

Impact of Pen Diameter on Writing Outcomes in Higher Secondary School Students at Pondicherry: An Ergonomic Analysis

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Abstract—Background: Handwriting remains a foundational skill for students, yet issues such as excessive grip pressure often compromise writing speed and reliability. Ergonomic experts suggest that the diameter of the pen grip—the specific area of finger contact—is a primary determinant of this pressure. **Objective:** This study aimed to investigate the impact of varying pen grip diameters (6 mm and 10 mm) on the writing capacity of higher secondary school students in Pondicherry. **Methodology:** An observational study was conducted involving 60 students from the 11th and 12th grades at Muthu Rathina Arangam Higher Secondary School. Handwriting speed, measured in words per minute (WPM), was assessed using a standardized one-minute writing task with three different tools: the student's normal pen, a 6 mm diameter pen, and a 10 mm diameter pen. **Results:** Statistical analysis revealed that while both experimental pen diameters showed some increase in writing capacity, the 10 mm diameter pen yielded a significantly higher mean word count (27.63 WPM) compared to the normal pen (24.02 WPM) and the 6 mm pen (24.88 WPM). **Conclusion:** Students demonstrated enhanced writing effectiveness and reduced potential for muscle strain when using a 10 mm diameter pen, suggesting that ergonomic pen selection can optimize academic performance.

I. INTRODUCTION

Handwriting is an indispensable skill for higher secondary students, serving as the primary medium for demonstrating knowledge during high-stakes examinations. Despite the rise of digital technology, the ability to write quickly, legibly, and comfortably remains a critical predictor of academic success in the Indian educational context. However, handwriting difficulties are prevalent, affecting an estimated 10–30% of school-aged children. These difficulties often manifest as reduced speed, poor legibility, and physical discomfort, which can negatively impact overall academic performance.

The ergonomics of writing tools, particularly the diameter of the pen barrel, play a significant role in these outcomes. An inappropriate pen size may lead to poor grip stability and excessive muscle fatigue, as the hand must work harder to maintain control over the instrument. Common clinical features of ergonomic mismatch include increased grip pressure, finger pain, cramping, and even the development of calluses. In severe cases, prolonged use of poorly designed tools can contribute to "Writer's Cramp," a disorder characterized by spasms in the muscles of the hand and forearm.

In Pondicherry, higher secondary students spend several hours daily engaged in handwriting tasks. Despite this high volume of work, there is a lack of empirical data regarding how pen design specifically impacts their performance. This study addresses this gap by examining how varying pen diameters influence writing speed and comfort among this population.

II. AIM AND OBJECTIVES

Aim: To assess the impact of pen diameter on writing performance among higher secondary school students in Pondicherry.

Objectives:

1. To evaluate the effect of different pen diameters on handwriting speed, legibility, and comfort.
2. To compare writing outcomes (e.g., neatness, fatigue, grip stability) across varying pen diameters.
3. To determine student preferences regarding pen diameter in relation to their personal writing experience.
4. To provide evidence-based recommendations for optimal pen design for the higher secondary student population.

III. METHODOLOGY

Study Design and Settings This was an observational study conducted at the Muthu Rathina Arangam Higher Secondary School in Puducherry. This setting was chosen to reflect the typical environment and writing demands faced by students in the region.

Participants A total of 60 students from the 11th and 12th grades were selected using a convenient sampling method.

- **Inclusion Criteria:** Students from grades 11 and 12; use of dominant hand (left or right); any grip style or current pen type.
- **Exclusion Criteria:** Students with learning struggles; recent dominant hand trauma, surgery, fractures, burns, or infections; existing ailments like writer's cramp or tennis elbow.

Materials The researchers utilized:

- Standardized 6 mm and 10 mm diameter pens (See Fig-1).
- Standardized writing passages (100–150 words).
- Stopwatches for precise timing.
- A4 writing paper and data recording sheets.

Outcome Measure The primary outcome measure was Handwriting Speed, calculated as Words Per Minute (WPM). Participants were instructed to write as quickly and legibly as possible for exactly 60 seconds. Only complete and legible words were counted toward the final score.

Procedure After obtaining informed consent from the subjects (See Fig-2, Fig-3), the researchers explained the experimental procedure. Each student performed the one-minute writing task three times, using a different tool for each session:

1. Their personal "Normal" pen.
2. A provided 6 mm diameter pen.
3. A provided 10 mm diameter pen. Writing performance was recorded and then analyzed using statistical tools to determine significant differences between the pen types.

IV. STATISTICAL ANALYSIS AND RESULTS

1. Descriptive Statistics

Table 1: Descriptive Statistics of Writing Performance by Pen Diameter

Descriptive Statistics					
Variable	N	Minimum	Maximum	Mean	SD
Age	60	15.00	16.00	15.68	0.47
Normal	60	11.00	42.00	24.02	6.36
Pen-6mm	60	13.00	34.00	24.88	5.36
Pen-10mm	60	13.00	48.00	27.63	6.09

The Table1 summarizes the overall descriptive statistics for 60 students. The mean age of participants is 15.68 years ($SD = 0.47$), showing a relatively homogeneous age group. For writing performance, the mean number of words written using a normal pen is

24.02 ($SD = 6.36$), using a 6mm pen is 24.88 ($SD = 5.36$), and using a 10mm pen is 27.63 ($SD = 6.09$). This suggests that students wrote more words on average with the thicker 10mm pen compared to the normal and 6mm pens.

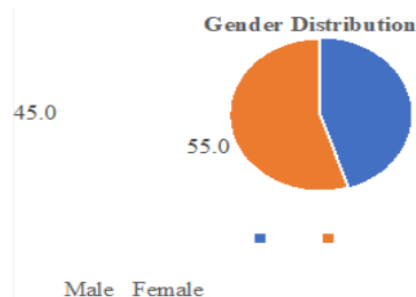
Table 2: Descriptive Statistics of Writing Performance by Gender

Descriptive Statistics - By Gender						
Gender	Variables	N	Minimum	Maximum	Mean	SD
Male	Age	27	15.00	16.00	15.67	0.48
	Normal	27	13.00	42.00	25.93	6.74
	Pen-6mm	27	13.00	34.00	25.67	5.78
	Pen-10mm	27	13.00	48.00	28.67	7.44
Female	Age	33	15.00	16.00	15.70	0.47
	Normal	33	11.00	33.00	22.45	5.66
	Pen-6mm	33	14.00	33.00	24.24	4.99
	Pen-10mm	33	19.00	36.00	26.79	4.66

Table 2 shows that when analyzed by gender, both males and females are of similar age (Males: 15.67 ± 0.48 ; Females: 15.70 ± 0.47). Males tend to write more words on average across all pen types than females. Standard deviations indicate slightly higher variability in male writing performance, particularly with the 10mm pen ($SD = 7.44$) compared to females ($SD = 4.66$). Overall, thicker pens (10mm) resulted in higher word counts for both genders.

Table 3: Gender Distribution of Participants

Gender	Frequency	Percent
Male	27	45.0
Female	33	55.0
Total	60	100.0



Among the 60 participants, 45% were male and 55% were female, showing a slightly higher representation of females in the study.

2. Intra-Group Analysis:

Hypotheses:

Null hypothesis, H_0 : There is no significant difference in mean word count between Normal and 6mm pens (or Normal and 10mm or 6mm and 10mm)

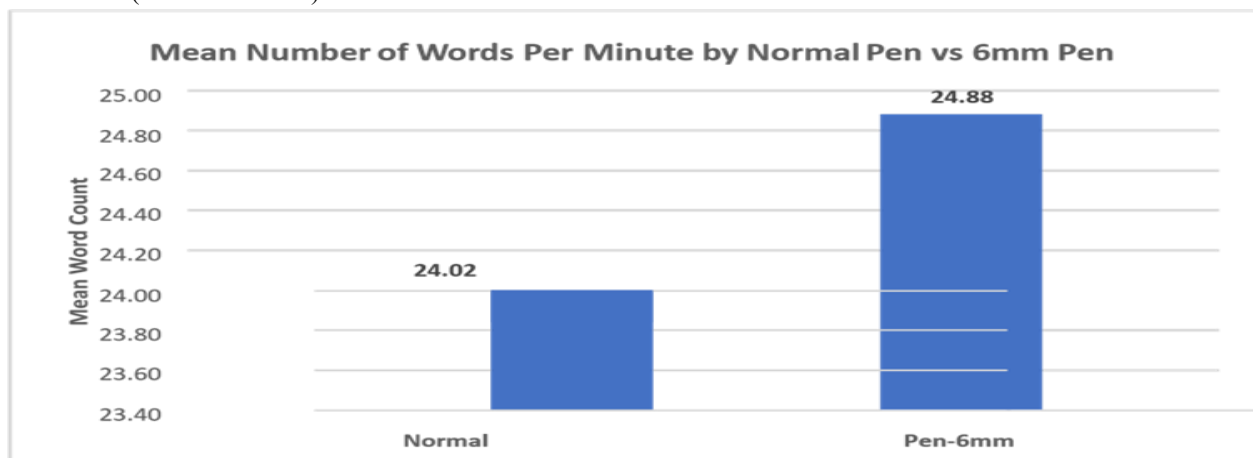
Alternate hypothesis, H_1 : There is a significant difference in mean word count between Normal and 6mm pens (or Normal and 10mm or 6mm and 10mm)

Table 4: Output of Paired Sample t-test:

Paired Samples Statistics							
Pair	Pen Type	N	Mean	SD	t-value	df	P-value
Pair 1	Normal	60	24.02	6.36	-1.46	59	0.150
	Pen-6mm	60	24.88	5.36			
Pair 2	Normal	60	24.02	6.36	-7.47	59	0.000
	Pen-10mm	60	27.63	6.09			
Pair 3	Pen-6mm	60	24.88	5.36	-5.15	59	0.000
	Pen-10mm	60	27.63	6.09			

The paired samples t-test was conducted to compare writing performance (number of words written per minute) between different pen types.

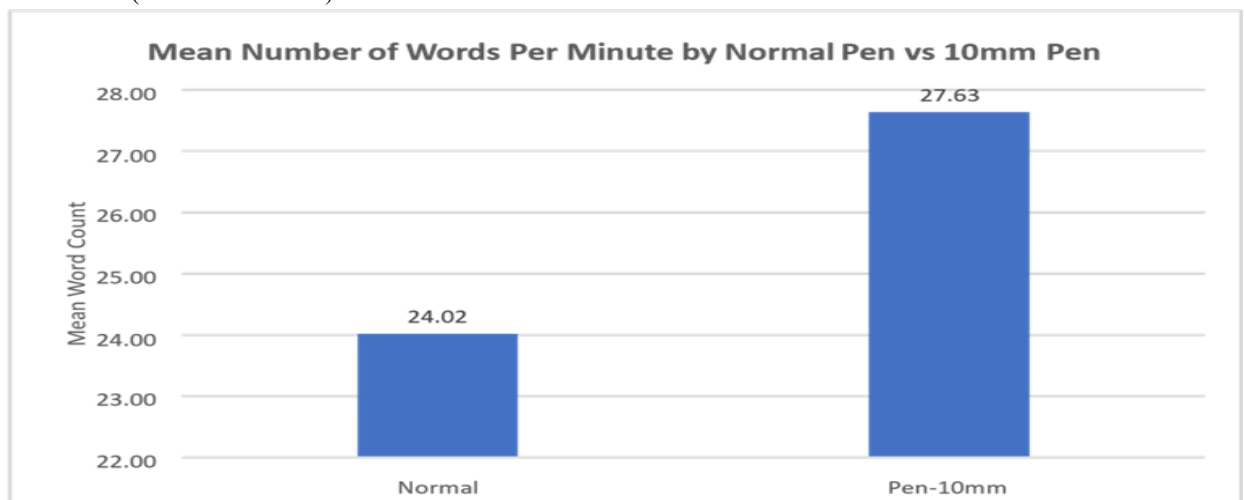
GRAPH 1: (Normal vs 6mm)



RESULT

The difference in word count between the normal pen (Mean = 24.02, SD = 6.36) and the 6mm pen (Mean = 24.88, SD = 5.36) is not statistically significant ($t = -1.46$, $df = 59$, $p = 0.150 > 0.05$). This indicates that writing performance using the normal pen and the 6mm pen was similar.

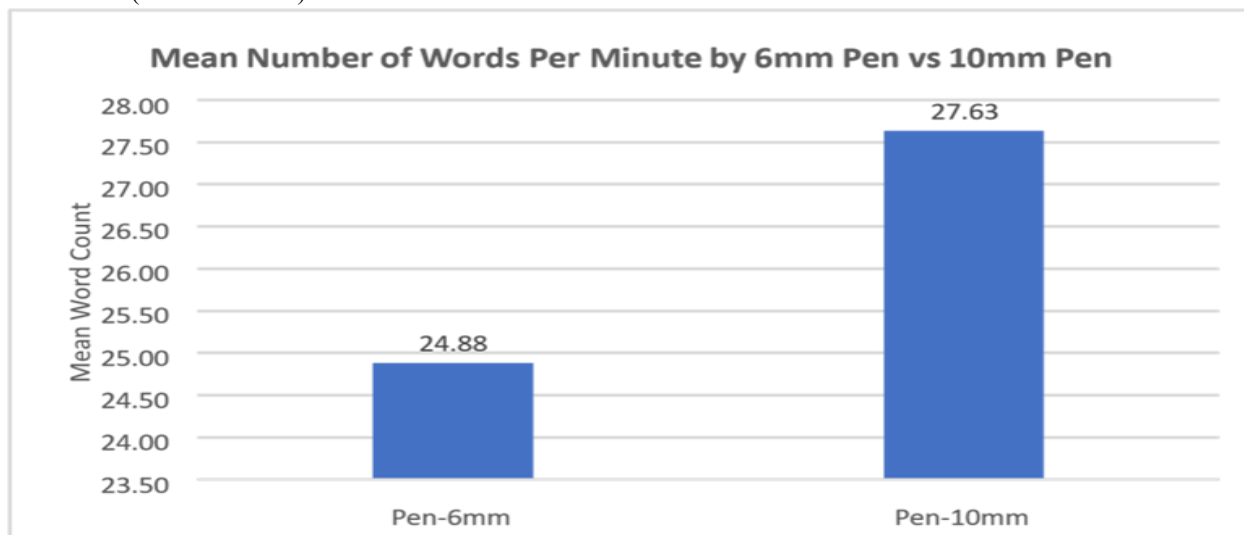
GRAPH 2: (Normal vs 10mm)



RESULT

The difference in word count between the normal pen (Mean = 24.02, SD = 6.36) and the 10mm pen (Mean = 27.63, SD = 6.09) is statistically significant ($t(59) = -7.47, p < 0.001$). This suggests that participants wrote significantly more words when using the 10mm pen compared to the normal pen.

GRAPH 3: (6mm vs 10mm)



RESULT:

Similarly, the comparison between the 6mm pen (Mean = 24.88, SD = 5.36) and the 10mm pen (Mean = 27.63, SD = 6.09) showed a significant difference, $t(59) = -5.15, p < 0.001$, indicating that writing performance improved with the thicker 10mm pen.

In terms of mean comparison, although the normal and 6mm pens produced similar results, the 10mm pen consistently yielded higher word counts, suggesting that pen diameter positively influences writing speed among students.

V. DISCUSSION

The results of this study clearly demonstrate that pen diameter significantly influences handwriting outcomes. The finding that the 10 mm pen outperformed both the students' normal pens and the thinner 6 mm pens aligns with established ergonomic principles.

Ergonomic Mechanics and Muscle Fatigue From a biomechanical perspective, very thin pen diameters (such as 6 mm) require higher grip pressure to maintain stability. This sustained pressure leads to faster onset of finger and hand muscle fatigue, which

eventually degrades both writing speed and legibility. Conversely, a moderately thicker pen, like the 10 mm diameter tested here, allows for a more relaxed yet firm grip. This "optimal" grip enables the hand muscles to function more efficiently, reducing unnecessary tension and allowing for greater endurance during prolonged tasks.

Comparison with Existing Literature Our results are consistent with Kulkarni et al. (2022), who found that larger diameter pens were associated with faster writing speeds and more stable grips. It also supports Kadam et al. (2019), who argued that optimal grip sizes help improve writing capacity without increasing hand tension. The preference for the 10 mm pen in our study echoes the findings of Goonetilleke et al. (2009), who noted that circular barrels of appropriate size allow for smoother finger movement.

Implications for Academic Performance In the competitive academic environment of Pondicherry, even a small increase in writing speed can be decisive during examinations. The 10 mm pen provided an average increase of approximately 3.6 words per minute over the normal pen. Over a standard three-hour exam, this could translate to a significant increase in the total volume of written work. Beyond speed, the

reported reduction in fatigue and improved comfort is critical for maintaining handwriting quality throughout an entire session.

Educational Importance of Ergonomic Awareness A key observation of this study is the general lack of awareness among students and educators regarding the impact of tool selection on performance. Many students continue to use pens that may be causing them physical strain or limiting their speed simply because they are unaware that an alternative exists. Incorporating ergonomic education—specifically regarding pen choice, posture, and grip—into the school curriculum could promote healthier and more efficient writing habits from an early age.

VI. CONCLUSION

This study concludes that pen diameter has a measurable and significant effect on writing speed and productivity among higher secondary school students. The 10 mm diameter pen consistently outperformed narrower alternatives for both male and female students. By selecting pens with an optimal diameter (approximately 9–10 mm), students can enhance their writing capacity, improve comfort, and reduce the risk of hand-related muscle strain. These findings suggest that schools and parents should prioritize ergonomic pen design to support the academic and physical well-being of students.

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