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Effect of TENS on cognition, behavior and memory in normal elderly persons

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Objective : *To study the effect of TENS over the temporal areas regarding cognition, behavior and memory in normal elderly persons.*

Design : *Experimental study with control group.*

Materials and Method : *Normal elderly subjects age 50 years and over were recruited in the study. They were either allocated into experimental and control group. All patients of both groups were stimulated with TENS on both sides of the temporal areas for 10 min per day, 5 days a week for 3 weeks. The control group received sham stimulation at the same site of stimulation on their head. The Thai Adaptation of the ABCD was applied before and after the test.*

Results : *Thirty-six elderly subjects (ranging 52 - 84 years old) were either allocated into experimental and control group of 23 and 13 subjects, respectively. There was no statistical difference between pretest and post-test of ABCD scores in the control group, but there was in the experimental group only in three constructions, namely: mental status, memory and linguistic expression.*

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Conclusions : *Cognitive and behavior functions and recent memory could be improve by TENS on the temporal areas.*

Keywords : *TENS, Memory, Affective behaviors.*

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วัตถุประสงค์ : *เพื่อศึกษาผลของการใช้ TENS กระตุ้นบริเวณขมับทั้งสองข้างต่อ ความคิดความเข้าใจ พฤติกรรมและความจำในคนปกติและสูงอายุ*

รูปแบบการวิจัย : *การศึกษาชนิดทดลองโดยมีกลุ่มควบคุม*

ตัวอย่างและวิธีการ : *ทำการวิจัยในผู้สูงอายุที่มีอายุมากกว่า 50 ปีขึ้นไป โดยจัดแบ่งออกเป็นกลุ่มตัวอย่างและกลุ่มควบคุมแบบสุ่ม โดยกลุ่มทดลองจะได้รับการกระตุ้นไฟด้วยเครื่อง TENS วันละ 10 นาที 5 ครั้งต่อสัปดาห์นาน 3 สัปดาห์ กลุ่มควบคุมจะได้รับการติดเครื่องมือ TENS แต่ไม่เปิดไฟ (SHAM) โดยผู้สูงอายุทั้งสองกลุ่มจะผ่านการทำแบบทดสอบอะริโซนาเพื่อวัดความสามารถในการสื่อความหมายของผู้ป่วยสมองเสื่อม (ABCD) ก่อนและหลังการใช้เครื่อง กระตุ้นไฟ TENS*

ผลการศึกษา : *ผู้สูงอายุ 36 คนมีอายุตั้งแต่ 52 - 84 ปี แบ่งเป็นกลุ่มควบคุม 13 คน และกลุ่มทดลอง 23 คน ในกลุ่มควบคุมไม่พบความแตกต่างของคะแนน ABCD ก่อนและหลังการทดสอบอย่างมีนัยสำคัญในทุกหัวข้อย่อยของแบบทดสอบ แต่จะพบการเพิ่มขึ้นอย่างมีนัยสำคัญทางสถิติของคะแนน ABCD หลังการกระตุ้น TENS ในกลุ่มทดลองทั้ง 3 ด้าน คือ ด้านสภาพสมองปกติ ด้านความจำ และด้านการแสดงออกทางภาษา*

สรุปผล : *การใช้ TENS กระตุ้นที่บนขมับทั้งสองข้างมีผลทำให้ความคิด ความเข้าใจและพฤติกรรม รวมทั้งความจำในระยะสั้นดีขึ้นในผู้สูงอายุ*

คำสำคัญ : *เครื่องไฟฟ้า TENS, ความจำ, พฤติกรรม.*

In recent years, there has been an increasing interest in age-related changes with cognitive function in adults. Dementia is an acquired syndrome of the elderly. Some investigators have reported the presence of cognitive-linguistic impairment among elderly individuals with dementia. Increased longevity without continued cognitive ability interferes with work, social activities and/or relationships with others.

Dementia or chronic brain syndrome or lewy body dementia (DLB) or vascular dementia is a loss of brain function. It is not a single disease. Instead, dementia refers to a group of illness that involves memory, behavior, learning and communicating problem. [1]

The two major causes of degenerative dementia are Alzheimer's disease and vascular dementia.

Dementia with DLB is a leading cause of degenerative dementia in elderly adults. This condition is linked to abnormal protein structures in certain areas of the brain. Conditions that damage blood vessels or nerve structures of the brain can also lead to dementia.

Dementia usually occurs in older age, mostly over the age of 60. Symptoms of dementia come from many problems of brain functions including, i.e., progressive memory loss, inability to concentrate, decrease in problem solving skills, confusion, hallucination, delution, altered sensation or perception, impaired recognition (agnosia), discrimination, motor system impairment, specific disorders of problems solving or learning, impaired language ability, personality changes and lack of spontaneity. [2]

In previous studies, transcutaneous nerve stimulation (TENS) was found to improve memory (recognition), semantic verbal fluency and independent and affective behaviors in patients with probable Alzheimer's disease (AD).[3,4] Moreover, TENS has no side effect; it is therefore perceived by patients as a type of neutral, friendly stimulation, easy to apply, except those with a peacemaker (Howson 1978). It seems completely safe.[4,5] The rationale underlying these studies was that TENS, through direct and indirect pathways, could activate the hippocampus and hypothalamus which play a role in memory and independent and affective behavior, respectively. [6 - 9] These areas are also affected in normal aging process. [9,10] The neuropathological hallmark of both AD and aging is brain atrophy. [9,11,12] Importantly, brain atrophy is characterized by shrinkage of cells rather than cell death; shrunken cells may still be subject to plastic changes.[9,12] Swaab hypothesizes that adaptive growth responses and regenerative processes could result from stimulation of the neuronal systems. [9,12]

This hypothesis was proved by applying short-term TENS over Th1 and Th5 and repeated a positive effect on verbal long-term memory (recognition) as well as on visual short-term (visual memory) and long-term memory (face recognition). [3, 13]

Sensory evoked potentials are subcortical and cortical post-synaptic action potentials resulted from the stimulation of the peripheral sensory organs. However, they are very small in amplitude, less than 10 microvolts, but can be picked up by scalp electrodes. [14] Vise versa scalp superficial electrical stimulation would be able to stimulate the brain.

Direct electrical stimulation to the brain was applied for the treatment of some brain disease.[15] There was a report of effectiveness of repetitive electrical stimulation direct on the temporal and frontal lobes to produce depolarization of the brain cells. [16]

It was proved that direct electrical stimulation testing did not appear to cause structural damage of the brain at the light microscope level. [17]

A compact TENS used in this study was built with specification of square wave current, 2 - 160 Hz frequency, 50 - 250 μsec width, 50 volts and 130 mA which proved to be effective in the treatment of mild OA knee. [18]

Early diagnosis is essential in order to detect cognitive deficits and to develop an effective treatment before the symptoms of dementia progress. The cognitive impairments associated with dementia can be measured by many tests such as the Blessed Dementia Scale [19], Mini-mental Status Exam [20], or Cambridge Cognitive Examination.[21] These tests can reveal cognitive impairment but have some limitations in measuring dementia in patients with physical disability such as visual loss or focal cognitive deficits such as aphasia. [22] A variety of language and communication tests have been designed to detect language impairment due to focal brain damage such as Porch Index of Communicative Ability [23], Boston Diagnostic Aphasia Examination [24], Token Test [25], and Western Aphasia Battery. [26] Although standard aphasia batteries can be useful and informative, these battery tests may be inappropriate and inadequate for patients with dementia whose communication deficits are often directly related to generalized intellectual deficits. [27]

The only standardized test designed to identify functional linguistic communicative deficits associated with Alzheimer's dementia, the most common type of dementia, is the Arizona Battery for Communication Disorders of Dementia (ABCD).[28] The ABCD was developed by Bayles and Tomoeda in 1993. This test was developed to comprehensively assess functional linguistic communication skills. It is based on longitudinal studies of the effects of dementia such as Alzheimer's disease, Parkinson's disease and Huntington's disease on linguistic communication. It was designed to measure receptive and expressive language deficits, orientation, and memory of patients with dementia. [22, 28 - 31] The ABCD subtests were found to highly correlate with three widely accepted measures of dementia severity [30,32] such as the Mini-mental State Examination[20], the Block Design Subtest of the Wechsler Adult Intelligence Scale [33], and the Global Deterioration Scale. [34] The ABCD test is a reliable instrument for measuring Alzheimer's dementia characteristics because it is able to differentiate normal people from mild Alzheimer's disease, and those with mild AD from those with moderate AD. [28,30,35]

Objective

This study is to prove whether this compact TENS applied over the skin of the temporal areas might be able to improve the cognition and behavior in the elderly persons.

Subject and Method

The sample consisted of elderly subjects aging 50 years and over. All subjects were excluded

from the program if they had history of psychiatric disorder, cerebrovascular disease, infection, neurological illness, alcoholism, language disorders and drug abuse.

TENS stimulation

In the both groups, two electrodes with gel were attached to both sides of the temporal area of the patients and fixed the two electrodes with tape. This TENS which consists of asymmetric biphasic square impulses, with an internal frequency of 160 Hz, a repetition 2 Hz, and a pulse width of 40 μs. The experimental group received a 10 min- a-day treatment with TENS through two electrodes placed on both sides of the temporal area. The control group received sham stimulation (no current was applied) at the same site of stimulation. TENS was applied for 5 days a week, during a 3-week period in both groups.

Measurement

All volunteers spoke and literate Thai language. They were required to pass the ABCD screening part which assessed their hearing and speech discrimination problems, visual field intactness, visual agnosia, elementary reading and facial and limb praxis by using Apraxia subtest of the Western Aphasia Battery.[26]

The recruited volunteers were either allocated into experimental group of 23 subjects or control group of 13 subjects. Both the experimental and control groups were tested by the Thai Adaptation of the ABCD.[35] Subjects were informed about the testing procedure. While the Thai Adaptation of the ABCD was being administered, the responses of the subjects were recorded and scored. All testing materials were performed by all subjects on the day before and the day after a period of 3 weeks of treatment by experimental and sham stimulations.

The testing materials used in this study are as follows:

The Thai Adaptation of the ABCD which consists of test manual, stimulus book, response record sheet, and the stimulus objects: an envelope and a nail.

The manual and some items content from some subtests of the Thai Adaptation of ABCD were adapted from the Arizona Battery for Communication Disorders of Dementia (ABCD). The items were changed according to the nature of the Thai language and culture. Twenty of fifty AD patients in the standardization study were checked for consistency of performance between the test and retest. The retest was given approximately a week after an initial testing based on the fact that dementia would not change within a week. [28]

The ABCD was developed to assess the function of linguistic communication skills. This test provides information about mental status, episodic memory, linguistic expression, linguistic comprehension and visuospatial construction. The test battery consisted of 17 subtests: mental status subtest, story retelling immediate subtest, story retelling delayed subtest, word learning free recall subtest, word learning cued recall subtest, word learning recognition subtest, object description subtest, generative naming subtest, confrontation naming subtest, concept definition subtest, following commands subtest, comparative questions subtest, repetition subtest, reading comprehension-word subtest, reading comprehension-sentence subtest,

generative drawing subtest and figure copying subtest. After the responses were scored following the ABCD scoring system, the results were computed and analyzed using statistical analysis methodology.

Data Analysis

The data were analyzed by SPSS program version 11.5.

The demographic and baseline data were presented by mean and standard deviation or number and percentage. Mann-Whitney U Test was used to compare baseline ABCD score between both groups. Wilcoxon signed Ranks test was used to compare the difference between pre- and post ABCD scores in both groups. A p - <0.05 was considered statistically significant.

Results

There were 3 males and 10 females, ranging in age from 52 to 84 years old. They were allocated into the control group who would receive sham stimulation. Clinical control trials of 13 subjects were tested by the Thai Adaptation of the ABCD before and after the sham stimulation. There were 5 males and 18 females, ranging in age from 52 to 81 years old. They were allocated into the experimental group who would receive electrical stimulation. In the experimental group, the 23 subjects were tested by the Thai Adaptation of the ABCD before and after electrical stimulation.

Table 1 shows demographic data of control and experimental groups. There was no statistical difference in age and sex between both groups.

Table 2 reveals means and standard deviations of raw scores of pretest between control and experimental groups of 13 subjects of each group. There were no statistical difference of raw scores of all pretests between the control and experimental groups.

Table 3 and 4 reveal means and standard deviations of each test between control and experimental groups. There were no statistical differences of all pretests and post-tests of the control group, but many tests in the experimental group show differences between pre- and post- tests.

Difference in mental status construction and episodic memory construction reveals improvement of the general memory of knowledge. Regarding the differences in episodic memory construction, 4 out of 5 subtests revealed improvement of recent memory.

The differences in linguistic expression and construction from 2 out of 4 subtests reveal improvements of expressive language. Regardign the differences in linguistic comprehension construction, 1 out of 5 subtests revealed no improvement of receptive language.

Table 1. Demographic data.

	Control group (n = 13)	**Experimental group (n = 23)**	**P**
Age	64.85 (11.47)	70.38 (4.15)	0.12
Sex (Female : Male)	10:3	18:5	0.93

Table 2. Comparisons of mean and standard deviation of raw score of pretest between control and experimental groups for 13 subjects of each group.

Subtest	Pre - Test (Control group) Mean (SD)	Pre - Test (Experimental group) Mean (SD)	P
Mental Status (MS)	12.23(1.01)	12.31(0.95)	0.89
Story Retelling Immediate (Sri)	10.38 (3.6)	11.00(3.65)	0.57
Word Learning: Free Recall (WLf)	8.38 (3.88)	7.46(2.76)	0.61
Word Learning: Total recall (WLt)	14.15 (4.41)	13.46(4.22)	0.13
Word Learning: Recognition (Wlr)	46.08 (4.13)	45.38(3.88)	0.15
Story Retelling Delayed (SRd)	10.46 (3.45)	10.84(3.89)	0.40
Following Commands (FoC)	8.62 (0.51)	8.46(0.88)	0.88
Comparative Question (CQ)	5.77 (0.44)	5.31(0.75)	0.84
Repetition (R)	62.38 (9.37)	66.38(9.61)	0.08
Reading Comprehension :word (RCw)	7.46 (0.66)	7.54(0.66)	0.72
Reading Comprehension :sentence (RCs)	6.23 (1.01)	6.31(0.85)	0.93
Object Description (OD)	6.38 (1.71)	7.38(2.99)	0.47
Generative Naming Category (GN)	12.54 (3.9)	13.31(4.27)	0.52
Confrontation Naming (CN)	17.08 (3.52)	16.69(3.25)	0.42
Concept Definition (CD)	45.92 (8.16)	44.92(10.62)	0.78
Generative Drawing (GD)	13.08 (1.66)	12.77(1.88)	0.78
Figure Copying (Fic)	11.38 (0.77)	11.62(0.65)	0.41

Table 3. Comparisons of mean and standard deviation of each pretest and post-test in control group.

	Pre - Test	Post - Test	p - value
Mental Status Construction			
Mental Status	12.23 (1.01)	12.62 (0.65)	0.13
Memory Construction			
Story Retelling Immediate	10.38 (3.6)	11.46 (1.98)	0.21
Word Learning: Free Recall	8.38 (3.88)	8.77 (3.37)	0.44
Word Learning: Total recall	14.15 (4.41)	14.00 (4.38)	0.52
Word Learning: Recognition	46.08 (4.13)	45.85 (3.83)	0.55
Story Retelling Delayed	10.46 (3.45)	10.08 (3.62)	0.49

Table 3. Comparisons of mean and standard deviation of each pretest and post-test in control group (continued).

	Pre - Test	Post -Test	p - value
Linguistic Comprehension Construction			
Following Commands	8.62 (0.51)	8.85 (0.38)	0.08
Comparative Question	5.77 (0.44)	5.85 (0.38)	0.56
Repetition	62.38 (9.37)	63.31 (6.22)	0.75
Reading Comprehension: word	7.46 (0.66)	7.69 (0.48)	0.18
Reading Comprehension : sentence	6.23 (1.01)	6.08 (1.66)	0.92
Linguistic Expression Construction			
Object Description	6.38 (1.71)	6.31 (1.80)	0.67
Generative Naming Category	12.54 (3.9)	13.23 (4.05)	0.47
Confrontation Naming	17.08 (3.52)	17.23 (3.65)	0.78
Concept Definition	45.92 (8.16)	44.62 (12.02)	0.92
Visuospatial Construction			
Generative Drawing	13.08 (1.66)	13.00 (1.47)	0.66
Figure Copying	11.38 (0.77)	11.46 (0.88)	0.66

Table 4. Comparisons of mean and standard deviation of each pretest and post-test in experimental group.

	Pre - Test	Post - Test	p - value
Mental Status Construction			
Mental Status	12.48 (0.79)	12.83 (0.39)	0.01*
Memory Construction			
Story Retelling Immediate	11.09 (3.04)	13.04 (3.13)	0.001*
Word Learning: Free Recall	8.04 (2.93)	9.83 (2.82)	0.001*
Word Learning: Total recall	13.96 (3.38)	15.17 (2.53)	0.001*
Word Learning: Recognition	45.52 (3.80)	46.65 (2.17)	0.1
Story Retelling Delayed	9.96 (4.46)	12.78 (3.77)	0.001*
Linguistic Comprehension Construction			
Following Commands	8.65 (0.72)	8.91 (0.29)	0.06
Comparative Question	5.43 (0.73)	5.65 (0.65)	0.17
Repetition	65.96 (8.09)	68.61 (4.58)	0.01*
Reading Comprehension: word	7.52 (0.59)	7.61 (0.66)	0.41
Reading Comprehension: sentence	6.09 (1.12)	6.43 (0.79)	0.1

Table 4. Comparisons of mean and standard deviation of each pretest and post-test in experimental group. (Continuous)

	Pre - Test	Post - Test	p - value
Linguistic Expression Construction			
Object Description	6.91 (2.47)	7.61 (1.31)	0.02*
Generative Naming Category	13.17 (3.90)	14.30 (4.22)	0.1
Confrontation Naming	17.09 (2.79)	17.65 (2.60)	0.03*
Concept Definition	45.65 (8.50)	48.78(10.29)	0.2
Visuospatial Construction			
Generative Drawing	12.91 (1.62)	13.04 (1.55)	0.76
Figure Copying	11.48 (0.73)	11.57 (0.73)	0.41

*significant at p-value <0.05

No differences of the subtests on generative drawing and figure copying revealed in visuospatial construction.

Discussion

These findings show that using this simple compact TENS to stimulate the skin over the temporal areas for 10 minutes every day, 5 days a week for 3 weeks is able to improve recent memory.

The stimulation on the temporal areas may transmit through the skin and skull into the temporal brain areas and directly stimulate the memory center, hippocampus. Secondary excitatory impulses transmitted to the parietal, temporal and occipital cortices producing permanent recovery of recent memory. [36]

There is evidence that the interpretation and understanding by the supramarginal and angular gyri of the parietal cortices are stimulated and transmits these impulses to the Broca's area. This result is ability to find the right words and correct grammars. [37 - 40]

Conclusion

These findings have proved that using this simple compact TENS to stimulate the skin on the temporal areas for 10 minutes every day, 5 days a week for 3 weeks being able to improve function of cognition and behaviors including recent memory.

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