Research Article

Correlation Between Pinch Grip and Handwriting in School Age Children

Walid Saber Hussain [1,2], Marwa Mounir Omar [3], Menna Allah Mohammed Abbas [4], Karim Sami ELSaharty [5], Heba Ahmed Abd El Azeem Haridy [6]

[1]Lecturer of Physical Therapy for Pediatrics, Faculty of Physical Therapy, October 6 University, Giza, Egypt, ORCID: 0009-0002-0152-7464.
[2]Department of Physiotherapy, Faculty of Allied Medical Sciences, Al-Hussein Bin Talal University, Ma'an, 71111, Jordan.
[3]Lecturer of Physical Therapy for Surgery, Faculty of Physical Therapy, October 6 University, Giza, Egypt, ORCID: 0009-0003-7512-354X.
[4]Lecturer of Physical Therapy for Women's Health, Faculty of Physical Therapy, October 6 University, Giza, Egypt, ORCID: 0000-0001-8707-8334.
[5]Lecturer of Physical Therapy for Pediatrics and Surgery, Modern University for Technology and Information University, Cairo, Egypt, ORCID:0000-0002-8256-8163.
[6]Lecturer of physical therapy for Basic science, Faculty of physical therapy October 6 University, Giza, Egypt,
ORCID:0009-0005-7180-0106
Corresponding author: Walid Saber Hussain; Email: dr.walid133@gmail.com

Abstract

Handwriting is an important childhood task for academic achievement; The connection between pinch grip strength and handwriting performance has not been thoroughly studied. The goal of the study is to assess the relationship between handwriting legibility and palmar pinch grip strength in Egyptian primary school students who are typically developing. A cross-sectional correlational design was employed in this investigation. Data collection took place in primary school on October 6 City, Giza Governorate. All the participants were assessed by using pinch gauge for palmar pinch grip strength and the assessment of handwriting was done by Handwriting Legibility Scale (HLS). The study's findings demonstrated a significant inverse relationship (r = -0.501) between right-handed children's handwriting legibility scores and pinch grip strength. Additionally, pinch grip strength and handwriting legibility ratings for left-handed youngsters showed a moderately negative connection (r = -0.468). The present study concludes that there is a significant correlation between palmar pinch grip power and handwriting legibility in normally developing Egyptian primary school children.

Keywords: Palmar pinch grip, Handwriting, Handwriting Legibility Scale (HLS), Egyptian children.

Introduction

Handwriting is one of the proficient fine motor skills. It is a crucial ability for schoolchildren to express, communicate, and record [1]**.** Handwriting and other fine motor tasks take up 31 to 60 percent of the school day for students [2]**.** Functional handwriting requires good motor coordination, powerful grip, control of hand movement, and ability to hold a pen or pencil with fingers and thumb [3]**.**

A student's ability to write legibly is important, and it depends on a variety of elements, including the anatomy of their extremities, their overall health, their mental clarity, the instrument they are using, and the evenness of their surface [4]**.**

Grip strength, also known as grasp power, is assessed as a hand function module and is utilized globally [5]. It is the greatest force that each finger can voluntarily flex under typical circumstances. A firmer grasp or grip is indicated by stronger handgrip strength. Numerous factors, including age, gender, muscle mass, body mass index, and hand measurements, influence handgrip strength[6].

Previous researches has examined the relationship between handwriting legibility and grip power in children around the globe [7,8]. However, due to variations in genetic composition, dietary practices, body type, and degree of activity, grip strength differs throughout populations and geographical areas[6]**.** In Egypt, efforts to characterize hand strength in children have been undertaken, yet these have addressed handgrip exclusively. Normative handgrip values for Egyptian children in the prepubertal stage were published [9]. Findings later extended across broader age bands by [10] and into the preschool years by [11]**.** Pinch grip strength, however, has not been similarly characterized in this population, leaving clinicians and researchers without a local reference framework for interpreting pinch measurement data in Egyptian children. This absence becomes particularly consequential in the context of handwriting research, where the relationship between fine digit force capacity and written output quality has yet to be examined in a typically developing Egyptian sample. The present study was designed with this gap in mind, seeking to determine whether palmar pinch grip strength correlates with handwriting legibility in normally developing Egyptian primary school children, due to the lack of information in this field, which will assist therapists in treating writing problems that are followed by hand muscle weakness.

Materials And Methods

Study Design and Setting

This research employed a cross-sectional correlational approach to investigate the connection between palmar pinch grip strength and handwriting legibility in typically developing school-aged children in Egypt. The data were gathered at a primary school located on October 6 City, Giza Governorate. The Research Ethics Committee at Cairo University, Giza, Egypt, provided ethical approval (approval number P.T.REC/012/004847), and the study was registered in advance on ClinicalTrials.gov (NCT07572474). All procedures followed the ethical criteria specified in the Declaration of Helsinki [12].

Participants

Seventy normally developed children of both sexes, aged 9 to 11 years were recruited from primary school on October 6 City through simple random sampling. To be eligible, children needed to have an estimated intelligence quotient above 50 to be able to understand and follow simple verbal instructions; those with diagnosed visual or auditory impairment were not included. Children with dysgraphia, attention-deficit/hyperactivity disorder, or any other neural development or cognitive issue that would reasonably impair handwriting or hand function were excluded, so that the relationship under investigation would not be confounded by an underlying developmental disorder. Prior to a child's participation, a parent or legal guardian signed a written informed consent form, and children gave their verbal agreement when it was suitable for their age and understanding.

Sample size calculation

To explore the connection between pinch grip strength and handwriting scores in children, a sample size estimation was performed using G*Power version 3.1.9 from Heinrich-Heine-University in Düsseldorf, Germany, for a two-tailed test. The effect size for this calculation was derived from a prior study [13]. Employing the Exact-Correlation: Bivariate normal model, the calculation determined a total sample size of 61 participants, with a Type I error (α) set at 0.05, power (1-β error probability) at 0.90, and a correlation (pH1) of 0.4. To ensure adequate statistical power for detecting a significant clinically meaningful difference, the study requires a minimum of 68 participants, accounting for a 10% dropout rate.

Ethical Considerations

All participant data were anonymized before analysis, and confidentiality was maintained throughout collection, storage, and reporting. Parents were given notice that their child's care and schooling would not be impacted if they decided to withdraw from the study at any time. Testing took place in a quiet, distraction-free room within the school so that the environment was consistent with participants.

Outcome Measures

Handwriting legibility. Handwriting was assessed with the Handwriting Legibility Scale (HLS), which rates five components of writing letter formation, alignment, size, spacing, and line quality on a five-point scale each, for a total possible score of 5 to 25; higher scores indicate poorer legibility [14]. The HLS has shown good internal consistency and inter-rater reliability across several languages and cultural settings, including a recent validation in children aged 8 to 11, supporting its use with the present sample. Each child completed a six-minute free-writing task on unlined A4 paper using their preferred writing implement. Handwriting samples were then scored by an examiner who was blinded to each participant's grip-strength results, reducing the risk of assessment bias[15].

Palmar pinch grip strength. The strength of the palmar pinch grip in the dominant hand, used for writing, was assessed in kilograms using a Baseline® mechanical pinch gauge. The testing posture adhered to the guidelines set by the American Occupational Therapy Association: participants were seated with their shoulders adducted and in a neutral rotation, elbows bent at 90°, forearms in a neutral position, and wrists extended between 0-15° with an ulnar deviation of 0-15° [16].

To minimize fatigue, three trials were conducted with a 60-second rest interval between each, and the average of these three measurements was utilized for analysis, in line with established pediatric dynamometry protocols [17,18].

Statistical analysis

All statistical analyses were performed using IBM SPSS Statistics (version 26.0; IBM Corp., Armonk, NY, USA). Descriptive statistics were computed for all study variables, with categorical data presented as frequencies and percentages, and continuous data reported as mean ± standard deviation (SD) with minimum and maximum values. Paired t-tests were conducted to compare right versus left hand measurements for both pinch grip strength and handwriting scores, with Cohen's d calculated as the effect size. Additionally, a linear mixed model (LMM) with random intercepts was employed as the primary analytical approach to examine the association between pinch grip strength (independent variable) and handwriting score (dependent variable), while accounting for within-subject correlation. The model included fixed effects for pinch grip strength, age, sex, and body mass index (BMI), with participants treated as random effects to account for repeated measurements from the same individual. For the primary model, unstandardized regression coefficients (β), 95% confidence intervals (CI), and P-values were reported. Standardized beta coefficients (β) and partial eta-squared (η^2) were calculated as measures of effect size. All reported P-values were two-sided, with statistical significance set at $P<0.05$. Confidence intervals were set at the 95% level for all effect estimates.

Results

Demographic and clinical characteristics

Table 1 summarizes the demographic and clinical characteristics of the 70 children who participated in the study (aged 9–11 years; mean age: 9.96 ±0.57years), with a balanced sex distribution (47.10% male, 52.90% female). Anthropometric measures (weight: 31.87 ±2.29kg; height: 134.30 ±3.69cm; BMI: 17.63 ±0.74 kg/m²) were within expected normative ranges for this age group. Right-hand dominance was prevalent (74.30%), consistent with general population trends. Pinch grip strength was comparable between hands (right: 4.47 ±1.00 kg; left: 4.30 ±0.94 kg), whereas mean handwriting scores differed notably (right: 8.80 ±2.23; left: 9.97 ±2.31).

Table 1. Descriptive statistic data of school age children 9-11 years (n=70)

Qualitative variables		**Number**	**Percentage**	
Gender	Boys	37.00	47.10%	
	Girls	33.00	52.90%	
Dominant hand	Right	52.00	74.30%	
	Left	18.00	25.70%	
Quantitative variables		Mean ±SD	Minimum	Maximum
Age (years)		9.96 ±0.57	9.00	11.00
Weight (kg)		31.87 ±2.29	27.00	38.00
Height (cm)		134.30 ±3.69	124.00	145.00
BMI (kg/m^2)		17.63 ±0.74	16.00	20.00
Pinch grip right hand		4.47 ±1.00	2.00	7.00
Pinch grip left hand		4.30 ±0.94	2.00	7.00
Right hand writing scale		8.80 ±2.23	5.00	13.00
Left hand writing scale		9.97 ±2.31	5.00	16.00

Qualitative variables data are expressed as number and percentage; Quantitative variables data are reported as mean ±standard deviation (SD)

Descriptive Outcomes and Effect Sizes

Paired t-test analysis revealed that left-hand handwriting scores were significantly higher than right-hand scores (9.97 ± 2.31 vs. 8.80 ± 2.23, respectively; mean difference = 1.17, 95% CI: -0.61 – 1.73), with a medium effect size (Cohen's d = 0.51, $P<0.001$). Moreover, a significant difference was observed between right and left pinch grip strength (d=0.17, 95% CI: 0.01 – 0.33, P= 0.036). Detailed descriptive statistics are shown in Table (2).

Table 2. Comparisons mean values of pinch grip strength and handwriting score between right and left hands

Items	Pinch grip strength (kg)	Handwriting score
Right hand	4.47 ±1.01	8.80 ±2.23
Left hand	4.30 ±0.88	9.97 ±2.31
Mean difference (change)	0.17	1.17
95% confidence interval	0.01 – 0.33	0.61 – 1.73
Effect size (Cohen's d)	0.18	0.51**
P-value	0.036*	0.0001*

Data are expressed as mean ±standard deviation P-value: probability value S: significant * Significant (P<0.05) NS: non-significant
Cohen's d: 0.2 = small, 0.5 = medium, 0.8 = large. **Medium effect size

Correlation Analysis

There was a strong negative correlation (Table 3 and Figure 1) between pinch grip strength and handwriting scores for right handed children (r = -0.501, 95% CI: -0.65 – -0.34, r^2 = 0.251, q = 0.361, P=0.0001). Moreover, moderate negative correlations were observed between pinch grip strength and handwriting scores for left handed children (r = -0.468, 95% CI: -0.71 – -0.23, r^2 = 0.219, q = 0.307, P=0.0001) (Table 3 and Figure 2) and pooled analysis (Table 3 and Figure 3) accounting for clustering showed a correlation coefficient of r = -0.489 (95% CI: -0.59 – -0.34, r^2 = 0.101, P= 0.0001), representing a moderate effect size (Cohen's q = 0.329).

Table 3. Correlation between pinch grip and handwriting score

Hand side	r	95% CI	r^2	Cohen's q	P-value
Right hand	-0.501	-0.65 – -0.34	0.251	0.361	0.0001*
Left hand	-0.468	-0.71 – -0.23	0.219	0.307	0.0001*
Pooled (both hands)**	-0.489	-0.59 – -0.34	0.101	0.329	0.0001*

Partial Pearson correlation coefficient value (r-value): strong correlation (±0.50 to ±1); moderate correlation (±0.30 to ±0.49); low correlation (< ±0.29)
**Pooled analysis using mixed model accounting for within-subject clustering; r^2: determination coefficient;
Effect size (Cohen's q): 0.10 (small), 0.30 (medium), 0.50 (large). P-value: probability value; *Significant: (P<0.05)

Figure 1. Relation between right hand writing scale and pinch grip right hand

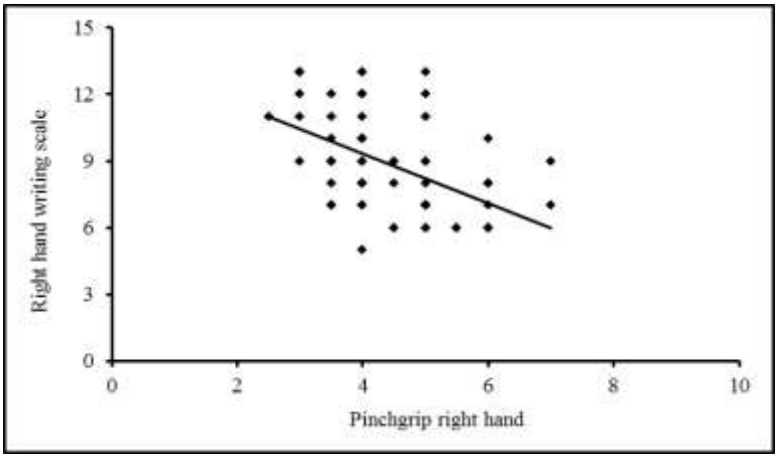


Figure 2. Relation between left hand writing scale and pinch grip left hand

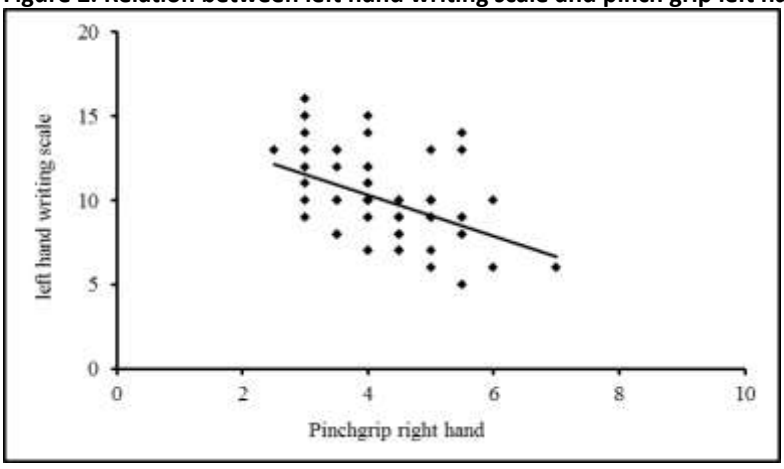
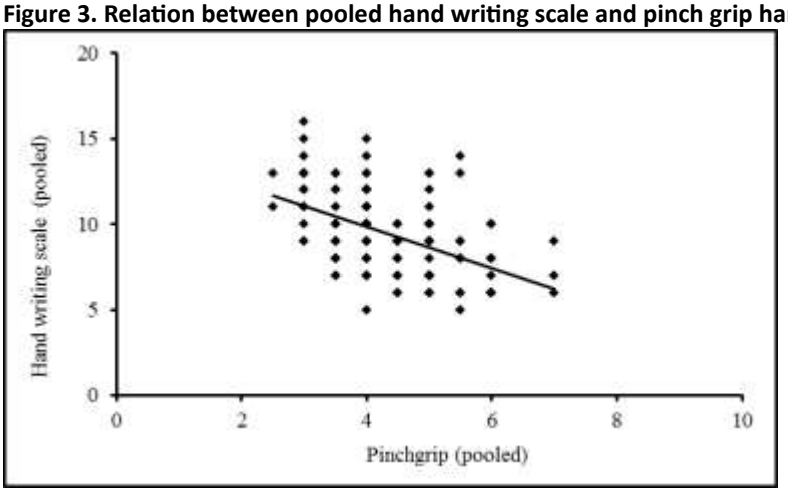


Figure 3. Relation between pooled hand writing scale and pinch grip hand (both hands)



Primary Mixed Model Analysis

The linear mixed model, demonstrated a significant negative association between pinch grip strength and handwriting score. In the unadjusted model, each 1 kg increase in pinch grip strength was associated with a -0.458-point decrease in handwriting score (95% CI: -0.17 – -0.75, β = -0.318, partial η^2 = 0.097, P=0.004). After adjusting for age, sex, and BMI, the effect remained significant and stable (β= -0.421, 95% CI: -0.13 – -0.71, β = -0.292, partial

η^2 = 0.085, P=0.006), age (β = -0.142, β = -0.071, P=0.501), sex (β = -0.458, β = -0.101, P=0.131), and BMI (β=0.189, β = 0.104, P=0.301) were not significant predictors in the adjusted model. The model explained 10.4% of the variance in handwriting scores (marginal R^2) and 68.4% when accounting for random effects (conditional R^2), indicating substantial between-subject variability (Table 4).

Table 4. Linear mixed model for factors associated with handwriting score

Predictors	β (Unstandardized)	95% CI	SE	β (Standardized)	Partial η^2	P-value
Pinch grip strength (Unadjusted)	-0.458	-0.17 – -0.75	0.146	-0.318	0.097	0.004*
Pinch grip strength (Adjusted)	-0.421	-0.13 – -0.71	0.148	-0.292	0.085	0.006*
Age	-0.142	-0.56 – 0.27	0.211	-0.071	0.005	0.501
Sex	-0.458	-1.05 – 0.14	0.301	-0.101	0.010	0.131
BMI	0.189	-0.17 – 0.55	0.182	0.104	0.011	0.301

Effect size (Partial eta square, η^2): 0.01 (small), 0.06 (medium), 0.14 (large). P-value: probability value; *Significant: (P<0.05)

Discussion

Handwriting legibility is the capacity to reliably produce letters, it necessitates the association of several processes and is essential to the development of fluent and automated handwriting [19]**.** Palmar pinch grip is essential to hold onto a pen or pencil**.** Academic performance skills may be impeded by handwriting difficulties, based on previous studies the strength of pinch grip can affect handwriting of student [8]**.**

The objective of the current study was to evaluate the relationship between handwriting legibility and hand grip strength in normally developing Egyptian primary school children. Palmar pinch grip strength was measured using a pinch gauge, and handwriting readability was evaluated by Handwriting Legibility Scale (HLS). The study's findings revealed a significant inverse relationship between pinch grip strength and handwriting legibility scores for right-handed children (r = -0.501). Moreover, moderate negative correlations were observed between pinch grip strength and handwriting legibility scores for left-handed children (r = -0.468).

Thus, this study showeds that as a palmer pinch strength decrease, handwriting legibility scale raises. It means that the less is palmer strength, the poor is handwriting legibility as picking up and pulling objects, as well as holding a pen vertically, requires a strong contraction of the muscles [5].

The result of this study is aligned with the previous study conducted by Kadaskar and Borkar (2020) who stated that if the strength of the palmar grip is weak, then handwriting tends to be poor. Conversely, if the palmar strength is good, the handwriting is usually legible [8]. Also, Alaniz et al. (2015) found that grip strength had been correlated with pencil control and handwriting legibility in typically developing children [20].

Several studies have documented a correlation between pinch grip strength and the handwriting abilities of students, noting a disparity in pinch grip strength between males and females. This difference in strength is attributed to inherent physiological differences in gender specific muscle fibres, as is found by [21,22]. Moreover, regarding the grip strength, a study done by Foley et al. (2025) documented that population wide statistics often show a higher

right-hand average than left hand. In addition, for right-handed individuals, the dominant hand typically has a 10% greater grip strength compared to the non-dominant hand [23].

On the other hand, Jha and Sethi (2021) stated that there was no correlation found between handwriting legibility and grip strength. However, a positive correlation was identified between grip strength and handwriting speed [4]. A similar finding was reported by Tayyab et al. (2019) who documented a positive correlation between handgrip strength and the speed of handwriting [24]. Also, Prunty et al. (2020) reported no significant correlations between any of the grip strength measures and the handwriting product and process measures in children with developmental coordination disorder [25].

There were few limitations found in our study. One limitation of the study was relatively small sample size. Secondly, limited representation (only one school) which limits the generalization of the results. A similar study could be done with more sample size with a different group of students, preferably from different schools.

Conclusion

This study presents evidence of a significant correlation between palmar pinch grip strength and handwriting legibility in typically developing Egyptian primary school children. The findings aim to assist in resolving calligraphic challenges among Egyptian students

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