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An Investigation to Determine the Most Muscle Fatigue Handwriting Pattern using EMG

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Abstract: This study aims to examine the effects of different pen-holding methods on muscle fatigue using Electromyography (EMG). Writing requires a complex coordination of sensory, motor, and cognitive functions, making it essential to understand how various techniques can influence muscle fatigue. The research focuses on six distinct pen-holding styles, including traditional tripod grips as well as unconventional approaches such as overhand and underhand grips. By monitoring muscle activity through EMG sensors during writing tasks, unique patterns of fatigue emerge. Consistently across multiple trials, the results highlight that overhand and underhand techniques induce the highest levels of muscle fatigue. These findings have significant implications for education, ergonomics, and occupational health by providing evidence-based recommendations for enhancing writing efficiency. Moreover, they pave the way for personalized interventions aimed at guiding individuals towards ergonomic pen-holding practices in order to improve overall well-being. Overall, this research contributes valuable insights into understanding the relationship between handwriting skills development process along with its associated factors like muscle fatigue while also offering a foundation for future applications across diverse fields.

Keywords: *Electromyography, pen-holding, tripod, muscle fatigue, grips*

1. Introduction

Writing on paper involves the coordination of senses, nerve signals, muscle memory, the brain, and the circulatory system. Touch and sight guide the process, while nerve signals facilitate voluntary and involuntary movements. Muscle memory improves writing skills over time. The brain sends signals to guide hand movements. The circulatory system maintains homeostasis and provides nutrients for concentration. Bones and precise muscle mass inside the hand and arm are concerned in the method [1]. More specifically, there are two standard actions even as handwriting. For the duration of the first motion, the index finger and thumb are held contrary every different and both pass to and from the hand palm (with the aid of flexion/extension of all finger joints), which ends up in again-and-forth moves of the pen tip [2,3].

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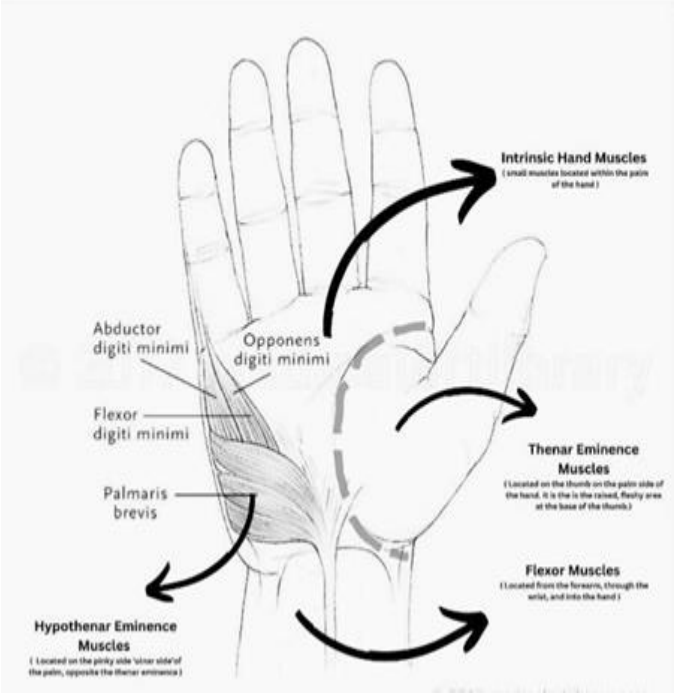


Fig. 1. Basic forearm anatomy (Source: https://medicalartlibrary.com/)

The second one usual motion is the rotation of the whole hand across the wrist via palmar flexion/extension and ulnar abduction in addition to movements of the thumb (radial abduction/dorsal flexion) [3].As shown in figure 1 the 4 top muscle tissues which are mainly involved in these two moves are thenar (thumb), wrist flexor, hypothenar and intrinsic muscles [4,5]. These moves are taken into consideration the main axes in handwriting, and their impact on the writing method and product has been notably studied [6,7 ,8,9].The study assumes that, by determining the variation in handwriting between natural pen hold and unconventional pen hold, would narrow down the analysis and therefore give us an idea of which pen hold causes the most fatigue to the muscle's. Types of pen hold as shown in figure 2 includes:

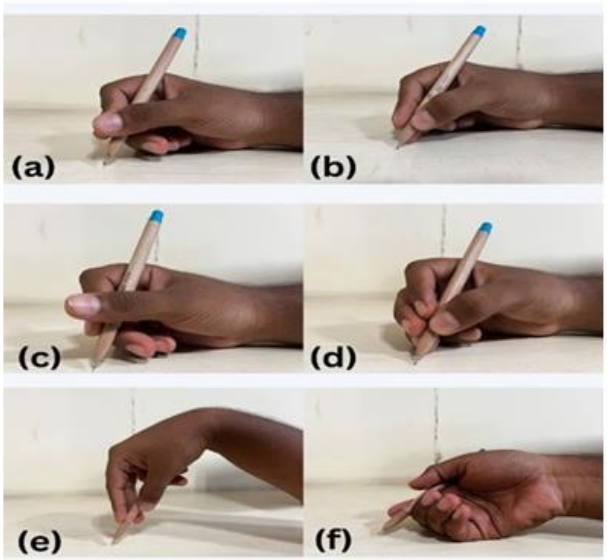


Fig. 2. a. dynamic tripod b. tripod c. lateral tripod d. quadrapod e. overhand f. underhand

1. Tripod Grip: This is the most common and widely recommended grip. It involves holding the pen between the thumb and index finger while resting it on the middle finger. The grip resembles a tripod, hence the name.
2. Dynamic Tripod Grip: Similar to the tripod grip, but with a slight difference. The pen rests on the middle finger while the thumb and index finger are positioned closer to the pen tip, providing more control and precision during writing.
3. Quadrapod Grip: on this grip, the pen is held using all four palms – thumb, index finger, center finger, and ring finger. The pen rests at the ring finger, providing greater stability.
4. Overhand Grip: Also known as an overhand or full-hand grip, this involves holding the pen higher up the barrel with all fingers placed above the pen tip. It's less common and may cause more fatigue due to less control.
5. Underhand Grip: In this grip, the pen is held closer to the tip, and all fingers are placed below it. It's also less common and may cause more strain and fatigue during extended writing sessions.
6. Lateral Tripod Grip: This grip is similar to the traditional tripod grip, but the thumb is moved away from the index finger, creating a "V" shape between them. The pen rests on the side of the middle finger. It's an unconventional grip but may suit some individuals.

The primary objective of this research study is to investigate and diagnose which pen-holding technique, out of the various ones mentioned above, induces the highest level of muscle fatigue. To achieve this goal, we will employ the use of an Electromyography (EMG) sensor.

Electromyography is an approach that enables the size and recording of electrical impulses generated with the aid of muscle interest at some point of pen usage. By analyzing the EMG information gathered from contributors using different pen-preserving strategies, we propose to benefit from comprehensive insights into the muscle fatigue levels associated with every technique. To behavior the study, a large group of contributors can be recruited, ensuring illustration from numerous ages businesses, genders, and writing experience. Those people may be gifted in a single or greater of the pen-holding strategies of interest. Ethical guidelines may be strictly followed to ensure player protection and confidentiality.

Each player could be required to carry out a sequence of standardized writing tasks using distinct pen-retaining strategies whilst wearing the EMG sensors. The EMG sensors will be placed strategically on the forearm and hand muscles to capture muscle activation patterns accurately.in the course of the writing responsibilities, we will closely reveal the contributors' muscle fatigue stages and gather real-time EMG data. The overall variety for electromyography (EMG) alerts for the duration of the act of writing usually falls in the range of approximately 1 to ten millivolts. Additionally, subjective feedback from participants will be gathered to assess their perceived levels of discomfort, strain, and fatigue associated with each pen-holding method.

Upon completion of data collection, comprehensive analysis and statistical methods will be employed to quantify and compare muscle fatigue levels among the different pen-holding techniques. The results will be presented in a clear and concise manner, illustrating which technique elicits the most significant muscle fatigue. The findings of this study hold potential implications for various fields, including education, ergonomics, and occupational health. By identifying the pen-holding technique that causes the most fatigue, we can provide evidence-based recommendations to educators, occupational therapists, and individuals seeking to improve their writing efficiency and reduce muscle strain.

In conclusion, this research aims to contribute valuable insights into the realm of penmanship and muscle fatigue, paving the way for better ergonomic practices and ultimately enhancing writing experiences for people of all ages.

2. Materials and Methods

2.1. Participants

A total of 20 everyday contributors of each the sexes belonging to age classes starting from a long time 19 to 40s had been selected for appearing this test. The participants had been from different activity backgrounds, maximum of them being college students and professors the individuals decided on for this test do no longer display any symptoms of pain even as writing.

Seeking consent from individuals before engaging with them in any activity is important. When approaching subjects, we begin by explaining the purpose of our interaction and the specific tasks involved. We used different questions to seek consent from individuals. During the consent process, we prioritize transparency, providing clear information about the intended use of any data collected. We emphasize that participation is totally voluntary, and they have the right to withdraw at any time without facing any repercussions. We encourage open communication throughout the process and make sure that the subjects have ample time to consider their decision. By fostering an environment of trust and mutual respect, we aim to build meaningful collaborations and contribute to responsible and ethical interactions in our endeavors.

2.2. Materials Used

- Ruled A4 sheets
- Reynolds 045 black ball pens
- Table
- Delsys AVANTI wireless EMG sensor
- Computer.

Flowchart

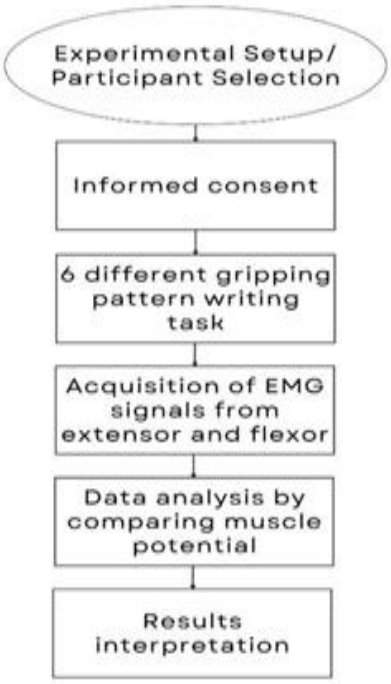


Fig. 3. Flowchart for the Experiment

2.3. Experimental Setup

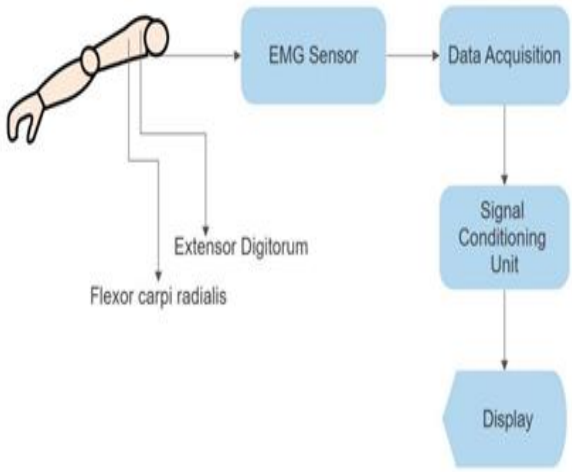


Fig. 4. Process Flow Diagram of the Experimental Setup

2.4. Delsys AVANTI wireless EMG sensor

The Delsys sensor as shown in figure 5 are used to degree and wirelessly transmit (≤ forty m) surface EMG (sEMG) alerts to the Trigno wi-fi basis system and then analyzed in real-time the usage of Lab Chart software and a Trigno wireless device enabler. The sensors are mild weight with signals streamed (≤ 40 m) to the Trigno Base Station (receiver) for freedom of motion. The benefit of Delsys AVANTI wi-fi EMG Sensor is generally one thousand for surface EMG alerts.

Inside the look at, 2 EMG sensors are hired to screen the electric capacity generated by way of muscle cells. This sensor produces an analog output signal, which can be study through a microcontroller. It involves the usage of sensors, measurement hardware, and a pc with programmable software.

Fig. 5. Delsys AVANTI Wireless electrode [Credits: https://www.medicalexpo.com/prod/delsys/product-123919-989580.html]

The display unit is accountable for offering facts and data derived from these measurements. It serves vital capabilities, such as tracking and control obligations. The display unit can consist of electronic presentations, hardcopy printouts, or even signaling devices like voice outputs.

2.5. Experimental Procedure

1. Vicinity EMG electrodes at the ventral (underside) aspect of the dominant forearm, close to the wrist, to goal the Flexor Digitorum Superficialis (FDS) and Flexor Carpi Ulnaris (FCU) muscle mass.
2. Function EMG electrodes on the dorsal (pinnacle) side of the dominant forearm, concentrated on the Extensor Digitorum (ED) and Extensor Carpi Ulnaris (ecu) muscle tissues.

Fig. 6. Delsys AVANTI wireless EMG sensor at work

3. As soon as the electrodes are in location and accurately secured, the handwriting undertaking is commenced.
4. As the individual writes, the EMG system will record the electrical activity from the muscles.
5. The individual is made to write one paragraph for 5minutes using the various gripping techniques one by one.
6. The signals from writing are obtained by the EMG system and displayed on the computer.
7. After the data acquisition process is complete the various data are analyzed to find out the required result.

3. Results and Analysis

From the EMG data obtained as shown in figure 7, a clear pattern emerged regarding the muscle fatigue induced by the various writing techniques investigated. Among the six pen-holding techniques assessed, the overhand and underhand methods consistently stood out as the primary culprits for inducing the

highest levels of muscle fatigue. This observation was not only apparent in the processed EMG data but was also evident in the raw EMG signal recordings. The measurement unit for EMG amplitude is in milliovolts, while the unit for time is in seconds.
The overhand and underhand techniques consistently exhibited heightened muscle activity across multiple subjects, as evidenced by the elevated EMG signal amplitudes. These findings substantiate the notion that these particular pen-holding methods place increased strain on the muscles involved in writing, resulting in more pronounced fatigue compared to other techniques. This consistent trend throughout both the processed and raw EMG statistics underscores the significance of our findings. The recognition of overhand and underhand techniques as the maximum fatiguing has critical implications for people seeking to optimize their writing practices.

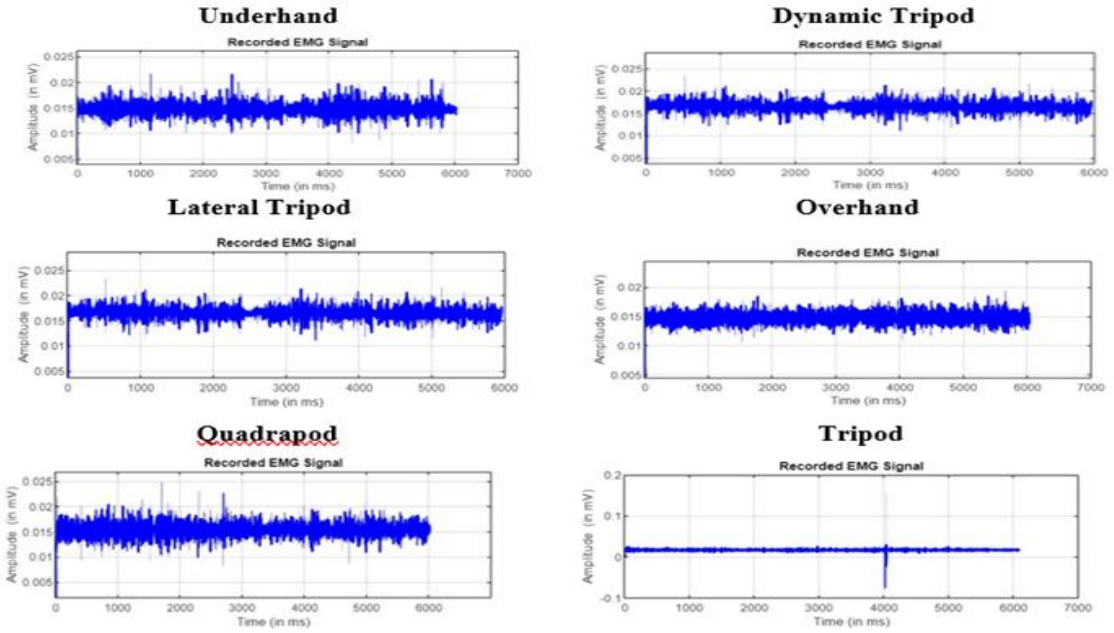


Fig.7. Signal Graphs

By identifying these intricate strategies, we are able to higher manual individuals in the direction of extra ergonomic and sustainable pen-conserving strategies, in the end improving their comfort and decreasing the risk of writing-related muscle fatigue.

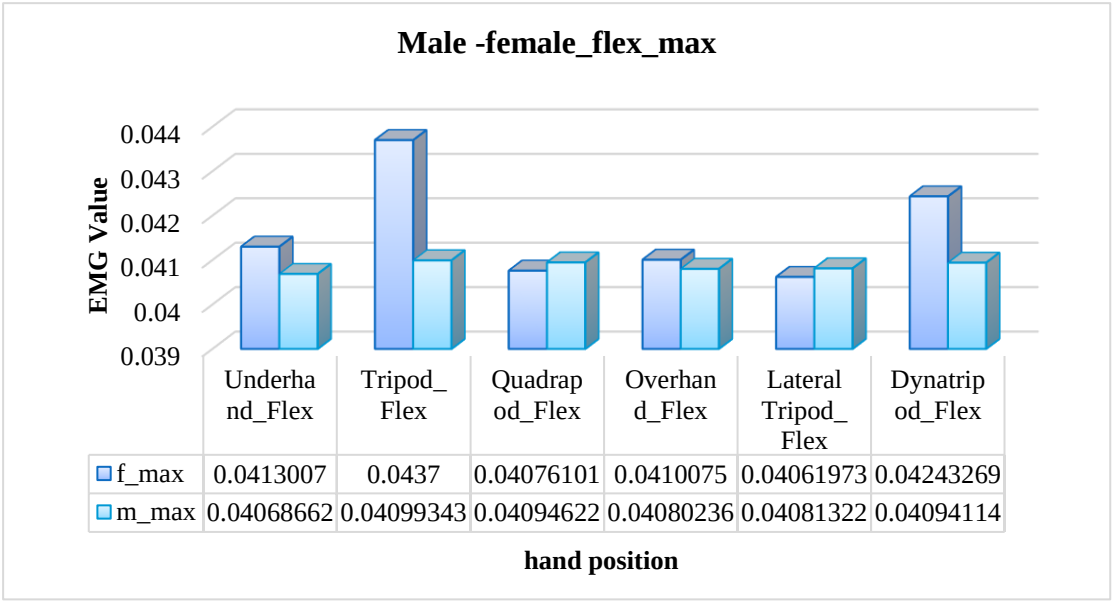
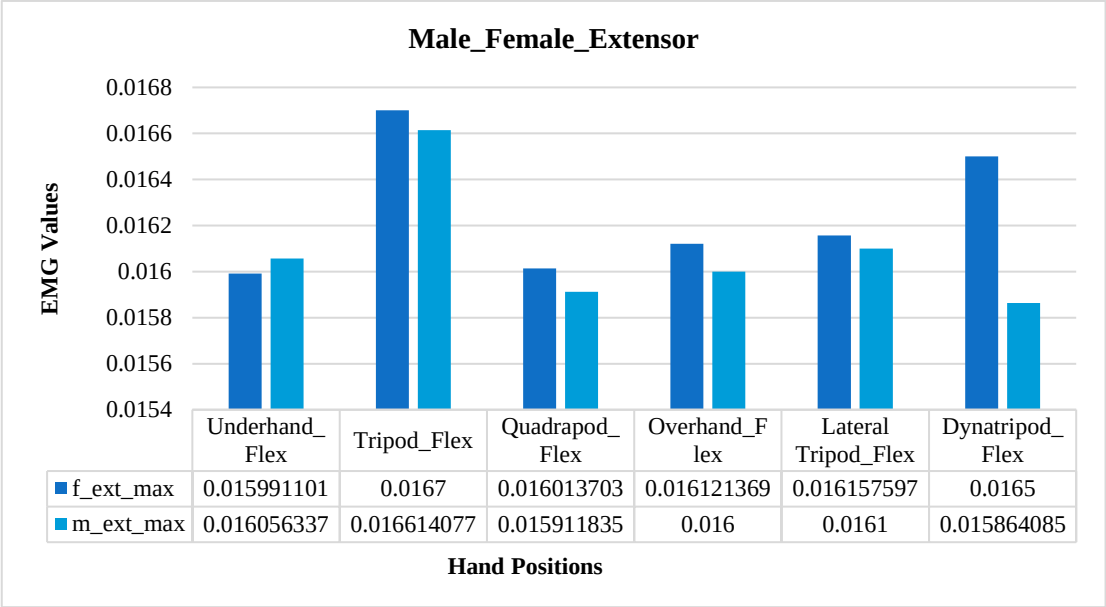


Fig. 8. Flexor Value between Male & Female

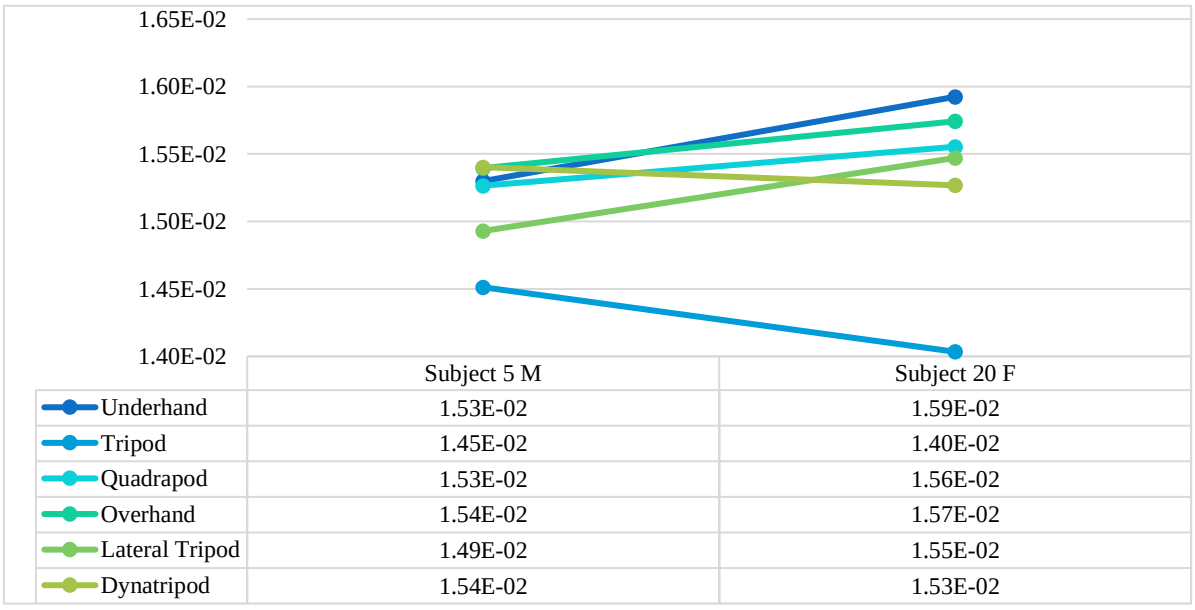
Based on the graph analysis of figure 8, it's far obvious that the extensor muscle groups experience considerably better fatigue levels in comparison to the flexor muscle tissues. This statement highlights the increased demand and pressure positioned on the extensor muscle groups at some point of the measured activity. further research and targeted interventions may be necessary to cope with and alleviate this discrepancy in fatigue tiers between the 2 muscle businesses.



	Underhand_ Flex	Tripod_Flex	Quadrapod_ Flex	Overhand_F lex	Lateral Tripod_Flex	Dynatripod_ Flex
f_ext_max	0.015991101	0.0167	0.016013703	0.016121369	0.016157597	0.0165
m_ext_max	0.016056337	0.016614077	0.015911835	0.016	0.0161	0.015864085

Fig. 9. Extensor Value between Male & Female

Regardless of gender, the findings as shown in figure 9 continue to be constant, displaying that extensor muscle mass are subjected to higher levels of fatigue while compared to flexor muscle tissues. This pattern shows that the increased demand on extensor muscle tissues is a consistent element of the interest across one of a kind genders. Similarly studies and interventions should bear in mind this commonality in muscle fatigue.



	Subject 5 M	Subject 20 F
Underhand	1.53E-02	1.59E-02
Tripod	1.45E-02	1.40E-02
Quadrapod	1.53E-02	1.56E-02
Overhand	1.54E-02	1.57E-02
Lateral Tripod	1.49E-02	1.55E-02
Dynatripod	1.54E-02	1.53E-02

Fig.10. Overhand & Underhand Value between Male & Female

In conclusion, when considering subjects of each gender, the information from the graph continually demonstrates that underhand and overhand gripping styles tend to induce the highest ranges of muscle fatigue. This indicates that regardless of gender, those gripping techniques are particularly stressful on the muscle tissue involved and need to be taken into account when designing exercising or training applications to optimize muscle patience and performance.

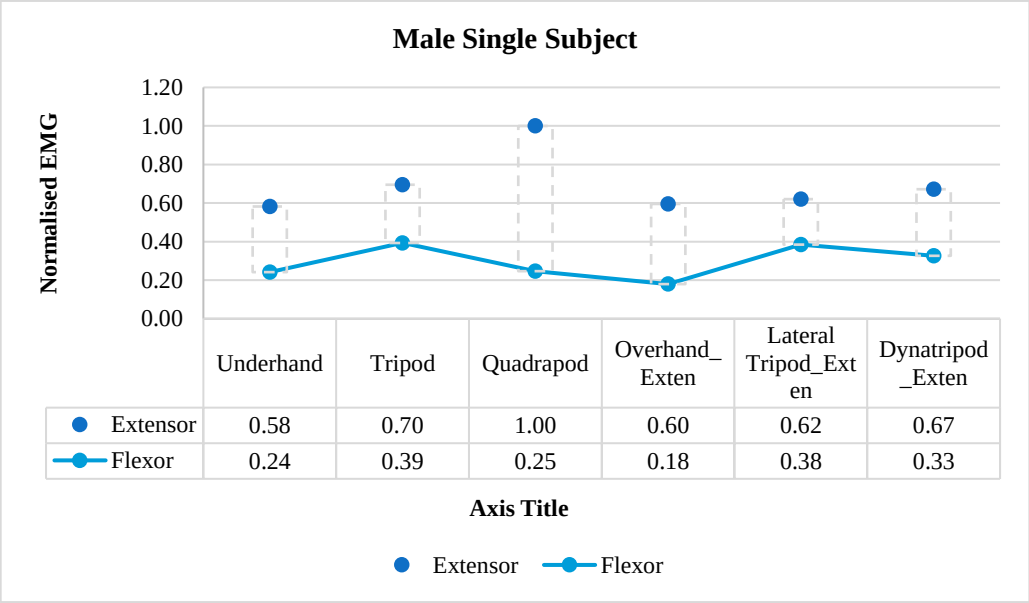


Fig. 11. Male Overhand Extensor Values

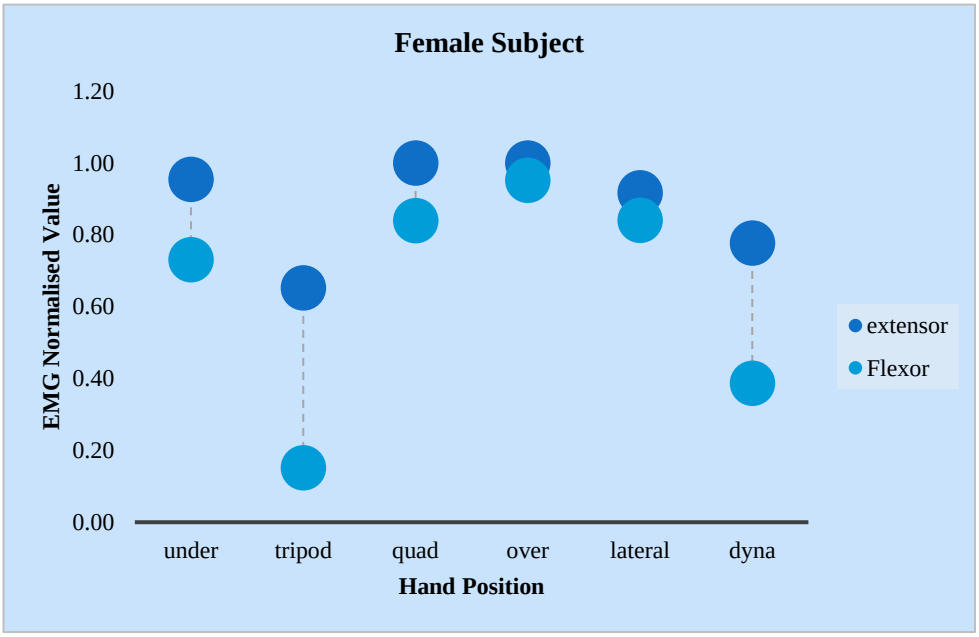


Fig. 12. Female Overhand Extensor Values

In summary, when reading information from each male and female topics, the graphs in figure 11 and 12 continually shows that extensor muscular tissues and overhand gripping styles consistently result in the highest ranges of muscle fatigue. This suggests that regardless of gender, these unique muscle businesses and gripping techniques region the finest demands on the muscle tissues, emphasizing their capability for fatigue in the course of physical sports.

4. Conclusion and Future Works

In this research study, we investigated and diagnosed the muscle fatigue induced by various pen-holding techniques using Electromyography (EMG) sensors. Our findings shed light on the differences in muscle fatigue levels across different techniques, providing valuable insights into the ergonomic aspects of pen-holding. Through the analysis of EMG signals, we were able to quantify and compare the muscle activity associated with each technique. The results of our study indicate that certain pen-holding techniques are more likely to induce higher levels of muscle fatigue compared to others.

Notably, we observed that the underhand and overhand pen-holding techniques consistently caused the highest levels of muscle fatigue for the majority of subjects. This information has important implications for individuals, educators, and healthcare professionals working with individuals who write extensively. By identifying the pen-holding techniques that cause the least amount of muscle fatigue, we can contribute to the development of ergonomic recommendations that promote more comfortable and sustainable writing habits. Moving forward, our research opens up avenues for further exploration and application. Our future work will focus on extending the findings of this study to practical applications, particularly in the context of individuals with writing disorders or discomfort.

We aim to develop personalized recommendations for individuals based on their muscle fatigue profiles and writing habits. Our future research endeavors will involve collaborating with experts in occupational therapy and rehabilitation to design interventions that guide patients with writing disorders toward adopting pen-holding techniques that minimize muscle fatigue. This can lead to improved writing experiences and potentially contribute to the overall well-being and productivity of individuals facing writing-

related challenges. Additionally, we envision expanding our research to include larger and more diverse participant groups, which can enhance the generalizability of our findings. Investigating the long-term effects of adopting ergonomic pen-holding techniques and their impact on muscle fatigue reduction will be another promising avenue for exploration. In conclusion, this research marks a significant step towards enhancing our understanding of the ergonomic implications of different pen-holding techniques and their relationship with muscle fatigue. By translating these findings into practical advice for individuals with writing difficulties, we aim to make a meaningful impact on their quality of life and comfort while writing.

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