TIRED FINGERS

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INTRODUCTION

Motivation

Fingers are critical for daily tasks
Daily finger usage has increased

- Computers & smartphones
- Texting: 5K characters/day
- Typing: 5K keystrokes/day
- Writing: 4.5K characters/day

Finger muscles can get tired
Long term impairment not known
Study is to understand finger fatigue

Applications

Help prioritize less fatigue activities
Ensure breaks for specific activities
Motivate voice/gestures for data entry

QUESTION

What is the effect of finger-related tasks: writing, typing & texting
on
activity of finger muscle groups?

HYPOTHESIS

If

duration of task is increased,

then

writing causes most finger muscle fatigue

VARIABLES

IV: Tasks: writing, texting, typing

Time for each task

DV: Fatigue metric

Control: Fatigue metric at the beginning of task

Experiment: Fatigue metric at the end of task

CONSTANTS

Keyboard for typing (Dell keyboard)

Mobile phone for texting (Iphone SE)

Writing instrument (No. 2 pencil)

Document used to text, type and write

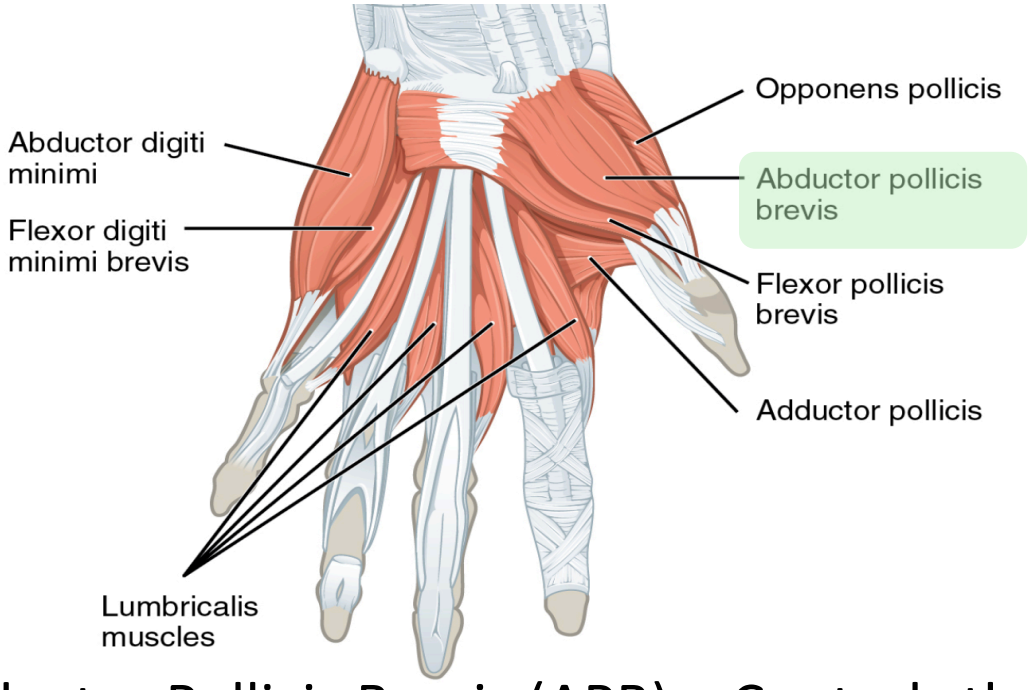
Muscle sensors (Myoware)

Microcontroller (Arduino Uno)

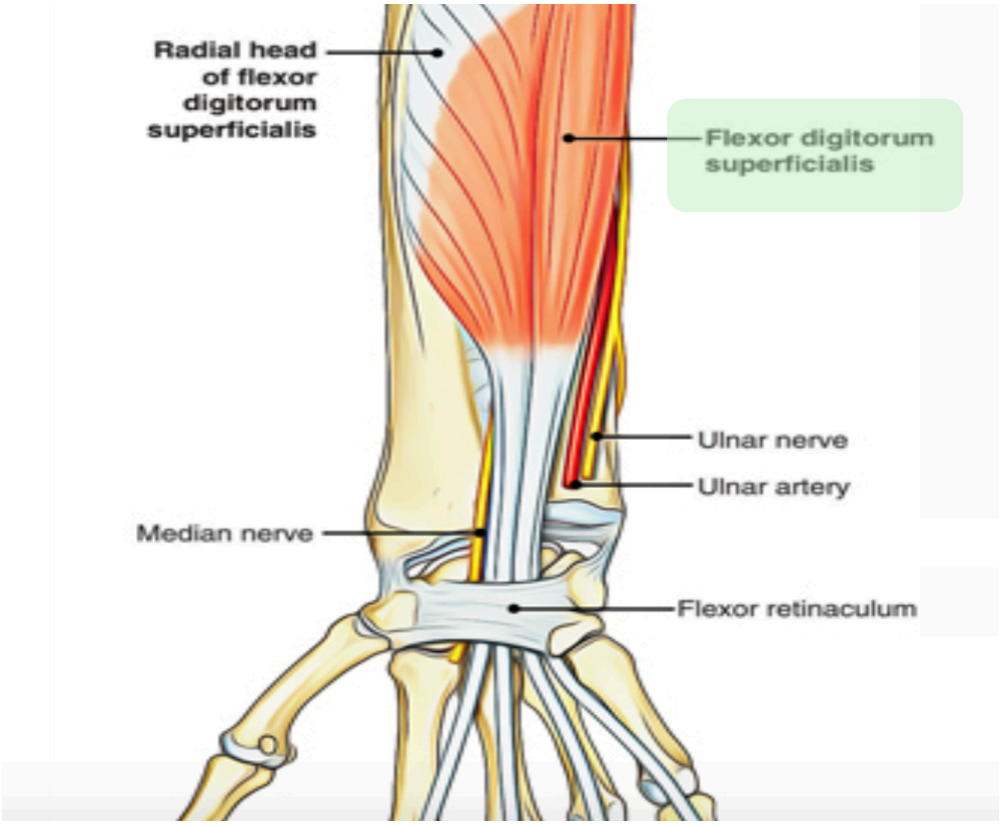
Location

RESEARCH

Muscles of the hand



Abductor Pollicis Brevis (APB) – Controls thumb



Flexor Digitorum Superficialis (FDS)
Controls other 4 fingers

RESEARCH

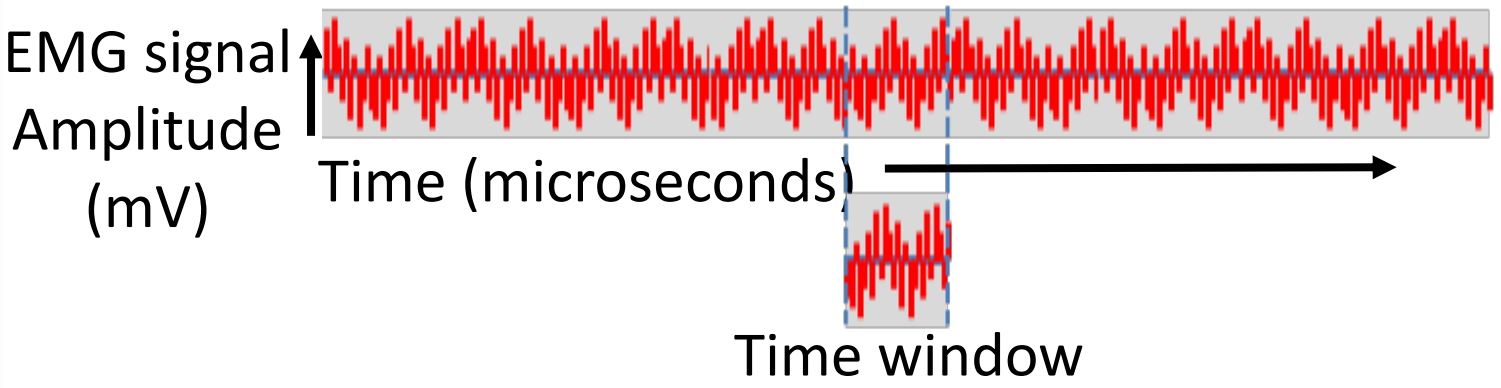
How does a muscle contraction occur?

- Brain sends signal to motor neurons
- Each motor neuron electrically activates a group of muscles
- Motor neuron and its muscles form a motor unit (MU)
- Muscle force depends on two factors
  - Number of MUs activated
  - Firing rate of MUs
- Action potential propagates through MU
- Activation propagation causes voltage switching

RESEARCH

Electromyography (EMG)

EMG signal: sum of action potentials in a muscle



EMG signal
- Captured with sensors placed on skin above muscle
- Series of (time, voltage) pairs

Tired muscle ⇒
- Abs(EMG amplitude)↑
- EMG frequency↓

Metrics calculated for sequence of time windows

Average Rectified Value(ARV) = Mean of abs(amplitude) for each time window

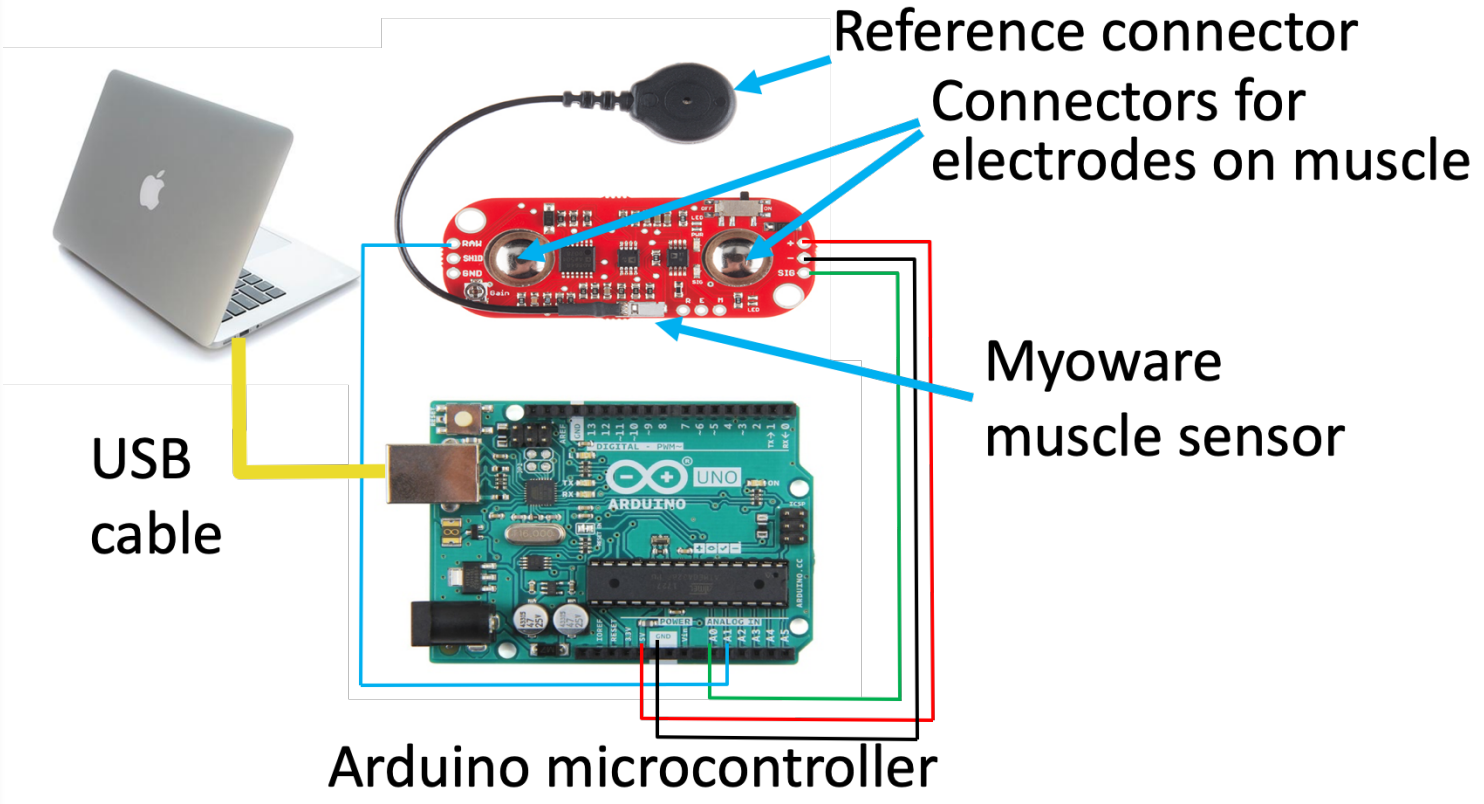
Mean Frequency (MNF) = Weighted mean of frequencies

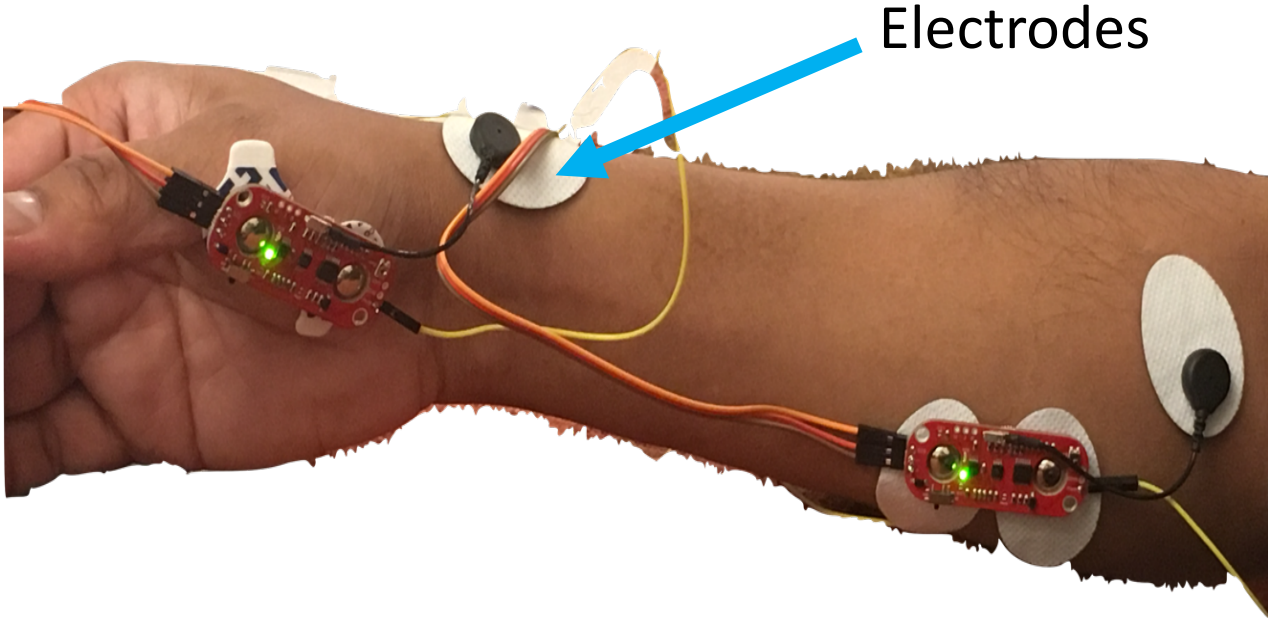
Ratio MNF/ARV ↓ ⇒ Fatigue ↑

Fatigue Metric = Gradient of MNF/ARV

Fatigue metric is negative ⇒ Muscle has fatigue

SETUP


Reference connector
Connectors for electrodes on muscle
Myoware muscle sensor
USB cable
Arduino microcontroller


Electrodes

MATERIALS

- Dell keyboard
- Writing utensil (#2 pencil) & paper
- Mobile phone (iPhone SE)
- 2 Myoware muscle sensors
- Pack of 3 dozen electrodes
- Isopropyl alcohol & cotton
- Arduino Uno to receive data from sensor
- 12 jumper wires (male-male, male-female)
- USB cable to connect Arduino to computer
- Macbook Pro computer
- Arduino program to read sensor data
- Python programs to record and process measurements to calculate fatigue metric
- 4 test subjects: Male aged 13, female aged 16, female aged 45, and a male aged 48

PROCEDURE

1. Designate one sensor each for APB and FDS
2. Connect each sensor to Arduino analog ports
3. Connect Arduino to computer as shown in setup
4. Clean skin above APB and FDS with alcohol/cotton
5. Paste two electrodes along APB on skin
6. Paste an electrode few inches from APB on skin
7. Repeat 5-6 for FDS
8. Connect sensors to APB and FDS electrodes
9. Simultaneously do the following 3 steps
   - Subject 1 starts to write from given document
   - Run Arduino program to receive sensors' values
   - Run Python program store sensor values to file
10. Repeat steps 1-9 for trials after a few hours
11. Repeat steps 1-10 for typing on keyboard
12. Repeat steps 1-10 for texting on Iphone SE
13. Repeat steps 1-12 for each of the other subjects
14. Repeat steps below for each subject and each muscle group using Python programs for a sequence of time windows
    1. Calculate ARV, MNF, MNF/ARV
    2. Calculate gradient of MNF/ARV over time
    3. Calculate mean gradient over three trials

DATA

Writing

APB muscle group

Subj	Mean fatigue metric
1	-1.86
2	-4.62
3	0.23
4	0.23

FDS muscle group

Subj	Mean fatigue metric
1	-0.71
2	0.31
3	1.43
4	-2.58

Typing

Subj	Mean fatigue metric
1	-0.17
2	1.28
3	4.96
4	-1.11

Subj	Mean fatigue metric
1	1.74
2	2.67
3	0.56
4	-0.34

Texting

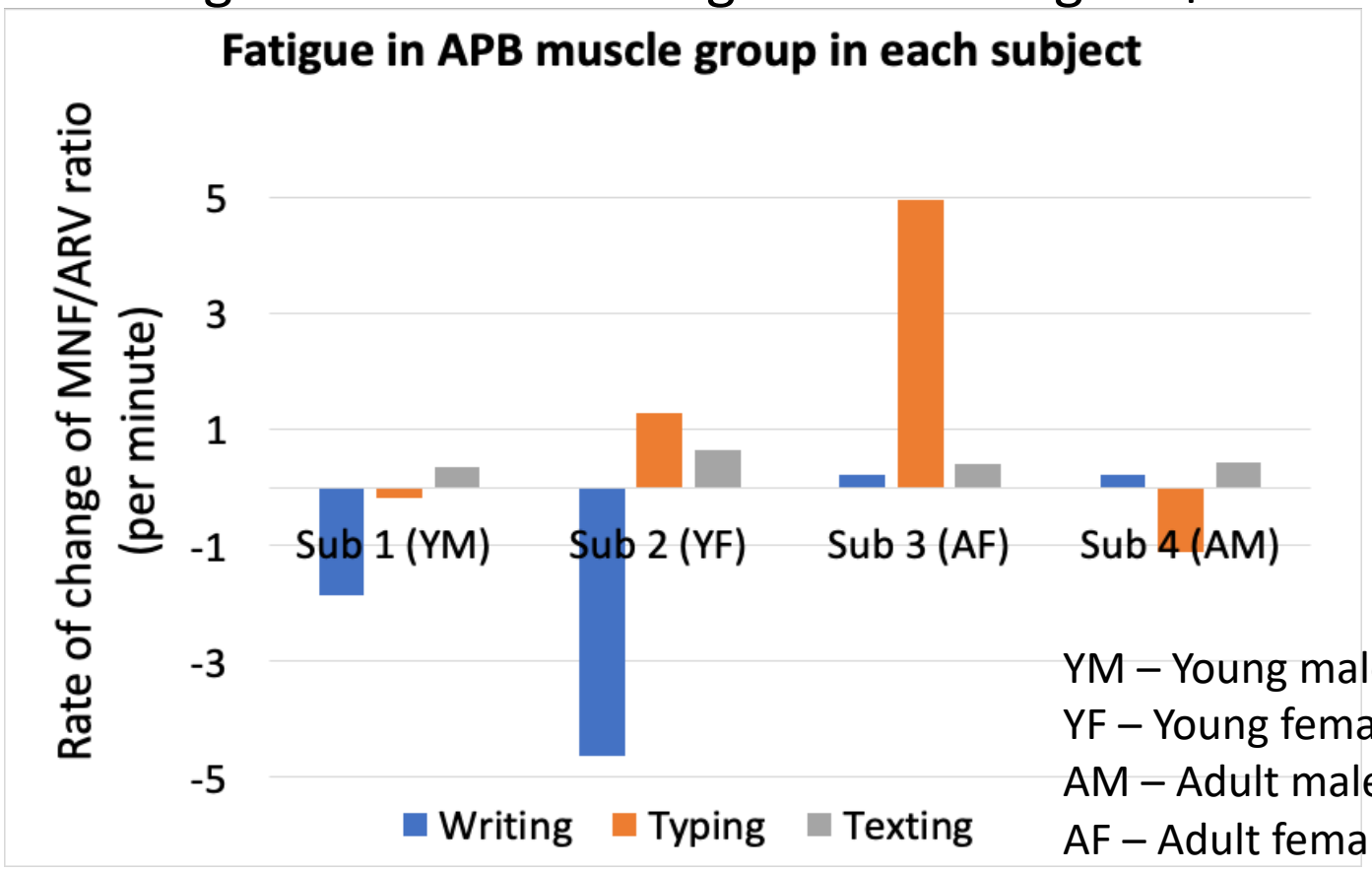
Subj	Mean fatigue metric
1	0.35
2	0.64
3	0.41
4	0.42

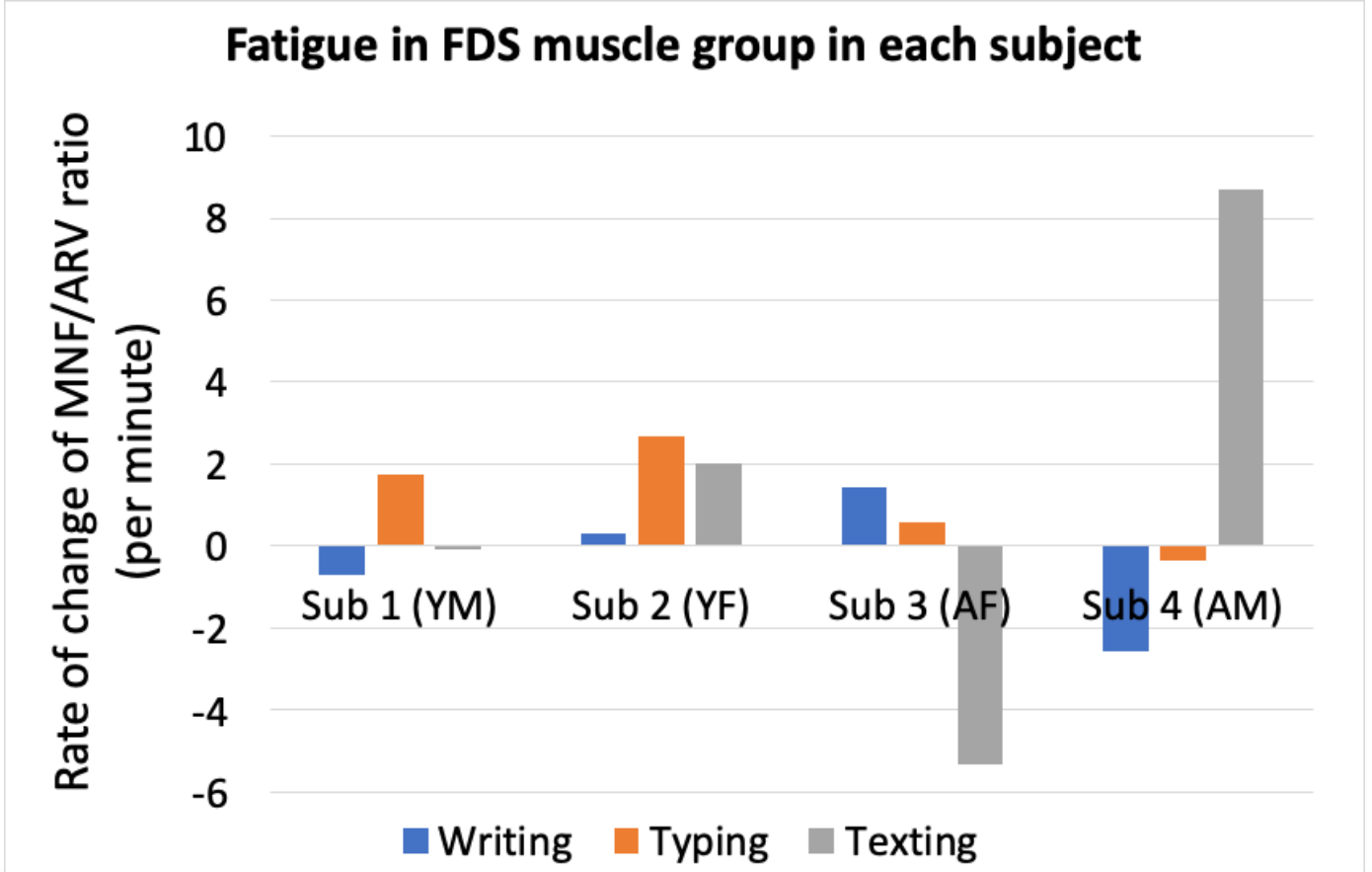
Subj	Mean fatigue metric
1	-0.09
2	2.01
3	-5.31
4	8.70

Subject 1 – Young male (13 yrs)
Subject 2 – Young female (16 yrs)
Subject 3 – Adult female (45 yrs)
Subject 4 – Adult male (48 yrs)

RESULTS

Fatigue metric more negative ⟹ Fatigue ↑





CONCLUSION

Hypothesis is proven correct in most cases

9 total fatigue cases (fatigue metric < 0) in APB and FDS
Overall, writing fatigue was the most encountered

- 2 subjects had maximum fatigue with writing in APB
- 2 subjects had maximum fatigue with writing in FDS
- 4/9 negative fatigue metric cases were with writing
- 3/9 negative fatigue metric cases were with typing
- 2/9 negative fatigue metric cases were with texting

By Gender

- Males had fatigue in 7 out of 12 combinations
  - Writing caused the most fatigue in 3 cases
- Females had fatigue in 2 out of 12 combinations
  - 1 case for writing and 1 case for texting

By Age

- Adults had fatigue in 4 out of 12 combinations
- Youth had fatigue in 5 out of 12 combinations

By Muscle

- Among 12 APB combinations, 4 cases had fatigue
- Among 12 FDS combinations, 5 cases had fatigue

FUTURE RESEARCH

- Include more test subjects
- Find faster & reliable way to position sensor
- Investigate fatigue in extensor muscles
- Investigate fatigue while using mouse
- Extend to investigate back fatigue/pain

SELECTED REFERENCES

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2. Lee, W. (2018, November 6). An Unofficial Introductory Tutorial to MyoWare Muscle Sensor Development Kit. Retrieved from https://medium.com/@leex5202/an-unofficial-introductory-tutorial-to-myoware-muscle-sensor-development-kit-e2169948e63.
3. Thongpanja, S., Phinyomark, A., Phukpattaranont, P., & Limsakul, C. (2013). Mean and Median Frequency of EMG Signal to Determine Muscle Force based on Time-dependent Power Spectrum. Retrieved from https://pdfs.semanticscholar.org/271c/9e986a85f2147d726fe08a1baa3bb321a651.pdf.
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