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Research

Use of Finger Tapping Test in Quantitative Evaluation of the Effectiveness of Rehabilitation Programs in Individuals with Chronic Hemiplegia

Kronik Hemiplejili Bireylerde Rehabilitasyon Programlarının Etkinliğinin Kantitatif Değerlendirilmesinde Parmak Vurma Testinin Kullanımı

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ABSTRACT

Objective: This study aimed to evaluate changes in upper extremity motor skills in individuals with chronic stroke using the finger tapping test (FTT) and clinical assessments.

Methods: This study was conducted between April 2019 and February 2021. Thirty volunteers with hemiplegia (mean age 61.7±7.22 years), in whom at least 6 months had passed since the first cerebrovascular accident, participated. A Bobath-based physical therapy program (45 minutes/day, 5 days/week, for 6 weeks) was applied to the affected hands. Pre- and post-treatment evaluations included a 20-second computer-based FTT and clinical tests, such as the Fugl-Meyer assessment upper extremity, the box and block test, the Duruöz hand index, and the functional independence measure.

Results: FTT showed an increase in tapping counts (from 58.8±20.52 to 75.5±19.31) and a reduction in mean inter-tapping intervals (ITI) (from 391.7±184.68 ms to 281.6±88.09 ms) ($p<0.001$). Clinical tests also revealed significant improvements in motor skills and reductions in disability ($p<0.001$). Both pre- and post-treatment ITI curves were described by linear equations with negative slopes; the slope before treatment (-2.1463) was steeper than that after treatment (-0.6286). Strong correlations were observed between FTT data and clinical test outcomes ($p<0.001$).

Conclusion: The ease of use and objective nature of the FTT highlight its potential for assessing motor recovery and prognosis in patients with hemiplegia, reducing errors associated with subjective assessments, and offering valuable insights for clinicians and researchers.

Keywords: Hemiplegia, motor performance, finger tapping test, temporal analysis

ÖZ

Amaç: Bu çalışmada kronik inme geçiren bireylerde, parmak vurma testi (PVT) ve klinik değerlendirmeler kullanılarak üst ekstremite motor becerilerindeki değişikliklerin değerlendirilmesi amaçlanmıştır.

Gereç ve Yöntem: Bu çalışma Nisan 2019-Şubat 2021 tarihleri arasında gerçekleştirilmiştir. Çalışmaya ilk serebral vasküler olayından sonra en az 6 ay geçmiş, hemiplejili 30 gönüllü (ortalama yaş 61,7±7,22 yıl) katıldı. Etkilenen ellere yönelik Bobath temelli fizik tedavi programı (günde 45 dakika, haftada 5 gün, 6 hafta boyunca) uygulandı. Tedavi öncesi ve sonrası değerlendirmeler, 20 saniyelik bilgisayar tabanlı PVT ile Fugl-Meyer üst ekstremite değerlendirmesi, kutu ve blok testi, Duruöz El İndeksi ve fonksiyonel bağımsızlık ölçümü gibi klinik testleri içerdi.

Bulgular: PVT sonuçlarında vuru sayılarında artış (58,8±20,52'den 75,5±19,31'e) ve ortalama vuru aralıklarında (OVA) azalma (391,7±184,68 ms'den 281,6±88,09 ms'ye) görüldü ($p<0,001$). Klinik testler, motor becerilerde önemli iyileşmeler ve engellilikte azalma olduğunu ortaya koydu ($p<0,001$). Hem tedavi öncesi hem de sonrası OVA eğrileri negatif eğimli doğrusal denklemlerle açıklanırken, tedavi öncesi eğim (-2,1463), tedavi sonrasına göre (-0,6286) daha dikti. PVT verileri ile klinik test sonuçları arasında güçlü bir ilişki bulundu ($p<0,001$).

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ÖZ

Sonuç: PVT'nin kullanım kolaylığı ve objektif yapısı, hemiplejik hastalarda motor iyileşmenin ve prognozun değerlendirilmesinde potansiyelini vurgulamakta, subjektif değerlendirme hatalarını azaltmakta ve klinisyenler ile araştırmacılar için değerli bilgiler sunmaktadır.

Anahtar Kelimeler: Hemipleji, motor performans, parmak vurma testi, zamanlama analizi

INTRODUCTION

Hemiplegia is a neurological condition characterized by paralysis (plegia) on one side of the body, typically resulting from damage to a specific area of the brain. Ischemic and hemorrhagic strokes are the most common causes of hemiplegia (1). Neurological disorders affecting the central nervous system, such as head injuries, brain tumors, multiple sclerosis, infections like meningitis or encephalitis, and vascular issues like stenosis of cerebral blood vessels, can also lead to hemiplegia. Treatment and support approaches used to enhance individuals' quality of life and aid in their functional recovery can vary based on the cause and severity of hemiplegia and patients' overall health condition (2).

In post-hemiplegic rehabilitation, various methods are employed, including conventional techniques (exercises for muscle strengthening and maintenance of normal joint range of motion; activities to enhance daily life skills; and balance and mobility exercises), neurophysiological treatment methods (such as Bobath, Rood, and Brunnstrom techniques and proprioceptive neuromuscular facilitation), biofeedback techniques, functional electrical stimulation, robot-assisted rehabilitation, constraint-induced movement therapy, and orthoses (3-6). Additionally, some other methods with different mechanisms of action, such as rehabilitation using sensory glove stimulation, virtual reality, and continuous passive motion devices, can be applied (7,8). Evaluating the effectiveness of rehabilitation is crucial for determining the patient's functional status, monitoring progress, setting treatment goals, and optimizing the rehabilitation process. Measurement tools with standardized scoring, such as the modified Ashworth scale (MAS), upper extremity Brunnstrom stage (UE-BS), box and block test (BBT), and Fugl-Meyer upper extremity motor assessment scale (UE-FMA), have been developed to assess an individual's functional status. These methods often involve scoring based on the therapist's observations during active or passive execution of motor movements (9). Treatment progress can be further evaluated quantitatively by tracking movement using electronic sensors (10,11). Another quantitative method used in rehabilitation assessment is the finger tapping test (FTT). FTT has long been used as a quantitative method to assess neuromotor function of the upper extremity (10). It has been frequently employed for the quantitative assessment of diseases such as Alzheimer's disease (12), ataxia (13), Parkinson's disease (14), and stroke (15). A longitudinal study by Chunyong et al. (16) used the FTT and functional magnetic resonance imaging to evaluate improvements in the hemiplegic hand during a three-month rehabilitation period. In monthly evaluations, they also observed significant increases in the average number of FTT taps. Térémetz et al. (17) used the BBT and the FTT in their pilot study to evaluate the effectiveness of "interactive manual dexterity training" therapy after stroke. They found an increase in BBT score and an acceleration in FTT in the training group.

Assessing rehabilitation programs typically relies on data collected from patients, their families, and caregivers. This assessment often hinges on self-reported outcomes and questionnaires. Nevertheless, these subjective approaches may lack precision and fail to accurately reflect the patient's current condition (9). This study aimed to evaluate upper-extremity function in adults with chronic hemiplegia before and after rehabilitation programs using clinical tests, including UE-FMA, Duruöz hand index (DHI), BBT, functional independence measure (FIM), and the novel computer-based test FTT. The study also aims to determine the potential relationship between FTT data and clinical tests to support the use of FTT as an objective assessment tool.

METHODS

The study was conducted in accordance with the Declaration of Helsinki and reviewed. Ethical approval for the study was obtained from the İstanbul Okan University Faculty of Health Sciences Ethics Committee (approval no: 6, date: 27.03.2019). This study was conducted between April 2019 and February 2021 and involved 30 patients who met the study criteria and presented to the Vision Physical Therapy and Rehabilitation Center. The sample size of the study was determined using the G*Power program. Based on the age-interaction relationship in the finger-tapping test reported by Özen et al. (8), a minimum of 28 participants would provide 81% statistical power at a 5% significance level. Considering a 10% attrition rate, the planned sample size was 30 participants.

Participants included individuals aged 18 or older who had experienced their first cerebrovascular accident (CVA) resulting in hemiplegia or hemiparesis, with at least 6 months elapsed since the CVA; who had a a Mini-Mental State Examination (MMSE) score of ≥16; who were in UE-BS stages 4-6; who had upper extremity spasticity ≤2 according to the Modified MAS (MMAS); and who had UE-FMA scores between 15 and 50 or who could perform a minimum of 10 degrees of extension or flexion in the wrist or fingers and could perform wrist extension and flexion five times consecutively without loss of range of motion. Individuals with two or more CVAs were excluded from the study. Participants with sensory aphasia, apraxia, hemianopia, rheumatoid arthritis, multiple sclerosis, Dupuytren's contracture, complete or incomplete spinal cord injury, Parkinson's disease, hand deformities resulting from fractures, and other medical conditions that could interfere with the tests were excluded. Those who had received botulinum toxin A injections in the affected upper extremity within the last 6 months were also excluded.

General Study Protocol

After obtaining written consent from the participants, detailed medical histories were taken, including height, weight, body mass index (BMI), age, occupation, education, date of stroke, dominant hand, etiology of hemiplegia, affected side, medications, and surgeries. Evaluations to determine eligibility were conducted using UE-BS, MMSE, and MMAS. Participants underwent a 6-week Bobath-based rehabilitation program, five days per week, 45-minute sessions, tailored to their needs. There were no interventions made in the patients' medical treatments.

Participants were assessed using UE-FMA, DHI, BBT, FIM, and FTT before (pre-treatment) and after (post-treatment) the 6-week rehabilitation program. FTT data—including mean tapping counts, mean inter-tapping intervals (ITIs, in milliseconds), and temporal variation patterns—were evaluated, whereas other clinical tests were assessed using standard scores.

Assessment Tools

UE-BS is a method used to assess the motor function and control of the upper extremity (arm, shoulder, hand, wrist) in individuals who have had a stroke. It categorizes seven stages ranging from stage 1, where muscles are completely flaccid and reflexes are absent, to stage 7, where all functions have returned to normal (18).

MMSE is a screening test developed in 1975 to assess cognitive impairment in adults. The test evaluates short-term memory, attention and calculation, language, orientation, and praxis. The evaluation is performed out of a total of 30 points. Scores below 10 indicate severe impairment; scores between 10 and 19 indicate moderate dementia; scores between 20 and 24 indicate early-stage dementia; and scores of 25 and above are considered normal.

Modified Modified Ashworth Scale

The scale, initially developed in 1964 to assess muscle spasticity in patients with multiple sclerosis, has been modified over the years, first into the MAS and then into the MMAS. The evaluation is based on range of motion and muscle tone during passive wrist movement. It is scored on a scale from 0 to 4, where 0 indicates no increase in muscle tone and 4 indicates stiff flexion or extension in the affected area (21).

Rehabilitation Protocol

All participants received Bobath-based physical therapy for six weeks, five days per week. This approach focuses on ensuring correct movement during activities to enhance proper functioning. The program includes exercises targeting different areas, such as the lower and upper extremities, the trunk, and postural control (22).

The computer-based FTT was used to evaluate the finger-tapping performance of hemiplegic patients. The system measures ITI with high temporal resolution and stores the data on the computer's hard disk. FTT was performed on the participants before and after the treatment. During the test, participants were seated comfortably, approximately 50 cm from the computer screen. They were instructed to tap a key on the computer keyboard using the index finger of their hemiplegic hand as quickly as possible for 20 seconds (10). The implementation of the test is shown in Figure 1.

Fugl-Meyer Upper Extremity Motor Assessment Scale

UE-FMA assesses sensorimotor recovery of the upper extremity. The method is based on the motor recovery stages described by Brunnstrom (18). The scale consists of five sections: motor function, joint range of motion, sensory function, balance, and joint pain. The motor function assessment is the most commonly used component and consists of 33 items assessing the upper extremity. Each item is rated on a scale: 0=unable to perform; 1=partially able to perform; 2=able to perform completely. The total score obtainable on the scale ranges from 0 to 66, and the assessment takes approximately 20 minutes (23).

The DHI, a Turkish-language validated tool, was used to assess participants' limitations in hand function. The test consists of 18 items assessing the individual's hand skills in self-care, work, kitchen activities, dressing, personal hygiene, and other general movements. Each item is scored

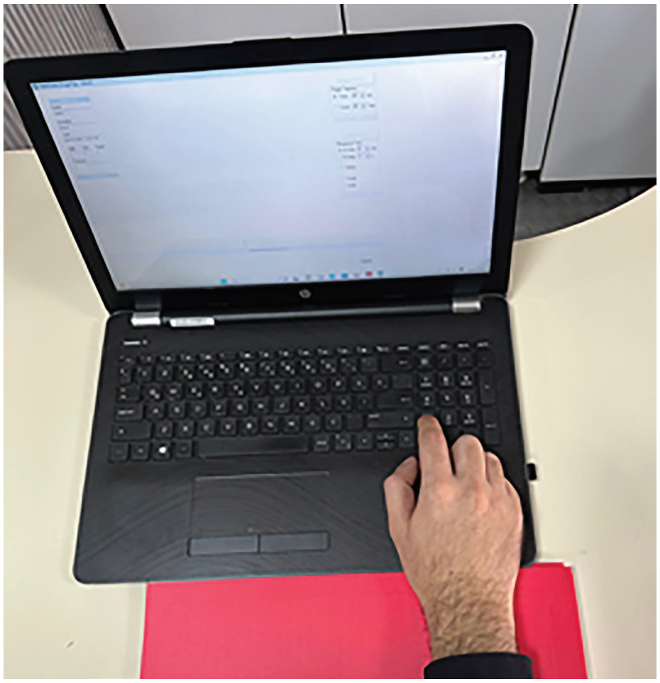

Figure 1. Procedure of the FTT test as applied to participants
FTT: Finger tapping test

from "0: no difficulty" to "5: impossible." A higher score indicates a greater activity limitation. The completion time for the index is approximately 3 minutes (24).

Box and Block Test

The test requires the patient to pick up a wooden block and place it into another section of the apparatus. The score is the number of wooden blocks placed in the other section within 60 seconds (25).

The FIM, developed in 1993 by Heinemann and colleagues, is a method used to evaluate physical disability. FIM, for which Turkish validity and reliability studies have been conducted, assesses physical and cognitive impairments, assistance needs, and caregiver burden in activities of daily living. FIM consists of 18 items, 13 for motor functions and 5 for cognitive functions. Each item is evaluated on a 7-point Likert scale indicating the level of assistance required (1=total assistance; 7=total independence). The evaluation is observation-based and takes, on average, 20 minutes (26). In this study, only the motor component of the FIM was used.

Briefly, the study standardized participants using MMSE to assess cognitive function, UE-BS to measure motor abilities, and MMAS to evaluate muscle spasticity. To assess the effectiveness of rehabilitation on motor skills, clinical tests including the UE-FMA, DHI, BBT, FIM, and FTT, a computer-based test, were administered.

Statistical Analysis

Descriptive statistics, including mean, standard deviation, count, and percentage, were provided for the study's categorical and continuous variables. The homogeneity of variances was checked using the Levene's test, a prerequisite for parametric tests. The normality assumption was assessed using the Shapiro-Wilk test. When it was desired to evaluate differences between two dependent groups, the dependent samples t-test was used when parametric test assumptions were met, and the Wilcoxon test was used when they were not. The relationship between two continuous variables was evaluated using the Pearson correlation coefficient when parametric assumptions were met; otherwise, the Spearman correlation coefficient was used. Regression analysis was applied to assess the relationships among the number of taps, ITI measurements, and other parameters. Statistical significance was considered at two levels: $p<0.05$ and $p<0.01$.

RESULTS

Of the 30 participants, 77% (n=23) were male and 23% (n=7) were female. The mean age of the participants was 61.7±7.22 years, with a mean height of 170±0.06 cm, mean weight of 82.7±9.78 kg, and mean BMI of 28.8±4.02 kg/m^2. Additionally, the participants had mean MMSE, MMAS, and UE-BS scores of 24.9±1.87; 1.2±0.46, and 4.7±0.52 points, respectively (Table 1).

Table 2 presents pre- and post-treatment values of tests and scales administered to volunteers before and after 6 weeks of rehabilitation. The data in the table indicate notable changes across various parameters. Specifically, post-

Table 1. Descriptive statistics of demographic data of participants (n=30)

Gender	**Male, n (%)**	**23 (77%)**
	Female, n (%)	7 (23%)
Age (year)		61.7±7.22
Height (cm)		170±0.06
Weight (kg)		82.7±9.78
Body mass index		28.8±4.02
Mini mental state examination score (MMSE)		24.9±1.87
Modified modified Ashworth scale (MAS)	**0 (%)**	1 (3%)
	1 (%)	23 (77%)
	2 (%)	6 (20%)
Upper extremity-Brunnstrom stages (UE-BS)	**4 (%)**	9 (30%)
	5 (%)	20 (67%)
	6 (%)	1 (3%)

Descriptive statistics are given as mean±standard deviation for continuous data and number (percentage) for categorical data treatment the number of tappings increased from 58.8 to 75.5, while ITI durations decreased from 391.7 ms to 281.6 ms; similarly, UE-FMA score increased from 37.3 to 40.7; DHI value decreased from 56.3 to 50.9; BBT score increased from 30.6 to 36.5; and FIM measurements increased from 63.1 to 66.8. The statistical analysis revealed that all changes in the tests were significant (p=0.001).

When investigating the relationship between pre- and post-treatment clinical test results and FTT tapping performance, we observed a strong negative correlation between the number of taps and the DHI scores. Additionally, the number of tappings was strongly positively correlated with UE-FMA, BBT, and FIM scores (all p=0.001). The details are provided in Table 3.

Examining the temporal variation of FTT tapping performance in the pre- and post-treatment periods, it was noted that ITIs shortened as the test progressed. The slopes of the linear fits to the time course of ITIs were negative for both pre- and post-treatment data. Notably, the magnitude of the negative trend in the pre-treatment data was greater than that in the post-treatment data (slopes were -2.1463 and -0.6286, respectively; Figures 1 and 2).

Figures 2 and 3 graphically presents the temporal behaviors of the FTT tapping performances of three randomly selected participants.

DISCUSSION

The routine clinical tests, which often include scales and questionnaires used in the assessment of rehabilitation, may sometimes be associated with relatively low precision and may be insufficient for quantitative assessment to provide an accurate reflection of the patient's condition. Hence, the reliability and validity of these measurements

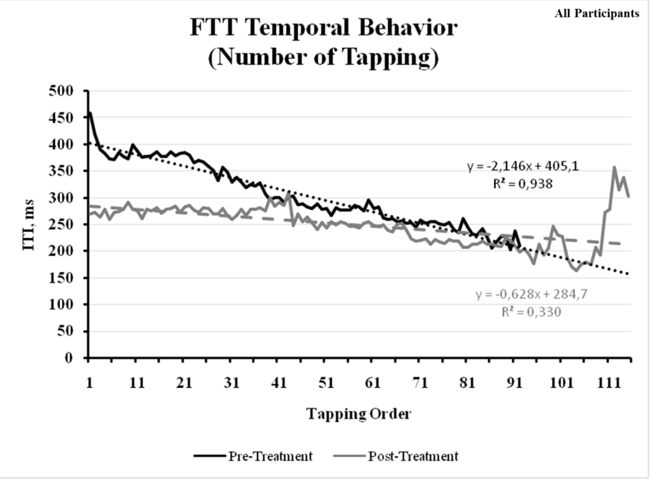

Figure 2. The temporal variation of FTT tapping performances in pre- and post-treatment period, linear regression equation and determination coefficient (R2) are given on thegraph (n=30)

FTT: Finger tapping test, ITI: Inter-tapping intervals

Table 2. Pre- and post-treatment values and significance levels of the tests and scales administered to the participants (n=30)

	Pre-treatment	Post-treatment	t	p-value
FTT # of tapping	58.8±20.52	75.5±19.31	-8.41	**<0.001**
FTT ITI, ms	391.7±184.68	281.6±88.09	5.33	**<0.001**
UE-FMA	37.3±3.93	40.7±4.73	-7.62	**<0.001**
DHI	56.3±6.95	50.9±7.62	6.49	**<0.001**
BBT	30.6±7.23	36.5±6.93	-8.18	**<0.001**
FIM	63.1±5.08	66.8±6.51	-6.71	**<0.001**

The table shows the mean±standard deviation values of the data
FTT # of tapping: Mean number of tapping, FTT ITI: Mean inter tapping interval, UE-FMA: Fugl-Meyer upper extremity motor assessment scale, DHI: Duruöz hand index, BBT: Box and block test, FIM: Functional independence measure scale, t: Paired-sample t-test

Table 3. Correlations and significance levels between pre- and post-treatment FTT mean number of tapping and the clinical tests (n=30)

		Pre-treatment	Post-treatment
UE-FMA	r	0.937	0.957
	p	**<0.001**	**<0.001**
DHI	r	-0.925	-0.945
	p	**<0.001**	**<0.001**
BBT	r	0.989	0.966
	p	**<0.001**	**<0.001**
FIM	r	0.814	0.907
	p	**<0.001**	**<0.001**

UE-FMA: Fugl-Meyer upper extremity motor assessment scale, DHI: Duruöz hand index, BBT: Box and block test, FIM: Functional independence measure scale, r: Pearson correlation coefficient

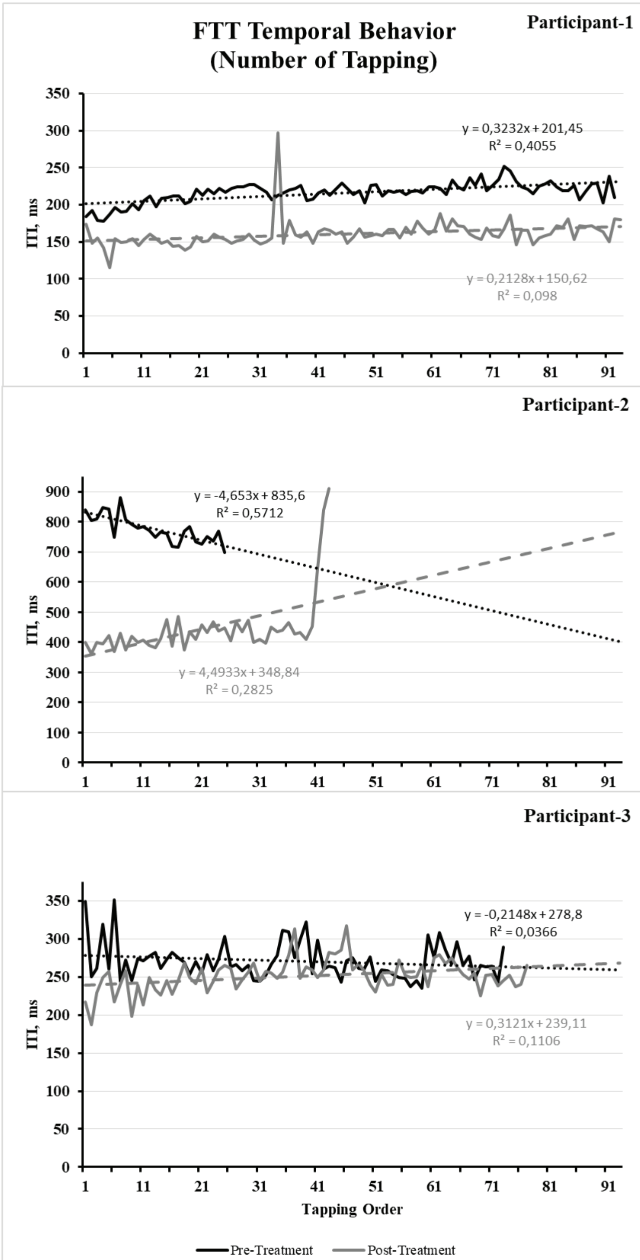

Figure 3. The temporal variation of FTT tapping performances in pre- and post-treatment period, linear regression equation and determination coefficient (R2) aregiven on the graph for three participations

FTT: Finger tapping test, ITI: Inter-tapping intervals

are limited, emphasizing the necessity for correlations with objective data obtained through technical systems that monitor movements (9). In this study, we conducted a quantitative evaluation of the impact of a rehabilitation program on the upper extremity motor skills of individuals with chronic hemiplegia. We administered standard clinical tests and the computer-based FTT. The FTT data, consistent with the clinical tests, indicated significant improvements in all measurements after six weeks of rehabilitation.

In our study, significant improvements were found in the UE-FMA, DHI, BBT, and FIM tests when comparing measurements performed before and after rehabilitation. These findings are similar to those of the following three studies. In a study by Lee at al. (27), 30 patients with hemiplegia received occupational therapy for eight weeks (five days per week). Sessions in the control group consisted of one hour of ergotherapy for the hemiplegic hand, whereas sessions in the experimental group comprised 30 minutes of ergotherapy for the hemiplegic hand followed by a 30-minute bilateral arm exercise session. Significant differences were found in the results of the UE-FMA, BBT, and modified Barthel index tests before and after treatment. Additionally, bilateral occupational therapy was more effective than unilateral occupational therapy. Kocyigit and Akaltun (28) conducted a study involving 51 stroke patients who underwent 30 sessions of rehabilitation therapy. They used various assessment tools, including the box and blocks test, Michigan hand assessment questionnaire (MHQ), dizziness handicap inventory (DHI), disabilities of the arm, shoulder, and hand (DASH) questionnaire, and ABILHAND questionnaire. They also observed significant improvements in the DHI, similar to improvements measured by other assessment methods (MHQ, DASH, and ABILHAND).

In the present study, we used a computer-based test (FTT) in addition to clinical tests, and found that the mean tapping counts on the FTT increased post-treatment. In a study by Özen et al. (8), FTT was performed on single and double fingers in patients with Parkinson's disease. They suggested that finger-tapping speed could be a practical, objective, and precise method for assessing upper extremity function and disease severity in patients with Parkinson's disease. Kang et al. (5) applied low-frequency repetitive transcranial magnetic stimulation combined with motor imagery and electrical stimulation to 20 stroke patients for two weeks. They evaluated upper-extremity motor functions subsequently. In contrast to our results, they found no significant changes in finger-tapping counts. Raghumahanti et al. (29) observed a statistically significant increase in finger-tapping counts in 15 hemiplegic patients after five weeks of combined modified constraint-induced movement therapy (COMBIT) and bimanual intensive training. We also found a significant increase in finger-tapping counts after 30 sessions of Bobath-based physiotherapy in patients with chronic hemiplegia, with the mean count rising from 58.8 to 75.5. While our results were similar to those reported in Raghumahanti et al.'s (29) study, they differed from those reported in Kang et al.'s (5) study. This difference can be explained by the varying efficacy of the applied treatment protocols.

Unlike the above-mentioned studies, our study included not only finger-tapping counts but also the time course of ITIs. Aydin et al. (10) suggested in their previous studies that temporal analysis of ITIs in healthy young adults could contribute to our understanding of motor skills, peripheral and central fatigue. The execution of maximum voluntary sequential movements results from a highly complex planning process that involves the formation of movement schemas in the central and peripheral nervous systems (10,30).

The temporal analysis of FTT data (Figure 1) in this study revealed that as the test progressed, ITIs shortened, indicating a decreasing trend in ITIs. This suggests adaptation to repetitive movements and the formation of movement schemas. Furthermore, as shown in the figure, the initial ITI values decreased from 459 ms before treatment to 270 ms after treatment, strongly supporting the effectiveness of the treatment. Moreover, the post-treatment trendline, which had a lower slope than the pre-treatment trendline, remained stable, implying that neurological recovery was approaching its upper limit. To facilitate clear interpretation, it would be advisable to repeat FTT at multiple intervals during treatment and to compare the results across different treatment durations in future studies.

While FTT may provide us with valuable information and interpretation about the neurological movement circuit, it does not provide a definitive answer as to whether the movement is functionally successful. For example, if an individual successfully completes the FTT using their index finger at a high tapping rate, it does not provide information about their functional ability to grasp a glass. Unlike other methods that involve multiple joints of the upper extremity, such as BBT, UE-FMA, DHI, and FIM, the application of FTT is limited to joints involved in movement of the index finger. However, the strong correlation we found between FTT and the other clinical methods in our study supports the utility of FTT for interim assessments, particularly in terms of ease of application.

Examination of the individual time courses of ITI derived from the FTT data (Figure 2) reveals that, although the overall trend aligns with performance based on average ITI values, significant interindividual variation exists in initial and final values. This variation can be attributed to clinical variables such as patients' pre-disease activity levels (sedentary versus active), gender differences, and neurological characteristics of the pathology causing hemiplegia, despite these patients having been subject to specific exclusion criteria. For instance, the pre-treatment ITI for participant 1 was 183.42 ms, whereas participant 2 had 840.08 ms, and participant 3 had 349.09 ms. Similarly, the post-treatment initial ITIs were 173.73 ms for participant 1, 400.38 ms for participant 2, and 216.69 ms for participant 3. Notably, participant 1, who began treatment with a higher score, exhibited an ITI change of 5.17%, whereas participants 2 and 3 showed changes of 52.34% and 37.92%, respectively. Based on this, narrowing the criteria for participant exclusion in future studies may lead to more reliable interpretations.

A wide variety of tools and measures are available to assess rehabilitation outcomes in patients with impaired upper-limb and hand function following stroke. However, this diversity can make it difficult for clinicians to select the most appropriate scales, tests, and instruments to assess therapy outcomes objectively (31). This is because the applications of these tools and the functions they assess can differ substantially. For example, the UE-FMA is a comprehensive test in which a health professional objectively assesses the patient's reflexes and upper limb function according to standardized instructions, whereas the DHI is a questionnaire in which the patient reports on various daily activities that require use of the hands, such as buttoning, writing, cutting food, opening doors, and lifting objects; the information is based on the patient's self-report (32,33). The BBT is a patient performance-based test that evaluates functions such as hand-eye coordination, fine motor skills, speed, and agility while the patient takes the blocks one by one from one box and moves them to another, whereas the motor-skill domain of the FIM is generally used to measure the level of functional independence of patients in activities of daily living, such as feeding, bathing, dressing, using the toilet, transferring, and walking, and the information is based on the patient's own or caregiver's statement (24,33). In this study, we aimed to evaluate the efficacy of computer-based FTT in rehabilitation. Rather than relying efficacy on a single assessment method, we sought to strengthen the evidence for its possible efficacy by examining its correlations with tests that clinically assess upper limb function in different ways (declarative scales: DHI, FIM; performance-based methods: UE-FMA, BBT) and that focus on different functional domains. We consider this to be the main of our study.

In this study, patients were standardized with respect to cognitive function and certain motor characteristics of the CVA-affected side. On the other hand, factors such as whether the patient's hemiplegic side was the dominant hand , gender, etiology of hemiplegia, and the degree of neurological damage were not taken into account, which can be considered weaknesses of our study.

Study Limitations

This study has some limitations. First, the relatively small sample size may limit the generalizability of the findings. Second, the study did not include a control group; therefore, the observed improvements cannot be attributed exclusively to the rehabilitation program. Finally, the FTT was administered for a relatively short period (20 seconds), and longer tapping durations or repeated measurements may provide additional information regarding the temporal characteristics of motor performance. Future studies with larger samples, control groups, and longer follow-up periods are warranted to further establish the clinical utility of FTT in individuals with chronic hemiplegia.

CONCLUSION

In this study, the combination of computer-based FTT with clinical evaluation methods such as UE-FMA, DHI, BBT, and FIM, together with temporal analysis of FTT, distinguishes our research. In conclusion, our study suggests that, compared with the clinical tests commonly employed to evaluate treatment effectiveness in hemiplegic individuals, FTT offers highly sensitive, quantitative measures in terms of both mean values and temporal aspects of movement.

Furthermore, because of its ease of administration and efficiency, FTT is regarded as a reliable tool for prognostic assessment of stroke patients. Being a computer-based test, it mitigates potential errors arising from subjective evaluations by caregivers, patients, and family members.

We believe that our findings are important for guiding future research objectives, particularly regarding homogenizing factors such as affected side, dominant hand, gender, etiology of hemiplegia, and the extent of brain damage.

ETHICS

Ethics Committee Approval: Ethical approval for the study was obtained from the İstanbul Okan University Faculty of Health Sciences Ethics Committee (approval no: 6, date: 27.03.2019).

Informed Consent: Informed consent was obtained from all study participants prior to their participation.

FOOTNOTES

Authorship Contributions

Surgical and Medical Practices: T.K., E.A., L.A., E.K., Concept: E.A., L.A., E.K., Design: E.A., L.A., E.K., Data Collection or Processing: T.K., L.A., E.K., Analysis or Interpretation: T.K., E.A., L.A., E.K., Literature Search: T.K., E.A., L.A., E.K., Writing: T.K., E.A., L.A., E.K.

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REFERENCES

1. Zhao HY, Xu H, Wang Z, Wang L, Qiu S, Peng D, et al. Analysis and evaluation of hemiplegic gait based on wearable sensor network. Information Fusion. 2023;90:382-91.
2. Paolucci T, Agostini F, Mussomeli E, Cazzolla S, Conti M, Sarno F, et al. A rehabilitative approach beyond the acute stroke event: a scoping review about functional recovery perspectives in the chronic hemiplegic patient. Front Neurol. 2023;14:1234205.
3. Liu J, Feng W, Zhou J, Huang F, Long L, Wang Y, et al. Effects of sling exercise therapy on balance, mobility, activities of daily living, quality of life and shoulder pain in stroke patients: a randomized controlled trial. Europe Journal of Integrative Medicine. 2020;35:101077.
4. Chaturvedi P, Kalani A. Motor rehabilitation of aphasic stroke patient: the possibility of Rood's approach. Neural Regen Res. 2023;18:551.
5. Kang JH, Kim MW, Park KH, Choi YA. The effects of additional electrical stimulation combined with repetitive transcranial magnetic stimulation and motor imagery on upper extremity motor recovery in the subacute period after stroke: a preliminary study. Medicine (Baltimore). 2021;100:e27170.
6. Lee HJ, Lee JS, Kim YM. Effects of action observation training and mirror therapy on the electroencephalograms of stroke patients. J Kor Phys Ther. 2021;33:106-13.
7. Malouin F, Richards CL, McFadyen B, Doyon J. Nouvelles perspectives en réadaptation motrice après un accident vasculaire cérébral. [New perspectives of locomotor rehabilitation after stroke]. Med Sci (Paris). 2003;19:994-8. French.
8. Özen B, Emre U, Korucu O, Köktürk F, Karaci R, Barut Ç. Quantitative assessment of finger-tapping performance in patients with Parkinson's disease. Journal of Neurological Sciences (Turkish). 2012;29:689-97.
9. Kutz DF, Fröhlich S, Rudisch J, Müller K, Voelcker-Rehage C. Finger tapping as a biomarker to classify cognitive status in 80+-year-olds. J Pers Med. 2022;12:286.
10. Aydin L, Kiziltan E, Gundogan NU. Polyphasic temporal behavior of finger-tapping performance: a measure of motor skills and fatigue. J Mot Behav. 2016;48:72-8.
11. Arias P, Robles-García V, Espinosa N, Corral Y, Cudeiro J. Validity of the finger tapping test in Parkinson's disease, elderly and young healthy subjects: is there a role for central fatigue? Clin Neurophysiol. 2012;123:2034-41.
12. Sudlow CL, Warlow CP. Comparing stroke incidence worldwide: what makes studies comparable? Stroke. 1996;27:550-8.
13. Nalçaci E, Kalaycioğlu C, Ciçek M, Genç Y. The relationship between handedness and fine motor performance. Cortex. 2001;37:493-500.
14. Giovannoni G, van Schalkwyk J, Fritz VU, Lees AJ. Bradykinesia akinesia inco-ordination test (BRAIN TEST): an objective computerised assessment of upper limb motor function. J Neurol Neurosurg Psychiatry. 1999;67:624-9.
15. de Groot-Driessen D, van de Sande P, van Heugten C. Speed of finger tapping as a predictor of functional outcome after unilateral stroke. Arch Phys Med Rehabil. 2006;87:40-4.
16. Chunyong L, Yingkai L, Fuda L, Jiang C, Liu Y. Longitudinal changes of motor cortex function during motor recovery after stroke. Top Stroke Rehabil. 2023;30:342-54.

17. Térémetz M, Hamdoun S, Colle F, Gerardin E, Desvilles C, Carment L, et al. Efficacy of interactive manual dexterity training after stroke: a pilot single-blinded randomized controlled trial. J Neuroeng Rehabil. 2023;20:93.

18. Brunnstrom S. Motor testing procedures in hemiplegia: based on sequential recovery stages. Phys Ther. 1966;46:357-75.

19. Folstein MF, Folstein SE, McHugh PR. "Mini-mental state". A practical method for grading the cognitive state of patients for the clinician. J Psychiatr Res. 1975;12:189-98.

20. Küçükdeveci AA, Kutlay S, Elhan AH, Tennant A. Preliminary study to evaluate the validity of the mini-mental state examination in a normal population in Turkey. Int J Rehabil Res. 2005;28:77-9.

21. Kaya T, Karatepe AG, Gunaydin R, Koc A, Altundal Ercan U. Inter-rater reliability of the modified Ashworth scale and modified modified Ashworth scale in assessing poststroke elbow flexor spasticity. Int J Rehabil Res. 2011;34:59-64.

22. van Vliet PM, Lincoln NB, Foxall A. Comparison of Bobath-based and movement science based treatment for stroke: a randomised controlled trial. J Neurol Neurosurg Psychiatry. 2005;76:503-8.

23. Salter K, Jutai JW, Teasell R, Foley NC, Bitensky J. Issues for selection of outcome measures in stroke rehabilitation: ICF body functions. Disabil Rehabil. 2005;27:191-207.

24. Sezer N, Yavuzer G, Sivrioglu K, Basaran P, Koseoglu BF. Clinimetric properties of the Duruoz hand index in patients with stroke. Arch Phys Med Rehabil. 2007;88:309-14.

25. Mathiowetz V, Volland G, Kashman N, Weber K. Adult norms for the box and block test of manual dexterity. Am J Occup Ther. 1985;39:386-91.

26. Küçükdeveci AA, Yavuzer G, Elhan AH, Sonel B, Tennant A. Adaptation of the functional independence measure for use in Turkey. Clin Rehabil. 2001;15:311-9.

27. Lee MJ, Lee JH, Koo HM, Lee SM. Effectiveness of bilateral arm training for improving extremity function and activities of daily living performance in hemiplegic patients. J Stroke Cerebrovasc Dis. 2017;26:1020-5.

28. Kocyigit BF, Akaltun MS. Assessment of responsiveness of four hand-related scales in stroke patients. Acta Neurol Belg. 2021;121:1633-9.

29. Raghumahanti R, Chitkara E, Agrawal P. Effectiveness of a distributed practice model utilizing combit protocol on tone and function of hemiplegic upper limb -a randomized comparison trial. Indian Journal of Health Sciences and Care. 2021;8:44.

30. Aydın L, Kızıltan E, Öğüş E, Azizağaoğlu B, Büyükkaraman A, Doğan S, et al. The impacts of central fatigue on the polyphasic nature of tapping performance. Gazi Med J. 2017;29.

31. Marek K, Redlicka J, Miller E, Zubrycki I. Objectivizing measures of post-stroke hand rehabilitation through multi-disciplinary scales. J Clin Med. 2023;12:7497.

32. Chen P, Liu TW, Tse MMY, Lai CKY, Tsoh J, Ng SSM. The predictive role of hand section of Fugl-Meyer assessment and motor activity log in action research arm test in people with stroke. Front Neurol. 2022;13:926130.

33. Oliveira CS, Almeida CS, Freias LC, Santana R, Fernandes G, Fonseca Junior PR, Moura RCF. Use of the Box and Block Test for the evaluation of manual dexterity in individuals with central nervous system disorders: a systematic review. MTP&RehabJournal. 2016;14:1-17.