



Examining the Impact of Various Postures on Natural Variations in Signatures: A Systematic Investigation

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

The present study aims to examine the impact of various postures on natural variations in signatures and for the same, 640 signature samples were collected from 80 individuals (32 male and 48 female) of Jaipur city of Rajasthan, India. All the 80 participants (from age 20 – 77 years) of the study were asked to sign in 8 different postures such as keeping the paper on hand, on wall, standing, in bending posture, etc. in a pre-designed sheet having 8 columns as per posture. Both individual as well as class characteristics were analysed in all the signature samples including rhythm, pen pressure, slant, placings of dot on letters, size, spacing and dimensions, etc.

The study showed that the natural writing is characterized by variation in form, size, proportion, slant, and character combinations within specified boundaries. No two writing samples are identical in every way, and these variations were observed after analysis of all the samples. The study concludes that the basic nature of signature remains unchanged, but the dimension and presence of tremors are the two major factors that are dependent on posture and support. Thus, it may be said that there are no as such variations in parameters such as rhythm, style of writing, placing of dot, connective strokes and formation of loop, however signatures show significant variation in pen pressure and diameter with respect to variable postures.

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1. INTRODUCTION

Forensic science uses scientific knowledge to evaluate and identify suspects from crime scenes, analysing questioned papers from victims, crime scenes, or ancient records, across various disciplines [1].

Forensic expertise in signatures and handwriting is utilized in criminal and civil law proceedings to identify and establish offenses related to personal document forgery and official document falsification [2].

A 'questioned document' is any object that contains handwritten, typewritten, or printed markings whose provenance or authenticity is in question including letters, checks, money receipts, and more common proof items [3].

A questioned document, also known as a contested or disputed document, arises when a questioning concern about the validity of a document or its part is raised [4].

Handwriting is a difficult perceptual motor skill, also known as neuromuscular writing, distinguished by handwriting rather than typing or word processing, as well as a distinct individual's signature style [14].

Handwriting is one of the distinguishing features that helps us to communicate with others by representing what is in our brains. Handwriting reflects one's true personality traits such as behaviour, emotional outbursts, self-esteem, fury, imagination, honesty, phobias, and many others [5].

Handwriting formation is influenced by various factors such as training, race, country, heredity, gender, writing surface, physical or psychological disturbances, age, and natural variations. Training starts with a fixed pattern, but as students' progress, they stray from this pattern, resulting in individualistic handwriting. Gender also plays a significant role, with women

influenced by decoration and men focusing on readability. Writing surfaces, physical or psychological disturbances, age, and natural variations also contribute to handwriting variances. Genetics, gender, and environmental variables all play a role in shaping handwriting [13].

Handwriting analysis, also known as Graphology, is a scientific method used to understand a writer's personality through their handwriting patterns. It reveals traits such as behaviour, emotional outburst, self-esteem, imagination, fears, and honesty [26].

Handwriting analysis, also known as graphology, has numerous applications in fields like forensics, recruitment, medical diagnosis, psychology, and human computer interaction [31]. It symbolizes human personality and behaviour, revealing aspects like psychiatric conditions, morals, hidden skills, health difficulties, and past experiences. This method provides insight into a person's personality [6].

A signature is a personal mark or sign that represents an individual's identity, often an enactment of their name or nickname [22].

According to Black's Law Dictionary, a signature is the act of writing one's name at the end of an instrument to attest its validity. In forensic inquiry, signatures are crucial evidence [17].

The signature has become increasingly distinctive, and a style has been developed for signature execution. Because there are no rules for drawing/producing the signature, people are free to create whatever they want [7].

Signatures can be classified into three types based on their formation: those composed entirely of letters, those composed entirely of certain letters and certain non-letter patterns, and those composed entirely of non-letter patterns [8].

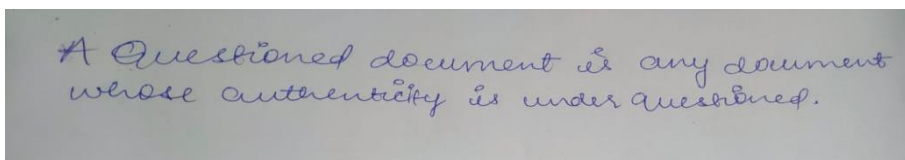


Fig. 1. Handwriting

A genuine signature is combination of writing which are reconcilable under natural circumstance surrounding the signature [4]. In forensic inquiry, a signature is regarded as the most important piece of evidence [19].

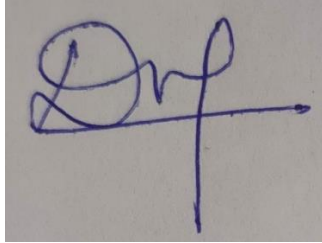


Fig. 2. Signature

Signatures can be used for personal identification since they are, at the very least, supposed to be unique [9]. An authentic signature combines writing characters with the natural surroundings of the signed document, unlike a forger's frame of mind. It demonstrates a lack of concentration during the writing process and a writer's willingness to be accused, as they have been signing their name for years [4].

Authentic signatures are smooth, written rapidly, and may miss certain formations. They also have rhythm and polished end strokes [28]. Signatures are unique to each individual, influenced by unconscious reflexive movements and the interaction of hand, eye, and brain. They can vary depending on the writer's emotional or physical state, position, and writing instrument [30]. However, commonalities arise as the focus is on content rather than the process of writing.

A person's signature on various surfaces is determined by some measures like as slant, loop, angle, baseline, and strokes, among others. Upadhyay et al., [1].

Class Characteristics are traits shared by members of a group, such as a common handwriting style, letters with specific shapes, a group's age range, or a common language [23].

Individual Characteristics are the traits that are found in the handwriting of individual such as pen pause, pen pressure, pen lifts, Starting and ending stroke, etc. [15]

Some of the Individual characteristics are-

- ❑ Rhythm- The art form involves uniform, coordinated strokes with sharp,

emphasized strokes rising and falling in flawless cones, with constant pressure changes from light to heavy or vice versa.

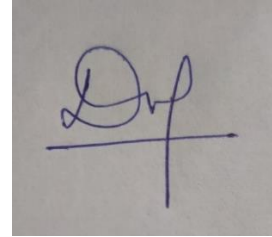


Fig. 3. Rhythm

- ❑ Style- Style is influenced by initial training, can be customized to suit personal preferences, ranging from angular to round designs, and can be straightforward or artistic.



Fig. 4. Style

- ❑ Pen Pressure- Writers' pressure and subconscious emphasis on words and letters can indicate spontaneity and authenticity, while deliberate, slow strokes may indicate forgery.
- ❑ Tremors- In the handwriting of some elderly, ill, inebriated, or illiterate people, tremors are normal. Since these tremors have a pattern of their own, it is possible to prove that the writing is fraudulent, if forged.

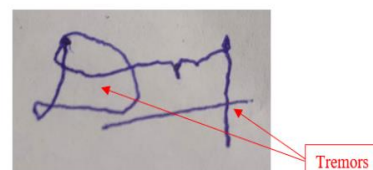


Fig. 5. Tremors

- ❑ *Pen pause*- Pen pause is a pause or stop in writing while the writing instrument remains in contact with the page [10].
- ❑ *Retouching*- Retouching is applied to some letters to finish, make sense, or create a visual impact. Nothing is being done to conceal it. Retouching, on the other hand, is used in fraudulent compositions to conceal pen lifts and pauses or to mimic the shading pattern of the original author. This makes the retouching easy to identify. Field & Field, [10]

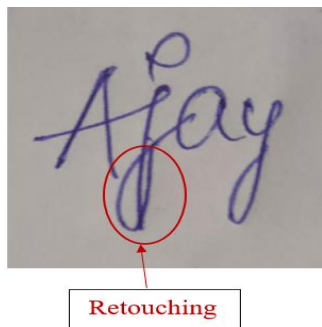


Fig. 6. Retouching

- ❑ *Slant*- It depicts the writing angle which can be forward, backward, upward, downward or straight [27].

One of the most engrained writing conventions is the slant, which takes on significant importance in several situations. The writers of the handwriting might be identified by a little tilt in two handwritings. Even if a glaring disparity might result from purposeful misrepresentation [25].

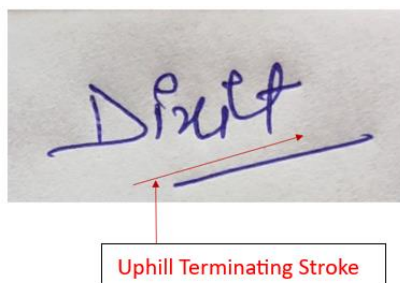


Fig. 7. Uphill Terminating Stroke

- ❑ *Diameter*- The length and breadth of letters, words and spacing between the can also help in analysing the writing, signature or author.

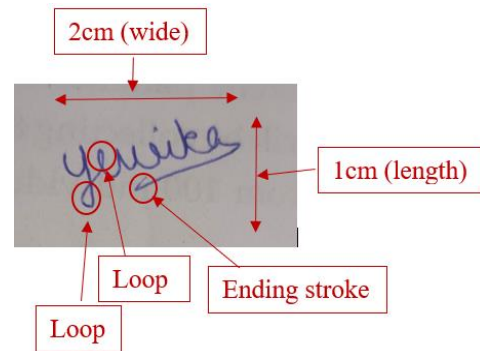


Fig. 8. Wide and longer

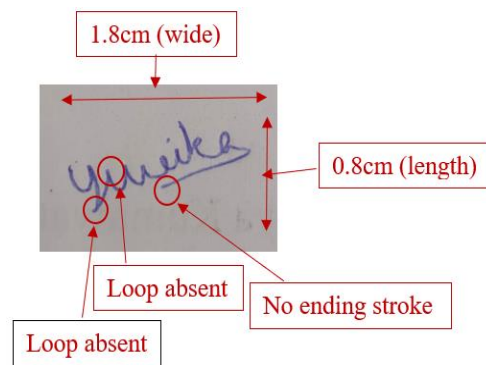


Fig. 9. Narrower and Smaller

- ❑ *Connective Strokes*- Connective strokes are continuous line in cursive writing that connects two neighbouring letters or words. It can be threadlike, shaded, or plain; angular, straight, or curved; short or widely spaced; heavy, or thin. (Richard Orsini - Forensic Terms, n.d.) [21].

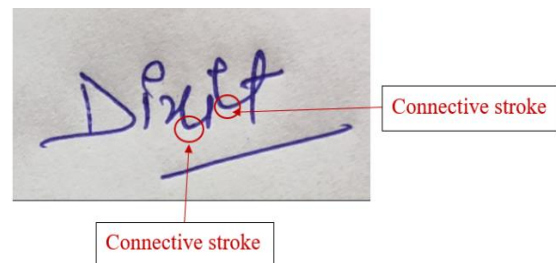


Fig. 10. Connective stroke

Natural variations in handwriting or signatures are genuine variations found naturally among individuals, and while they are common, they do not always indicate forgery [16]. Detecting these variations in signatures is challenging, as it requires determining if they are inherent differences or if they are significant enough to rule out forgery attempts [29].

Natural variation in signatures is a difficulty for signature verifiers because they must determine whether the variation is due to a natural difference between distinct instances of a signature or whether the variance is big enough to dismiss the instances as forgeries [18].

Natural variances are the essence of any individual's writing and are extremely likely to show in one's handwriting, but these variations are limited. Rajwar & Singh, [11].

Signature identification is based on generic handwriting principles and unique characteristics such as coordination, muscular control, age, health, temperament, and frequency of writing [32]. If a signature matches the standard, it can be concluded that it was written by the same person. Forensic handwriting analysis is a branch of forensic science that aims to detect and compare handwriting samples for investigation purposes [24]. This scientific analysis provides an outline of key principles, methodologies, and techniques used to evaluate handwriting evidence. The examination examines the significance of handwriting analysis in criminal investigations, analyses underlying scientific principles, and highlights the challenges faced by forensic professionals in this area.

Forensic handwriting inspection and comparison is based on three fundamental principles:

1. No two experienced writers exhibit similar handwriting traits.
2. Every person's writing has a variety of inherent differences.

3. No writer's talent level may be exceeded. +Kumar & Shukla, [12].

2. MATERIALS AND METHODS

All samples for this pilot study were taken from individuals from the age of 20 to 77 years. All samples were chosen at random.

All of the samples were taken on a white A4 sheet (form) using a blue ball tip pen. The predesigned form was prepared for signature sample collection containing 8 separate columns for 8 different postures duly mentioning the numbers and type of posture to avoid any confusion. As mentioned, the signatory was asked to sign in the respective column of respective posture number. 640 samples were collected from 80 individuals. Each individual had to sign in eight different posture/surface. In signatures where support was required a copy with 80 pages was used as a support. Individuals were photographed while giving samples using phone camera of model "Realme 7 Pro".

The eight different posture/surface were:

- P1: Standard (sitting on chair with copy as support on table)
- P2: On wall (without copy)
- P3: On hand (without copy)
- P4: On lap (without support)
- P5: Standing with bended posture (table and copy below)
- P6: Back support (without copy)
- P7: Knee bend on table (without copy)
- P8: Lying with knees bended (without copy)

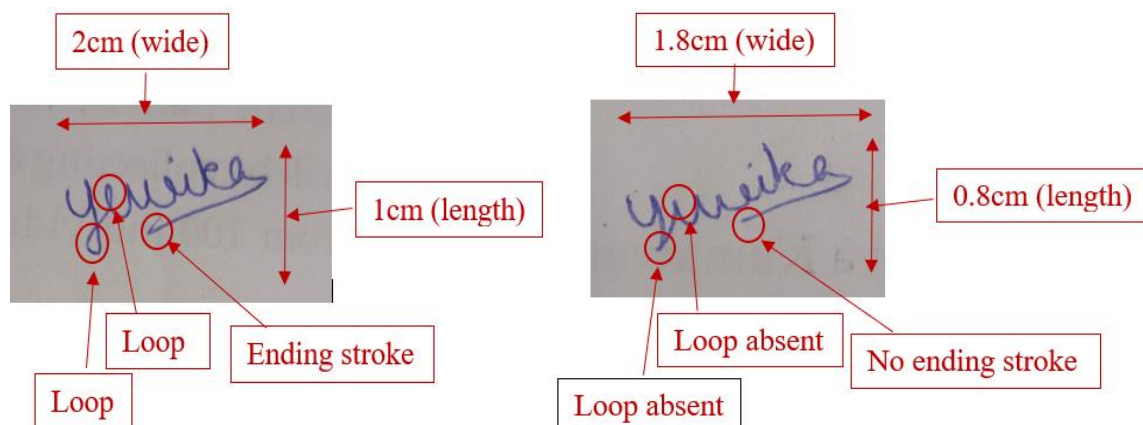


Fig. 11. Comparison of signature of same person for natural variation



Image 1. Various posture/surface used for signature



Image 2. Map indicating Jaipur city of Rajasthan from where samples were collected [33]



Image 3. Jaipur City Map [34]

2.1 Analysis of Samples

A ruler, scale, magnifying glass and pencil were used to analyze the samples.

First, the samples were assessed based on the writer's class characteristics. The variance in class features was found in comparison to the class characteristics of each individual writer's standard handwriting. The following class features were considered:

- Rhythm: Present, Absent.
- Style: Round, Angular or Mixed.
- Pen pressure: Heavy, Medium or Light.
- Tremors: Present, Absent.
- Pen pause: Present, Absent.
- Retouching: Present, Absent.
- Slant: Upward, Downward, or Straight.
- Diameter (breadth)
- Diameter (length)
- Connective stroke: Present, Absent.
- Formation of loop: Present, Absent or small

3. RESULTS

The study showed that the natural writing is characterized by variation in form, size,

proportion, slant, and character combinations within specified boundaries. No two writing samples are identical in every way, and these variations were observed after analysis of all the samples.

4. DISCUSSION

After analysis of samples, the observation made are discussed below:

4.1 Standard (Sitting on chair and table support)

The research analysed 80 samples, revealing 60% had rhythm, 36% mixed, and 51% round style. Pen pressure was light, placing was absent, pen pause was present, and retouching was absent. Samples were 26% longer, 61% smaller, 63% wide, 47% narrow, and 10% not proper.

4.2 Standing on Wall

The research analysed 80 samples, revealing 4% had rhythm, 10% mixed, and 11% round style. 10% had tremors, 39% had light pen pressure, 2% absent, 1% improper, 5% pen pause, and 4% retouching. Samples were 71%

longer, 20% smaller, 63% wide, 30% narrow, and 10% had massive differences.

4.3 On Hand (without support)

The research analyzed 80 samples, revealing 4% had rhythm, 8% mixed, and 18% round style. 7% had tremors, and pen pressure varied. Samples were 41% longer, 45% smaller, and 7% had massive differences. Connection strokes were 11%, and 15% were absent. 8% were not proper.

4.4 On Lap

The research analysed 80 samples, revealing varying patterns in signature styles. 5% had

rhythm, 17% mixed, and 6% had tremors. Pen pressure varied, with 3% light, 18% medium, and 18% heavy. Samples were longer, 41% smaller, and had massive differences. Connection strokes were present in 4%, 8% absent, and 5% not proper.

4.5 Waist Bend and Table Support

The research analysed 80 samples, revealing varying pen pressure, placement, pen pause, and retouching. The samples were 42% longer, 36% smaller, and 8% had massive differences. Connection strokes were present in 15%, 21% absent, and 8% not proper compared to the standard sample.

Table 1. Observations of various parameters in standard sample (Sitting Posture)

| Parameter | Variation in percent |
|-----------------------|--|
| 1. Rhythm | Present in 75 (93%), absent in 5 (6% present) |
| 2. Style | Mixed in 29 (36%), round in 49 (51%), angular 2 (3%) |
| 3. Tremors | Absent |
| 4. Pen pressure | 38 light (47%), 27 medium (33%), 15 (18) light |
| 5. Placing of dot | Absent in 4 (5%), not proper in 2 (3%), |
| 6. Pen pause | Present in 7 (8%) |
| 7. Retouching | Absent |
| 8. Slant | 11 straight (13%), 79 upward (98%) |
| 9. Diameter (length) | 21 longer (26%), 49 smaller (61%), 10 (8%) same and 1 (1%) had massive difference |
| 10. Diameter (breath) | 25 wide (63%), 47 narrow (58%), 8(10%) same and 5 (6%) had massive difference in breadth |
| 11. Connective stroke | 26 absent (33%), 54 present (67%) |
| 12. Formation of loop | 17 absent (21%), 47 present (58%) and 16 (20%) not proper |

Table 2. Observations of various parameters in sample (Standing and with wall as support)

| Parameter | Variation in percent |
|-----------------------|---|
| 1. Rhythm | Present in 3, absent in 1 (4% present) |
| 2. Style | Mixed in 8 (10%), round in 9 (11%) |
| 3. Tremors | Present in 8 (10%) |
| 4. Pen pressure | 31 light (39%), 1 medium (1%) |
| 5. Placing of dot | Absent in 2 (2.5%), not proper in 1 (1%) |
| 6. Pen pause | Present in 4 (5%) |
| 7. Retouching | Present in 3 (4%) |
| 8. Slant | 4 upward (5%), 2 downward (1%) |
| 9. Diameter (length) | 57 longer (71%), 16 smaller (20%), 7 (8%) same and 10 (8%) had massive difference |
| 10. Diameter (breath) | 49 wide (63%), 24 narrow (30%), 7(8%) same and 8 (9%) had massive difference in breadth |
| 11. Connective stroke | 14 absent (17%), 10 present (12%) |
| 12. Formation of loop | 10 absent (12%), 8 present (10%) and 4 (5%) not proper |

Table 3. Observations of various parameters in sample (on hand without support)

| Parameter | Variation in percent |
|-----------------------|---|
| 1. Rhythm | Present in 3, absent in 1 (4% present) |
| 2. Style | Mixed in 7 (8%), round in 15 (18%) |
| 3. Tremors | Present in 6 (7%) |
| 4. Pen pressure | 2 light (1%), 20 medium (25%), 9 heavy (11%) |
| 5. Placing of dot | Absent in 4 (5%), not proper in 2 (1%), present in 1 |
| 6. Pen pause | Present in 4 (5%) |
| 7. Retouching | Present in 5 (6%) |
| 8. Slant | 6 upward (7%), 1 downward (1%) |
| 9. Diameter (length) | 33 longer (41%), 36 smaller (45%), 11 (13%) same and 6 (7%) had massive difference |
| 10. Diameter (breath) | 30 wide (37%), 39 narrow (45%), 7(8%) same and 24 (30%) had massive difference in breadth |
| 11. Connective stroke | 1 absent (1%), 9 present (11%) |
| 12. Formation of loop | 12 absent (15%), 13 present (16%) and 7 (8%) not proper |

Table 4. Observations of various parameters in sample (on lap)

| Parameter | Variation in percent |
|-----------------------|---|
| 1. Rhythm | Present in 4, (5% present) |
| 2. Style | Mixed in 14 (17%), round in 5 (6%) |
| 3. Tremors | Present in 5 (6%) |
| 4. Pen pressure | 3 light (3%), 15 medium (18%), 15 heavy (18%) |
| 5. Placing of dot | Absent in 2 (1%), not proper in 2 (1%), Present in 1 |
| 6. Pen pause | Present in 9 (11%) |
| 7. Retouching | Present in 4 (5%) |
| 8. Slant | 5 upward (6%), 6 downward (2%), 2 Straight |
| 9. Diameter (length) | 39 longer (48%), 33 smaller (41%), 8 (8%) same and 6 (8%) had massive difference |
| 10. Diameter (breath) | 34 wide (42%), 3 narrow (2%), 8 (10%) same and 10 (12%) had massive difference in breadth |
| 11. Connective stroke | 5 absent (6%), 14 present (17%) |
| 12. Formation of loop | 7 absent (8%), 3 present (4%) and 4 (5%) not proper |

Table 5. Observations of various parameters in sample (waist bend and table support)

| Parameter | Variation in percent |
|-----------------------|--|
| 1. Rhythm | Present in 4, (5% present), absent in 2 |
| 2. Style | Mixed in 9 (11%), round in 10 (12%) |
| 3. Tremors | Present in 3 (4%) |
| 4. Pen pressure | 14 light (17%), 17 medium (21%), 10 heavy (12%) |
| 5. Placing of dot | Absent in 4 (5%), not proper in 3 (4%), Present in 2 |
| 6. Pen pause | Present in 7 (9%) |
| 7. Retouching | Present in 3 (4%) |
| 8. Slant | 9 upward (5%), 3 downward (2%), 1 Straight |
| 9. Diameter (length) | 34 longer (42%), 36 smaller (45%), 10 (8%) same and 4 (8%) had massive difference |
| 10. Diameter (breath) | 36 wide (45%), 33 narrow (41%), 11 (13%) same and 11 (13%) had massive difference in breadth |
| 11. Connective stroke | 6 absent (7%), 7 present (8%) |
| 12. Formation of loop | 17 absent (21%), 12 present (15%) and 7 (8%) not proper |

Table 6. Observations of various parameters in sample (back support)

| Parameter | Variation in percent |
|-----------------------|--|
| 1. Rhythm | Present in 2, (3% present), absent in 1 |
| 2. Style | Mixed in 6 (7%), round in 14 (17%), angular 1 (%) |
| 3. Tremors | Present in 0 (0%) |
| 4. Pen pressure | 2 light (1%), 19 medium (23%), 34 heavy (42%) |
| 5. Placing of dot | Absent in 3 (2%), not proper in 3 (2%), Present in 0 |
| 6. Pen pause | Present in 3 (4%) |
| 7. Retouching | Present in 5 (6%) |
| 8. Slant | 5 upward (6%), 5 downward (6%), 0 Straight |
| 9. Diameter (length) | 51 longer (63%), 21 smaller (26%), 8 (10%) same and 6 (8%) had massive difference |
| 10. Diameter (breath) | 37 wide (46%), 33 narrow (41%), 10 (12%) same and 10 (12%) had massive difference in breadth |
| 11. Connective stroke | 5 absent (6%), 13 present (16%) |
| 12. Formation of loop | 16 absent (20%), 4 present (5%) and 13 (16%) not proper |

Table 7. Observations of various parameters in sample (knee bend and table support)

| Parameter | Variation in percent |
|-----------------------|---|
| 1. Rhythm | Present in 4, (5% present), absent in 1 |
| 2. Style | Mixed in 13 (16%), round in 13 (16%), 1 angular |
| 3. Tremors | Present in 5 (6%) |
| 4. Pen pressure | 23 light (28%), 0 medium, 18 heavy (22%) |
| 5. Placing of dot | Absent in 3 (4%), not proper in 7 (8%), Present in 1 |
| 6. Pen pause | Present in 6 (7%), absent in 3(%) |
| 7. Retouching | Present in 3 (4%) |
| 8. Slant | 6 upward (7%), 1 downward (1%), 3 Straight (2%) |
| 9. Diameter (length) | 44 longer (55%), 28 smaller (35%), 8 (10%) same and 5 (6%) had massive difference |
| 10. Diameter (breath) | 38 wide (47%), 35 narrow (43%), 17 (21%) same and 9 (11%) had massive difference in breadth |
| 11. Connective stroke | 5 absent (6%), 13 present (16%) |
| 12. Formation of loop | 15 absent (18%), 13 present (16%) and 7 (8%) not proper |

Table 8. Observations of various parameters in sample (lying with knees bend)

| Parameter | Variation in percent |
|-----------------------|---|
| 1. Rhythm | Present in 4 (5% present), absent in 4 |
| 2. Style | Mixed in 7 (8%), round in 13 (16%) |
| 3. Tremors | Present in 4 (5%) |
| 4. Pen pressure | 17 light (21%), 17 medium (21%), 0 heavy |
| 5. Placing of dot | Absent in 1, not proper in 4 (5%), Present in 2 |
| 6. Pen pause | Present in 2 (3%), absent in 4 (%) |
| 7. Retouching | Present in 5 (6%) |
| 8. Slant | 8 upward (10%), 2 downward (1%), 4 Straight (5%) |
| 9. Diameter (length) | 47 longer (58%), 23 smaller (28%), 10 (12%) same and 8 (10%) had massive difference |
| 10. Diameter (breath) | 42 wide (52%), 26 narrow (32%), 12 (15%) same and 9 (11%) had massive difference in breadth |
| 11. Connective stroke | 3 absent (4%), 14 present (17%) |
| 12. Formation of loop | 13 absent (16%), 6 present (7%) and 11 (13%) not proper |

4.6 Back Support

The research analysed 80 samples, revealing a mix of rhythm, mixed styles, and round styles. Pen pressure was light, placing was absent, pen pause was present, and retouching was present. Samples were 63% longer, 26% smaller, and had massive differences, connection strokes, and varying degrees of properness.

4.7 Knee Bend and Table Support

The research analysed 80 samples, revealing 52% had rhythm, 16% mixed, and 7% round

style. 6% had tremors, 28% had light/heavy pen pressure, 4% had improper placing, 7% had pen pause, and 4% had retouching. Samples were 55% longer, 35% smaller, and had massive differences.

4.8 Lying with Knees Bend

The research analysed 80 samples, revealing 5% had rhythm, 8% mixed, and 16% round style. 5% had tremors, 21% had light pen pressure, 3% had retouching, and 6% had retouching. Samples were 58% longer, 28% smaller, 52% wide, 32% narrow, and 17% had connection strokes.

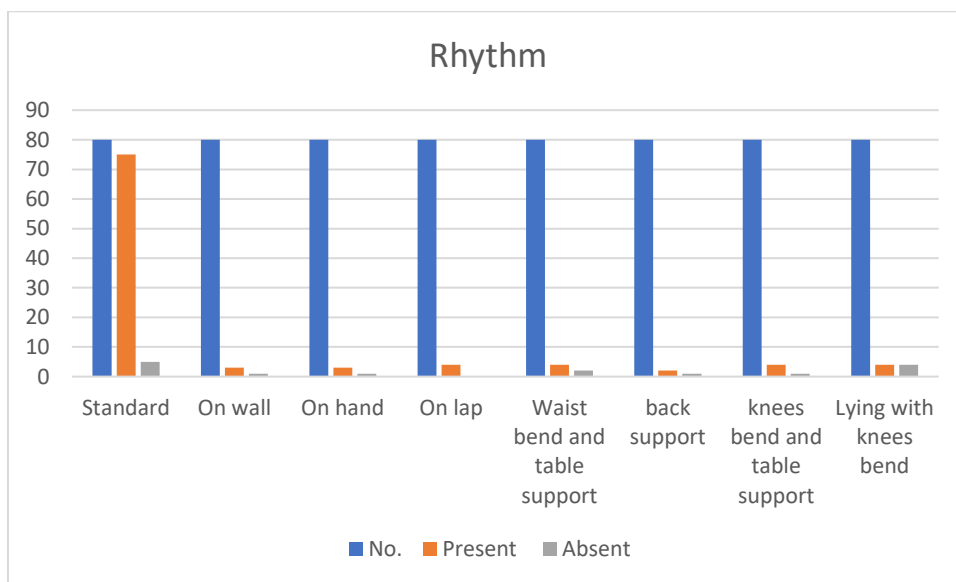


Fig. 12. Graph showing Rhythm in signature in various postures

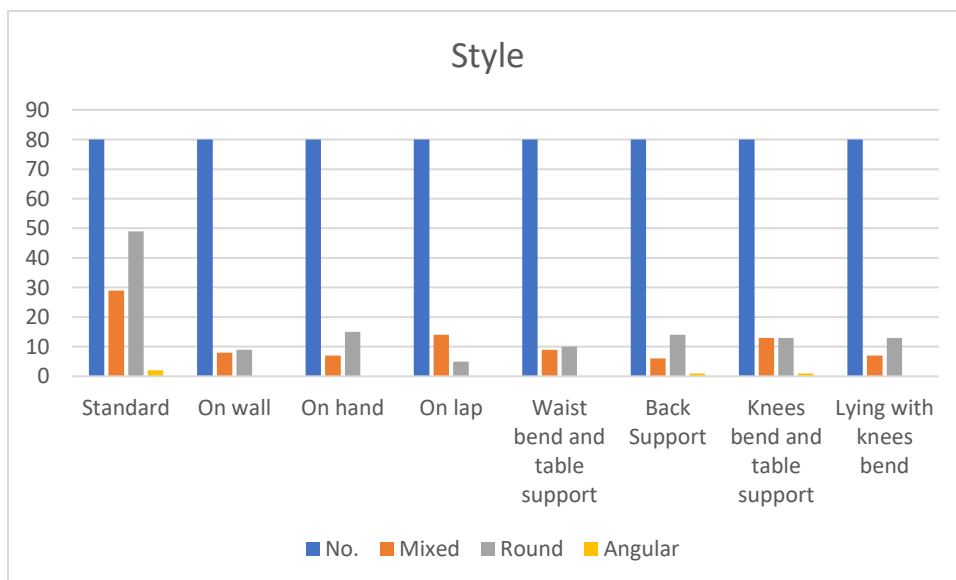


Fig. 13. Graph showing style of in signature in various postures

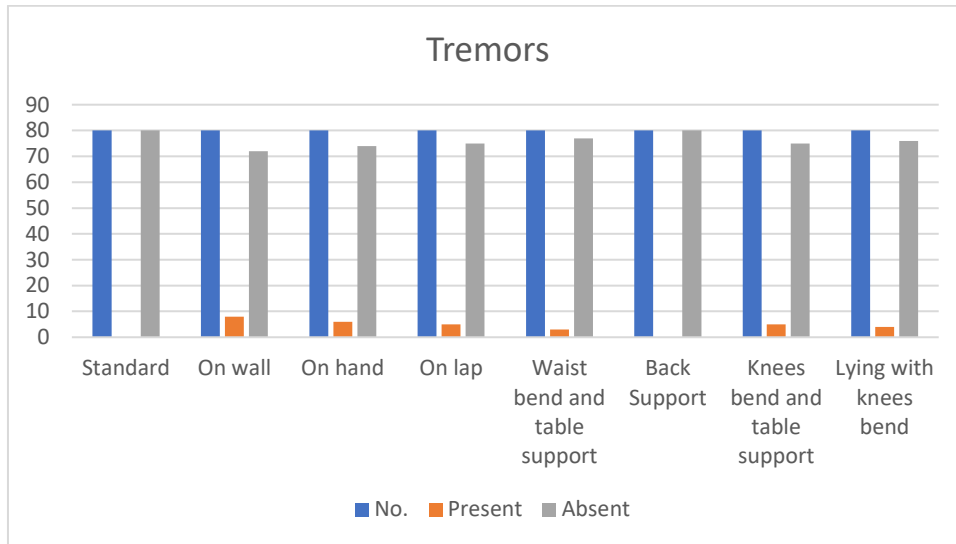


Fig. 14. Graph showing Tremors in signature in various postures

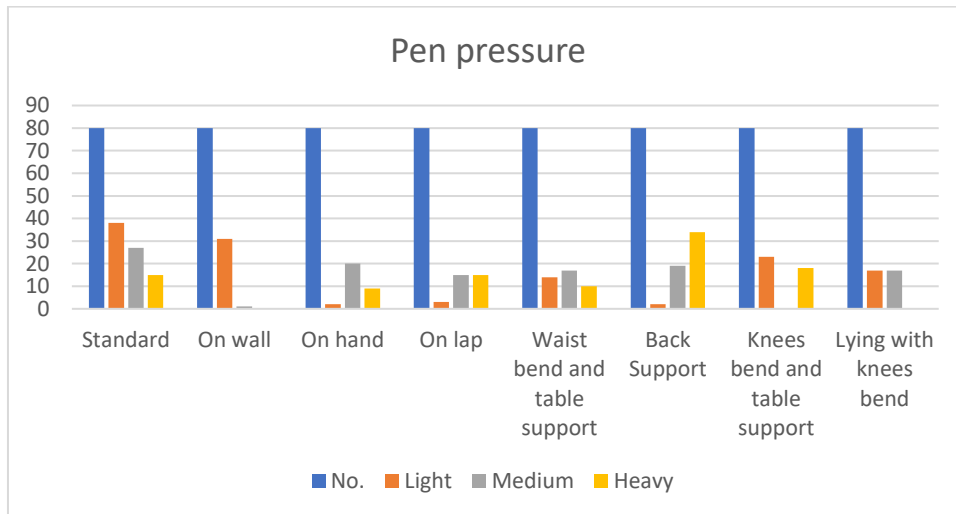


Fig. 15. Graph showing Pen pressure of signature in various postures

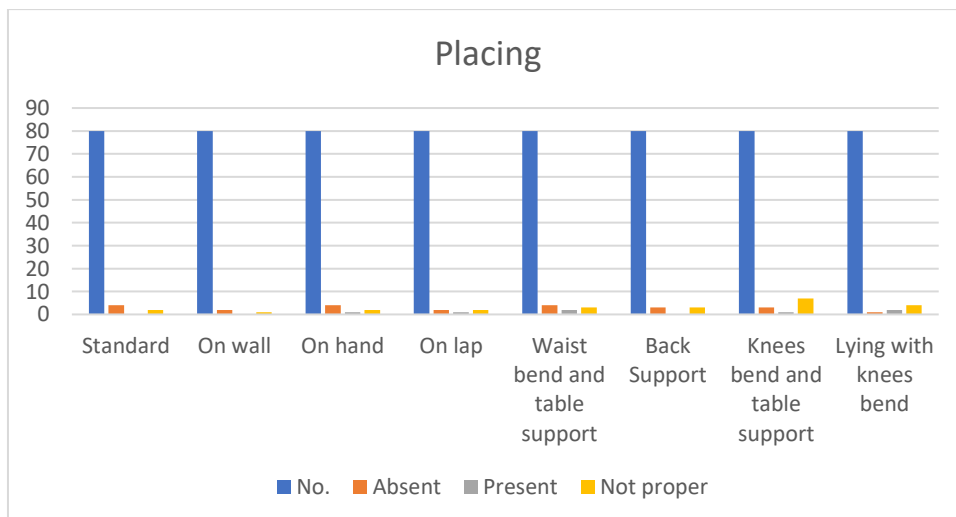


Fig. 16. Graph showing Placing of dot in signature in various postures

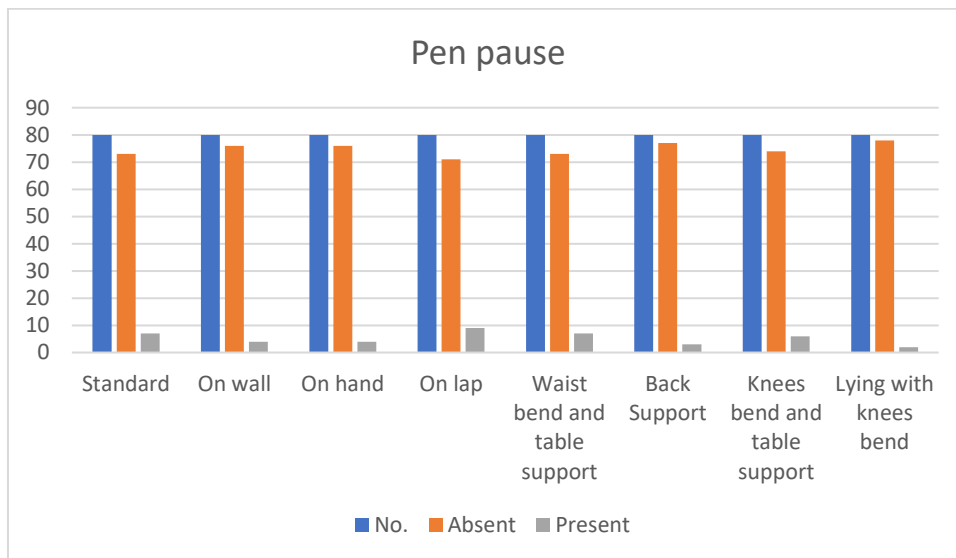


Fig. 17. Graph showing Pen Pause in signature in various postures

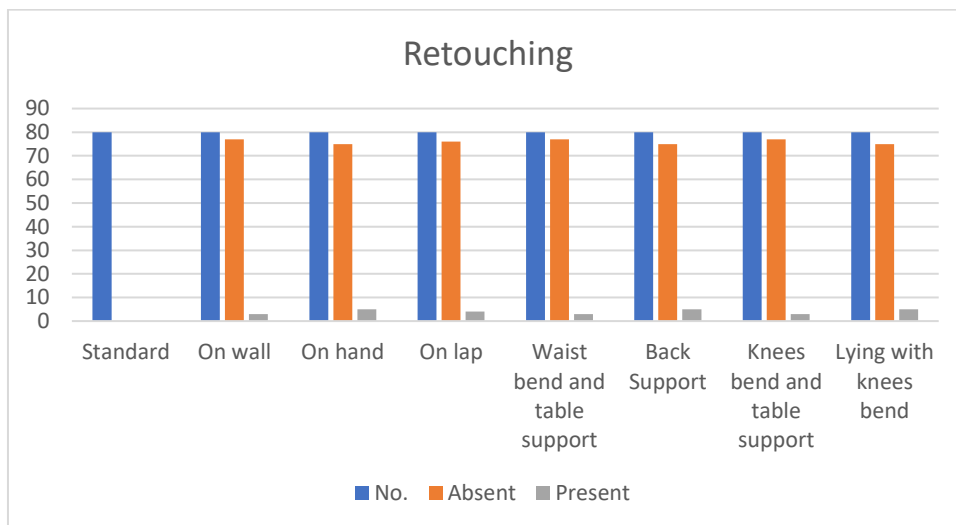


Fig. 18. Graph showing Retouching in signature in various postures

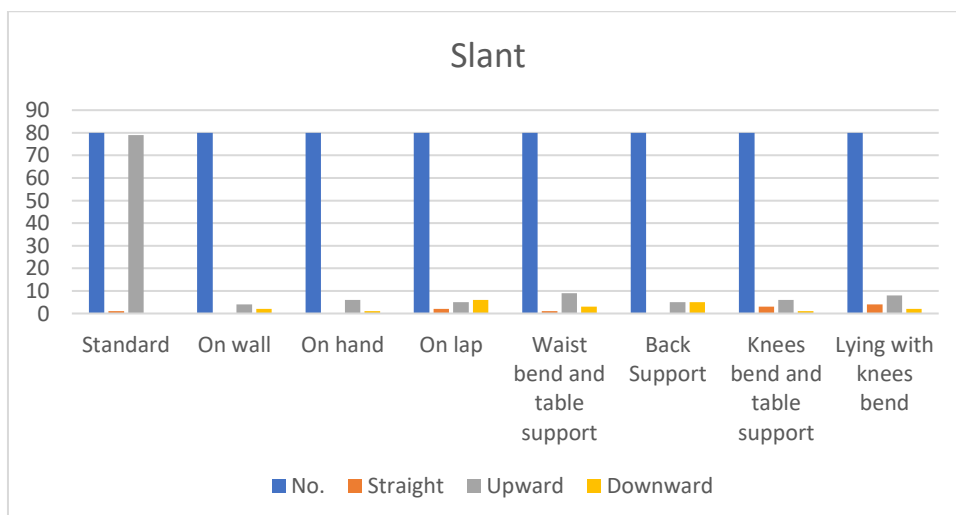


Fig. 19. Graph showing Slant in signature in various postures

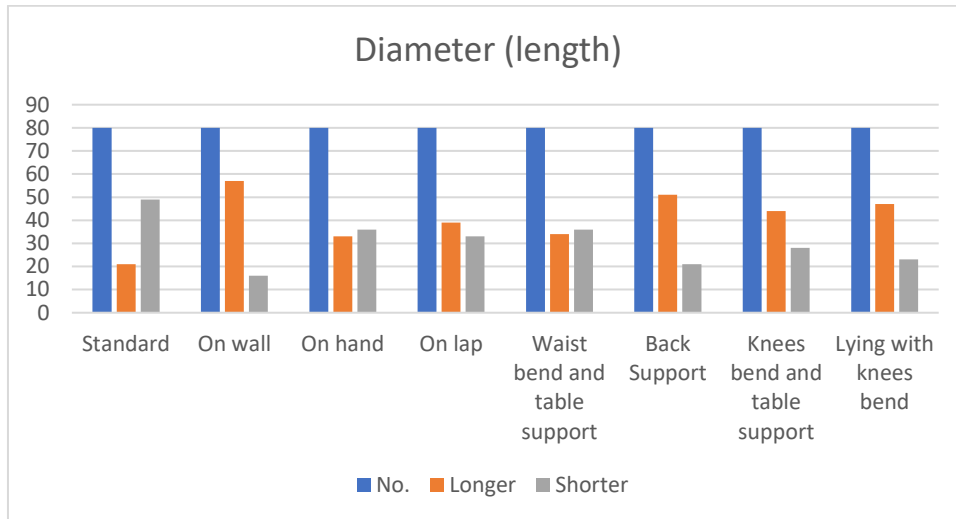


Fig. 20. Graph showing Diameter (Length) of signature in various postures

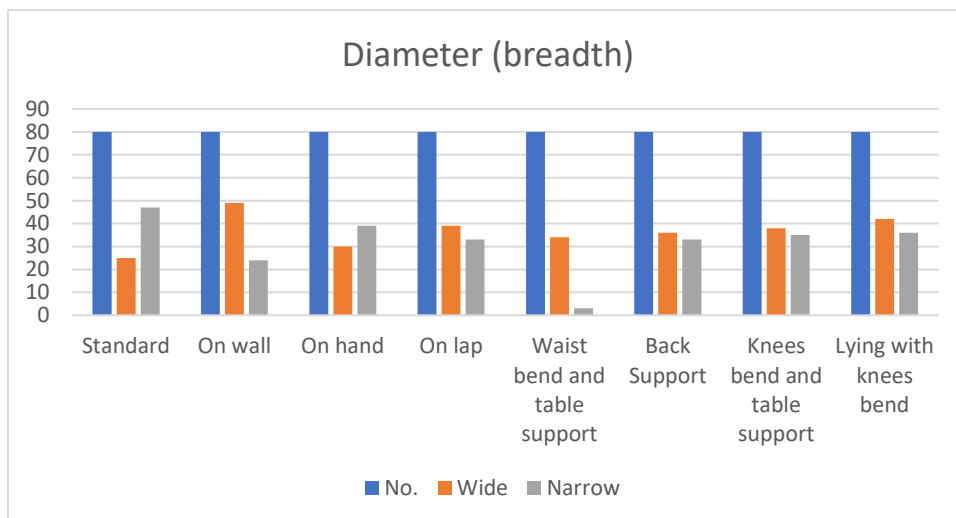


Fig. 21. Graph showing Diameter (breadth)

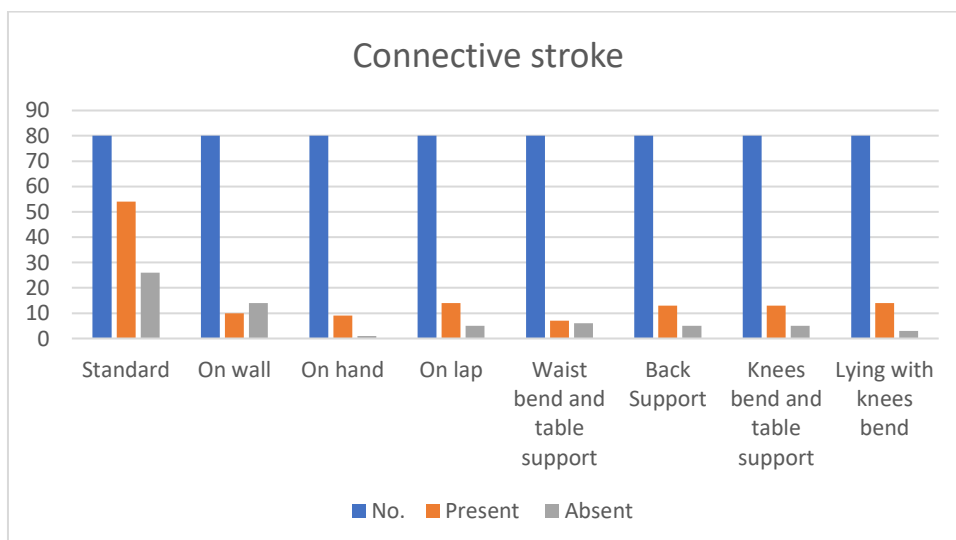


Fig. 22. Graph showing Connective strokes in signature in various postures

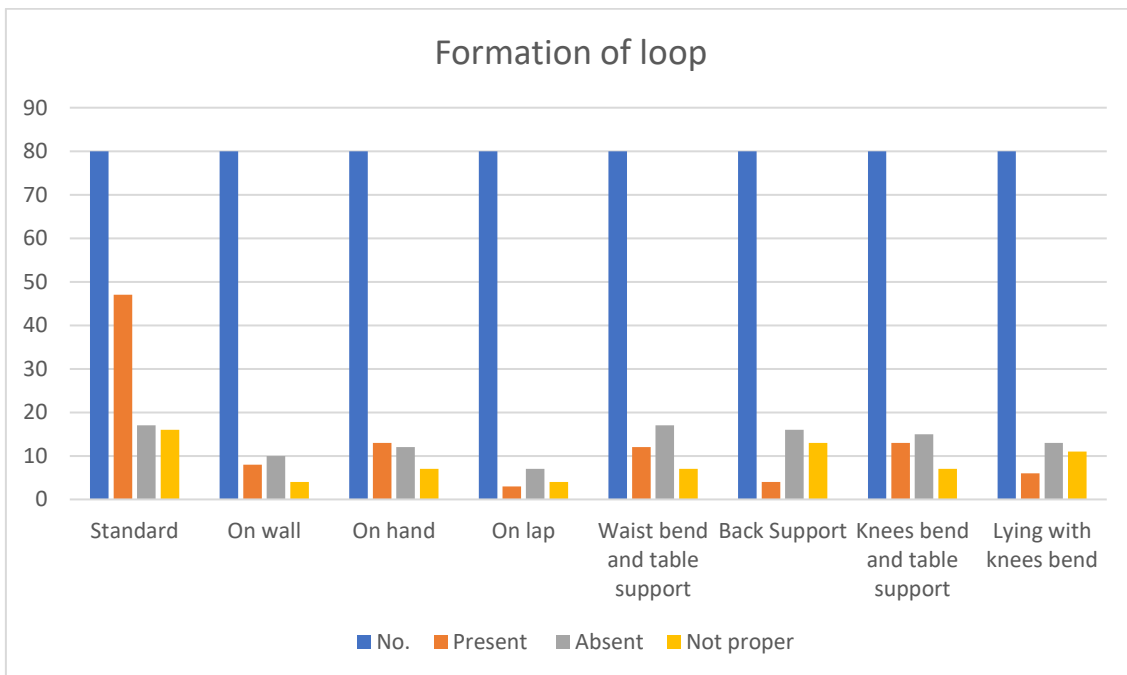


Fig. 23. Graph showing Formation of loop in signature in various postures

5. CONCLUSION

The study reveals that the size of a signature may vary depending on the writer's comfort. A comfortable posture, such as sitting on a chair with firm support, results in uniform dimensions with usually medium pen pressure. However, if the signature is done on the palm, the size shrinks. The basic letter formations remain the same, but the dimensions vary depending on posture and surface. For instance, if the document is held on the palm or lap, the size of the signature reduces, while if a wide area is provided, the size increases. Tremors are usually a result of aging and moving surfaces, but when firm support is not present, they can be seen. The study concludes that the basic nature of signature remains unchanged, but the dimension and presence of tremors are the two major factors that are dependent on posture and support.

CONSENT

The participants were briefed about the study and made comfortable before giving samples and consent was obtained prior to sampling.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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