hootman, Murphy, Langmaid, & Helmick, 2010), is one disability that impacts the use of the hand (Bagis, Sahin, Yapici, Cimen & Erdogan, 2003). These individuals, in addition to persons with conditions such as stroke, and hand injuries, may lack enough pinch force to complete daily activities (Ranganathan, Siemionow, Sahgal, & Yue, 2001). For example, in a study of 498 individuals who had received treatment for hand injuries within the four years preceding the study, 90% had reported residual deficits. Lifestyle adaptations included withdrawing from meaningful activities and changing professions to accommodate deformity or pain (Bell, Gray, & Kingston, 2010).

Hand function is often evaluated using grip and pinch strength. Pinch strength is measured using a pinch gauge. It is imperative that physical and occupational therapists (OTs) use accurate measures when assessing pinch strength. This includes consistent use of assessment tools among raters. The current study aims to improve accuracy by addressing finger placement on the pinch gauge during pinch strength measurements. This chapter provides an overview of the current study including background to the

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problem, problem statement, purpose, significance of the problem, research questions, and key concepts.

Background to the Problem

It has been found that hand strength and functional activities of daily living (ADLs) are directly correlated (Rajan, Premkumar, Rajkumar, & Richard, 2005). In this study, researchers found that “when hand strength increased, the ability to do the basic daily activities also increased” (p. 42). Additionally, minimum pinch forces needed to complete functional activities have been identified. For example, Rice, Leonard, and Carter (1998) found that a minimum pinch force of 2.23 lb was needed to access various containers. Pinch has also been correlated with return to work outcomes such as successfully returning to a prior job and resuming work within a reasonable time period (Chang, Wu, Lee, Guo, Chiu, 2010). The relation between pinch strength and function demonstrates the importance of hand strength in clinical practice.

Pinch strength is a key point of interest for OTs and physical therapists, especially those working specifically with hand injuries, because they are interested in preventing deformities and preserving functional performance (Poole, Watzlaf, & D’Amico 2004). Three different types of pinch are typically used in strength measurement: lateral, three-jaw-chuck, and tip pinches. The strength of these pinches is measured using a pinch gauge. Clinicians use pinch measurements to compare clients’ pinch strength with normative standards and document improvement or deterioration in a clients’ strength status (Mathiowetz et al., 1985). These data may help motivate clients to improve and can be used to characterize upper extremity strength impairment (Mathiowetz, Vizenor, & Melander, 2000). Additionally, they are used to record a baseline of hand strength,

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determine functional goals, and demonstrate industry research outcomes (Ranganathan, Siemionow, Sahgal, Liu, & Yue, 2001).

Regardless of the reason for measuring pinch strength, accurate and reliable pinch measurements are vital in determining and providing appropriate interventions (Mathiowetz, Weber, Volland, & Kashman, 1984). According to Lindstrom-Hazel, Kratt, & Bix, (2009), measurement variances may be due to: (a) not having one clinician re-test the same client for each consecutive measurement, (b) client fatigue, (c) non-adherence to American Society of Hand Therapists' (ASHT) recommendations for arm position, and (d) calibration of the gauge. The ASHT recommends positioning for the shoulder, elbow, forearm, and wrist (Mathiowetz et al., 1984). One question that seems to confound research, however, is whether or not pinch strength measurements vary depending on finger position on the pinch gauge. The problem may be due to how clinicians guide clients to place fingers on the pinch gauge versus calibration standards of the pinch gauge.

Bernadette and Linda (B&L) Engineering pinch gauges are calibrated with a digital force gauge by placing the pinch gauge (see Figure 1) into the force gauge at the groove (L. Barnes, personal communication, November 28, 2011). Therefore, the owner of B&L, Lee Barnes, recommends that clients place fingers on the groove of the pinch gauge (see Figure 2) when taking pinch measurements. Regardless of this recommendation, many clinicians feel that placing fingers and the thumb on the bridge of the gauge (see Figure 3) is a more natural position. Researchers in one study regarding the effect of forearm position on pinch strength recommended that the "pinch meter needs to be further standardized to be in the groove or on the bridge because the latter

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position is easier to accomplish clinically” (Stegink Jansen, Kocian Simper, Stuart, & Pinkerton, 2003, p. 336). Even when trying to pinch on the groove, it is difficult to keep fingers and the thumb from pressing the bridge. There were no studies found specifying the area of contact between the tip of the finger and thumb, but authors who presented illustrations of the test position showed that subjects pressed the bridge of the pinch meter rather than the groove (Stegink Jansen et al., 2003).

Figure 1. B&L Engineering pinch gauge

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Figure 2. Fingers on groove

Figure 3. Fingers on bridge

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Problem Statement

Inter-rater differences in scores can produce more than acceptable measurement errors (Edwards, Feightner, & Goldsmith, 1995); therefore, reliability between data collectors is vital. Sometimes more than one therapist takes measurements on the same patient at different points throughout the rehabilitation process and because pinch strength measurements are small, even small variations among therapists can largely impact pinch measurement scores (McCoy & Dekerlegand, 2011). It is important to establish inter-rater consistency when administering assessments to measure client progress, impairment, or baseline (Lindstrom-Hazel et al., 2009). Without a standard for finger placement on the pinch gauge, data may be unreliable and invalid.

Purpose/Aims

In this study, the investigators attempted to demonstrate a difference between pinch measurements obtained through finger placement on the bridge or groove of a B&L Engineering pinch gauge. Further, it was intended that this research demonstrate the need for industry standardization of finger placement on the bridge or groove of B&L Engineering pinch gauges for all pinch measurements (three-jaw-chuck, tip, and lateral pinch).

Significance of Problem

A significant difference between pinch strength measurements when fingers are placed on the bridge or groove of the pinch gauge would have implications for the OT profession. OT is a holistic and client-centered health profession focused on allowing individuals to complete meaningful activities as independently as possible. These meaningful activities, termed “occupations,” include leisure, play, work, rest and sleep,

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education, activities of daily living (ADL), instrumental activities of daily living (IADLs), and social participation (AOTA, 2008). This study pertains to the field of occupational therapy because minimum strength requirements have been identified for completing these occupations. Therefore, small differences in pinch strength due to non-standardized pinch strength assessment could determine whether an OT recommends returning to work, living independently, or continuing therapy.

As professionals, OTs and other healthcare providers who measure pinch strength must maintain their practice ethics by utilizing evidence-based practice to provide accurate information and meet the needs of their clients. Beneficence is one ethical guideline dictated in the Occupational Therapy Code of Ethics and Ethics Standards (Reed et al., 2010). Beneficence is the concern for the well-being and safety of individuals, and includes using evidence-based practice evaluation measures such as pinch strength assessment (Reed et al., 2010). If a difference between pinch strength due to finger placement had been found, researchers would have recommended industry standardization of finger placement during pinch strength evaluations to prevent inaccurate measurements. B&L Engineering would have been informed of the differences so that they could determine if industry calibration methods and user training should be altered.

Research Questions

The current researchers sought to answer the following questions:

- Is there a difference in lateral pinch strength when measured with fingers placed on the bridge versus the groove of a B&L Engineering pinch gauge?

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- Is there a difference in three-jaw-chuck pinch strength when measured with fingers placed on the bridge versus the groove of a B&L Engineering pinch gauge?
- Is there a difference in tip pinch strength when measured with fingers placed on the bridge versus the groove of a B&L Engineering pinch gauge?

Based on these research questions, the current study had three null hypotheses: (1) There is no significant difference in lateral pinch strength when measured with fingers placed on the bridge or groove of a B&L Engineering pinch gauge, (2) There is no significant difference in three-jaw-chuck pinch strength when measured with fingers placed on the bridge or groove of a B&L Engineering pinch gauge, and (3) There is no significant difference in tip pinch strength when measured with fingers placed on the bridge or groove of a B&L Engineering pinch gauge. These research questions introduce terms that may not be familiar to all readers.

Key Concepts

Key concepts are the traditional and operational definitions of terms relevant to the research questions. Several key concepts are significant in this study:

B&L Engineering pinch gauge: The “gold standard” for measuring the force of pinch (Mathiowetz et al., 2000). It is calibrated to measure pounds and kilograms, and is a certified medical device in the United States and Europe (L. Barnes, personal communication, November 28, 2011). It also has “high test-retest and very high inter-rater reliability” (Mathiowetz et al., 2000).

Finger placement: The interface point between the fingers and the B&L Engineering pinch gauge in either the groove or bridge (Stegink Jansen et al., 2003). The groove is

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the concave area located on the distal aspect of the pinch gauge, while the bridge is the convex area located on the proximal aspect of the pinch gauge (Mathiowetz et al., 1985).

Outcome score: The number that the pinch gauge reads (pounds versus kilograms).

Traditionally, OTs use “the first, highest, or mean of three trials” as outcome scores in clinical settings (Stegink Jansen et al., 2003, p. 326). In this study, the first outcome score was used.

Pinch: A type of prehension pattern that uses two or three fingers (Casanova & Grunert, 1989). Three types of pinch positions are commonly assessed: three-jaw-chuck, tip pinch, and lateral pinch. Three-jaw-chuck pinch, also known as three-point pinch and palmar pinch, is defined as thumb pad to the pads of the index and middle fingers and is used when picking up a block. Tip pinch, also known as two-point pinch, is defined as thumb tip to index fingertip and is used when threading a needle. Lateral pinch, also known as key pinch, is defined as the thumb pad to the lateral aspect of the index finger and is used while turning a key (Mathiowetz et al, 1985; Casanova & Grunert, 1989).

Pinch strength: The measurable ability to exert force with the fingers (Mathiowetz et al., 1985). The ASHT positioning recommendations for measuring pinch strength were used: The patient was seated with his or her shoulder adducted and neutrally rotated, elbow flexed at 90°, forearm in neutral position, wrist in neutral position between 0-30° of extension and 0-15° of ulnar deviation, and feet flat on the floor (Allen & Barnett, 2011). Furthermore, the ulnar three digits were in the flexed position during tip pinch strength testing (McCoy & Dekerlegand, 2011) and the interphalangeal (IP) of the thumb was flexed (Apfel, 1986).

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Reliability: This indicates the ability of the assessment tool to measure dependably and predictably (Fess, 1986).

Validity: This indicates the truthfulness of the tool, meaning that the assessment tool measures what it is intended to measure (Fess, 1986).

Summary

In OT, pinch strength is one objective measurement of hand strength and provides evidence for determining functional improvements in the clinical setting. The ASHT has provided specific positioning guidelines for assessing pinch strength; however, recommendations for finger placement positioning on the groove or bridge of the B&L Engineering pinch gauge were not included. Despite the lack of standardization in pinch strength measurement, the B&L Engineering company calibrates the pinch gauge in the groove. Therefore, when measuring pinch strength, B&L recommends positioning fingers on the groove rather than the bridge of the pinch gauge.

The purpose of the current study was to determine if there is a significant difference between pinch measurements depending on finger placement, and to contribute to the standardization of positioning during pinch strength measurement. More specifically, the current study attempted to answer the research questions regarding the difference in lateral, three-jaw-chuck, and tip pinch strengths when measured with fingers placed on the bridge versus groove of a B&L pinch gauge. With findings from this study, the researchers hope to add to existing literature. In Chapters Two, Three, Four, and Five the study will be described in greater depth. More specifically, a review of the literature, overview of methodology, presentation of results, and discussion of findings will be discussed in the following chapters.

Chapter Two:

Literature Review

Introduction

Chapter One provided an overview of the study including background, problem, purpose, significance, research questions, and key concepts. The purpose of this chapter is to review the relevant literature for this study. Topics include forces and anatomy of the human hand, factors affecting pinch strength, the relation between pinch and function, connection to OT, reliability and validity of pinch strength measurement, and positioning during pinch strength evaluation. The researchers were able to identify gaps in the literature, demonstrating the need for the current study. Databases utilized to obtain relevant research include: CINAHL, EBSCOhost, Google Scholar, Grand Valley State University Summons, and PubMed.

Review of the Literature

The human hand.

Basic Anatomy.

The human hand is comprised of components that allow individuals to interact with the environment during tip, lateral, and three-jaw-chuck pinches. During tip pinch, the tips of the thumb and index finger meet. In the thumb, the carpometacarpal (CMC) joint is slightly flexed, while the metacarpalphalangeal (MCP) and IP joints are extended. The CMC joint is also in slight palmar abduction. Abductor pollicis brevis, opponens pollicis, the first dorsal interosseus, flexor pollicis brevis, abductor pollicis, and adductor pollicis work together to create smooth movements in the thumb (Brand, 1999). The index finger is flexed at the MCP, proximal interphalangeal (PIP), and distal

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interphalangeal (DIP) joints. The MCP is flexed by the lumbricals as well as the dorsal and palmar interossei. The PIP and DIP joints are flexed by flexor digitorum superficialis and flexor digitorum profundus (Brand, 1999). These same muscles are used to simultaneously flex digits three, four, and five.

The two remaining pinch types vary slightly from tip pinch. During lateral pinch, the index finger flexes more than during tip pinch, and the thumb is in a neutral or adducted position instead of abducted at the CMC joint. Flexor digitorum profundus flexes the IP and DIP of the second digit until the tip of the finger rests on the palm, just distal to the thenar eminence (Brand, 1999). In three-jaw-chuck, the thumb and second digit resume the position of tip pinch, and the third digit extends slightly from a fist position to rest alongside the index finger on the thumb. The DIP joints of digits two and three extend depending on the level of force used in pinch. Throughout lateral and three-jaw-chuck pinch, the wrist may fall into slight ulnar deviation and extension through contraction of extensor carpi ulnaris (Cooper, 2007). Throughout tip, lateral, and three-jaw-chuck pinch, lumbricals as well as palmar and dorsal interossei assist as a group to flex the MCP joints of digits two through five. Contractions of the interossei are noted during adduction of the second and third digits during three-jaw-chuck (Brand, 1999). The median, ulnar, and radial nerves must innervate the hand to complete all three pinch positions (Cooper, 2007).

Forces.

Review of the literature revealed themes of visual feedback, surface materials, and friction as the primary effects on forces applied by the hand during pinch. One three-part experiment found that visual feedback may not be necessary to determine

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appropriate use of force in manipulating objects during tip pinch (Di Luca, 2011). In his experiments, right handed participants were prevented from seeing the objects they were asked to manipulate. They were then asked to identify the perceived compliability, otherwise known as malleability, of objects. Test subjects were not informed of the study's purpose. All subjects were paid recruits from a research institute database. Results showed that sensory information was gathered through multiple sources during pinch; however, perception of object compliability was primarily determined by the index finger rather than the thumb or vision.

In her 2009 study, Seo attempted to show product developers how altering materials and structure affects user safety during daily activities. She looked at safety margins for maximum pinch force using the Mathiowetz et al. (1985) figure averaging 14.6 lb. This contrasts with recent research that placed daily pinch force in the .22 to 4.5 lb range (Seo, 2009). Seo had participants squeeze a test instrument at five force levels (100%, 80%, 60%, 40%, and 20%) using lateral pinch. Participants were guided in achieving these force levels through visual feedback on a computer screen. Seo found that the average push force in lateral pinch was 7.42 lb on aluminum surfaces, and 13.7 lb on rubberized surfaces. She used different test positions in comparison to other studies. This research demonstrated that altering the surface of the material could alter one's ability to use common tools with aluminum surfaces based on one's maximum pinch strength. Clinical implications include addressing client safety margins and pinch grip force deficits before making recommendations. Results were limited because the researcher did not consistently follow ASHT guidelines (Mathiowetz et al., 1984).

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This study also only addressed lateral pinch. Both limitations reduce generalizability and restrict comparison of the study to other studies.

Multiple studies found many characteristics of the hand to have an effect on force applied during tip and lateral pinch. These characteristics include skin stiffness, thickness of papillary ridges, and direction of force on the finger (Seo, 2009). Internal forces placed on muscles, tendons, and joints, as well as thumb stability during pinch, may also affect the force applied during functional pinch (Cooney & Chao, 1977). The size of the object being manipulated has also been found to affect the force applied by individual fingers during grip strength assessments (Lee, Kong, Lowe, & Song, 2009). In this particular study, participant grip strength was assessed using instruments with grip spans of 45 mm to 65 mm (testing at 5 mm increments). Whole hand grip strength and isolated finger forces were identified, with small hand size and 45 mm grip span instruments producing the greatest force. Large hands had the greatest force on 50 mm grip spans, and the lowest hand strength for all groups was found with the 65 mm grip span. A major critique of this study was that although researchers identified individual finger forces during grip strength, they overlooked application of finger force data to functional tool development relative to pinch.

Factors influencing pinch strength.

Significant research has been conducted over many years to determine factors that affect pinch strength measurements. Demographics such as age, gender, height, and weight, as well as biological and environmental elements have been addressed. It is important to realize that multiple elements may influence an individual's pinch strength measurement.

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Research on hand dominance and the impact on pinch strength has been inconclusive. One study addressed tip pinch in relation to pinch strength using 149 healthy volunteers; 128 were right hand dominant and 21 were left hand dominant (Incel, Ceceli, Durukan, Erdem, & Yorgancioglu, 2002). The researchers utilized a manual pinch meter to measure tip pinch three times on each hand. Results indicated significantly larger pinch strength values on the dominant side; however, 28.19% of the subjects were found to have equal or larger pinch strength values with the non-dominant hand. Similarly, Bechtol (1954) concluded that the dominant hand may be 30% stronger than the non-dominant hand. In contrast, Swanson, Matev, and de Groot (1970) concluded there may not be as large of a difference due to hand dominance as was once thought because their research resulted in only a 4-6% weaker non-dominant hand among the 100 participants. Bechtol only tested tip and lateral pinch and his conclusion was based on grip measurements in addition to pinch measurements. Many confounding variables were present in the Swanson et al. study including difference in type of work. All three studies were limited by a small left hand dominant population and non-adherence to ASHT positioning recommendations (Mathiowetz et al., 1984).

Multiple studies have been conducted in which gender and age have proven to be factors that influence pinch strength measurements. In 1996, Dempsey and Ayoub studied the relationship between sex and pinch. The researchers studied lateral, three-jaw-chuck, and tip pinch. Only 16 participants (eight male and eight female) were tested in this study and many confounding variables may have influenced the difference between genders. Results indicated a significant main effect ($F=10.80$) for gender. Females tended to be 37.1% weaker than their male counterparts, which is similar to

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previous research done by Imrhan and Loo (1989) and Hallbeck and McMullin (1993). More recently, Puh (2010) found all values of lateral, tip, and three-jaw-chuck pinch measurements to be lower for females than for males. This researcher also found a curvilinear pattern in pinch strength measurements according to age, meaning that pinch strength increases, peaks, and then declines with age. Some researchers have reported no changes in functional use of the hand until after 65 years of age (Carmeli, Patish, & Coleman, 2003); however, Puh (2010) did not agree with that finding. Participants consisted of healthy individuals who were not randomly selected. Additionally, only one participant was left hand dominant. Of these studies, Dempsey and Ayoub (1996) followed ASHT positioning standards (Mathiowetz et al., 1984) except for the wrist positions, and Puh (2010) followed all positioning guidelines. These elements may limit the generalizability of these research findings.

Occupation is another factor that has been shown to influence pinch strength. One study addressed the differences between non-manual, light manual, and heavy manual workers (Josty, Tyler, Shewell, & Roberts, 1997). Participants included 34 office workers (non-manual), 38 car garage workers (light manual), and 32 farmers (heavy manual). The researchers did not specify the type of pinch measured and they did not determine what type of work fit into each category. They also only studied right hand dominant males who volunteered. These researchers followed ASHT positioning recommendations (Mathiowetz et al., 1984) when measuring pinch strength. Results indicated significant differences in pinch strength between right and left hands according to groups. Office workers showed the weakest grip and largest variance between hands. This finding is consistent with another study in which occupational activity, separated

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into six categories, was found to be a predictor of grip and pinch strength measurements (Angst, Drerup, Werle, Herren, Simmen, & Goldhahn, 2010). Major limiting factors in this study were the lack of participants reporting very high occupational demands, lack of left hand dominant subjects, and the subjective manner in which participants were categorized. These researchers also did not follow ASHT positioning recommendations (Mathiowetz et al., 1984).

Disability and biological changes may be the most significant factors that influence pinch strength measurements. Bagis et al., (2003) found significant lower grip and pinch strength measurements among participants with osteoarthritis compared with healthy controls. Participants in the study included 170 postmenopausal women with osteoarthritis and 70 females without osteoarthritis. The 70 controls were matched according to age and weight. These researchers did not address the type of pinch studied, forearm and wrist position during pinch strength testing, or sex-related factors. The effect of menopause was also not addressed in this study, and according to Kurina et al. (2004), menopause is a factor that decreases pinch strength.

Function and pinch strength.

Functional use of the hand is essential for a person to participate and perform a variety of purposeful activities and occupations necessary for daily life. For instance, three-jaw-chuck pinch is used when tying a tie; tip pinch is used when threading a needle; and lateral pinch is used when inserting a card into an ATM. The thumb provides 40% of overall hand function; therefore, it is the most significant digit contributing to the pinch function of the hand (Emerson, Krizek, & Greenwald, 1996). Impairment or aging can negatively impact functional use of the hand because of decreased muscle mass, strength,

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coordination, finger dexterity, hand sensation (Ranganathan et al., 2001), and joint stability (Carmeli et al., 2003).

Several studies have been conducted to investigate the relationship between pinch strength and daily functioning. Bagis et al. (2003) found that individuals with hand osteoarthritis often have problems with hand function as well as decreased pinch strength. However, this study did not specify the type of pinch used, nor did it examine a direct relationship between the two variables. A study by Incel, Sezgin, As, Cimen, and Sahin (2009) aimed to document the association between hand-muscle function and activity restriction in a geriatric sample using tip pinch measurements and six questionnaires. Results revealed a strong relationship between pinch strength measurements and the Duruoz and Dreiser questionnaires, which were strongly correlated with instrumental activities of daily living (IADLs) and quality of life. These findings are also compatible with a study by Bruyns et al. (2003) which found that tip pinch strength was a predictor of return to work in patients with combined ulnar and median nerve impairment.

Two studies have examined the direct correlation between pinch strength (tip, lateral, and three-jaw-chuck) and 12 ADLs. ADLs included picking up food with the fingers, combing hair, cutting nails, fastening buttons, holding soap, using the tap, cleaning self after toilet, handling money, and manipulating lids. In a sample of 62 patients with leprosy, Rajkumar and colleagues (2002) found that three-jaw-chuck was the only pinch type significantly correlated with ADLs. As three-jaw-chuck strength increased, the ability to perform ADLs also increased. Rajan et al. (2005) conducted a similar study with a sample consisting of 62 individuals with ulnar and median nerve impairment. Ulnar nerve impairment as well as combined ulnar and median nerve

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impairment reduced performance in ADLs by 45% and 60% respectively. For each pinch type, it was also found that as strength increased, the ability to do ADLs also increased. This effect was only significant for the dominant hand, however. One limitation of this study was that it only concentrated on loss of motor function and ignored the relationship between loss of sensation, pinch, and function.

Pinch strength has also been associated with function in studies that have identified certain pinch forces needed to complete functional activities. Smaby et al. (2004) established target lateral pinch forces necessary to accomplish ADLs requiring lateral pinch. In 14 individuals with spinal cord injury, pinch strength and ability to perform six ADL tasks were recorded. ADL tasks included opening and closing zippers; manipulating plugs, keys, and an ATM; picking up food with a fork; and using a remote control. A robot arm, equipped with a force sensor, measured the forces applied to objects while completing the tasks. Pinch forces were found to range from 0.3 lb to 7.1 lb, with a majority of tasks requiring 2.3 lb or less. Using this criterion, 81.1% of subjects' ADL task performance was correctly predicted. Smaby et al. (2004) suggested that poor positioning of the thumb, or poorly directed thumb force, could account for incorrect predictions of people who should have been able to do a task, but could not. One limitation of this study was that target pinch force requirements were conservatively defined by adding two standard deviations to the mean force measured by the robot; therefore, force requirements were likely overestimated. Additionally, investigators were unable to detect if participants used adaptive strategies. This may have altered the findings because the model for converting the object force to key pinch force assumed that participants utilized a pure key pinch.

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In a similar study, Rice et al. (1998) measured the forces required to open six common household containers using force sensing resistors. Pinch force values used while accessing the containers ranged from 2.23 lb to 12.67 lb. Overall, a weak relationship exists among tip, lateral, and three-jaw-chuck strength and the forces used when accessing the containers was found. The correlation between tip pinch measurement and the ability to open the bottle with a pop-off lid was the only significant relationship. However, the study cannot generalize this relationship to other age groups or those individuals with impairment because the sample was limited to normal college students.

As a follow-up to Rice and his colleagues (1998), Rahman, Thomas, and Rice (2002) examined the relationship between pinch strength and forces used to open containers in healthy, elderly persons. Pinch forces used while accessing the containers ranged from 2.19 lb to 9.76 lb. Several correlations between tip, lateral, and three-jaw-chuck pinch strength and forces used to open containers were significant, with the highest correlations between the lateral and three-jaw-chuck pinch strengths and the force used to open the dual-pinch safety squeeze bottle. Regardless of significance, it was concluded that only a fair relationship exists between pinch strength and the amount of force participants used to open containers. In comparison, the correlations were larger for the well elderly participants than for their younger counterparts. The geriatric individuals also had lower pinch strength measurements for all three types of pinch compared to the younger participants. This finding suggests that the relationship between pinch strength and function strengthens as the degree of hand weakness and impairment increases.

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Another important finding was that the elderly individuals appeared to use a greater proportion of their available strength than their younger counterparts to access the containers. The same relationship was found for grip strength in individuals with hand osteoarthritis (Guimaraes de Oliveira, Nunes, Aruin, & Jose dos Santos, 2011). However, conclusions were limited by an exclusively female sample and lack of data on degree of joint and finger deformities. These findings suggest that in order for individuals with hand impairment to successfully perform functional ADLs, they will require a maximum voluntary pinch strength measurement higher than the minimum force requirements necessary for the tasks. Similar limitations were found for the Rice et al. (1998) and Rahman et al. (2002) studies. While the sensors were found reliable for measuring static forces, they were not designed for measuring the dynamic forces generated by the human hand. Additionally, the presence of sensors may have made it difficult to hold the containers using a natural grasp.

Connection to occupational therapy.

The biomechanical frame of reference is the theoretical framework used as a basis for this study. Recent OT graduates identified this frame as the most frequently used theory in practice (NBCOT, 2004). The biomechanical frame of reference applies principles of physics, such as the forces of gravity, to movement and posture (Cole & Tufano, 2008). Various healthcare professionals use the biomechanical approach to improve function in individuals who have limitations in strength, range of motion (ROM), or endurance. Evaluation includes goniometry for ROM; manual muscle testing, dynamometry, and a pinch gauge for strength; and duration of activity for endurance

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(Cole & Tufano, 2008). In OT, the biomechanical principles must be applied to a client's engagement in the occupations of everyday life.

The biomechanical frame of reference is especially relevant for OT practitioners. According to the Occupational Therapy Practice Framework: Domain and Process 2nd edition (2008), strength, ROM, and endurance are client factors referred to as body functions. These neuromusculoskeletal and movement-related functions may affect performance in all areas of occupations including ADLs, IADLs, rest and sleep, education, work, play, leisure, and social participation. Since the aim of this frame is to improve strength, ROM, and endurance, it is also compatible with remediation, an occupational intervention approach. Areas of practice using this frame of reference include musculoskeletal disorders; cumulative trauma, such as back injuries or carpal tunnel syndrome; work hardening; hand injuries; ergonomics; and prevention (Cole & Tufano, 2008).

The biomechanical frame of reference serves as an appropriate model for this study because the researchers are studying strength, a major component of the frame. By addressing the reliability of a pinch strength evaluation, this study aims to add to the existing literature supporting the use of biomechanical assessment. In the future, the American Occupational Therapy Association (2007) envisions an improvement in the use of evidence-based practice within the OT profession. Objective and reliable evaluation, such as the pinch strength measurement, will contribute to this vision by providing evidence to inform clinical practice and a means with which to test the effectiveness of various biomechanical and occupation-based interventions.

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Measurement.

A pinch gauge is a quantitative assessment tool. According to Fess (1986), “quantitative measurement allows delineation of baseline pathology, prediction of rehabilitation potential, planning and evaluation of treatment programs, and definition of final functional capacity when rehabilitation efforts reach an end point” (p. 621). Pinch strength measurements are taken using a pinch gauge and there are many types of pinch gauges. In choosing a pinch gauge, important elements to consider are reliability, validity, and established norms (Fess, 1986). Research to access these elements has been conducted on many different pinch gauges, including the B&L Engineering pinch gauge.

The B&L Engineering pinch gauge is considered the “gold standard” when measuring pinch strength (Mathiowetz et al., 2000). One study tested the reliability and validity of hand strength measurement tools. Mathiowetz et al. (1984) used two B&L Engineering pinch gauges to test lateral, tip, and three-jaw-chuck pinches. Two different examiners tested each pinch three times, one week apart. Results indicated high inter-rater reliability, with a correlation coefficient of at least .97. Results also indicated high test-retest reliability, as the mean of three trials for each pinch showed correlation coefficients of at least .80. To test validity of the pinch gauges, these researchers hung known weights on the groove of B&L Engineering and Preston pinch gauges. The B&L Engineering pinch gauge was proven to be most valid, with accuracy at +/- 1%. One major limitation of this study included the limited population: 27 female OT students at the University of Wisconsin-Milwaukee.

In a similar study, MacDermid, Kramer, Woodbury, MacFarlane, and Roth (1994) tested inter-rater reliability of the B&L Engineering pinch gauge on 38 volunteers with

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cumulative trauma disorder. Each subject's lateral, tip, and three-jaw-chuck pinch strength measurements were taken by two different testers on the same day. Both testers were experienced and took the measurements with the subjects positioned according to ASHT recommendations (Mathiowetz et al., 1984). The researchers found very high reliability coefficients (.87 and higher). They stated, "inter-rater reliability was almost perfect" (MacDermid et al., 1994, p. 13). This study was limited by a nonrandom sample and pinch measurements taken on the same day.

Another recent study attempted to address concurrent validity and inter-instrument reliability between the B&L Engineering pinch gauge and two Baseline pinch gauges (Mathiowetz et al., 2000). According to these researchers, the Baseline pinch gauges were designed to produce measurements equivalent with the B&L gauge. However, results from this study indicated large differences between the B&L pinch gauge and both Baseline gauges. Although this study was not designed to test which gauge was more accurate, findings revealed that gauges should not be interchanged. Therefore, only B&L Engineering pinch gauge measurements should be compared with normative data that is collected with a B&L pinch gauge.

Clinically, pinch measurements have no meaning unless normative data is available to compare the measurements. In 1984, Mathiowetz and his colleagues studied a total of 628 people, ages 20 to 94. All the participants were from the greater Milwaukee area. The participants were positioned according to ASHT recommendations (Mathiowetz et al., 1984) and lateral, tip, and three-jaw-chuck pinches were measured. The mean of three trials was used, with each measurement taken three times. Results of this study indicated norms for pinch measurements using the B&L Engineering pinch

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gauge. Measurements were divided by 12 age groups, sex, and right or left hand. Results also indicated that men have more hand strength than women, and that age can impact hand strength. In similar study, British researchers Gilbertson and Barber-Lomax (1994) developed normative data that were comparable to American norms. However, normative pinch strength data for the British population studied was overall lower than the American data, demonstrating the importance of utilizing normative data for the appropriate population. Both studies discuss similar limitations. Neither set of normative data describes the difference in pinch strength between dominant and non-dominant hands and neither sample was randomly selected. Both studies also suggest that the population studied may not be representative of the entire population. Difficulty placing fingers in the correct position on the pinch gauges due to large fingers and long fingernails were noted in the British and American studies, respectively.

Positioning.

Position of the upper extremity during hand strength measurement has been a topic of discussion for decades. In 1981, the ASHT published suggested norms for arm position during grip strength tests. Fess and Moran recommended, “the patient should be seated with his shoulder adducted and neutrally rotated, the elbow flexed to 90°, and the forearm and wrist in neutral position” (as cited in Mathiowetz et al., 1984, p. 222). These recommendations were meant to be used with grip strength measurements (Stegink Jansen et al., 2003); however, it has been recommended that the same arm positioning is used in measuring pinch strength (Mathiowetz et al., 1984). In the last 30 years, research has been conducted to validate these recommendations and develop additional standards.

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One two-part study attempted to address the effect of arm and wrist positioning on peak pinch strength measurements (Halpern & Fernandez, 1996). The first part of the study examined shoulder and elbow positions. In this experiment there were 35 different combinations of shoulder and elbow positions. The shoulder positions included flexion from neutral at 0, 30, 60, 90, 120, 150, and 180 degrees. The elbow positions included flexion from neutral at 0, 30, 60, 90, and 120 degrees. Results indicated no effect of shoulder position on pinch strength measurements, but a large effect of elbow position on pinch strength measurements. Small variations in pinch strength occurred when the elbow was flexed anywhere from 0 to 90 degrees, but large decreases in the measurements occurred when the elbow was flexed 120 degrees or more. This study only examined three-jaw-chuck pinch measurements; therefore, results could differ with other types of pinches.

The second part of Halpern and Fernandez's (1996) study examined forearm and wrist positions. This experiment included 27 combinations involving three different pinches (lateral, tip, and three-jaw-chuck), three forearm positions, and three wrist positions. Results of this study indicated that for all three types of pinch, maximum flexion and extension of the wrist resulted in decreased pinch strength measurements. The pronated forearm position also showed decreased pinch strength measurements (up to 7%), as compared with supinated and neutral forearm positions. A small (20), nonrandom sample, consisting of healthy males between the ages of 20 and 34 years old limited both parts of the Halpern and Fernandez (1996) study. The researchers also did not address whether all other ASHT positioning recommendations (Mathiowetz et al., 1984) were followed.

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Although the ASHT recommends the forearm be in a neutral position when being tested (Mathiowetz et al., 1984), research has been inconclusive as to whether forearm position actually affects pinch strength measurements. Stegink Jansen et al. (2003) researched the effect of three forearm positions on lateral, tip, and three-jaw-chuck pinch measurements. Using a B&L Engineering pinch gauge, these researchers evaluated pinch measurement with the forearm in supinated, pronated, and neutral positions. ASHT shoulder and elbow positioning recommendations (Mathiowetz et al., 1984) were followed. This study agreed with an earlier study by Woody and Mathiowetz (1988), which found that forearm position did not affect three-jaw-chuck pinch measurements. Unlike those researchers and Halpern and Fernandez (1996), Stegink Jansen and her colleagues (2003) found differences in lateral and tip pinch measurements between the different forearm positions. They found measurements of lateral pinch to be lowest in the supinated position, while tip pinch measurements were lowest when the forearm was pronated. Although these differences were noted, none of the differences were found to be statistically significant (largest effect size .144). The researchers used these findings to suggest that “standardization of forearm position is recommended when measuring pinch strength, but not required” (Stegink Jansen et al., 2003, p. 335). They also suggested that the lack of standardization regarding finger placement, on the bridge or groove of a B&L Engineering pinch gauge, could impact results of both their study and previous studies conducted by others. Stegink Jansen and her colleagues used a nonrandom sample of convenience and only tested the B&L Engineering pinch gauge; therefore, the results may not be applicable to other pinch gauges.

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In 1972, Kraft and Detels studied the effect of position on function of the wrist. In this study, the researchers evaluated five functional tasks, along with two strength tests: grip and pinch. Different splints were made to hold the wrist in four different positions: 15 degrees flexion, neutral, 15 degrees extension, and 30 degrees extension. Results indicated no significant differences in pinch strength measurements when the wrist was positioned in neutral, 15 degrees extension, or 30 degrees extension. However, when the wrist was flexed to 15 degrees, the pinch strength measurement was approximately two pounds less than the other three angles. The researchers also indicated 15 degrees flexion “as an undesirable angle in a number of tasks” (Kraft & Detels, 1972, p. 274). There were many limitations to this study. All 20 subjects were healthy volunteers and were right hand dominant. It is also possible that the splints limited carpal metacarpal joint movement. With the exception of the wrist, the article did not address position during pinch strength measurement. Additionally, the researchers did not address how many times pinch measurements were taken, order of pinch, or type of pinch used.

Although little research has been done on the effect of finger position on pinch strength measurements, one study researched the effect of the position of the three ulnar fingers during tip pinch. McCoy and Dekerlegand (2011) addressed the lack of standardization for positioning of the three digits. These researchers suggested that lack of standardization could greatly impact pinch strength measurements because the values are small, so even small differences could largely impact pinch measurement scores. This study evaluated 76 healthy volunteers; 89% were right hand dominant and the remaining 11% were left hand dominant. The participants were not randomly selected

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and were all healthy individuals, which may have impacted the outcomes. Results indicated that tip pinch measurements significantly varied with both hands depending on whether the three ulnar fingers were flexed or extended. In this study, pinch strength measurements were larger when the fingers were flexed, which agreed with findings by Hook and Stanley (1986). Unlike Hook and Stanley, McCoy and Dekerlegand (2011) did not address whether all ASHT positioning recommendations (Mathiowetz et al., 1984) were followed during the testing process. McCoy and Dekerlegand (2011) recommended establishing a standardized testing position; however this standard has not been implemented.

One study has been conducted to determine if thumb position effects lateral pinch measurements (Apfel, 1986). This study examined two IP joint positions, flexed or extended. Participants included 19 females and 12 males with varying occupations. Subjects were asked to spontaneously grab the pinch gauge (IP joint flexed or extended), and one pinch measurement set was taken. A second measurement set was taken, in which subjects grasped the gauge in the alternate position. Most participants spontaneously pinched the gauge with the IP joint flexed. Findings included significant differences in pinch strength measurements depending on IP joint position when all ASHT positioning standards (Mathiowetz et al., 1984) were followed. For females, IP joint flexion showed a 28-30% increase in measurements as compared to IP joint extension measurements. Males showed a 36-38% increase in measurements when the IP joint was flexed. This study only addressed IP joint position with lateral pinch. Subjects were all normal participants, so this information may not be generalizable to those with hand injuries or impairments.

Chapter Summary and Implications

Past literature regarding pinch strength measurements focused on a wide variety of factors that affect pinch strength measurements, the reliability and validity of the pinch gauge, the relationship between pinch strength and function, and positioning recommendations. This literature review has revealed dated research involving small sample sizes with normal subjects. Suggestions for future research broadly focused on conducting larger studies that are more current and include clinically relevant populations, such as those with hand impairment.

While past research regarding positioning during strength measurements is valuable, it does not provide a standard testing position specific to pinch strength. Several studies have provided recommendations for standardizing pinch strength positioning independent of grip strength; however, positioning the finger on the bridge or the groove of the pinch gauge has not been carefully described. No studies specifying the area of contact on the pinch gauge between the fingers and thumb were found, but illustrations of test positions revealed that subjects pressed the bridge of the pinch gauge rather than the groove. This contradicts B&L Engineering company's recommendation to position fingers on the groove because the pinch gauge is calibrated in the groove (L. Barnes, personal communication, November 28, 2011). The current study determined if this discrepancy is clinically relevant and possibly introduce finger positioning recommendations.

This chapter provided a review of the literature involving the human hand, factors affecting pinch strength, the relation between pinch and function, and positioning during pinch strength evaluation. This chapter also applied the study to the field of OT using the

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biomechanical frame of reference and OT practice framework. Lastly, this chapter reviewed the reliability and validity of pinch strength measurement procedures using a B&L pinch gauge. Next, Chapters Three, Four, and Five will address the study design and procedures, analysis and findings, and discussion of the results, respectively.

Chapter Three:

Methodology

Introduction

Chapter One provided an overview of the study including background, problem statement, significance, research questions, and key concepts. Additionally, the overall purpose of the study was discussed in Chapter One: to determine if there is a difference in tip, lateral, and three-jaw-chuck pinch strength measurements when fingers are placed in the groove or on the bridge of a B&L pinch gauge. Chapter Two discussed the findings of the literature review conducted on the following topics: forces and anatomy of the human hand, factors affecting pinch strength, the relation between pinch and function, positioning during pinch strength evaluation, reliability and validity of pinch strength measurement, and the connection to OT through the biomechanical frame of reference and Occupational Therapy Practice Framework (AOTA, 2008). This chapter will discuss the methods used to conduct the present study, including study design and rationale, data analysis, location and context, participants and sampling methods, instrumentation and materials, validity and reliability of testing processes, procedure, and limitations.

Study Design and Rationale

The research design chosen for this study was a observational quantitative, quasi-experimental approach. In quantitative design, measurement of variables produces numerical data that can be analyzed using statistical procedures (Creswell, 2009). Quantitative research, especially quasi-experimental design, is a rigorous type of research, which provides evidence about the probability that a certain variable has an effect on an outcome. Such rigorous research was appropriate in this study because the

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researchers hoped to determine whether finger position on a B&L pinch gauge affects pinch strength. Since pinch strength is easily quantified and has a well-developed standardized assessment tool available to measure it, the rigorous observational quantitative, quasi-experimental design was appropriate. Additionally, this design was suitable because the possible confounding variables that could influence the outcome variable have been previously studied and are currently well understood (Kielhofner, 2006).

There are several variations of the quantitative, quasi-experimental design. Specifically, a crossover design involving multiple dependent variables was selected for the present study. A crossover study is a type of repeated-measures or within-subjects design in which participants receive both conditions of the independent variable (Kielhofner, 2006). It also involves randomization and counterbalancing. Therefore, in the present study, participants completed pinch strength measurements on both the bridge and the groove. The multiple dependent variables include three different types of pinch strength: lateral, three-jaw-chuck, and tip. These three types of pinch are the most commonly assessed by OTs (Flinn, Trombly Latham, & Robinson Podolski, 2008). The researchers chose the crossover variation of the observational quantitative, quasi-experimental design to provide strong control of participant variables, obtain statistical significance with fewer participants, and be efficient. Because the crossover design controls for type I error (reporting a relationship when there is none), and reduces the chances of type II error (failure to report a relationship when one exists), the researchers hoped they would be able to predict with confidence that finger position alone affects pinch strength. The researchers chose to include multiple dependent variables in the

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study design because it provides more detailed information regarding specific types of pinch and is more efficient than gathering data from three separate studies (Kielhofner, 2006).

Study Site and Population

This study was submitted to the Grand Valley State University Human Research Review Committee (GVSU HRRC), and an information sheet was created (see Appendix A). After approval, this study was performed at the Cook DeVos Center for Health Sciences (CHS) in Grand Rapids, Michigan. Permission to use the facilities and a table for data collection was granted by email from CHS Client Services on January 20, 2012. The researchers collected data in one high-traffic area in the building.

Study participants were volunteers recruited from GVSU's student body, faculty, and guests. Posters (see Appendix B) were hung in various places on GVSU's CHS building to publicize this study. A sign that said "How hard can you pinch?" was used to label the data collection table. One month prior to data collection, faculty members of GVSU occupational and physical therapy programs announced the study purpose, location, date, and time to their cohorts.

The researchers recruited 36 healthy individuals of both genders. To increase reliability of data, potential subjects were informed of exclusion criteria similar to those used by Stegink Jansen et al. (2003). These included neurological or other dysfunction disorders of one or both upper extremities, history of upper extremity surgery or impairment within the last 12 months, and inability to follow commands. Participants were asked to report age, gender, and handedness on a demographic form (see Appendix C).

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Equipment

There are many different pinch gauges on the market. The B&L engineering pinch gauge is known as the “gold standard” for pinch strength measurement (Mathiowetz et al., 2000). The 0-30 lb pinch gauge with one pound increments was utilized in this study. This instrument was chosen for use in our study because as addressed in Chapter Two, this instrument has high test-retest reliability, very high inter-rater reliability, and was proven to be most valid (Mathiowetz et al., 1984).

The B&L pinch gauge that was used in this study was purchased from Wisdom King. It was calibrated by the manufacturer and was not used prior to data collection. Each participant was asked to pinch the gauge once on the bridge and once on the groove for each of the three pinches (lateral, tip, three-jaw-chuck), totaling six pinches.

Validity and Reliability

The ASHT published recommendations for upper extremity and body position while measuring grip strength in 1981. These recommendations included “the patient should be seated with his shoulder adducted and neutrally rotated, the elbow flexed to 90°, and the forearm and wrist in neutral position” (Mathiowetz et al., 1984, p. 222). The purpose of these recommendations was to standardize the testing process, so that results from reliability studies can possibly be generalized to future studies utilizing the same protocol (MacDermid et al., 1994). These recommendations were followed when normative data for pinch strength measurements were developed (Mathiowetz et al., 1985); therefore, it is important to follow these standards when comparing a patient’s pinch strength measurements with the normative data. ASHT recommendations

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(Mathiowetz et al., 1984) were followed in the current study in order to promote reliability of the data.

Trained raters following standardized procedures when measuring pinch strength are important (Stegink Jansen et al., 2003) to ensure reliability. One rater measured the pinch strengths of the participants in the current study. This rater is an OT student, and also a Certified Occupational Therapy Assistant (COTA) with five years of experience. As a COTA, she routinely uses the B&L pinch gauge to measure pinch strengths of adults in an inpatient rehabilitation setting. All methods and procedures were followed in the testing process.

Each participant was given one opportunity to pinch the gauge for each of the six pinch positions. Research has shown no significant difference in pinch strength measurements when the mean of three trials, best of three trials, and one trial have been used to collect data (Hamilton, Banave, & Adams, 1994; McDermid et al., 1994; Stegink Jansen et al., 2003). Using one trial was selected for the current study to attempt to limit fatigue during the six pinch tests. In addition, participants were given a 15-second recovery period between each test trial. This time was determined to be adequate by Trossman and Li (1989), who found that there was no significant difference in grip strength performance between intertrial rest periods of 60, 30, and 15 seconds, as well as Mathiowetz (1990), who found that fatigue did not significantly affect grip strength evaluations.

Data Analysis

Pounds of force used during maximum pinch were gathered from the B&L engineering pinch gauge. A statistician was consulted to determine the appropriate

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method of statistical analysis for the data collected. Researchers input data into the Statistical Package for the Social Sciences (SPSS) 13.0 and utilized inferential statistics. Specifically, the researchers used the parametric paired t-test and the nonparametric Wilcoxon signed ranks test to analyze the data for each pinch type, and an alpha level of 0.05 was used to determine significance.

Procedure

On the day of testing, the researchers verbally explained the research procedures and an informational sheet was given to each participant. Any questions regarding the research process were answered. Next, participants completed a demographic form indicating dominant hand, gender, and inclusion criteria (see Appendix C).

Participants then proceeded to pinch measurement. The order of pinch was randomly assigned among participants with each order being represented equally. Prior to data collection, the researchers listed order combinations on the demographic forms. Order combinations included pinch type (tip, lateral, three-jaw-chuck) starting finger position (bridge or groove). Each participant pinched the gauge a total of six times; once of the bridge and once on the groove for each type of pinch. The order of the pinches were written on each sheet, along with either “bridge” or “groove,” signifying which finger position the participant would complete first for each of the three types of pinch. Thus, there were 12 possible order combinations, and since 36 participants were partaking in the study, each pinch combination was written on three different demographic forms. Order combinations included the following;

- Bridge- lateral, tip, three-jaw-chuck
- Groove- lateral, tip, three-jaw-chuck

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- Bridge- lateral, three-jaw-chuck, tip
- Groove- lateral, three-jaw-chuck, tip
- Bridge- tip, lateral, three-jaw-chuck
- Groove- tip, lateral, three-jaw-chuck
- Bridge- tip, three-jaw-chuck, lateral
- Groove- tip, three-jaw-chuck, lateral
- Bridge- three-jaw-chuck, tip, lateral
- Groove- three-jaw-chuck, tip, lateral
- Bridge- three-jaw-chuck, lateral, tip
- Groove- three-jaw-chuck, lateral, tip

After equally distributing orders onto the demographic forms, the forms were randomized. This was accomplished by tossing demographic forms into the air and then randomly picking them up. On the day of testing, each participant was simply given the next demographic form in the pile. Randomization was crucial to eliminate any potential order effects.

After assignment of order, participants were placed in the position that was recommended for hand strength measurement by ASHT (Mathiowetz et al., 1984). Specifically, “the patient should be seated with his shoulder adducted and neutrally rotated, elbow flexed at 90° and the forearm and wrist in neutral position” (Mathiowetz et al., 1984, p. 222). Research has shown that a neutral forearm position does not significantly affect lateral, tip, and three-jaw-chuck pinches (Stegink Jansen et al., 2003). Literature also suggests no significant difference in pinch strength when the wrist is extended up to 30° (Kraft & Detels, 1972), so slight variations in wrist position up to 30°

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extension were permissible. Additionally, the ulnar fingers and the IP joint of the thumb were flexed during the pinch measurement because research suggests these positions result in greater pinch force (McCoy & Dekerlegand, 2011; Apfel, 1986). This position was visually estimated, and then maintained throughout the testing process with verbal feedback from the researchers.

One trained rater performed the pinch strength testing. This rater demonstrated how to hold the gauge, specifically the difference between the bridge and the groove. To ensure the safety of participants and the pinch gauge, the rater held the pinch gauge and wrapped the strap around her wrist while each participant applied force. Each participant then was given one submaximal pinch warm-up in the first pinch position that was randomly assigned because this type of warm-up has been found to result in increased strength measurements (Marion & Niebuhr, 1992). The participant proceeded through the six pinch trials (bridge and groove for each of the three pinches), with 15-second breaks in between, in the order that was randomly selected. Pinch measurements were taken with the dominant hand only because research has found a correlation between ability to complete ADLs and pinch strength for the dominant hand only (Rajan et al., 2005). The rater encouraged the participant to squeeze as hard as possible during each trial by saying “go, go, go, stop”, as the use of consistent instructions is important for standardization of the test protocol (Richards & Palmiter-Thomas, 1996). This contraction time was no more than three seconds, which is supported by Smith and Lukens (1983). An additional researcher assisted the rater in determining which trial to perform next. This researcher recorded each pinch measurement on the demographic form (see Appendix C) as verbally expressed by the rater. When participants were

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finished completing six pinch measurement trials, they were told that the study was complete and thanked for their contribution. Any remaining questions were answered at this time.

Conclusion

This chapter provided a brief overview of the methods that were used to implement the present study. The researchers discussed the crossover design involving multiple dependent variables, rationale for choosing this research design, participants and sampling methods, procedures, and location of the study. The reliability and validity regarding the B&L pinch gauge, positioning, number of pinch trials, length of rest periods, and use of a warm-up test were also explained. Finally, the researchers proposed the quantitative data analysis and limitations of the present study. Next, Chapters Four and Five will present and interpret the results of data collection.

Chapter Four:

Results and Data Analysis

In Chapter One, the researchers provided an overview of the study including background, problem statement, significance, research questions, and key concepts. Additionally, the overall purpose of this study was discussed in Chapter One: to determine whether there is a difference in tip, lateral, and three-jaw-chuck pinch strength measurements when fingers are placed in the groove or on the bridge of a B&L pinch gauge. Chapter Two discussed the findings of the literature review conducted on the following topics: forces and anatomy of the human hand, factors affecting pinch strength, the relation between pinch and function, positioning during pinch strength evaluation, reliability and validity of pinch strength measurement, and the connection to OT through the biomechanical frame of reference and Occupational Therapy Practice Framework (AOTA, 2008). Chapter Three outlined the methods used to conduct this study, including design and rationale, data analysis, location and context, participants and sampling methods, instrumentation and materials, validity and reliability of test procedures, and an explanation of data collection procedures.

Characteristics of Subjects

A convenience sample of 36 volunteer subjects, ages 19-49, participated in the study. All 36 participants met the criteria for participation in the study and they all were able to complete each of the six pinches. Of the 36 participants, nine were male, 27 female; 33 participants were right hand dominant, and of the three left hand dominant participants, one was male, and two were female. The average age of all participants was

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27 years old. Participants were students, faculty, and guests of Grand Valley State University's Cook-DeVos Center for Health Sciences.

Techniques of Data Analysis

Data were collected and analyzed using SPSS 13.0. Inferential statistics were utilized, and it was determined that the appropriate parametric test was the paired t-test. The assumptions for the parametric t-test include the following: differences came from normal populations, differences were independent from each other, and there were no extreme outliers. All assumptions were met to determine the difference between bridge and groove measurements for both tip and lateral pinches using the paired t-test.

However, the differences between bridge and groove for three-jaw-chuck pinch did not meet all assumptions. These differences did not come from a normal population (kurtosis coefficient= 1.97 and skewness coefficient= 2.34), therefore the non-parametric Wilcoxon signed ranks test was done. Assumptions for this test were met, which included: differences were independent and both variables were measured on at least an ordinal scale. For all tests, an alpha level of 0.05 was used to determine significance.

Results

Lateral pinch.

The parametric paired t-test was also used to complete data analysis for lateral pinch measurements because all assumptions were met. For lateral pinch, the p-value was 0.51 (see Table 1), which is greater than the alpha (0.05). Therefore, this difference was also not significant. The data did not provide significant evidence to indicate that mean lateral pinch strength measurements differ when fingers are placed on the bridge versus the groove for lateral pinch.

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Three-jaw-chuck pinch.

For three-jaw-chuck pinch, all assumptions for the parametric paired t-test were not met. Since both the skewness (2.34) and kurtosis (1.97) coefficients were not between -1.96 and 1.96, there is reason to question the normality assumption. Since the differences did not come from normal populations, the non-parametric Wilcoxon signed ranks test was completed. Assumptions for this test were met. Since the p-value (0.059) was greater than the alpha (0.05), the difference was not found to be significant. The data did not provide significant evidence to indicate that the median three-jaw-chuck pinch strength measurements differ when fingers are placed on the bridge versus the groove.

Tip pinch.

Data analysis compared the difference in pinch strength measurements and sought to find if there was a difference between bridge and groove measurements. For tip pinch, all assumptions were met, so the parametric paired t-test was completed. Since the p-value (0.656) was greater than the alpha (0.05), the difference was not found to be significant. This data did not provide significant evidence to indicate that the mean tip pinch strength differs when fingers were placed on the bridge versus the groove of the B&L engineering pinch gauge.

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Table 1

P-values of Statistical Analysis

Pinch Type	Criteria	Test	P-Value
Lateral	Bridge, Groove	Paired t-test	0.51
Three-Jaw Chuck	Bridge, Groove	Wilcoxon Signed Ranks	0.059
Tip	Bridge, Groove	Paired t-test	0.656
Lateral	Right Hand Dominant	Paired t-test	0.507
Three-Jaw Chuck	Right Hand Dominant	Wilcoxon Signed Ranks	0.110
Tip	Right Hand Dominant	Paired t-test	0.703
Lateral	Male	Paired t-test	0.154
Three-Jaw Chuck	Male	Paired t-test	0.360
Tip	Male	Paired t-test	0.165
Lateral	Female	Paired t-test	1.00
Three-Jaw Chuck	Female	Paired t-test	0.159
Tip	Female	Paired t-test	0.473

Other Findings

The researchers considered the possible effects of hand dominance and gender on pinch strength in this study. Due to the small sample size of left hand dominant participants ($n = 3$), the researchers did not pursue statistical analysis using only left hand dominant participants. Statistical analysis was completed utilizing data from only right hand dominant participants for each type of pinch. The paired t-test was applied to

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compare bridge and groove measurements for both tip and lateral pinches, but results were not found to be statistically significant ($p=.703$ and $p=.507$ respectively). The Wilcoxon signed ranks test was employed to analyze data for three-jaw-chuck pinch and differences for this type of pinch were also not significant ($p=.110$).

In addition to hand dominance, the researchers addressed differences of finger position based on gender. Nine males and 27 females participated in this study. Results of paired t-tests comparing bridge and groove measurements from only male participants did not prove to be significant for tip, lateral, or three-jaw-chuck pinches ($p=.165$, $p=.154$, and $p=.360$, respectively). P-values for tip (.473), lateral (1.00), and three-jaw-chuck pinches (.159) were also not significant at the alpha level (.05) when data from only females was used to determine differences in bridge and groove measurements. Review of the literature found that outcomes are consistently different for both genders, thus gender was not further analyzed in this study (Puh, 2010). The study design and randomization should have eliminated any potential order effects; therefore, it was unnecessary to address pinch sequence in further data analysis.

Mean pinch values from this study were visually compared with normative values found by Mathiowetz, et al. (1985) and Mathiowetz, Wiemer, & Federman (1986). Tables 2, 3, and 4 summarize mean pinch values for male participants based on pinch type and finger position.

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Table 2

Mean Tip Pinch Measurements for Males Compared with Normative Data

Age	Hand	Bridge	Groove	Norm
20-24	R (4)	13.1	11.8	18.0
	L (1)	15.0	13.0	17.0
35-39	R (1)	13.0	13.0	18.0
	L (0)			
45-49	R (1)	16.0	13.0	18.7
	L (0)			

Table 3

Mean Lateral Pinch Measurements for Males Compared with Normative Data

Age	Hand	Bridge	Groove	Norm
20-24	R (4)	21.2	22.2	26.0
	L (1)	26.0	26.0	24.8
35-39	R (1)	26.0	27.0	26.1
	L (0)			
45-49	R (1)	22.0	23.0	25.8
	L (0)			

Table 4

Median Three Jaw Chuck Pinch Measurements for Males Compared with Normative Data

Age	Hand	Bridge	Groove	Norm
20-24	R (4)	17.0	18.0	26.6
	L (1)	18.0	18.0	25.7
35-39	R (1)	18.0	18.0	26.3
	L (0)			
45-49	R (1)	13.0	16.0	24
	L (0)			

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Tables 5, 6, and 7 summarize mean pinch values for female participants based on pinch type and finger position. In general, males in the current study had lower pinch strength measurements than those from the normative study, but female pinch strength measurements from the current study are comparable to the normative data.

Table 5

Mean Tip Pinch Measurements for Females Compared with Normative Data

Age	Hand	Bridge	Groove	Norm
0-19	R (1)	9.0	8.0	13.5
	L (0)			
20-24	R (16)	10.4	10.1	11.1
	L (2)	10.0	10.5	10.5
25-29	R (4)	11.8	11.5	10.5
	L (0)			
35-39	R (2)	10.0	9.5	11.6
	L (0)			
40-44	R (1)	11.0	8.0	11.5
	L (0)			
45-49	R (3)	13.5	14.5	13.2
	L (0)			

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Table 6

Mean Lateral Pinch Measurements for Females Compared with Normative Data

Age	Hand	Bridge	Groove	Norm
0-19	R (1)	11.0	14.0	18.1
	L (0)			
20-24	R (16)	17.3	17.0	17.6
	L (2)	18.5	18.5	16.2
25-29	R (4)	16.3	16.3	17.7
	L (0)			
35-39	R (2)	16.0	16.5	16.6
	L (0)			
40-44	R (1)	15.0	12.0	16.7
	L (0)			
45-49	R (3)	19.0	20.0	17.6
	L (0)			

Table 7

Median Three Jaw Chuck Pinch Measurements for Females Compared with Normative Data

Age	Hand	Bridge	Groove	Norm
0-19	R (1)	14.0	14.0	20.2
	L (0)			
20-24	R (16)	15.5	17.0	17.2
	L (2)	16.5	19.0	16.3
25-29	R (4)	14.5	15.0	17.7
	L (0)			
35-39	R (2)	18.5	20.0	17.5
	L (0)			
40-44	R (1)	17.0	10.0	17.0
	L (0)			
45-49	R (3)	20.0	19.0	17.9
	L (0)			

Summary

Data collected from a convenience sample of 36 participants and analyzed using SPSS 13.0 indicated no significant difference in pinch strength measurements for lateral, tip, and three-jaw-chuck pinches on the bridge versus the groove of the B&L Engineering pinch gauge. The researchers described the necessity for this study in Chapter One, and followed with a literature review in Chapter Two to show the relation between pinch and function as it pertains to OT practice and documentation using the Occupational Therapy Practice Framework (AOTA, 2008). Chapter Three discussed the methodology used to recruit test subjects and collect data. Chapter Four analyzed the data collected, which the researchers will apply to current OT professional guidelines and clinical practice in Chapter Five. The researchers will summarize and close with suggestions for future research in the measurement of pinch strength for OT practitioners.

Chapter Five:

Discussion and Conclusions

The purpose of this study was to determine if there was a difference in pinch strength between two fingers placements, bridge versus groove, on a B&L Engineering pinch gauge when all other criteria match industry standards for pinch testing. In Chapter One, the researchers provided an overview of the study and introduced the topics of finger placement and pinch strength. In Chapter Two, literature relevant to these topics was reviewed. Through this literature review, the researchers found that no substantive research to date addressed the impact of finger position on pinch strength. Methodology of the study was discussed in Chapter Three. The researchers utilized a quantitative, experimental approach which consisted of a crossover design involving multiple dependent variables. Each participant performed six pinches on a B&L pinch gauge: three pinch types with fingers placed on the bridge and groove. In Chapter Four, quantitative results of the study were presented. This chapter will discuss these results of the study, including a discussion of findings in accordance with research questions, application to OT practice, limitations, and suggestions for further research.

Discussion of Findings

Research question one.

Research question one stated: Is there a difference in lateral pinch strength when measured with fingers placed on the bridge versus the groove of a B&L Engineering pinch gauge? The corresponding hypothesis was that there is a significant difference in lateral pinch strength when measured with fingers placed on the bridge or groove of a B&L Engineering pinch gauge. Results revealed slightly higher lateral pinch strength

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when fingers are placed on the groove of the pinch gauge; however, this difference was not statistically significant ($p=0.51$). Additionally, the average difference between the placements of fingers on the bridge versus groove was less than one pound. Since one pound is the smallest scale on the B&L pinch gauge and the difference is smaller than can be observed on the pinch gauge scale, this finding is also likely not clinically relevant. Based on these results, the researchers fail to reject the null hypothesis and conclude that there is no significant difference in lateral pinch measurements based on finger position. This suggests that maximum pinch strength does not vary according to finger position for lateral pinch. Unlike forearm position (Stegink Jansen et al., 2003), wrist position (Halpern & Fernandez, 1996), and thumb interphalangeal position (Apfel, 1986), pinching on the bridge or groove may result in a similar lateral pinch strength measurement on a B&L engineering pinch gauge.

Research question two.

Research question two stated: Is there a difference in three-jaw-chuck pinch strength when measured with fingers placed on the bridge versus the groove of a B&L Engineering pinch gauge? The corresponding hypothesis was that there is a significant difference in three-jaw-chuck pinch strength when measured with fingers placed on the bridge or groove of a B&L Engineering pinch gauge. Like lateral pinch, results revealed slightly higher three-jaw-chuck pinch strength when fingers are placed on the groove of the pinch gauge. This finding was also not statistically significant ($p=0.059$).

Additionally, the average difference between the placements of fingers on the bridge versus groove was less than one pound, again less than the sensitivity that can be obtained with a B&L pinch gauge. Based on these results, the researchers fail to reject

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the null hypothesis and conclude that there is no significant difference in three-jaw chuck pinch based on finger position. This suggests that maximum pinch strength may not vary according to finger position for three-jaw-chuck pinch. Unlike wrist position (Halpern & Fernandez, 1996) and similar to forearm position (Stegink Jansen et al., 2003), pinching on the bridge or groove may result in a similar three-jaw-chuck pinch strength measurement on a B&L engineering pinch gauge.

Research question three.

Research question three stated: Is there a difference in tip pinch strength when measured with fingers placed on the bridge versus the groove of a B&L Engineering pinch gauge? The corresponding hypothesis was that there is significant difference in tip pinch strength when measured with fingers placed on the bridge or groove of a B&L Engineering pinch gauge. Unlike three-jaw-chuck pinch and lateral pinch, results indicated slightly higher tip pinch strength when fingers are placed on the bridge of the pinch gauge; however, this finding was not statistically significant ($p=0.656$). Furthermore, the average difference between the placements of fingers on the bridge versus groove was less than one pound; therefore, clinical relevance is doubtful. Based on these results, the researchers fail to reject the null hypothesis and conclude that there is no significant difference in tip pinch measurements based on finger position. This suggests maximum pinch strength does not vary according to finger position for tip pinch. Unlike wrist position (Halpern & Fernandez, 1996), forearm position (Stegink Jansen et al., 2003), and ulnar finger position (McCoy & Dekerlegand, 2011), pinching on the bridge or groove may result in a similar tip pinch strength measurement on a B&L engineering pinch gauge.

Other findings.

When visually comparing normative and current data, some discrepancies in pinch strength measurements were noted. In Tables 1 and 5, which looked at male tip and three-jaw-chuck pinches, all pinch measurements were lower than the norms. In addition, Table 3 addressed lateral pinch for males. In this table, right hand dominant males between the ages of 20-24 had lower pinch measurements than the normative data. Female data collected in the current study for all types of pinch were similar to data collected for the normative study.

Differences in measurements for males may be due to the current study's participant population. A study by Josty et al. (1997) found differences in pinch strength measurements based on type of occupation. Many of the participants were students, which can be considered a non-manual or light manual occupation. Members of the normative data population may have had higher occupational demands, such as farming, than students in the current study population, which could impact upper extremity strength. Additionally, only nine males participated in this study so mean pinch measurements for the current study were based on low frequencies. This alone could skew results because the margin of error is higher for a smaller sample size.

Application to OT Practice

The results of the present study are a valuable contribution to the existing literature regarding standardized measurement of pinch strength. Specifically, these results provide insight into standardization and reliability of a well-known and evidence-based OT assessment tool. The pinch gauge assists practitioners in evaluating service recipients in accordance with the biomechanical frame of reference, a predominant

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remedial theory of practice (NBCOT, 2004). The major components of this frame are strength, range of motion, and endurance, all of which are body functions noted in the Occupational Therapy Practice Framework: Domain and Process 2nd edition (AOTA, 2009). These functions can potentially affect performance and engagement in all seven areas of occupation: ADLs, IADLs, rest and sleep, education, work, play, leisure, and social participation. Therefore, pinch measurement using a pinch gauge not only measures pinch strength, it also indicates overall hand function. Numerous studies provide evidence for this relation between pinch strength and function (Rajan et al., 2005; Ranganathan et al., 2001; Bagis et al., 2003; Incel et al., 2009; Bruyns et al., 2003; Rajkumar et al., 2002). Such studies signify the clinical importance of pinch strength.

One question that has seemed to confound research in standardizing the pinch gauge is whether or not finger placement on the bridge or groove affects the three prominent pinch strength measurements: tip pinch, three-jaw-chuck pinch, and lateral pinch. The problem may be due to how clinicians guide clients to place fingers on the pinch gauge versus calibration standards of the pinch gauge. B&L Engineering recommends that clients place fingers on the groove of the pinch gauge since pinch gauges are calibrated with a digital force gauge by placing the pinch gauge into the force gauge at the groove (L. Barnes, personal communication, November 28, 2011).

Although no studies specify the area of contact between the fingers and thumb, pictures of testing positions reveal that practitioners most likely guide clients to place fingers on the bridge because it is easier to accomplish. It was hypothesized that this discrepancy may ultimately affect inter-rater reliability of pinch strength measurements. Such inter-rater differences in scores produce significant measurement errors when measuring

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client's impairment, baseline, or progress (Edwards et al., 1995). The present study results are influential because they reveal that the discrepancy between calibration measurement and clinical measurement is not significant, implying that inter-rater reliability is not compromised. Clinicians may have increased confidence that measurements may be accurate regardless of whether they, or other healthcare personal, guide clients to place fingers on the bridge or groove of the pinch gauge.

Such evidence informs clinical practice by allowing OT practitioners to make accurate and ethical decisions regarding appropriate client intervention, characterization of impairment, functional goals, and discharge recommendations. These actions are increasingly relevant given that minimum strength requirements have been identified for safely completing certain occupations (Rice et al., 1998; Smaby et al., 2004).

Additionally, the reliable pinch gauge can also be used as an objective measure to demonstrate research outcomes revealing the effectiveness of various biomechanical and occupation-based interventions (Ranganathan et al., 2001). Together, these resulting implications may provide some contribution to the OT profession in attaining the American Occupational Therapy Association's (2002) vision of a powerful, evidence-based profession meeting society's needs.

Limitations

The researchers acknowledge that there were several limitations to this study. Due to funding and time constraints, a nonrandom convenience sample of volunteers from the Grand Rapids area was used for the study population. More specifically, the majority of the sample consisted of female, GVSU students who attend class at CHS. This threatens the external validity of the study such that results may not generalize to

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other populations (Creswell, 2009). Additionally, since the sample only consisted of 36 students, the statistical strength and power of findings was somewhat compromised.

Perhaps with a larger sample, the researchers would have found significant differences in pinch strength based on finger position (Creswell, 2009).

Yet another limitation of the study was the assessment tool. The researchers used one new B&L pinch gauge, which was reportedly calibrated by the manufacturer, with every participant. Although the researchers used a new B&L pinch gauge for the study and every participant utilized this same instrument, the researchers did not verify the calibration of this pinch gauge directly prior to data collection. According to Fess (1987), this can result in more than acceptable measurement error. She states that instruments with a correlation of .9994 or better and a difference between the means of 1.5 pounds or less do not need calibration; however, when the correlation coefficient is less than .9994, the instrument must be returned to the manufacturer for recalibration. Since the researchers did not calibrate, the correlation coefficient is unknown. Therefore, the validity of the pinch gauge could have been compromised, resulting in inaccurate and inconsistent measurements for the entire sample. Despite this limitation the researchers attempted to minimize this effect as much as possible by using the strategies listed above. Additionally, only one pinch gauge was used throughout the study: the B&L pinch gauge. Although MacDermid, Evenhuis, & Louzon (2001) found similar scores when using the B&L, JTech (JTech Medical Instruments), and NK (NK Biotechnical Engineering Company), researchers still caution that results may not generalize to pinch gauges other than the B&L.

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Yet another limitation was the testing procedure itself. Researchers chose to visually estimate maintenance of all standardized positioning from shoulders to fingers rather than measuring with a goniometer. Although this is not ideal in terms of validity, the decision was made based on testing procedures applied in the literature (Stegink Jansen et al., 2003; Mathiowetz et al., 1985; MacDermid et al., 2001; Apfel, 1986) and because it reflects common clinical practice. The number of trials chosen by the researchers was yet another potential testing procedure limitation. Research regarding number of trials is somewhat inconsistent as to whether the mean of three trials, best of three trials, or one trial produce the most reliable maximum pinch strength. Historically, the mean of three trials was the most popular outcome score used (Mathiowetz et al., 1985; MacDermid et al., 1994); however, recent research indicates excellent reliability for all outcome scores resulting in no significant difference in pinch strength measurement (Stegink Jansen et al., 2003; Hamilton et al., 1994). Based on time constraints and the negating effects of fatigue on maximum voluntary pinch strength (Trossman & Li, 1989), the researchers chose one trial.

Suggestions for Further Research

Based on the findings and limitations of this study, the researchers recommend several modifications and suggestions for future research. Conducting a similar study using a larger sample size would only increase the statistical power since effects are harder to detect in smaller samples (Creswell, 2009). This would not only allow researchers to generalize their findings to other healthy and normal populations, it would additionally support the findings of this study with more accuracy and confidence. In addition to a larger sample size, a sample that represents age, gender, ethnicity, and race

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more realistically would be beneficial. It is also important to consider additional populations when measuring pinch strength. Other pertinent populations include those with hand impairment or disability as well as older adults. These populations are relevant based on the findings in the literature which suggest that the relationship between hand strength and functional activities changes with these variables (Puh, 2010; Carmeli et al., 2003; Bagis et al., 2003). Lastly, because this study simply introduced the topic of finger positioning to the literature, the researchers chose to forgo a qualitative component in the study. In future studies, a qualitative component involving participants' perceptions of pinching on the bridge or groove may aid in understanding the effect of this variable on pinch strength measurements or lack thereof (Kielhofner, 2006).

Conclusions and Summary

In OT, pinch strength is one objective measurement of hand strength and provides evidence for determining functional improvements, designing appropriate intervention, reporting research outcomes, characterizing disability, and making discharge recommendations. Using a quantitative research design, the researchers sought to determine if there was a difference in tip, three-jaw-chuck, and lateral pinch strengths when fingers were placed on the bridge or groove of a B&L pinch gauge. Results revealed no significant differences; therefore, the researchers concluded that finger placement may not affect pinch strength. Per this finding, the researchers recommend that practitioners guide clients to place fingers on the bridge or groove during pinch strength assessment. This study produced findings that support the use of a pinch strength evaluation to inform clinical OT practice and to demonstrate the effectiveness of

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occupation-based interventions. Further research on this topic is needed to support the findings from this study.

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Appendix A

**Pinch Strength Study
Participant Informational Sheet for Volunteers**

I am being asked to participate in a research study entitled "Impact of Finger Position on Pinch Strength", conducted by Rachel Boerema, Jamie Powers, Kelsey Walukonis, all occupational therapy students at Grand Valley State University, and Dr. Jeanine Beasley, OTR and research chair.

The purpose of this study is to determine if there is a difference when fingers are placed on the bridge versus the groove of the Bernadette and Linda (B & L) Engineering pinch gauge when all other criteria match industry standards for pinch strength testing.

I also agree to complete a demographic form that includes some health history information.

Although I may not receive any direct benefit from participating in this study, information from the study may provide insight as to the importance of standardizing finger position on a pinch gauge when measuring pinch strength.

All information collected during this study will be done without revealing my identity and will be kept confidential. The results will be disseminated in aggregate form ONLY. Study participants will be provided results in aggregate form upon request. I also understand that all data collection records will be kept in a locked file cabinet at Grand Valley State University accessible only to the Principal Investigator.

No risks or discomforts are expected to result from this study. I understand that I may withdraw from the study at any time.

I agree that the study has been explained to me and I have been given an adequate opportunity to ask questions about it. I also agree that participation in this study is voluntary and that I may refuse to participate in or withdraw from the study at any time.

I understand that if I have questions, I am free to contact the Principal Investigators, Rachel Boerema at boeremar@mail.gvsu.edu, Jamie Powers at olenderj@mail.gvsu.edu, or Kelsey Walukonis at walukonk@mail.gvsu.edu. Research chair, Dr. Jeanine Beasley, OTR, can be contacted at beasleyj@gvsu.edu.

This research protocol has been approved by the Human Research Review Committee at Grand Valley State University. File No. 12-204-H Expiration: June 5, 2013.

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Appendix B

RESEARCH VOLUNTEERS NEEDED!

How much can you pinch?

Come find out!

Help close gaps in research used by
Occupational Therapists, Physical Therapists,
Physician Assistants, Physicians.

May 30, 2012 | 10:00 a.m. – 3:00 p.m.

Cook-DeVos Center for Health Sciences

301 Michigan Street NE | Grand Rapids, MI | 49503

Three Occupational Therapy students want to know if there is a difference in strength measurements taken when fingers are placed on the **groove** of the pinch gauge (manufacturer's directions) versus the **bridge** (where most clinicians direct patients).

WHAT YOU NEED TO KNOW:

- PARTICIPATION IS VOLUNTARY
- REFRESHMENTS WILL BE PROVIDED
- STUDY WILL BE HELD IN THE CHS FOYER
- WALK-INS WELCOME

**FOR ADDITIONAL INFORMATION OR
TO VOLUNTEER, CONTACT:**

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KELSEY WALUKONIS

COMMITTEE CHAIR:

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Demographic/Exclusion Criteria Form

Demographics:

Age: ____ Years

Gender: ☐ Female ☐ Male

Hand dominance: ☐ Ambidextrous ☐ Left ☐ Right

Exclusion Criteria:

Please check the box indicating "Yes" or "No" as it applies to you.

1. Do you currently have a neurological disorder? ☐ Yes ☐ No
2. Do you have a history of hand, elbow, or shoulder dysfunction? ☐ Yes ☐ No
3. Do you have a history of hand, elbow, or shoulder surgery within the last 12 months? ☐ Yes ☐ No
4. Are you able to speak or understand English and follow commands? ☐ Yes ☐ No
5. Do you have a history of hand, elbow, or shoulder fractures within the last 12 months? ☐ Yes ☐ No

(Do not continue, researcher use only)

Measurements:

Order	Pinch Type	Bridge	Groove
	Tip		
	Lateral		
	Three-Jaw Chuck		