Implementation of Single and Double Finger Tapping Tests in Healthy Young Individuals and Evaluation of Results

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***Abstract*— This study focuses on examining the hand dominance, gender, and average single (index) and alternate double (index and middle) finger tapping speed in 60 healthy young individuals (30 males and 30 females aged between 18-25 years) using a Graphical User Interface. Our test results have shown that, a) Double-finger mode has lower tapping frequency than the single (index) finger mode, b) There is weak correlation between the single-finger and double-finger modes for both genders, c) Since males have higher FT frequencies than females in all modes of FTTs, gender appears to be a factor, in contrast to a previous report.**

***Keywords*—finger tapping; double finger tapping; gender; graphical user interface, neurophysiology, neuropsychology.**

I. INTRODUCTION

The Finger Tapping Tests (FTT) are used to assess motor speed and rhythm to predict the severity of motor symptoms, to monitor disease progression and to evaluate treatment efficacy [1]. Research has shown that FTT average values are significantly lower in Parkinson's, Huntington's, Multiple Sclerosis and fibromyalgia patients than in healthy individuals [2, 3].

While repetitive tapping with index finger (`single-finger mode') was used by most of the previous studies, using a two finger alternate tapping (`double-finger mode') was not fully explored [4-6]. An earlier study [4] provided descriptive temporal and force data for double-finger mode of 11 healthy right-handed males ranging in age from 18 to 32 years. They run tests for 7 seconds duration using force sensors in dominant (right) hands of the subjects. Their results showed that, 1-the double-finger mode had faster tapping frequency than the single-finger mode, 2-there was no correlation between the single-finger and double-finger modes in the temporal data.

Here, we attempt to test these results in a larger sample size of healthy young subjects by including 30 males and 30 females, and run each test for 10 seconds duration. We used a keyboard and Graphical User Interface program on a computer (for both hands of the subjects) to understand gender and hand dominance effects and whether double-finger tapping provides new data on an individual's distal motor function is different from that with one finger.

II. MATERIALS AND METHODS

A. Sample Size

In this study, the number of participants was determined as (minimum) 57 people to ensure its statistical power and reliability. While determining this number, the confidence level was taken as 80% (this value is equal to 1.28 z-score) and the margin of error was taken as 8.5%. Nevertheless, the number of participants in this study was chosen as 60.

B. Participants

This study was conducted on 30 female and 30 male participants aged between 18 and 25 years. It was essential that the participants are mentally and physically healthy. The participants did not have any neurological, physical or mental problems that could prevent hand and finger movements. Each participant was dominantly right-handed.

C. Graphical User Interface and data analysis

Each test was performed by collecting data through the Graphical User Interface (GUI) depicted in Figure 1, and recorded on an HP laptop computer (Intel(R) Core(TM) i5-1035G1 CPU @ 1.00GHz 1.19 GHz; x64-based processor, Windows Feature Experience Pack 1000.22688.1000.0). Time duration of tests can be selected on the computer screen for either 5- or 10-seconds duration. Finger tapping time and intervals between tappings are seen on the GUI while running the tapping test. Timer stops at the end of the test automatically, and recorded finger tapping intervals can be transferred to an Excel file by clicking available soft button or exported to other files for post-processing. The code for the GUI was written in C-Sharp programming language. The same computer and keyboard were used throughout the study. Microsoft Excel with data analysis add-in supplemental program were used to analyze the test results.

D. Ethical

This study was approved by Yeditepe University Non-Interventional Clinical Research Ethics Committee (Approval Number 202303Y0593).

All participants were informed about the experimental procedures and signed an Informed Voluntary Consent Form

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before they participate in the study. All procedures were performed in accordance with the Declaration of Helsinki and in compliance with the relevant ethical regulations.

E. Experimental Procedure

In running the experiments, a participant sat on the chair in a dynamic sitting position with his/her back straight, legs at 90 degrees and leaning back with his/her feet at 90 degrees to the floor. The laptop computer was placed on the table at a distance where the participant could reach comfortably. The hand was placed with the palms facing the table, the wrist and other fingers that were not used during the experiment were fixed on the table, and the fingers to be tested were placed so that they coincided with the spacebar of the laptop. Then, the participant was asked to press the spacebar as fast as possible for 10 seconds. The touchpad was disabled. In addition, if any problems were encountered during the experiment, a minimum of 10 minutes break was taken so that the experiment could be performed again.

F. Finger Tapping Test Protocols

Protocol I was designed to evaluate the participant's tapping performance by focusing on the spacebar of the keyboard. The participant is asked to tap on the spacebar (as fast as possible) using the single index finger of the dominant hand (right hand) during the test.

Protocol II is the double-finger tapping phase in which the participant is asked to tap as fast as possible on the spacebar using the index and middle finger of the dominant hand (right hand) in alternating manner. Hand and finger positions for these two protocols are shown in Figure 2.

Protocol III tests the single index finger of the non-dominant hand (left hand).

Protocol IV is the application of the test on double-fingers (the index and middle finger) of non-dominant hand (left hand) in alternately tapping form.

Automated test duration of each these protocols is 10 seconds.

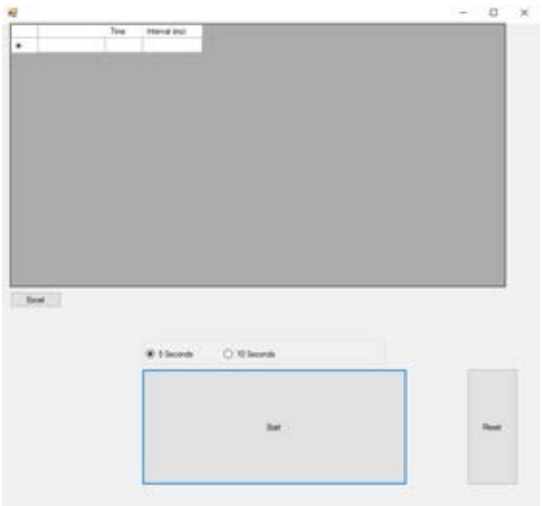


Figure 1: Graphical User Interface (GUI) used in the experiments.

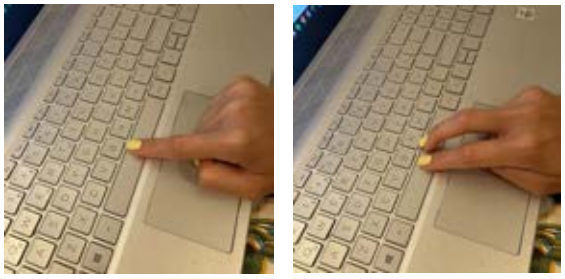


Figure 1: Right hand single-finger (left) and double-finger tapping positions (right).

TABLE I: Descriptive Statistical Data for FT Tests (Number of Taps/10s)

	Right	D.Right,	Left	D.Left
Average, All	73.3	56.5	66.3	50.5
Average, Males	76.4	59.9	70.0	54.4
Average, Females	70.1	53.1	62.5	46.6
St. Dev. Males	11.3	12.1	11.2	13.0
St. Dev. Females	8.7	13.3	7.7	13.4
Max. Males	104	81	97	87
Min Males	58	38	48	37
Max. Females	102	75	85	94
Min. Females	57	25	52	19

III. RESULTS

There was no significant difference in the mean age of the two genders (males 21.5 years/females 21.3 years, two-tailed test, $p<0.05$). Descriptive statistical results pertaining to the experiments are summarized in Table I. It's noted here that for protocol I (Right hand index finger tapping), the maximum finger tapping (FT) is 104 taps/10s and the minimum FT is 58 taps/10s. Standard deviations for males and females are 11.3 and 8,7 taps/10s, respectively. The average FT of 30 male participants was calculated as 76.4 taps/10s, while the same parameter for females has a value of 70.1 taps/10s.

In protocol II (double-right alternate index and middle finger tapping), the maximum FT for males is 81 taps/10s, and the minimum FT is 38 taps/10s, standard deviations for males and females are 12.1 and 13.3 taps/10s, respectively. The average FT of males was 59.9 taps/10s, while the same parameter for females has a value of 53.1 taps/10s.

For protocol III (left index finger tapping), the maximum FT count for males is 97 taps/10s, and the minimum FT is 48 taps/10s, standard deviations for males and females are 11.2and 7.7 taps/10s, respectively. The average FT of males was 70 taps/10s, while the same parameter for females was 62.5 taps/10s.

Protocol IV (double-left alternate index and middle finger tapping), has the maximum FT count for males (females) as 87 (94) taps/10s, and the minimum FT of males (females) is 37 (19) taps/10s, standard deviations for males and females are 13.0 and 13.4 taps/10s, respectively. The average FT of males was 54.4

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taps/10s, while the same parameter for females has a value of 46.6 taps/10s.

Application of Student-t test in these experiments has shown that differences of average FT counts between males and female participants in a given protocol, as well as between different protocols were statistically significant (two-tailed test, $p<0.05$).

Figure 3 and Figure 4 present the relationships between four different tapping modes of males and females. Table II lists linear cross-correlation coefficients between different parameters of finger tapping tests within each gender, as well as between males and females.

IV. Discussion & Conclusion

Finger tapping FT tests are often used in the assessment of motor performance of the upper extremities, and the number of published research papers related to FT tests is increasing every year.

In recent clinical practice, FT tests are included in standard neuropsychological evaluations such as the Halstead Reitan Neuropsychology Battery, which considers only the average number of single (index) finger taps [7].

An earlier study [4] provided some descriptive temporal and force data for double-finger mode, but it is limited to a small number of (11) healthy right-handed young males only. Besides, they run tests for short (7s) duration using force sensors on the fingers of subjects. In our experiments, we compared their results in a larger sample size of healthy 60 young subjects consisting of 30 males and 30 females, and run each test for longer (10s) duration. Instead of using force sensors, we used a keyboard and GUI program on a computer (for both hands of subjects) to understand gender and hand dominance effects.

Our FTT results have shown that,

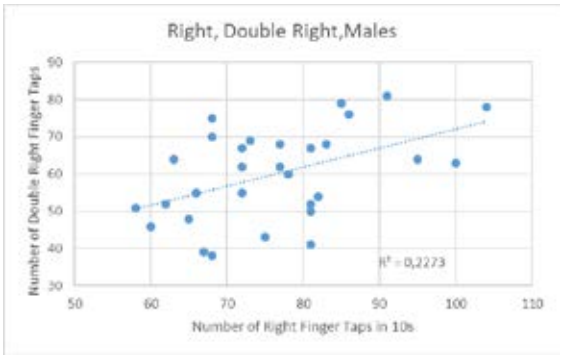
a) The double-finger mode has lower tapping frequency than the single (index) finger mode,

b) There is weak correlation between the single-finger and double-finger modes for both genders,

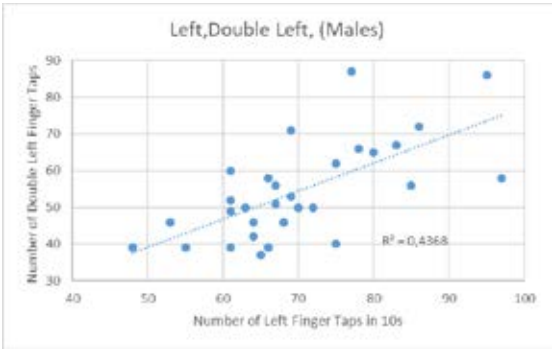
c) Since males have higher FT frequencies than females in all modes of FTTs, gender appears to be a factor, in contrast to a previous report [5],

TABLE II: Cross-Correlations Between Different Parameters of Finger Tapping Tests

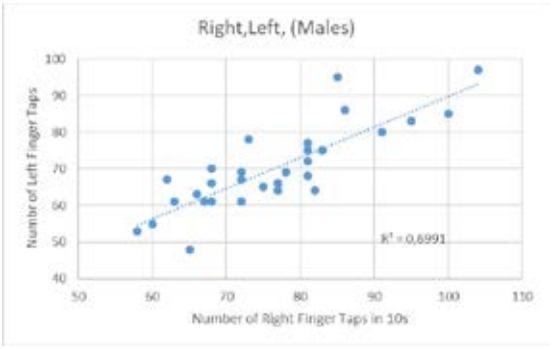
Parameter	Right M	D. Right, M	Left, M	D. Left, M	Right, F	D. Right, F	Left, F	D. Left, F
Right M	1,00							
D. Right M	0,48	1,00						
Left,M	0,84	0,58	1,00					
D Left, M	0,40	0,48	0,66	1,00				
Right F	0,05	-0,08	-0,10	-0,02	1,00			
D Right F	0,02	-0,01	-0,16	-0,17	0,44	1,00		
Left F	-0,10	0,00	-0,18	-0,04	0,83	0,37	1,00	
D Left F	0,08	0,04	0,00	0,14	0,40	0,51	0,33	1,00



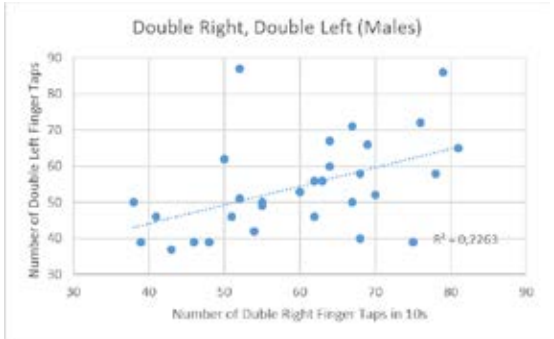
A



B



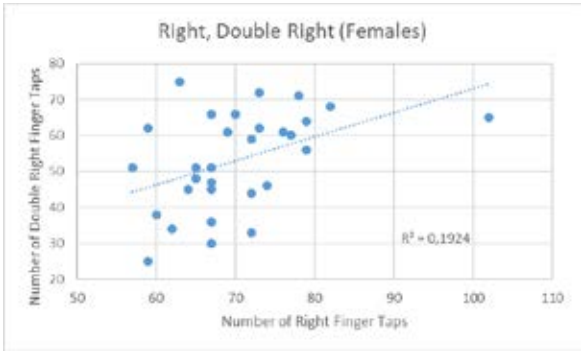
C



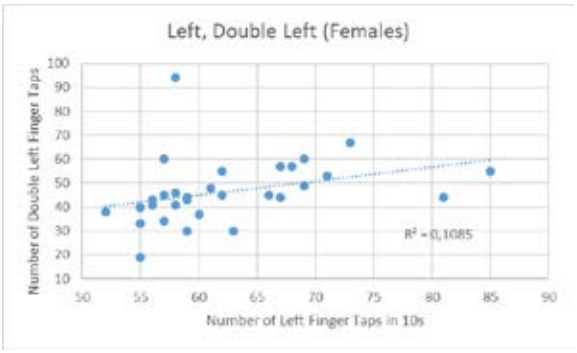
D

Figure 3: Relations between different tapping modes for male participants. A) Between right index finger and alternate double right index and mid-finger, B) between left index finger and alternate double left index and mid-finger, C) between right and left index fingers, D) between alternately tapping double right and double left fingers.

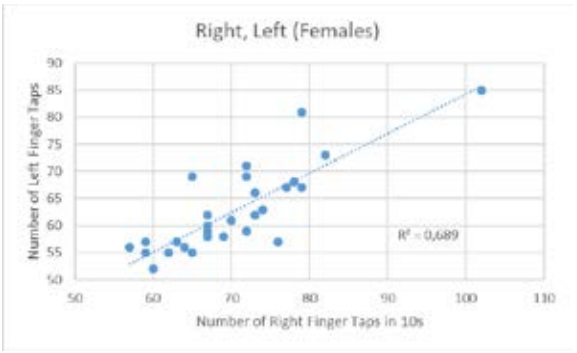
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A



B



C



D

Figure 4: Relations between different tapping modes for females. A) Between right index finger and alternate double right index and mid-finger, B) between left index finger and alternate double left index and mid-finger, C) between right and left index fingers, D) between alternately tapping double right and double left fingers.

d) Dominant hand has higher FT frequencies than the left hand (for both males and females).

This is a preliminary study of a larger project in which age effects, individual tapping rate variability (in analogy with heart rate variability [8]), as well as estimation of cortical connectivity from high resolution EEG recordings [9] and functional brain imaging (fMRI) will also be taken into consideration in different modes of FTTs. These will assist us to understand whether alternate double-finger tapping affects distal motor function differently from that with single (index) finger.

This study has some limitations. Although the sample size was relatively sufficient, a larger sample size would have been more informative. Our inability to check some potential confounders (e.g., medication during tests) further limits the general application of the findings.

The code for GUI (screen display of which we displayed in Figure 1) will be freely available to interested researchers who are willing to pursue a finger tapping study, upon their reasonable written request from the authors.

ACKNOWLEDGMENT

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