



Original Article

# Interrelationship between the general characteristics of Korean stroke patients and the variables of the sexual functions: random forest and boosting algorithm

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**Abstract.** [Purpose] The purpose of this study is to examine patient preferences for counseling related to sexuality post-stroke in Korea. [Subjects and Methods] A survey was conducted on 200 stroke patients. Among the 200 submitted questionnaires, 156 responded but 147 cases are available. The questionnaire is composed of 27 questions such as 8 independent variables related to the general characteristics of the patients, 7 dependent variables in conjunction with sexual intercourse and changed muscle tone, 6 questions regarding to changed sexual function, and 6 questions about a changed motor and a sensory function after stroke. To analyze the factors related to a sexual function after a stroke, we used the random forest, boosting algorithm and MANOVA. [Results] The most important variable in variable group 1 is VAR1, and then VAR22, VAR23, VAR26, VAR27, VAR25, VAR21 and VAR 24 respectively. The most important variable in variable group 2 is VAR22, and then VAR26, VAR23, VAR25, VAR1, VAR27, VAR21 and VAR 24. Finally, for variable group 3, VAR1 has the most important percentage, and we have the order as VAR26, VAR23, VAR27, VAR22, VAR25, VAR21 and VAR 24 among the rest of variables. The result of variable importance in boosting algorithm is somehow the same as that of random forest. [Conclusion] As a result of our analysis, we figured out that duration of illness, age, and education level are important factors of sexual functions for Korean Stroke patients.

**Key words:** Survey, Sexual functions, Korean stroke patients

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## INTRODUCTION

Sexuality is an integrant and essential part of quality of life (QoL), and patient affected by neurological disability, including stroke, should also be investigated and treated for sexual disorders<sup>1)</sup>. Sexual dysfunction is common after stroke, but is frequently not addressed by healthcare providers<sup>2)</sup>.

Post-stroke impaired sexual activity encompasses sexual dysfunction and/or impaired sexual satisfaction. The latter is defined as a decline in libido in both genders, erectile dysfunction and poor ejaculation in men and diminished lubrication and orgasm in women<sup>3, 4)</sup>. Post-stroke patients reported a marked decline in all the measured sexual functions, ie, libido, coital frequency, erectile and orgasmic ability, and vaginal lubrication, as well as in their sexual satisfaction. The spouses also reported a significant decline in their libido, sexual activity, and sexual satisfaction as a consequence of stroke<sup>5)</sup>. Sexual dysfunctions after stroke reported to be due to multiple etiologies, including both physical and psychosocial causes<sup>1, 2)</sup>.

Sexual function relies on a complex network of peripheral and central pathways involving the participation of autonomic

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and somatic nerves and the integration of numerous spinal and supraspinal sites in the central nervous system, with the hypothalamic and limbic regions playing a pivotal role<sup>6, 7</sup>).

Many studies have shown significant relationships between symptoms of depression and functional outcome in patients from 3 months to 2 years after stroke. Also, reduced quality of life after stroke appears to be related not only to the physical disability but also to psychologic factors<sup>8-10</sup>. Depression and fear of a recurrent stroke are examples of psychological factors influencing sexual function and, in particular, sexual desire<sup>3</sup>. The role of psychological factors in poststroke sexual dysfunctions (SD) is further confirmed by the observation that sexual disorders are reported not only by the patients, but also by their spouses or partners<sup>8, 11, 12</sup>. Nevertheless, most of the patients received little information about sexuality following stroke on sexual behavior and attitudes of the stroke patients' spouses, although they are very important in terms of stroke survivors' well-being.

The decreased sexual activities of the stroke patients in Korea mainly result from psychological burden and physical disability caused by a disorder, but most of them tend to avoid consultation with experts<sup>13</sup>. Additionally, avoiding sexual intercourse and conversation is another important factor of decreasing sexual life due to a concern about aggravating a spouse's condition<sup>14</sup>.

Random Forest is a bagging algorithm which reduces variance of a large number of "complex" models with low bias<sup>15</sup>. While boosting, which uses a set of weak classifiers and combine them to derive a strong classifier, reduces bias of a large number of "small" models with low variance<sup>16</sup>. We compared the result of some machine learning algorithms, among them random forest and boosting algorithm are the best for our purpose.

Many studies on changed psychological and physical health regarding rehabilitation after stroke have been conducted, but there are not enough comparative studies on the general characteristics of the patients and sexual index. The purpose of this study was to examine patient preferences for counseling related to sexuality of post-stroke patients in Korea by using the random forest, boosting algorithm and MANOVA. Studies about stroke patients' sexual life which were unofficially discussed could be an important factor to improve the quality of patients' life and family life including a spouse as well.

## SUBJECTS AND METHODS

The survey was conducted by 147 patients who were diagnosed with stroke from university hospitals located in Seoul/Gyeonggi, South Korea. The survey procedure was sufficiently explained beforehand to the subjects who voluntarily participated by signing the survey consent form. This study was approved by the Institutional Ethics Committee of Namseoul University.

We firstly revised and used Brief Sexual Functioning Questionnaire for men (BSFQ) and Brief Index of Sexual Functioning for Woman (BISF-W). The revised BSFQ, BISF-W are used to diagnose a disorder of sexual behavior and function, according to the objective of this study<sup>17, 18</sup>. The revised questionnaire was then reviewed by an expert group consisting of three professors in the Department of Physical Therapy to examine content validity and suitability of the questions. The questionnaire was composed of 27 questions such as 8 independent variables related general characteristics of the patients, 7 dependent variables in conjunction with sexual intercourse and changed muscle tone, 6 questions regarding a changed sexual function, and 6 questions about a changed motor and a sensory function after stroke (Table 1). The alpha value of Cronbach was 0.688 which was used to indicate internal consistency of the dependent variables. Data for this study had been collected for 98 days: feasibility study for 8 days and main survey 90 days. A physical therapist at the hospital fully explained the objectives and procedures of this study to the patients, and the questionnaires were filled by voluntary patients. Total 156 questionnaires out of 200 were collected, and 147 questionnaires except 9 unsuitable questionnaires were used for final analysis.

The collected questionnaires were analyzed by R version 3.3.1. To figure out an interrelationship between the general characteristics of the patients and the variables of the sexual function, random forest, boosting algorithm and MANOVA were used for analysis. Statistical significance was accepted for values of  $\alpha \leq 0.05$ .

## RESULTS

The general characteristics of 147 subjects are age, duration of illness, weight, gender, marital status, education level, income level and occupation. The mean age of our study population (97 men; 65.99% and 50 women; 34.00%) was 53.56 years. Highest frequency of age is 50's with 60 patients (40.82%). The forty-six patients (31.30%) have more than 1 year but no longer than 3 years of a duration of illness, and it is examined the mean duration of illness is 3.18 years. For the weight factor, the most number of the patients are fifty-four (36.73%) whose weight is between 60 kg and 70 kg, and its mean is 67.05 kg. For the marital status factor, one hundred thirty-seven patients (93.20%) are married and 10 patients (6.80%) are single or divorced person. The factor of education level, sixty-seven patients (45.58%) are graduated in high school. For the income level factor, fifty-six (38.10%) of patient's income is over 3 million won per month. In occupation factor, self-employed patients are twenty-eight (19.05%), company employee twenty-two (14.97%), housewife eighteen (12.24%).

The random forest is the best method to find variable importance, we applied this method for each variable group, in variable group 1, VAR1 is the most important, and then VAR22, VAR23, VAR26, VAR27, VAR25, VAR21 and VAR 24

**Table 1.** Classification of group and definition for each variables

Group	Variables	Definition	Group	Variables	Definition	
Independent	1	Duration of illness	Dependent	15	Changes of muscle tone after stroke	
Dependent 1	2	Communication about sexual activities	3	16	Balance ability after stroke	
	3	Necessity of study about sexual activities		17	Fine movement after stroke	
	4	Have a sex partner		18	Changes of tactile sense after stroke	
	5	Try to sexual intercourse after stroke		19	Changes of smell sense after stroke	
	6	Frequency of sexual Intercourse/month		20	Changes of taste sense after stroke	
	7	Changes of muscle tone during sexual intercourse		Independent	21	Gender
	8	Level of muscle tone during sexual intercourse			22	Age
Dependent 2	9	Changes of Frequency of sexual intercourse after stroke		23	Weight	
	10	Frequency of kissing and romantic touching after stroke		24	Marriage	
	11	Thinking about sex with Interest or Desire after stroke		25	Occupation	
	12	Ability to become sexually aroused after stroke		26	Education level	
	13	Overall level of sexual satisfaction after stroke		27	Income level/month	
	14	Obstacles during sexual intercourse				

Dependent 1: Sexual intercourse and changed muscle tone; Dependent 2: Changed sexual function; Dependent 3: Changed motor & sensory function

**Table 2.** Interrelationship between the general characteristics of the patients and the variables of the sexual function

Independent Variables	Dependent variables		
	Group 1 %IncMSE <sup>†</sup>	Group 2 %IncMSE <sup>†</sup>	Group 3 %IncMSE <sup>†</sup>
1	30.6***	19.3***	29.5**
21	15.5**	14.4	19.5
22	26.5***	28.7***	24.7
23	25.2***	25.2*	26.7**
24	10.7***	10.1*	4.8
25	19.6	19.6**	22.1
26	23.3***	25.4***	27.3
27	23.1**	19.3*	25.5

%IncMSE: % Increase in MSE (mean squared error)

<sup>†</sup>Variable importance in random forest

\*p≤0.05; \*\*p≤0.01; \*\*\*p≤0.001

respectively. The most important variable in variable group 2 is VAR22, and then VAR26, VAR23, VAR25, VAR1, VAR27, VAR21 and VAR 24. Finally, for variable group 3, VAR1 has the most important percentage, and we have the order VAR26, VAR23, VAR27, VAR22, VAR25, VAR21 and VAR 24 among the rest of variables (Table 2).

The result of variable importance in boosting algorithm is somehow the same as that of random forest.

## DISCUSSION

The purpose of this study was to examine patient preferences for counseling related to sexuality of post-stroke patients in Korea by using the random forest, boosting algorithm and MANOVA.

Random forest is an excellent method to determine variable importance, as it fits a number of decision tree classifiers on

various sub-samples of the dataset. It uses averaging to improve the predictive accuracy and control over-fitting, so there is no need for cross-validation to get better (or unbiased) estimation, since according what we said it is already done internally. However, it is difficult to interpret the result with multiple outcome variables in random forest, for this purpose using multivariate tree boosting that is a method for non-parametric regression is useful. In this study we are extending these three methods along with linear regression for one group of independent variable and three different groups of dependent variables to analyze the dataset and find the importance of group of independent variables to predict the group of dependent variables as well as illustrate the correlation between groups of dependent variables. This study is to realize the effect of sexual functions in stroke patients in computer science point of view. Moreover, we applied 10-fold cross-validation for getting better result in multiple linear regressions<sup>19)</sup> and compared the result of these three methods on our data that we conclude the best result from random forest and boosting algorithm.

As a result of questionnaire analysis, duration of illness, age, and education level among 8 independent variables strongly affect by other dependent variables which are sexual intercourse and changed muscle, changed sexual function, and changed motor & sensory function.

According to analysis the quality of life targeted at stroke patients who have less than 1 year duration of illness, the quantitative and qualitative measures of most patients related to sexual life were decreased<sup>12)</sup>. Patients who have more than 1 year duration of illness had the same result<sup>14)</sup>. This is due to the fact that most stroke patients did not enjoy traveling and an engaging in outdoor activities so that the quality of life was reduced<sup>12)</sup>. The sexual function of most stroke patients in this study was also reduced because patients and their spouses focused on rehabilitation for the first year after an illness occurred, and there was absence of sex education after one year<sup>21)</sup>. Forsberg-Wärleby et al.<sup>12)</sup> pointed out the necessity of sex education for stroke patients and their spouses in terms of the quality of life. Mild stroke patients especially needed such education after a stroke<sup>20)</sup>. Appropriate sexual life and sex education according to the duration of illness are also considered important factors to improve the quality of life, and it needs to examine a detailed sexual life and an education based on the seriousness of a stroke in the future.

Age is the second biggest independent variable that affects dependent variables. Approximately 60% of the stroke patients between 60s and 70s showed reduction of the sexual function with the erectile dysfunction, and it reported the high possibility of the erectile dysfunction as getting old<sup>21)</sup>. In this study, the sexual activity of the patients between 40s and 50s was reduced after a stroke occurred compared to patients between 60s and 70s. Since this referred to the physiological age-related characteristic and they had active sexual life compared to other age groups, variables related to a sexual function were proportionally lower than they were before illness occurred.

An education level is the third biggest independent variable that affects dependent variables. An education level is categorized according to graduation: before graduating elementary school, graduated from middle school, graduated from high school, and after graduating university. As an education level goes up, it shows that patients who graduated university tend to often have a conversation about the sexual topic, and this group also showed the high statistical result regarding the necessity of a sexual study, sexual intercourse status, and the number of sexual intercourse. This was due to the possibility that they might have more sexual education opportunities so that they could have more chances of sexual intercourse<sup>14, 20)</sup>.

There was a research limitation. Patients between 60s and 70s did not respond to some questionnaire items due to passive attitude and repulsion. This limitation caused the low response rate so that we had a difficulty to generalize the research result. Yet, we found out that sexual education for disabled Koreans needed to be developed urgently and hopefully this study would be a good guideline for developing such sexual program.

In conclusion, this study found out that duration of illness, age, and education level were important factors that affected patients' sexual life and function. It is required to make more specific descriptions of the questionnaire items and needs to complement a questionnaire for the future work.

## REFERENCES

- 1) Calabrò RS, Bramanti P: Post-stroke sexual dysfunction: an overlooked and under-addressed problem. *Disabil Rehabil*, 2014, 36: 263–264. [[Medline](#)] [[CrossRef](#)]
- 2) Stein J, Hillinger M, Clancy C, et al.: Sexuality after stroke: patient counseling preferences. *Disabil Rehabil*, 2013, 35: 1842–1847. [[Medline](#)] [[CrossRef](#)]
- 3) Calabrò RS, Gervasi G, Bramanti P: Male sexual disorders following stroke: an overview. *Int J Neurosci*, 2011, 121: 598–604. [[Medline](#)] [[CrossRef](#)]
- 4) Bugnicourt JM, Hamy O, Canaple S, et al.: Impaired sexual activity in young ischaemic stroke patients: an observational study. *Eur J Neurol*, 2014, 21: 140–146. [[Medline](#)] [[CrossRef](#)]
- 5) Korpelainen JT, Nieminen P, Myllylä VV: Sexual functioning among stroke patients and their spouses. *Stroke*, 1999, 30: 715–719. [[Medline](#)] [[CrossRef](#)]
- 6) Jung JH, Kam SC, Choi SM, et al.: Sexual dysfunction in male stroke patients: correlation between brain lesions and sexual function. *Urology*, 2008, 71: 99–103. [[Medline](#)] [[CrossRef](#)]
- 7) Pistoia F, Govoni S, Boselli C: Sex after stroke: a CNS only dysfunction? *Pharmacol Res*, 2006, 54: 11–18. [[Medline](#)] [[CrossRef](#)]
- 8) Robinson-Smith G, Johnston MV, Allen J: Self-care self-efficacy, quality of life, and depression after stroke. *Arch Phys Med Rehabil*, 2000, 81: 460–464. [[Medline](#)] [[CrossRef](#)]
- 9) Choi-Kwon S, Kim JS: Poststroke emotional incontinence and decreased sexual activity. *Cerebrovasc Dis*, 2002, 13: 31–37. [[Medline](#)] [[CrossRef](#)]
- 10) Owolabi MO, Ogunniyi A: Profile of health-related quality of life in Nigerian stroke survivors. *Eur J Neurol*, 2009, 16: 54–62. [[Medline](#)] [[CrossRef](#)]

- 11) Wade DT, Legh-Smith J, Hewer RL: Effects of living with and looking after survivors of a stroke. *Br Med J (Clin Res Ed)*, 1986, 293: 418–420. [[Medline](#)] [[CrossRef](#)]
- 12) Forsberg-Wärleby G, Möller A, Blomstrand C: Life satisfaction in spouses of patients with stroke during the first year after stroke. *J Rehabil Med*, 2004, 36: 4–11. [[Medline](#)] [[CrossRef](#)]
- 13) Kim JH: [Relationship among sexual knowledge, frequency, satisfaction, marital intimacy and levels of depression in stroke survivors and their spouses]. *Taehan Kanho Hakhoe Chi*, 2008, 38: 483–491. [[Medline](#)]
- 14) Giaquinto S, Buzzelli S, Di Francesco L, et al.: Evaluation of sexual changes after stroke. *J Clin Psychiatry*, 2003, 64: 302–307. [[Medline](#)] [[CrossRef](#)]
- 15) Segal M, Xiao Y: Multivariate random forests. *Wiley Interdiscip Rev Data Min Knowl Discov*, 2011, 1: 80–87. [[CrossRef](#)]
- 16) Ryff CD, Keyes CL: The structure of psychological well-being revisited. *J Pers Soc Psychol*, 1995, 69: 719–727. [[Medline](#)] [[CrossRef](#)]
- 17) Mazer NA, Leiblum SR, Rosen RC: The brief index of sexual functioning for women (BISF-W): a new scoring algorithm and comparison of normative and surgically menopausal populations. *Menopause*, 2000, 7: 350–363. [[Medline](#)] [[CrossRef](#)]
- 18) Jo HH, Jung IC, Kim HY, et al.: Evaluation of sexual function and problem in Korean women using BISF-W questionnaire. *Korean J Obstet Gynecol*. 2002, 45: 2158–2166.
- 19) Ganesh S: Multivariate linear regression, 3rd ed. Palmerston North: International Encyclopedia of Education, 2010, pp 324–331.
- 20) Seymour LM, Wolf TJ: Participation changes in sexual functioning after mild stroke. *OTJR (Thorofare, NJ)*, 2014, 34: 72–80. [[Medline](#)]
- 21) Bener A, Al-Hamaq AO, Kamran S, et al.: Prevalence of erectile dysfunction in male stroke patients, and associated co-morbidities and risk factors. *Int Urol Nephrol*, 2008, 40: 701–708. [[Medline](#)] [[CrossRef](#)]