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EXTENDING OSBORN'S FRAMEWORK: COMPARATIVE ANALYSIS OF HAND AND FOREARM MOVEMENT CHARACTERISTICS IN FORENSIC HANDWRITING EXAMINATION

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Abstract: Handwriting is a complex motor skill, a neuromuscular activity, involving 27 bones and 40 muscles. The movement used in writing, whether executed by the hand or the forearm, is recognized as a significant factor in shaping handwriting characteristics, and this aspect is considered important in forensic document analysis. This study aims to compare the handwriting characteristics, such as alignment, line quality, and inter-word spacing, in hand and forearm movements within the same group of participants. The study used a descriptive design, with primary data collected from 100 subjects (18-45 years), both male and female, from students and non-students via purposive sampling. All subjects were asked to write the same passage twice: one with hand movement (wrist held) and the other with forearm movement (forearm held) in a sitting position using a ballpoint pen on A4 paper. The characteristics were scored and statistically analyzed using a paired T-test in MS Excel. Percentage analysis was also applied. The findings showed significant differences ($p < 0.05$) in all three characteristics. Movement of the hand resulted in (63%) more variety in alignment, (81%) uneven line quality, and (86%) less inter-word spacing. Forearm movement resulted in (63%) less variety in alignment, (76%) even line quality, and (86%) greater inter-word spacing. These results are consistent with Albert S. Osborn's theory and can be used in forensic document examination to distinguish normal from abnormal handwriting characteristics.

Index Terms **-** Handwriting, Hand movement, Forearm movement, Alignment, Line quality, Inter-word spacing, Questioned document examination.

I. INTRODUCTION

Writing by hand with a writing implement, such as a pen or pencil, is known as handwriting. It is considered a neuromuscular activity, involving 27 bones and 40 muscles [1,2]. Handwriting is distinct from formal calligraphy or typography, and it encompasses both block and cursive styles. Because handwriting varies and is distinctive to each individual, it can be used to define the writer of a specific writing sample [3]. No two pieces of writing can be identical because each person has a unique handwriting style. Even identical twins who share the same appearance and genetics do not have the same handwriting. Natural variation exists in all handwriting, meaning that no two writing samples from the same writer are alike because the human brain is not a computer and cannot reproduce the same thing repeatedly in the same fashion [4,5]. Handwriting analysis is a common forensic technique used to determine a person's real identity. Analyzing a person's physical and mental conditions is also beneficial. In modern document analysis, it is used to

detect forgeries. Factors affecting handwriting include environment, motor, vision, perception, attitude, attention or memory, and emotion [6-8].

Albert S. Osborn**,** the father of science in questioned document examination in North America, provided a description of the movements in handwriting analysis in his book "*Questioned Documents"* through his research. It helps to study the degree of similarity and differences between the handwriting analysis of hand and forearm movement, and this can be significant in forensic analysis [9]. The description, thus provided by him, has not been explained or worked upon in detail by other researchers. This present study helps to understand the difference between hand and forearm movements in handwriting, shows the importance of muscle coordination in affecting writing features like alignment, spacing, and line quality, define natural variations and unusual writing patterns better, information on hand and forearm motions can help professionals to examine writing more accurately, differences in movement patterns can help forensic scientists to identify genuine handwriting from that written under coercion or physical duress.

The present study aims to compare the differences between hand and forearm movement in handwriting analysis. The objectives of the study are to analyze and compare the handwriting characteristics produced through hand and forearm movement in the same person, to identify and evaluate the similarities in handwriting characteristics that emerged between hand and forearm movement, and to analyze how major hand and forearm muscles influence handwriting movement and to evaluate their impact on alignment, line quality, and spacing for forensic questioned document examination.

II. RESEARCH METHODOLOGY

Study design and participants

A descriptive research design was used in this study. The sample size for the study is 100, including male and female age groups between 18-45. Purposive (non-probability) sampling was used.
The primary data for the study was collected from students or people in the age group between 18-45 years who have no neuro- muscular disorders. Only right-handed writers were included in the study to maintain uniformity in samples; all subjects were required to be fluent in English and were willing to write under the standardized conditions, ensuring legible and consistent handwriting samples across all participants.

Sample collection

Handwriting samples were obtained from the subjects only after their written consent had been secured. The subjects were asked to write the same text twice, once in hand movement and again in forearm movement, in a sitting position using the ballpoint pen (Hauser XO) and an A4 sheet on the same writing surface. The text used to collect the sample was:

"Handwriting is an acquired skill, basically a neuromuscular task, which involves 27 bones and 40 muscles. It is habitual as well as individualized, and this individualization is the basic principle in document examination."

The samples of the hand movements were taken by holding the wrist of the subject, and the samples of forearm movements were taken by holding the forearm of the subject.

Compliance with ethical standards

All participants provided their written consent, and ethical approval was not required for this noninterventional study.

Sample Analysis

Three handwriting characteristics were analyzed: (1) Alignment — the variety of different types of alignments (even, ascending, descending, arch, and mixed) present in hand or forearm movement, coded as 0 for even, 1 for less variety of alignment, and 2 for more variety of alignment ; (2) Line Quality — the quality of line in hand and forearm movement, coded as 1 for even and 2 for uneven; and (3) Inter-word Spacing — the space between words, coded as 1 for less space and 2 for more space.

Statistical Analysis

For all three characteristics, the paired T-Test in MS Excel was used to analyze whether there is a significant difference between hand and forearm movement. Percentage analysis was performed by dividing each component's value by the total number of samples and multiplying by 100.

III. RESULTS AND DISCUSSION

Alignment

The number of samples in which the variety of different types of alignment differed on analysis between hand and forearm movement is 77 out of 100 (77%). The T-test used to compare the alignment between hand and forearm movement showed a p-value $P = 0.0012 \times 10^{-6}$, which is statistically significant ($p < 0.05$).

In hand movement, out of 100 samples, 63% samples have a more variety of alignment, 14% samples have a less variety of alignment, and 23% samples have an even variety of alignment. In forearm movement, out of 100 samples, 14% samples have a more variety of alignment, 63% samples have a less variety of alignment, and 23% samples have an even variety of alignment.

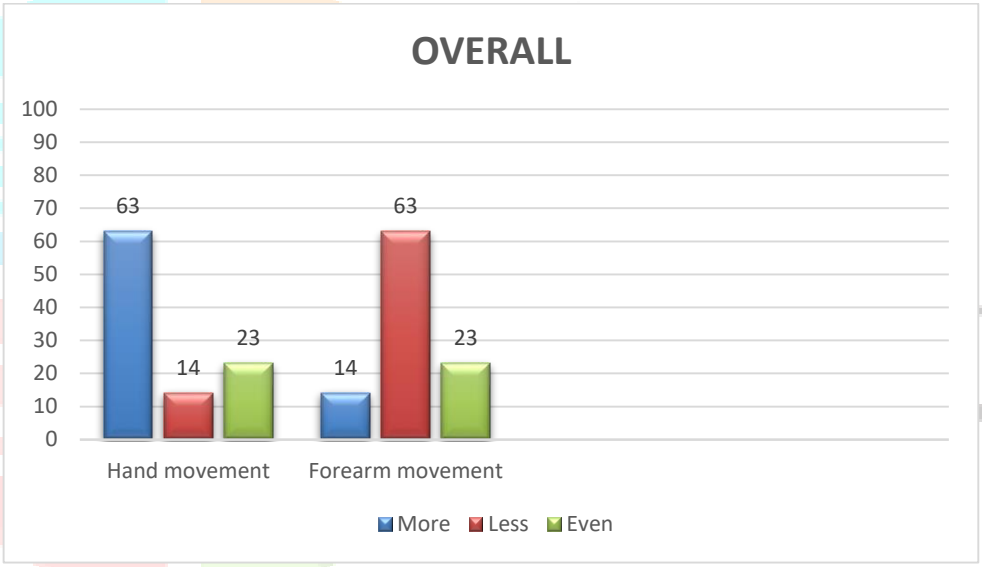

Fig 1: The graph shows the variety of different types of alignment present in hand and forearm movement

In analyzing the hand movement out of 100 samples, 5% show even, 55% show ascending, 15% show descending, 12% show arch, and 13% show mixed; and in forearm movement out of 100 samples, 5% show even, 71% show ascending, 9% show descending, 9% show arch, and 6% show mixed. Compared to forearm movement, hand movement shows a high number of descending, arch, and mixed movements and has a lower number of ascending and the same number of even.

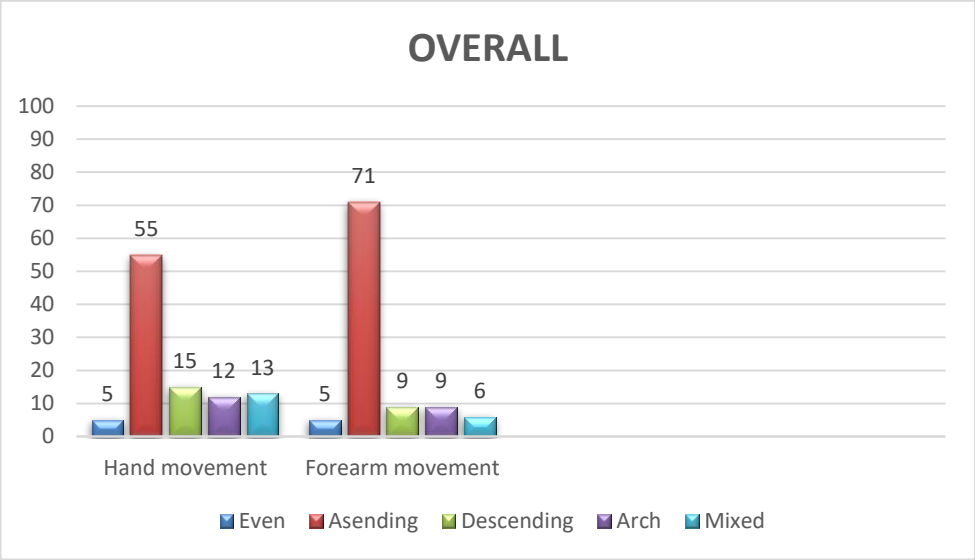

Fig 2: The graph shows the alignments present in hand and forearm movement

Line quality

In hand movement, out of 100 samples, 81% samples have uneven line quality, and 19% samples have even line quality. In forearm movement, out of 100 samples, 24% samples have uneven line quality, and 76% samples have even line quality. In the analysis, we can see a high proportion of uneven line quality in hand movement and a high proportion of even line quality in forearm movement. The p-value for Line Quality is $P = 0.825 \times 10^{-14}$, which is statistically significant ($p < 0.05$).

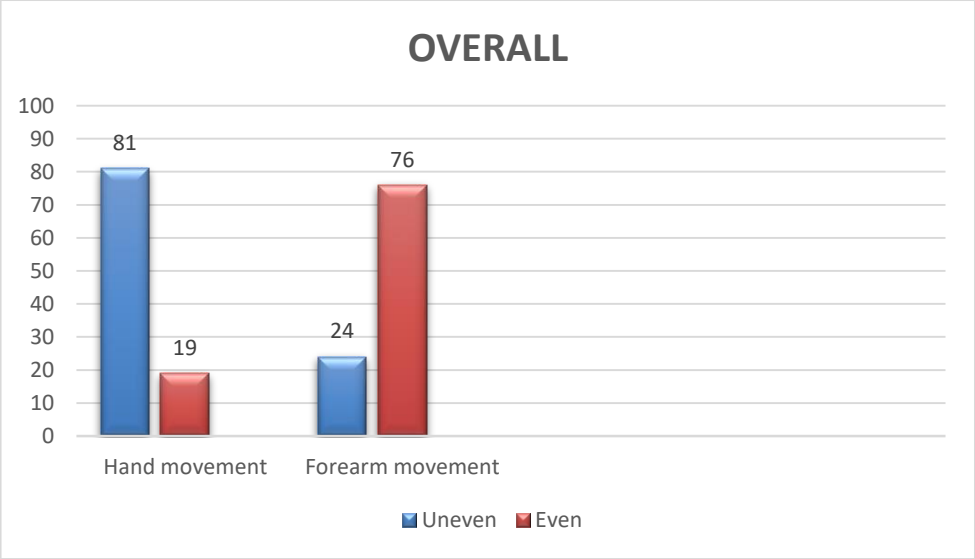

Fig 3: The graph shows the line quality present in hand and forearm movement

Inter-word spacing

In hand movement, out of 100 samples, 86% samples have less space, and 14% samples have more space. In forearm movements, out of 100 samples, 14% samples have less space, and 86% samples have more space. In the analysis, we can see a high number of Less Space in Hand Movement, and a high number of More Space in Forearm Movement. The p-value for Inter-word Spacing is $P = 0.216 \times 10^{-16}$, which is statistically significant ($p < 0.05$).

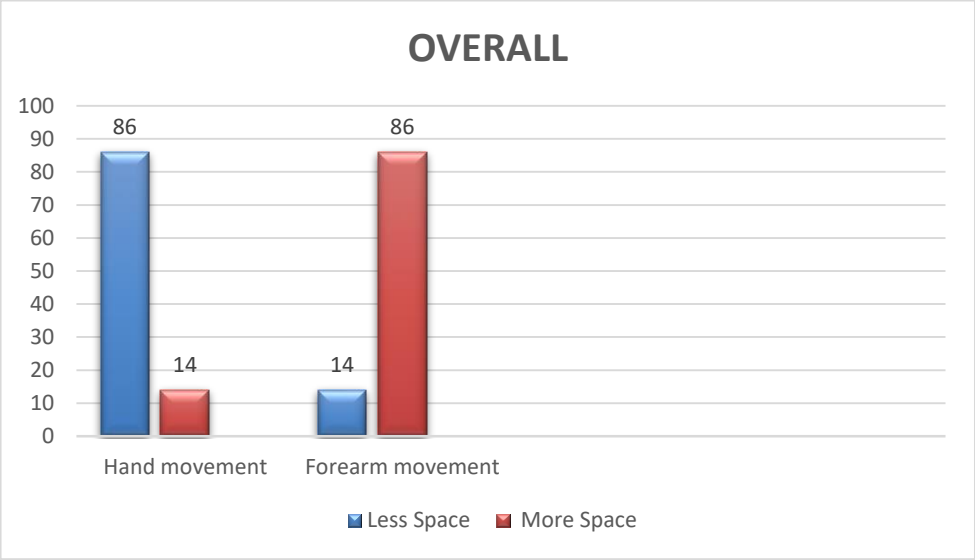

Fig 4: The graph shows the inter-word spacing present in hand and forearm movement

The present study helps to determine the effects of hand and forearm movement on handwriting characteristics such as alignment, line quality, and inter-word spacing. Using a paired t-test for analysis, the results showed statistically significant differences ($p < 0.05$) for all three variables, confirming that the variations are not due to chance. The study shows that hand movement produces more variation, with a greater variety of alignment patterns, uneven line quality, and less spacing between words. In forearm movement, it shows less variety of alignment patterns, even line quality, and more space between words. These results show that the nature of movement is a crucial factor in the production of handwriting because the various muscle activities produce varying writing quality and consistency.

According to Albert Osborn's theory of alignment, we can see a difference between hand and forearm movement. Compared to forearm movement, hand movement shows a high number of descending, arch, and mixed movements and has a lower number of ascending movements. This is consistent with the understanding that wrist action produces a longer, continuous motion, and the hand swings from left to right, causing the baseline to frequently create an arc in the lettering.

These findings are backed up by studies. The identification and analysis of handwriting characteristics, including structural layout and line quality, are crucial in forensic handwriting examination [10]. Features such as pen movement, alignment, and stroke connectivity serve as measurable parameters that enable examiners to establish writing patterns and assess individuality in questioned documents [11]. The accuracy and reliability of handwriting comparison findings highlight the importance of the analysis with different stages [12].

The results of these findings can be explained by neuromuscular activity. Previous studies have shown that both distal hand muscles (intrinsic finger flexors and extensors) and proximal forearm muscles (flexor carpi radialis, extensor carpi ulnaris, pronator teres) are involved in handwriting execution, with skilled writers using their intrinsic finger muscles for fine control and using the forearm muscles for stabilization [13]. This supports the present study's observation that biomechanical differences between the hand and forearm movements significantly influences alignment, line quality, and spacing in questioned document examination.

The present study faced certain limitations. The sample size was small; therefore, the findings might not be generalizable to a wider population. The handwriting was collected in controlled conditions; hence, it may not be a complete reflection of natural writing conditions. Additionally, characteristics such as alignment

are subject to interpretation, which could lead to slight differences. Very few handwriting features were studied, and other important features like speed and pressure were not considered.

IV. CONCLUSION

The current study proves that freedom of muscle movement is one of the most important factors that affect the quality of the handwriting and consistency of it. Hand movement resulted in more variation in alignment, uneven line quality and less spacing compared to forearm movement, which resulted in more stable alignment along with smoother strokes and wider spacing. Such differences show the significance of the biomechanical factors plays an important role in the execution of handwriting of a human being.
The results shows forensic applicability for questioned document examination, parameters derived from movement can help examiners to differentiate between genuine and suspicious or confined handwriting patterns, improving the accuracy of document examination. The results of this research offers a foundation for future studies of handwriting variability and will aid the incorporation of movement analysis into forensic practice.

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References

[1] Kehkashan H, Manohar YM. Comparative study of handwriting characteristics in Hindi transcript written on different surfaces: a forensic perspective. J Criminol Forensic Stud 2024;6:180078. doi:10.33513/JOCFS/180078.
[2] Huber RA, Headrick AM. Handwriting identification: facts and fundamentals. 2nd ed. Boca Raton (FL): CRC Press; 1999;11.
[3] Khajuria A, Pillai A. Forensic handwriting examination: an updated clinical review. Santosh Univ J Health Sci 2023;9:223–8. doi:10.4103/sujhs.sujhs_47_23.
[4] Srihari SN, Cha SH, Arora H, Lee S. Individuality of handwriting. J Forensic Sci 2002;47:856–72. doi:10.1520/JFS15409J.
[5] Thomas MW, Rajan SK. Genuine handwriting variations in 10 years: a pilot study. Egypt J Forensic Sci 2019;9:49. doi:10.1186/s41935-019-0154-2.
[6] Feder KP, Majnemer A. Handwriting development, competency, and intervention. Dev Med Child Neurol 2007;49:312–7. doi:10.1111/j.1469-8749.2007.00312.x.
[7] Farhana SN, Harun D, Lokman AH. Revisiting handwriting fundamentals through an interdisciplinary framework. Malays J Med Sci 2022;29:18–33. doi:10.21315/mjms2022.29.1.3.
[8] Fajariani D, Suyama N, Yamanishi Y, Phadsri S, Komariyah DA, Ito Y. Analyzing occupational performance of children with handwriting difficulties: parent and teacher experiences and perspectives. Occup Ther Int 2025;2025:8882049. doi:10.1155/oti/8882049.
[9] Osborn AS. Questioned documents: a study of questioned documents with an outline of methods by which the facts may be discovered and shown. Rochester (NY): Lawyers Cooperative Publishing Company; 1910;105–25.
[10] Jones K, Bird C. Forensic handwriting examination: analysis, comparison and evaluation of handwriting and signatures. WIREs Forensic Sci 2024;6:e70010. doi:10.1002/wfs2.70010.
[11] Gupta S, Kumar P, Sharma BK, Misra VC. Age determination of male writers through certain handwriting characteristics. Int J Multidiscip Res Dev 2015;2:451–5.
[12] Hicklin RA, Eisenhart L, Richetelli N, Miller MD, Belcastro P, Burkes TM, et al. Accuracy and reliability of forensic handwriting comparisons. Proc Natl Acad Sci USA 2022;119:e2119944119. doi:10.1073/pnas.2119944119.
[13] Gerth S, Festman J, Jolly C. Muscle activity during handwriting on a tablet: an electromyographic analysis of the writing process in children and adults. Children (Basel) 2023;10:748–53. doi:10.3390/children10040748.