Pinch Strength and its Relationship to Penmanship and ADLs: Research Findings

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Casa Colina Centers for Rehabilitation
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Casa Colina Children's Services Center

- Helping children - from infancy to 15 years of age - make remarkable progress despite challenges.

- Children's Services has access to:
  - Two sensory gyms for occupational therapy and physical therapy
  - Three speech therapy rooms for private speech and language therapy
  - One feeding room for therapy sessions focused on swallowing and feeding difficulties
  - Two early intervention classrooms
  - One physician examination room primarily used by world renowned pediatric neurologist, Dr. Margaret Bauman
  - Social skills training groups
  - Outdoor adaptive playground equipment that is wheelchair accessible
  - Two therapeutic pools utilized for aquatic therapy and adapted swim lessons
  - Interactive Metronome equipment
  - Dynavision equipment
Presentation Outline

• Study Objectives
• Background
• Study Design
• Participants characteristics
• Correlations between grip and pinch strength and functional activities
• Effectiveness of home program for improving grip and pinch strength
Study Objectives

• To identify grip and pinch strength norms for children 4-10 years of age

• To describe the relationship between grip and pinch strength and functional skills

• To describe the effectiveness of a home program on developing pinch strength
Pinch and grip strength norms

- Pinch and grip strength norms vary widely from study to study

![Graph showing grip strength in males across different studies](image)
Grip Strength trends for typically developing children

- Grip strength in children increases with age
- Differences in grip strength between males and females begins around age 12 and becomes pronounced as teens
- Non significant association for hand dominance and strength

(Butterfield and Lønnhard, 2009)
Pinch Strength trends for typically developing children

- Pinch strength in children increases with age
- Boys are typically stronger than girls at all ages
- Palmer (3 jaw chuck / tripod pinch) is stronger than Lateral pinch strength (key pinch) and tip

(Ager et al., 1984; Mathiowetz et al., 1986)
Relationship between Grip and Pinch Strength and Functional Abilities in Children

• In children with motor disorders, grip strength correlates with delays in fine motor skills, and functional tasks, i.e., scissors, buttoning. (Li-Tsang CW, 2003)

• Grip force has been found to play a key role in determining handwriting quality and handwriting stroke characteristics in 1st and 2nd graders. (Falk TH Chau T, 2010)

• Significantly lower tripod-pincher strength was found among children (3rd to 5th grade) with dysgraphia in comparison to typically developed peers. This deterioration in tripod-pincher strength was associated with a significant deterioration in handwriting processes. (Engel-Yeger B and Rosenblum S, 2010)
Study rationale

- Grip and Pinch strength have been used for years as markers of physical growth and development.
- Clinicians have assumed that grip and pinch strength are important for everyday activities such as dressing and handwriting however, no standardized measures have been used to assess this correlation.
- Based on the current literature the purpose of this two part study is to
  1. identify norms for grip and pinch strength in children aged 4 - 10
  2. determine if grip and pinch strength correlate with functional abilities and handwriting, and
  3. examine the effect of a 10-week strengthening home program on grip and pinch strength and re-examine the relationship with functional abilities.
**Design**

Subjects are tested for grip strength using a dynamometer and pinch strength using a pinch meter following established positioning guidelines outlined by The American Society of Hand Therapists (ASHT).

Following strength testing, subjects complete the Beery VMI motor coordination subtest, the Evaluation Tool of Children's Handwriting (ETCH), and a functional questionnaire.

**Subject selection and criteria**

- **Inclusion criteria**
  - Male or female
  - 4 – 10 years of age
  - Ability to understand and follow directions and complete the testing

- **Exclusion criteria**
  - Inability to meaningfully participate in the test procedures
Study Design: Part 2

**Design**
Subjects from Part 1 who need specialized strength training are enrolled in the 10-week Strong Hands Program. After completion of the 10-week intervention, subjects are tested for grip and pinch strength and complete the Beery VMI motor coordination subtest, ETCH, and functional questionnaire.

*The Strong Hands Program* is a home strength-training program developed by occupational therapists at Casa Colina. The purpose of this home program is to increase a child’s grip and pinch strength. Each week a new exercise is sent home and practiced 5 days of the week. Families are provided with written instructions, a tracking log, and manipulatives needed for the exercise. Each week, they return the manipulatives and tracking log and receive a new exercise to take home.
Relevance to Occupational Therapy

• The primary referral reason for occupational therapy in the school is handwriting remediation (Chandler, 1994; Chu 1997, Reisman, 1991)

• When evaluating dysgraphia, measurement of pinch strength has been recommended by research (Engel-Yeger & Rosenblum) and is a common practice

• The primary referral reason for OT in the medical model is to increase independence with activities of daily living

• Hand strengthening activities are consistently used as a therapeutic approach for developing handwriting and self care skills
Experimental endpoints

**Strength testing**
Grip strength and tip, lateral, and palmar pinch strength are assessed using a dynamometer and pinch meter. Measurements are reported in pounds as an average of 3 trials for each hand.

**Functional Questionnaire**
Measures functional abilities including those related to dressing, mealtime, and grooming.

**Beery Visual-Motor Integration - motor coordination subtest**
The VMI is a standardized test used for both research and clinical purposes in children 2 – 18 years of age. The motor coordination subtest assesses pencil control.

**Evaluation Tool of Children's Handwriting (ETCH)**
The ETCH is a standardized test used to evaluate children 6-12 years 5 months of age. It assess handwriting legibility.

**Still Photograph of Pencil Grasp Pattern**
A photograph was taken of the child’s grasp pattern while completing the testing.
## Study Participants: Demographics

<table>
<thead>
<tr>
<th>Participant Characteristics</th>
<th>Total population</th>
<th>Autism Spectrum Disorder (ASD)</th>
<th>Other developmental disabilities (ODD)</th>
<th>Typically developing (TD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample size</td>
<td>n=61</td>
<td>n=23</td>
<td>n=10</td>
<td>n=28</td>
</tr>
<tr>
<td>Age, years</td>
<td>6.9 ± 1.75 (range = 5.15-8.65)</td>
<td>6.8±1.5 (range = 5.3-8.3)</td>
<td>7.9 ± 1.6 (range = 6.3-9.5)</td>
<td>6.7±1.9 (range = 4.8-8.6)</td>
</tr>
<tr>
<td>Sex</td>
<td>66% male 34% female</td>
<td>78% male 22% female</td>
<td>70% male 30% female</td>
<td>54% male 46% female</td>
</tr>
</tbody>
</table>

ASD = Autism, PDD, and Asperger’s
ODD = fine motor delays, speech delays, ADHD
Grip and Pinch strength measurements

- Grip
- Lateral pinch (key pinch)
- Palmar pinch (3-jaw chuck/ tripod pinch)
- Tip pinch
Influence of Cognition on Strength Testing - Effort

How much **effort** a child seemed to exert during strength testing was ranked on a scale of 0-3. These scores correlated with:

**Whole Population:**
- Dominant grip strength
- Non dominant grip strength
- Pinch strength measurements did not correlate

**Typical Population:**
- No correlations

**Autism Population:**
- No correlations

**ODD Population:**
- No correlations
Influence of Cognition on Strength Testing- Level of Understanding

A child’s **level of understanding** of the directions during strength testing was rated on a scale of 0-3. These scores correlated with:

**Whole Population:**
- Dominant grip strength
- Non dominant grip strength

**Typical Population:**
- No correlations

**Autism Population:**
- Dominant grip strength
- Non dominant grip strength

**ODD Population:**
- No correlations
Grip and pinch strength follow the established trends for age, gender, and hand dominance.
Grip and pinch strength follow the established trends for age, gender, and hand dominance.
Measuring Motor Coordination

Beery VMI, 5th edition- Motor Coordination Subtest

• Measures pencil control by having children draw lines inside of progressively more narrow and complex shapes
Relationship between motor coordination and grip strength

![Graph showing the relationship between VMI (T-score) and Grip Strength (lb) for different groups: All*, TD*, ASD*, and ODD.](image-url)
Grasp Pattern

Pencil Grasp pattern was rated on a scale from 0-8 using the following parameters:

- Web Space
- Pencil Orientation
- Thumb Position
- Wrist Position
Grasp correlations

Grasp pattern correlated with dominant grip strength only in the typical population. There was no correlation between pencil grasp and strength in children with disabilities.
Grasp correlations

Grasp pattern did correlate with the following functional skills:

Whole Population:
• VMI T score (pencil control)
• Independence with functional abilities

Typical Population:
• Independence with functional abilities
• ETCH speed- numbers

Autism Population:
• ETCH legibility- lower case

ODD Population:
• ETCH speed- upper case
Measuring Handwriting Legibility

The Evaluation Tool of Children’s Handwriting (ETCH)

Measures:
• Writing Legibility for upper case letters, lower case letters and numbers
• Speed
Relationship between handwriting abilities and grip and pinch strength
Relationship between handwriting abilities and grip and pinch strength

**Whole Population:**
- Legibility of upper case and lower case letters correlated with dominant grip strength.

**Typical Population:**
- Legibility of upper and lower case letters and numbers correlates with dominant grip strength
- Speed of lower case letters correlates with dominant grip strength

**Autism Population:**
- **No correlations**

**ODD Population:**
- Speed of numbers with dominant lateral pinch strength and grip strength
Relationship between functional abilities and grip and pinch strength
Relationship between functional abilities and grip and pinch strength

Independence with functional activities correlates with:

**Whole Population:**
- Lateral pinch strength bilaterally
- Palmar pinch strength bilaterally
- Tip pinch bilaterally

**Typical Population:**
- Non dominant grip strength
- Dominant palmar pinch strength
Relationship between functional abilities and grip and pinch strength

Independence with functional activities correlates with:

**Autism Population:**
- Grip strength bilaterally
- Lateral pinch strength bilaterally
- Non dominant palmar pinch strength

**ODD Population:**
- Non dominant grip strength
- Dominant lateral pinch strength
- Non dominant palmar pinch strength
Functional activities significantly correlated with grip and pinch strength

<table>
<thead>
<tr>
<th>Functional Activity</th>
<th>F ratio</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open a small snack (tearing)</td>
<td>6.6</td>
<td>0.02</td>
</tr>
<tr>
<td>Opens twist off bottle caps with unbroken seal</td>
<td>13.1</td>
<td>0.004</td>
</tr>
<tr>
<td>Able to cut food with knife</td>
<td>5.2</td>
<td>0.04</td>
</tr>
<tr>
<td>Puts straw in juice box</td>
<td>9.3</td>
<td>0.01</td>
</tr>
<tr>
<td>Takes cap off toothpaste</td>
<td>5.7</td>
<td>0.038</td>
</tr>
<tr>
<td>Squeezes toothpaste on toothbrush</td>
<td>8.2</td>
<td>0.01</td>
</tr>
<tr>
<td>Turns key to unlock door</td>
<td>8.7</td>
<td>0.01</td>
</tr>
<tr>
<td>Turns doorknob to open door</td>
<td>6.6</td>
<td>0.02</td>
</tr>
</tbody>
</table>
Week One – Marble Madness

Have your child push the marbles through the hole in the lid one at a time. Make sure he/she uses the appropriate finger on the dominant hand to push them in.

You can make the task more difficult by having your child hold several marbles in his/her hand while pushing only one in at a time. Push 20 marbles in with the right/left pointer finger and 20 marbles in with the right/left thumb everyday.
Conclusions & Future Directions

- Our data in typically developing children is supported by the existing literature looking at trends and norms for grip and pinch strength.
- Our data present novel trends for children with developmental delays.
- While a larger sample size is needed to more clearly define these relationships, an effect does appear to be present between grip and pinch strength and functional abilities.
THANK YOU!

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