Original Article

Evaluation of sensory processing abilities following stroke using the adolescent/adult sensory profile: implications for individualized intervention

SANG MI CHUNG, OT, PT, PhD¹⁾, BO KYOUNG SONG, OT, PhD^{2)*}

¹⁾ Department of Occupational Therapy, Sangji Youngseo College, Republic of Korea

²⁾ Department of Occupational Therapy, Kangwon National University: 346 Hwangjo-gil, Dogye-eup, Samcheock-si, Gangwon-do 245-710, Republic of Korea

Abstract. [Purpose] The present study aimed to understand characteristics of sensory processing in patients who have experienced a stroke using the previously established, self-diagnostic Adolescent/Adult Sensory Profile (AASP). [Subjects and Methods] Data from 180 total Korean patients who had been diagnosed as having experienced a stroke were collected and analyzed between May and August of 2015. [Results] Average scores for each sensory processing domain were as follows: low registration (32.1), sensation seeking (34.3), sensory sensitivity (36.7), and sensation avoiding (34.0). Study participants exhibited similar scores to healthy controls (data obtained from previous studies) with the following frequencies: low registration (65%), sensation seeking (77.2%), sensory sensitivity (65%), and sensation avoiding (62.2%). Significant differences were observed between control data and scores obtained for study participants in all domains except that of sensory sensitivity. [Conclusion] The results of the present study indicate that therapeutic intervention following the experience of a stroke should account for individual differences in sensory processing abilities to provide the environment most conducive to the patient's overall cognitive and physical improvement.

Key words: Sensory processing, Stroke

(This article was submitted Apr. 12, 2016, and was accepted Jun. 27, 2016)

INTRODUCTION

Following a stroke, the majority of patients experience alterations in a variety of behavioral patterns, ranging from physical disability to psychological impairment. Among the secondary cognitive impairments observed are deficits in speech and memory, as well as emotional disturbance or dysregulation¹⁾. Sensory processing is the neural process by which information regarding the environment is transmitted to the brain via the peripheral nervous system, ultimately allowing the individual to select actions and responses appropriate to the immediate environment²⁾. As many cognitive functions are significantly affected by an individual's ability to process sensory information, sensory processing difficulties following stroke may lead to further cognitive and behavioral impairments³⁾. Further, individual differences are observed in both perception and cognitive processing of this peripheral information, resulting in differential responses to changing sensory information⁴⁾. The strength of a given stimulus with respect to any individual does not necessarily correlate with the actual, measured intensity of the stimulus. For example, individuals adopting a strategy of avoidance may do so because of heightened sensitivity to changes in environmental stimuli. Such levels of sensory information processing vary from individual to individual, with different patterns of sensory processing resulting in apparent differences in behavior^{5, 6)}. The choices one makes regarding action are therefore dependent on the individual's experience and ability to process the situation, with such choices accumulating over time to eventually exert effects on the individual's quality of life⁴⁾.

*Corresponding author. Bo Kyoung Song (E-mail: bksong@kangwon.ac.kr)

©2016 The Society of Physical Therapy Science. Published by IPEC Inc.

This is an open-access article distributed under the terms of the Creative Commons Attribution Non-Commercial No Derivatives (by-nc-nd) License <<http://creativecommons.org/licenses/by-nc-nd/4.0/>>.

Brown and Dunn theorized that difficulties in social functioning such as delayed response times, unintended actions, and failure to grasp the social atmosphere in a given situation may be due to impairments in sensory processing⁷⁾. A previous study comparing the sensory processing capabilities of children with developmental disabilities to those of typically-developing adults revealed that adults exhibited sensory defensiveness in four of six areas of behavior, similar to results obtained for children with developmental delays. Some authors have further emphasized the need for research regarding sensory processing in adults⁸⁾. Previous research has also described the relationship between reactions to sensory stimuli and associated behavioral responses, proposing a framework for adult sensory defensiveness⁹⁾. Kinnealey et al. have further advocated for research regarding sensory processing in adults based on observations that 15% of adults exhibit sensory defensiveness¹⁰⁾. Korean researchers have similarly observed the significant impact of sensory processing ability on overall function. Park et al. investigated the ability of non-traditional methods to improve a variety of cognitive functions, including sensory processing, in the elderly, who tend to exhibit decreased cognitive performance across numerous domains that appears resistant to improvement with more traditional methods aimed at direct improvement of specific functions (i.e., memory, speed, etc.)¹¹⁾. Also, Kim et al. reported that adults begin to exhibit passive behavioral patterns as the cultural background and social environment exert influence on their individual sensory processing abilities¹²⁾. Though these adults have not experienced structural damage that would indicate decreases in function, a lack of opportunity to experience various, enriching environments may still result in difficulties in sensory processing similar to those observed when actual structural damage has occurred¹³⁾. In this way, the sensory processing of basic characteristics determines behavior for all individuals, not just those affected by diagnosed neurological impairments. The present study aims to identify alterations in sensory processing patterns following the experience of a stroke, with the goal of providing information regarding the roles of environment, culture, and physical condition with respect to physical and occupational therapeutic interventions. Such information may then allow for improvements in quality of life in addition to functional recovery.

SUBJECTS AND METHODS

Participants for the present study were selected from among those patients receiving physical, occupational, and speech therapy following the experience and subsequent diagnosis of stroke at a number of general and university hospitals located in South Korea. Prior to participation in the study, 240 patients who had experienced a stroke and fulfilled the selection criteria received written information regarding the study and subsequently provided their written informed consent. Patients were required to meet the following selection criteria for inclusion in the study: 1) diagnosis of stroke by a specialist; 2) score of more than 75 points on the Modified Barthel Index (MBI); 3) a score of more than 20 points on the Korean version of the Mental State Examination (K-MMSE); 4) no history of heart disease; 5) no severe visual impairments; 6) no severe auditory impairments; 7) no orthopedic conditions; 8) no history of psychological disorders; 9) no other impairment that would significantly affect ability to participate in the study. This study was approved by the Institutional Review Board of Kangwon National University (number KWNUIRB-2015-03-005-001), in accordance with the ethical standards of the Declaration of Helsinki (1975, revised in 1983). Questionnaires were distributed to patients themselves, though those with visual disabilities were assisted by their protectors/therapists in reading the questions. Additional information was collected by an experienced therapist using a recording sheet. A total of 480 questionnaires were collected out of the 550 that had been initially distributed. A reliability test was conducted using data from 340 collected questionnaires to assess the degree to which the AASP produced stable and consistent results. After excluding for vote and illegible writing, information from 180 questionnaires was used for further analyses. The total data collection period extended from May to August 2015. The frequency of each questionnaire item was calculated, and data regarding general, medical, and functional participant characteristics were analyzed using frequency analysis. A one-sample t-test was performed to evaluate differences in the distribution of scores between patients who had experienced stroke and healthy controls of previous studies. A χ^2 test was used to evaluate statistically significant differences in each of four areas of Dunn's model of sensory processing with respect to behavioral responses, general clinical and functional patient characteristics, and the neurological threshold. For all analyses, the level of statistical significance was set at $p < 0.05$.

RESULTS

The average AASP score of 180 patients who had experienced a stroke was analyzed to investigate the sensory processing patterns of the patient group (Tables 1 and 2). The average score on the low registration domain, which may indicate a pattern of passive behavioral responses in which the individual requires stronger-than-normal stimuli to elicit a response, was 32.1 points. The average score on the domain of sensation seeking, indicative of a pattern of active behavioral responses associated with enjoying or creating sensory-rich environments, was 34.3 points. The average score on the domain of sensory sensitivity, indicative of a pattern of active behavioral responses associated with hyper-awareness of surroundings and easy distractibility, was 36.7 points. The average score on the sensation avoiding domain, indicative of an active, intentional withdrawal from or blocking of sensation, was 34.0 points. The results of the analysis of sensory processing patterns according to the frequency of particular sensory processing domain scores are presented in Table 3. Of the 180 participants, 65% appeared to accept the low registration sensory stimulus, a result similar to that observed for healthy controls. With regard to

Table 1. General characteristics of the participants

General characteristics		N (%)	Mean $\pm$ SD
Gender	Male	96 (53.3)	57.63 $\pm$ 13.87
	Female	84 (46.7)	
Age (years)	<30	4 (2.2)	
	30–39	11 (6.1)	
	40–49	40 (22.2)	
	50–59	46 (25.6)	
	>60	79 (43.9)	
Marital status	Single	16 (8.9)	
	Married	164 (91.1)	
Family relatives living together	Yes	162 (90.0)	
	No	18 (10.0)	
Caregivers	Spouse	49 (27.2)	
	Children	12 (6.7)	
	Parents	14 (7.8)	
	Caregivers	78 (43.3)	
	None	27 (15.0)	
	Blue-collar Job	24 (13.3)	
Job type before the onset	Office workers	28 (15.6)	
	Tech job	23 (12.8)	
	Service industry	31 (17.2)	
	Unemployed	74 (41.1)	
Return to work	Yes	5 (2.8)	
	No	171 (96.6)	
Job desires	Yes	94 (53.1)	
	No	80 (45.2)	
Education	No education	12 (6.7)	
	Elementary school	19 (10.6)	
	Middle school	26 (14.5)	
	High school	52 (29.1)	
	College	13 (7.3)	
	University or higher	57 (31.8)	
Average monthly income	<100	25 (15.8)	
	100–199	31 (19.6)	
	200–299	35 (22.2)	
	300–399	33 (20.9)	
Total	>400	34 (21.5)	
Total		180 (100.0)	

Mean $\pm$ SD: mean and standard deviation**Table 2.** Distribution of scores for each quadrant

Quadrant	Raw score	Much less than most people	Less than most people	Similar to most people	More than most people	Much more than most people
		(–)	(–)	(=)	(+)	(++)
1. Low registration	/75	15–17	18–22	23–39	40–52	53–75
2. Sensation seeking	/75	15–19	20–26	27–41	42–51	52–75
3. Sensory sensitivity	/75	15–19	20–26	27–45	46–55	56–75
4. Sensation avoiding	/75	15–19	20–24	25–44	45–55	56–75
Score distribution		2%	14%	68%	14%	2%

Table 3. Average sensory processing scores for participants

Quadrant	Mean ± SD	Score analysis
1. Low registration	32.11 ± 8.64	Similar to most people
2. Sensation seeking	34.26 ± 7.48	Similar to most people
3. Sensory sensitivity	36.56 ± 9.36	Similar to most people
4. Sensation avoiding	34.79 ± 9.29	Similar to most people

Mean ± SD: mean and standard deviation

Table 4. Distribution of sensory processing scores for participants

Quadrant	Much less than most people	Less than most people	Similar to most people	More than most people	Much more than most people	Total
			N (%)			
1. Low registration***	10 (5.6)	43 (23.9)	117 (65)	9 (5)	1 (0.5)	180 (100)
2. Sensation seeking*	3 (1.6)	26 (14.4)	139 (77.2)	11 (6.1)	1 (0.6)	
3. Sensory sensitivity*	4 (2.2)	26 (14.4)	117 (65)	30 (16.7)	3 (1.7)	
4. Sensation avoiding***	2 (1.1)	39 (21.6)	112 (62.2)	23 (12.7)	4 (2.2)	
Control distribution	2%	14%	68%	14%	2%	(100)

*p<0.05 ***p<0.001

Table 5. Comparison of average scores for participants versus those of healthy controls

	N	Low registra- tion***	Sensation seeking***	Sensory sensitivity	Sensation avoiding*
		Mean ± SD			
Hemiplegic patients	180	32.1 ± 8.6	34.3 ± 7.5	36.6 ± 9.4	34.8 ± 9.3
Healthy control ¹²	300	34.6 ± 6.9	39.8 ± 7.1	35.3 ± 8.0	37.0 ± 7.7

Mean ± SD: mean and standard deviation *p<0.05, ***p<0.001

the sensation seeking domain, 77.2% of study patients appeared to accept the sensory stimulus, and 14.4% ± 1.6% exhibited a higher than average neurological threshold, with the exception of passive behavioral responses on stimulus searching items. With regard to the sensory sensitivity domain, 65% of the 180 subjects exhibited typical patterns of sensory processing, while 16.7% ± 1.7% were more sensitive and 14.2% ± 2.2% were less sensitive than average. With regard to the sensation avoiding domain, 62.2% of patients responded similarly to healthy control subjects, 21.6% exhibited fewer avoidant responses, and 12.7% exhibited more avoidant responses than average. Average sensory processing scores for study participants with respect to each domain are presented in comparison to scores obtained for healthy Korean adults in Table 4. The comparison of average sensory processing scores between study participants and healthy controls revealed significant differences in the low registration, sensation seeking, and sensation avoiding domains (p<0.05, p<0.001). No significant difference was observed between the scores of study participants and control data with respect to sensory sensitivity (p>0.05) (Table 5).

DISCUSSION

Early physical and occupational therapists assessed individual differences in sensory processing ability using separate measures for each area. However, sensory processing is not characterized by isolated analysis of information from specific areas; rather, it encompasses a vast array of sensory information¹⁴. Stable trends in sensory processing capabilities are more indicative of the complex cognitive processes involved in the analysis of and response to sensory information than individual measures alone. Therefore, research regarding this multidimensional processing of sensory information should encompass both the sensory experience and the individual response to environmental conditions, focusing on *how* the sensation is processed rather than *how well* it is processed. Though research regarding sensory processing patterns has been conducted using active instruction directed at children, insufficient data exist regarding these patterns in adult subjects. For patients who have experienced a stroke, the pathological characteristics of the central nervous system result in secondary difficulties in both perception and cognition, though some decline occurs as part of the normal aging process. Difficulty in connecting accepted sensory information to motor function is influenced not just by neurological damage but also by internal factors such as personality and genetic characteristics, as well as by external factors such as familial and environmental characteristics¹⁵. Therefore, the present study utilized the AASP to explore the sensory processing patterns exhibited by patients who have

experienced a stroke.

Average scores for each quadrant of the AASP were as follows: low registration (32.1 points), sensation seeking (34.3 points), sensory sensitivity (36.7 points), and sensation avoiding (34.0 points). Also, the results of the analysis of sensory processing patterns in stroke patients showed that 65.0% of the 180 people (117 patients) showed a similar pattern in low registration. Analysis of sensory processing patterns in study participants revealed that 65% of the 180 patients (n=117) exhibited patterns of low registration similar to those observed in controls, while 23.9% (n=43) exhibited higher responses to environmental stimuli. Very high attention to such stimuli was observed in 5.6% of patients (n=10). The aforementioned results may indicate that alterations in sensory threshold caused by brain damage and the resultant cognitive instability cultivate passive behavioral patterns that contribute to increased responses to stimuli. Dunn et al. observed that individuals with elevated sensory registration capabilities more quickly react to stimuli and exhibit a passive behavioral pattern⁶). Brown and Dunn further revealed that the sensation seeking domain has a high neurological threshold and necessitates an active pattern of behavioral response as individuals attempt to create or seek out enriched sensory environments⁷). Individuals scoring high on this domain would therefore benefit from sensory rich environments and experience difficult in low sensory environments, particularly in therapeutic settings. In the present study, similar patterns were observed with respect to the sensation seeking domain for both study participants (77.2%, n=138) and healthy controls. However, 14.4% of study patients were observed to have lower scores than previously studied controls. This difference may be attributed to difficulties in navigating and participating in the external environment in daily life. Patients experiencing such difficulties may benefit from the non-traditional therapeutic interventions previously proposed by Brown and Dunn⁷). Such interventions account for the sensory-seeking nature of the individual patient, utilizing sensation of the environment as an interactive strategy and allowing for frequent exposure to environmental stimuli, such as changes in food or the arrangement of furniture. With regard to sensory sensitivity, 65% of participants (n=117) exhibited similar patterns of sensory processing to those observed for healthy controls, while 16.7% (n=30) were observed to be more sensitive than controls. Such a result may be related to decreases in sensory threshold and the presence of unstable cognitive states following the experience of stroke. For individuals scoring high on the sensory sensitivity domain, these aspects should be considered, and intervention should focus on reducing patterns of sensitivity through repeated training and task consistency, with the ultimate goal of reducing difficulties in performance related to inability to block irrelevant stimuli^{6, 7}). Though 62.2% (n=112) of patients exhibited sensation avoiding patterns similar to those observed for healthy controls, 21.6% (n=39) reported greater patterns of sensory avoidant behavior with respect to the control population. Decreases in sensory sensitivity and impaired ability to evaluate various situations are considered to result from losses in cognitive function and may account for patterns of sensory avoiding behavior, according to Dunn's model of sensory processing⁶). Consequently, differences in sensory processing scores were observed between stroke patients and healthy controls. With respect to the low registration, sensory sensitivity, and sensation avoiding domains, scores obtained for study participants ranged from 1.2 to 3.7 points below those of healthy controls, with scores as much as 2.6 points lower for the sensory sensitivity domain. Such a high sensory threshold may be the result of impaired perception and cognitive functioning caused by stroke-related neurological damage, and expectations of physical recovery may further actively heighten the response. In conclusion, an average of 67% of study participants exhibited similar patterns of sensory processing to healthy controls on most aspects of processing, while the remaining 32% showed a pattern divergent from that observed in the same control population. Further research is required to assess the correlation among sensory processing, psychological factors, and motor function in patients who have experienced a stroke.

REFERENCES

- 1) Nam TS: Behavioral and Psychological Symptoms in Patients with Acute Cerebral infarction. Chonnam National University, Dissertation of Master's Degree, 2008.
- 2) Yack E, Aquilla P, Sutton S: Building bridges, 2nd ed. Las Vegas: Sensory resources, 2002, pp 34–46.
- 3) Jeong SM: A study on sensory processing based on traits in stroke patients. Yongin University, Dissertation of Doctor's Degree, 2012.
- 4) Kim SJ: The development and validation of sensory processing scale. Seoul National University, Dissertation of Master's Degree, 2010.
- 5) Aron EN, Aron A: Sensory-processing sensitivity and its relation to introversion and emotionality. *J Pers Soc Psychol*, 1997, 73: 345–368. [Medline] [Cross-Ref]
- 6) Dunn W: The sensations of everyday life: empirical, theoretical, and pragmatic considerations. *Am J Occup Ther*, 2001, 55: 608–620. [Medline] [CrossRef]
- 7) Brown C, Dunn W: The adolescent/adult sensory profile: user's manual. San Antonio: The Psychological Corporation, 2002.
- 8) Baranek GT, Foster LG, Berkson G: Sensory defensiveness in person with developmental disabilities. *OTJR (Thorofare, NJ)*, 1997, 17: 173–185.
- 9) Kinnealey M, Oliver B, Wilbarger P: A phenomenological study of sensory defensiveness in adults. *Am J Occup Ther*, 1995, 49: 444–451. [Medline] [Cross-Ref]
- 10) Wilbarger P: The sensory diet: activity programs based on sensory processing theory. *AOTA Sens Integr Spec Interest Sect Newsl*, 1995, 18: 1–4.
- 11) Park MH: A study on the construct validity of adolescent/adult sensory profile for stroke patients. Inje University, Dissertation of Doctor's Degree, 2007.
- 12) Kim JK, Choi JD, Lee TK: The study of adult sensory processing. *J Korean Soc Occu Ther*, 2007, 15: 115–124.
- 13) Zoltan B: Vision, Perception and Cognition, 3rd ed. Slack, 1996.
- 14) Kandel ER, Schwartz JH, Jessell TM: Principles of Neural Science, 4th ed. McGraw Hill, 2000.
- 15) Hong EK: Analysis internal external factors that affect the sensory processing ability of normal children and children with developmental disorders. Inje University, Dissertation of Master's Degree, 2008.