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EVALUATION OF IDEOMOTOR APRAXIA IN PATIENTS WITH STROKE: A STUDY OF RELIABILITY AND VALIDITY

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Objective: **This aim of this study was to determine the reliability and validity of an established ideomotor apraxia test when applied to a Turkish stroke patient population and to healthy controls.**
Subjects: **The study group comprised 50 patients with right hemiplegia and 36 with left hemiplegia, who had developed the condition as a result of a cerebrovascular accident, and 33 age-matched healthy subjects.**
Methods: **The subjects were evaluated for apraxia using an established ideomotor apraxia test. The cut-off value of the test and the reliability coefficient between observers were determined.**
Results: **Apraxia was found in 54% patients with right hemiplegia (most being severe) and in 25% of left hemiplegic patients (most being mild). The apraxia scores for patients with right hemiplegia were found to be significantly lower than for those with left hemiplegia and for healthy subjects. There was no statistically significant difference between patients with left hemiplegia and healthy subjects.**
Conclusion: **It was shown that the ideomotor apraxia test could distinguish apraxic from non-apraxic subjects. The reliability coefficient among observers in the study was high and a reliability study of the ideomotor apraxia test was therefore performed.**

Key words: apraxia, ideomotor apraxia test, hemiplegia, cognitive function.

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INTRODUCTION

Praxis is the proper performance of learned or skilled complex movements, without any motor or sensorial disorders or ataxia. Apraxia is the term used for a disorder of this ability (1–4). Ideomotor apraxia is caused by the disturbance of the relationship between the sites storing images for movements and the sites executing them. Supramarginal gyrus (40th site) in lesions of dominant parietal lobe, supplementary motor areas or corpus callosum lesions, results in apraxia (1, 5). Patients remember how to make the movement they want and can define it verbally, but fail to perform it when given a verbal command (6). For example, a patient with ideomotor apraxia may be able to close his or her eyes spontaneously, but may fail to do so when instructed verbally. These patients are able to perform simple, spontaneous and automatic movements perfectly. Ideomotor apraxia can be defined, in brief, as a movement disorder arising from damage to the parietofrontal connections that control deliberate movements (7).

Successful maintenance of a rehabilitation program for patients with stroke depends on the patient's fulfilment of given instructions as well as their performance of prescribed exercise. Due to the inadequacy of patients with apraxia in following oral and/or visual instructions, their functional outcomes are adversely affected (8). A study by Pedersen et al. (9) using the Bartel index indicated that apraxia affects functional outcomes negatively. Apraxia is an important determinant in the dependency level of patients' activities of daily living (ADLs) (9, 10). It should be remembered that apraxia may be present in patients with low FIM™ scores. Thus patients with stroke should be considered standard with respect to apraxia. Though various apraxia tests have been described in the literature, their validity and reliability have not always been reported (9). In one study an apraxia test was applied comparatively to Turkish and American patient groups. However, that study included Alzheimer's and Parkinson's disease patients and healthy subjects (11). There are no published studies in which an apraxia test has been applied to a Turkish patient group with stroke.

The aim of this study was to determine the reliability and validity, in Turkish patients with stroke and in healthy controls, of an established ideomotor apraxia test (IAT), known to have a reliability coefficient of $r=0.99$, which was developed by Kertesz (12) for assessing ideomotor apraxia.

METHODS

Subjects

The study was conducted at Ankara Physical Medicine and Rehabilitation, Education and Research Hospital, which with 200 beds is one of the largest national rehabilitation centres in Turkey. Patients with stroke comprise approximately 30% of the patient population. The focus of the rehabilitation program for patients with stroke is to optimize functional independence and to educate them and their families regarding medical care and the daily exercise program. Rehabilitation consists of assessment and treatment by a multidisciplinary team comprising physiotherapy, occupational therapy, psychology, speech therapy, nutrition and dietary services.

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The study group included 50 patients with right hemiplegia and 36 with left hemiplegia who had developed hemiplegia due to cerebrovascular accident (CVA), and 33 healthy age-matched controls. All subjects were informed of the study procedures and participated voluntarily in the study. Stroke was defined according to the World Health Organization's criteria as follows: rapidly developing clinical signs of focal disturbance of cerebral function, lasting more than 24 hours with no apparent origin other than vascular (13). Patients aged between 35 and 68 years with mean stroke period of 85 days were included in the study. Patients were divided into 3 groups according to event period: acute (0–1 month); sub-acute (1–3 months); and chronic (3–10 months) (14).

Inclusion criteria for the study were as follows: ability to co-operate, right hand dominancy, ability to speak Turkish, a minimum education of primary school graduation. Exclusion criteria included the following: subjects with previous history of CVA, with neurological deficits in the form of ataxia in the body parts to be subjected to the IAT, with vision defects or psychological illness, patients developing stroke due to tumour or similar reasons, and those with bilateral stroke. For the healthy subjects, inclusion criteria were: ability to co-operate, right hand dominancy, ability to speak Turkish, and a minimum education of primary school graduation. Exclusion criteria for the healthy subjects were neurological deficits in the body parts to be subjected to the IAT, vision defects or psychological illness.

Brunnström stages (15) of the patients were determined by clinical examinations conducted by the same physiatrist. In addition, lesion localizations were divided into 4 groups according to cranial tomography (CT) results: cortical, subcortical, cortical and subcortical, and normal.

Instruments

Patients were evaluated with respect to ideomotor apraxia by IAT. Mini Mental Status Examination (MMSE) was applied in order to assess cognitive function. The Gülhane Aphasia Test (GAT), a version of Boston Disease Aphasia Examination adapted to Turkish patient groups, was used to assess language components such as understanding what is heard, understanding what is read, repeating and naming. ADLs (self-care, mobility, communication and social perception) were measured using the FIM™ test, a global test used to assess disability.

Ideomotor apraxia test

The IAT comprises 20 items, divided into 4 categories (facial, upper extremity, instrumental and complex) each containing 5 items. (The items marked with an asterisk may involve objects where necessary.)

The instructions for each category were as follows:

- Facial: (1) Put out your tongue, (2) Close your eyes, (3) Whistle, (4) Sniff a flower*, (5) Blow out a match*.
- Upper extremity: (1) Make a fist, (2) Salute, (3) Wave goodbye, (4) Scratch your head, (5) Snap your fingers.
- Instrumental: (1) Use a comb*, (2) Use a toothbrush*, (3) Use a spoon to eat*, (4) Use a hammer*, (5) Use a key*.
- Complex: (1) Pretend to drive a car*, (2) Pretend to knock at the door*, (3) Pretend to fold a newspaper*, (4) Pretend to light a cigarette*, (5) Pretend to play the saz* (a lute-like stringed local instrument having a straight head with tuning pegs, a little longer than a lute).

Item 5 in the final section was originally as "act as if playing a piano", but was replaced with the version given above since playing the saz is more common in Turkey.

Application and scoring of the test

The subjects were first asked to perform each single movement upon verbal commands. When the subjects did not reply correctly or responded differently, they were shown the movement again and asked to imitate it. Verbal commands and demonstrating the movement were repeated at most twice. A correct performance was awarded 3 points, insufficient but recognizable performance 2 points, and partially recognizable movements 1 point. When the subject was able to perform correctly only when given an object, 1 point was awarded. Zero points were given when an unrecognizable, irrelevant or no response was obtained, or when a mistake was made in using any object. The maximum possible score for the test was 60 (14).

Procedure

Subjects were applied IAT, MMSE, GAT and FIM™ in a silent room at midday, ensuring they were not disturbed during the test. Tests were carried out during the first week following their admission. On the first evaluation day, Brunnström stages of the subjects were determined and FIM™ was applied. IAT was applied on the following day. Subjects were seated in such a manner that the instructor remained at the centre of their vision. The same person delivered each instruction in the IAT to each subject as verbal commands. Each subject was simultaneously assigned a test score by 3 different observers (A, B, C) separately. The average test running time was 10 minutes in patients and 4 minutes in healthy subjects. On the third day, the subjects performed the MMSE and GAT, at intervals.

Statistics

SPSS-10 software was used for the statistical analysis. The following methods were used: chi-square test, Student's t-test, Kolmogorov-Smirnov test, one-way ANOVA, multivariate analysis of variance (MANOVA) and Pearson correlation. A p-value ≤ 0.05 was considered statistically significant.

RESULTS

Subjects

Thirty-one female patients (39.5%), of whom 18 had right hemiplegia and 13 left hemiplegia, and 55 male patients (60.5%), of whom 32 had right hemiplegia and 23 left hemiplegia, and 33 healthy subjects (controls) (16 women (48.5%), 17 men (51.5%)) were included in the study. The chi-square test indicated no significant differences among these 3 groups with respect to sex and education levels (respectively, $\chi^2 = 1.544$, $p = 0.462$; $\chi^2 = 0.292$, $p = 0.864$, Table I).

The mean ages of the groups were: 54.1 (SD 9.3) years for the right hemiplegia group, 54.0 (SD 7.5) years for the left hemiplegia group and 51.2 (SD 7.1) years for the controls. The groups did not indicate any statistically significant difference with respect to age distribution ($p = 0.228$, Table I).

There was no significant difference in stroke period between right and left hemiplegia groups (t = 0.239, df = 84, $p = 0.812$). Mean stroke period for right hemiplegic patients was 87.1 (SD 50.9) days and for left hemiplegic patients 83.2 (SD 45.6) days. For all patients, 18 were in acute, 43 were in sub-acute and 25 were in chronic status. The aetiology was tromboembolic CVA in 60 patients (69.8%) and haemorrhagic CVA in 26 patients

Table I. *Mean (SD) ages and demographic characteristics of the subjects*

	Hemiplegia		
Characteristic	Right	Left	Healthy subjects
Mean age, years (SD)	54.10 (9.32)	54.00 (7.49)	51.15 (7.05)
Gender			
Women	18	13	16
Men	32	23	17
Education			
Primary school	40	29	25
Secondary school	10	7	8

(30.2%). Examination of lesion localizations did not reveal any significant difference between right and left hemiplegia groups ($\chi^2 = 6.063$, $p = 0.109$, Table II).

No significant difference was found between right and left hemiplegia groups with respect to FIM™ admission scores (t = −0.905, df = 84, $p = 0.368$). A Kolmogorov-Smirnov test was performed in order to determine whether there was any difference between right and left hemiplegia groups with respect to Brunnström stages. According to the analyses conducted, there was no significant difference between the groups with respect to Brunnström stages of the hand, arm or lower extremity ($p = 0.589$, $p = 0.623$ and $p = 0.623$, respectively).

Apraxia test

In order to determine the cut-off value of the apraxia test, IAT scores for healthy subjects were ranked from the highest to the lowest. A statistically significant difference was observed between the first 27% of the group and the last 27%. To calculate cut-off value, the score given to each subject was divided by the corresponding item number and the arithmetic mean of each subject was calculated and this value was then subtracted from the group mean. The cut-off value was determined by calculating the arithmetic means of the scores obtained by this procedure. The low limit in the cut-off value was calculated according to standard deviation. The cut-off value was finally calculated as 51.56, and patients with scores lower than this were accepted as apraxic. Of those patients with scores below 51.56, the 25% of the group with the highest scores (i.e. scores between 48 and 51.56) was defined as mildly apraxic, the 25% with the lowest scores (26.30 and below) as severely apraxic and the 50% in between (scores of 26.3–48) as moderately apraxic. Of 86 patients, apraxia was found in 36. Nine (25%) of the patients indicated severe apraxia, and these all had right hemiplegia. Moderate apraxia was found in 19 patients, of whom 16 (44.4%) had right and 3 (8.3%) left hemiplegia. Eight (22.2%) patients presented with mild apraxia, of whom 2 (5.6%) had right hemiplegia and 6 (16.7%) left hemiplegia.

To determine the reliability of the IAT, reliability coefficients between the observers were examined. The reliability coefficient between observers A and B was $r = 0.866$ ($p = 0.000$), between observers A and C $r = 0.898$ ($p = 0.000$), and between observers B and C $r = 0.791$ ($p = 0.000$).

An ANOVA test was applied to determine whether there was any difference between patients with right and left hemiplegia and healthy subjects with respect to apraxia scores. A significant difference was found among the 3 groups ($p = 0.000$). Tukey HSD test was applied in order to determine from which group the difference arose. According to the results of this test, a statistically significant difference was found between right and left hemiplegia subjects ($p = 0.000$), and between right hemiplegia and control subjects ($p = 0.000$). However, there was no significant difference between left hemiplegia and healthy subjects ($p = 0.549$). As can be seen in Table III, average apraxia scores of right hemiplegia subjects were lower compared with the other 2 groups.

When apraxia scores were examined according to stroke stages, apraxia was found in 7 subjects in acute stage, in 15 subjects in subacute stage and in 14 subjects in chronic stage. No statistical significance was found between apraxia scores of acute, sub-acute and chronic patients (F = 1.943, $p = 0.150$). Mean apraxia scores for the patients in acute, sub-acute and chronic stages were found to be 28.7 (SD 19.8), 40.5 (SD 8.0) and 35.7 (SD 12.6), respectively. Six acute apraxic patients were right hemiplegic and 1 left hemiplegic. Ten subacute apraxic patients were right hemiplegic and 5 left hemiplegic, and 11 chronic apraxic patients were right hemiplegic and 3 left hemiplegic.

Table II. *Localization of patients' lesions according to cranial findings*

Localization	Cortical (%)	Subcortical (%)	Cortical and subcortical (%)	Normal (%)
Right hemiplegia	22.5	32.5	32.5	12.5
Left hemiplegia	25	57.1	14.3	3.6

Aphasia and cognitive functions

In order to investigate the presence of apraxia and hemiplegia side on GAT scores and MMSE scores, multivariate analysis of variance (MANOVA) was performed. A significant difference was observed in repeating and naming scores depending on the hemiplegia side. There was a statistically significant difference with respect to repeating ($p = 0.002$) and naming ($p = 0.026$) scores between right and left hemiplegia groups. The related means reveal that the means of naming and repeating scores in patients with right hemiplegia are lower than in patients with left hemiplegia.

A significant difference was also found regarding GAT sub-test scores and MMSE scores between apraxic and non-apraxic groups. All relevant means in the apraxic group were found to be lower than in the non-apraxic group ($p = 0.000$). In addition, the interaction effect of apraxia presence and hemiplegia side on the repeating function was found to be significant ($p = 0.023$). Mean values are given in Table III.

DISCUSSION

Within the scope of this study, a validity and reliability study of IAT was performed on a Turkish patient population sample. As stated in the methods section, the subjects included in the study were matched according to sex, age and educational level. Moreover, disease period, motor activity level and ADL levels, which are considered to have effects on the test scores in the patient group, were similar in patients with left and right hemiplegia. Thus, confounding variables that may have an interfering impact on the study were kept under control. The fact that apraxia scores revealed a significant difference between hemiplegic and healthy subjects indicates that the test has been able to distinguish between apraxic and non-apraxic subjects, in

Table III. *Mean values of apraxia scores, language functions and Mini Mental Status Examination (MMSE) scores of the right and left hemiplegic subjects (SD in parentheses)*

Side	Apraxia	Apraxia scores	Understanding what is heard	Understanding what is read	Repeating	Naming	MMSE
Right	Apraxic	32.70 (12.85)	10.55 (5.63)	4.44 (3.03)	6.37 (4.02)	4.51 (3.36)	11.13 (8.40)
($n = 50$)	Non-apraxic	55.75 (2.40)	17.52 (3.27)	13.39 (2.82)	16.43 (3.08)	11.73 (1.51)	20.68 (5.75)
	Total	43.30 (14.99)	13.76 (5.82)	8.56 (6.10)	11.00 (6.44)	7.84 (4.02)	15.52 (8.68)
Left	Apraxic	47.41 (5.22)	13.66 (3.64)	7.00 (5.56)	13.11 (4.59)	8.11 (4.01)	15.36 (4.91)
($n = 36$)	Non-apraxic	56.43 (2.33)	18.48 (1.55)	13.18 (2.54)	17.33 (1.90)	12.11 (1.01)	22.36 (4.86)
	Total	54.18 (5.09)	17.27 (3.04)	11.63 (4.38)	16.27 (3.30)	11.11 (2.74)	20.66 (5.68)

line with the purpose of the test. Similarly, the finding that apraxia scores of right hemiplegic patients were lower than those of the left hemiplegic group shows the validity of the IAT. According to our findings, we conclude that the IAT is a test able to distinguish apraxic from healthy subjects. A high reliability coefficient among the observers also confirms that IAT is a reliable test.

IAT, of which reliability ($r = 0.99$) was proven by Kertesz, was applied to Turkish subjects in this study (12). The cut-off value of the test was found to be 51.56, quite close to the value (49.7) reported previously by Kertesz & Ferro (14). Since praxis is a dominant hemisphere function, apraxia was observed more often in right hemiplegia patients. Apraxia was found in 27 (54%) of 50 patients with right hemiplegia and in 9 (25%) of 36 patients with left hemiplegia. Similarly, Kertesz et al. (16) found apraxia in 54.6% of patients with right hemiplegia. Donkervoort et al. (17) reported apraxia in approximately one-third of the patients with right hemiplegia. Since apraxia is observed more often in left hemisphere dysfunction, all the patients with severe apraxia were right hemiplegic.

De Renzi (18) emphasizes that, as a general rule, the left hemisphere is dominant in the planning of movements, but that the extent of this effect varies from individual to individual, and that there might be cases in which both hemispheres are effective at the same rate. Bizzozero et al. (19), in a study in which they investigate the role of the right hemisphere in apraxia, emphasize that even Liepman, who strongly believes in left hemisphere dominancy in praxis function, has not ruled out the probability that the right hemisphere may play a role in praxis function. Pedersen et al. (9), in a study conducted on patients with stroke in acute stage, found apraxia in 10% and 4% of patients with left and right hemisphere lesions, respectively. In this present study, also, moderate apraxia was observed in only 3 left hemiplegia patients and mild apraxia was observed in 6 patients, and these findings were consistent with the relevant literature. Presence of apraxia in patients with left hemiplegia could be related with spatial cognitive deficiency accompanying right hemisphere injury. In other words, apraxia may develop in left hemiplegic patients due either to the inability of the patient to visualize the assigned task or to the distribution of spatial-attention. Presence of apraxia in patients with left hemiplegia may vary according to the addition of neglect to the clinical picture. In fact, a study conducted on patients with neglect syndrome, one of the most common pathologies of spatial cognition, reported that as many as 90% of patients with right hemisphere injury are apraxic (20).

Aphasia and apraxia are usually encountered together (21). Some authors regard this situation as evidence of joint use of common mechanisms and structures by language and praxis functions (16, 17, 22). Aphasia is associated with inferior parietal, superior temporal and inferior frontal sites, which are also important in praxis functions. Aphasia and apraxia develop as a result of middle cerebral artery occlusion causing damage widely in these sites (16). In conformity with the literature, this study found that all language functions of patients with apraxia were significantly lower than those of non-apraxic patients. The lack of any significant difference between MMSE scores of patients with right and left hemiplegia may be explained by the fact that MMSE is a test reflecting the functionality of both hemispheres. However, lower MMSE scores observed in patients with apraxia compared with non-apraxic patients may indicate that existing cognitive function is affected more by the presence of apraxia. Along with the low MMSE scores, test score means related to understanding what is read and what is heard were also low for apraxic patients with right hemiplegia. Thus, low levels in MMSE scores in this group probably originated from the deficiency in comprehension. Although the effects of apraxia and hemiplegic side were not statistically significant on the understanding of what is read and heard, the examination of the relevant means revealed that scores for understanding what is read and heard were lower for patients with right hemiplegia (Table III).

The natural recovery course of apraxia has not been widely studied. Basso and colleagues (23) conducted one of the few studies on the recovery from ideomotor apraxia in acute stroke patients. Improvement was found to take a long time and was related only to the site of the lesion. They reported that ideomotor apraxia continued to some extent in 45% of the patients one year after the onset of the stroke. No statistical significance was found between the apraxia score of the patients with respect to stroke stages. However, the mean apraxia score for subacute patients was higher than that for chronic patients, which could be due to the fact that the number of left hemiplegic patients in the subacute phase was higher. In order better to study the recovery of apraxia over time, one would have to form a study pattern with repeated measurements in the same patient group.

In conclusion, the possibility of apraxia should be kept in mind when assessing patients with stroke. In particular, patients with right hemiplegia should be tested with respect to apraxia and their apraxia levels should be determined. To this end, we propose using an IAT in the assessment of ideomotor apraxia in patients with hemiplegia, the reliability and validity of which we investigated with Turkish subjects in this study. However, further studies are required in order to investigate the effects of apraxia on the rehabilitation program and on the rehabilitation of apraxia.

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