

Original Article

Factor analysis on symptoms and signs of stroke based on traditional Korean Medicine theory

Byoung-Kab Kang^{1*}, Tae-Yong Park^{2*}, Ju Ah Lee¹, Tae-Woong Moon³, Myeong-Soo Lee¹

¹Division of Medical Research, Korea Institute of Oriental Medicine, Daejeon, Republic of Korea; ²Department of Oriental Medicine, Catholic Kwangdong University International St. Mary's Hospital, Incheon, Republic of Korea; ³Jaseng Oriental Hospital, Bundang, Republic of Korea. *Equal contributors.

Received November 3, 2014; Accepted January 7, 2015; Epub January 15, 2015; Published January 30, 2015

Abstract: The purpose of this study was to classify factors of symptoms and signs, which is the same implication with items of factor, from patients with stroke based on the Traditional Korean Medicine (TKM) theory by using factor analysis, and to find out the inter-relations between factors and patterns. A cross-sectional study was conducted among 2905 patients with stroke in 11 Oriental Medicine hospitals of Korea. Outcome measures comprised patterns decided by TKM doctors considering 44 items and 44 items that were based on inspection, listening and smelling, inquiry, and palpation. Factor analysis was used as statistical method for classifying 44 items, and dominant pattern of the four patterns [Qi deficiency (QD), Fire-heat (FH), Yin deficiency (YD), Dampness-phlegm (DP)] for each factor was determined by Chi-square test. Thirty-three items belonged to some factors, but 11 items did not. 14 factors were extracted. Six factors which had a negative loading were separated, and distinguished using hyphen. The fourteen factors accounted for 9.42%, 6.97%, 5.75%, 4.22%, 4.15%, 3.82%, 3.32%, 3.14%, 2.95%, 2.65%, 2.62%, 2.47%, 2.37% and 2.29% of total variance respectively, and totally 56.14%. In conclusion, there are 10 factors which belong to exclusive pattern, and 9 factors which belong to inter-related pattern. It was statistically found out that there are inter-relation between DP and QD, between DP and FH, between FH and YD, and between YD and QD for stroke patients.

Keywords: Stroke, symptoms and signs, factor analysis, Korean Medicine

Introduction

Cerebrovascular disease is the second leading cause of death worldwide. It is a disease that predominantly occurs in mid-age and older adults. WHO estimated that in 2005, stroke accounted for 5.7 million deaths worldwide, equivalent to 9.9% of all death [1].

Stroke is caused by the interruption of the blood supply to the brain, usually because a blood vessel bursts or is blocked by a clot. This cuts off the supply of oxygen and nutrients, causing damage to the brain tissue [2]. The most common symptom of stroke is sudden weakness or numbness of the face, arm or leg, most often on one side of the body [2]. Approximately half of the stroke survivors in the United States and Korea engage in some form of CAM therapy [3, 4]. The estimated direct and indirect cost of stroke for 2010 in the United

States is \$73.7 billion [5]. In addition, sequelae of stroke, acute stroke and pre-symptoms of stroke ranked No. 2, No. 6 and No. 19 respectively, when being arranged in order of frequently treated diseases in Traditional Korean Medicine (TKM) [6]. However, diagnosis of stroke by Traditional Eastern-Asia Medicine (TEAM) including TKM, has not been fully standardized. Although there are many symptoms and signs required to be considered by clinician, TKM theory behind stroke has never been quantitatively supported by data. Therefore, there is a strong need to examine underlying factors of this condition so that TKM research on this disease could be carried out in the future.

When certain symptoms and signs co-appear, they may show certain underlying pathophysiology. In addition, factor analysis is statistically able to play a role in showing classification and

Factor Analysis on Symptoms and Signs of Stroke

Table 1. Demographic characteristics of patients with stroke

variables	Mean (SD), n (%)	
Age (yrs), Mean (SD)	66.98 (11.55)	
Gender, n (%)		
Male	1530	52.67%
Female	1375	47.33%
Drinking history, n (%)		
No	1041	35.91%
Yes	1858	64.09%
Smoking history, n (%)		
No	862	29.74%
Yes	2036	70.26%
Weight (kg), Mean (SD)	57.05 (9.62)	
Height (cm), Mean (SD)	157.92 (8.50)	
Marriage		
Single	62	2.16%
Married	2049	71.37%
Divorce	62	2.16%
Bereavement	698	24.31%
Diabetes		
No	2113	73.27%
Yes	771	26.73%
Hyperlipidemia		
No	2498	87.37%
Yes	361	12.63%
Hypertension		
No	1140	39.46%
Yes	1749	60.54%
Anticoagulant treatment		
No	1913	67.86%
Yes	906	32.14%
NIHSS score	4.32 (3.78)	

SD: standard deviation.

association of underlying pathophysiology [7]. Generally, a factor must be loaded with more than one item, an item can be loaded to more than one factor. Items that are not loaded to any factor are said to have high uniqueness [7-9]. Factor analysis is performed to identify these factors and unique items. Also we investigate inter-relations displaying dominant patterns for each factor in diagram form by using Chi-square test.

The aim of this study was to identify underlying factors for patient with stroke in TKM theory, to classify dominant pattern of factors, and to detect the inter-relation of dominant pattern. The knowledge from this study is expected to

allow TKM doctors to understand the TKM theory of stroke discerningly.

Material and methods

Extraction process of pattern identification questionnaire

An Expert Committee (EC), which was composed of 19 professors who specialized in stroke from 11 Oriental Medicine hospitals, was organized for The Fundamental Study for the Standardization and Objectification of Pattern Identification in TKM for Stroke (SOPI-Stroke) [10]. After the EC and Korean Institute of Oriental Medicine (KIOM) had several meetings, 5 patterns (Fire-heat pattern, Dampness-Phlegm pattern, Qi deficiency pattern, Yin deficiency pattern, Blood-Stasis pattern) and 122 pattern indicators for stroke were derived from 10 books in the literature focused on stroke in TEAM including TKM [11-20]. The principle of pattern indicators extraction was as follows [10].

- 1) To reflect the characteristic of stroke symptoms and to exclude its own symptoms such as hemiparesis, dysphagia, dysarthria, facial palsy and so on.
- 2) To identify stroke patterns based on the present state of TKM clinically.
- 3) To consider the association with the previous studies.
- 4) To reflect the recent trend of stroke in TKM literature.

After these pattern indicators were applied to a clinical field and modified repetitively, Korean standard PI for stroke I (K-SPI-Stroke I) [10], Korean standard PI for stroke II (K-SPI-Stroke II) [21] and Korean standard PI for stroke III (K-SPI-Stroke III) [22] were developed successively. As a result of these procedures, Blood-Stasis pattern was excluded due to rare diagnosis (n = 89 [23]), thus K-SPI-Stroke III composed of 4 pattern and 44 pattern indicators was adopted as the Pattern Identification Questionnaire (PIQ). 44 pattern indicators were used as items for factor analysis. It was then reexamined by the EC and adjusted to maximize its validity. Descriptions of grading the severity for each pattern indicators (described below as symptoms and signs or items for factor) were scored

Factor Analysis on Symptoms and Signs of Stroke

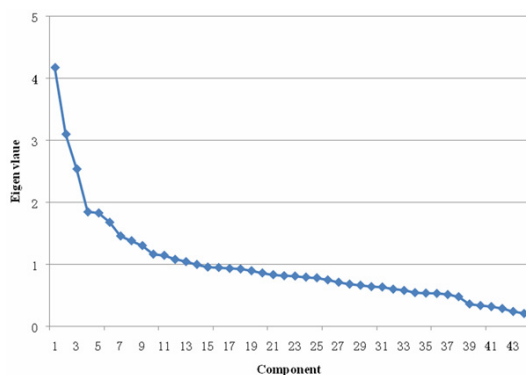


Figure 1. Scree plot of eigenvalues for factor retention.

as follows: 1 = not significant, 2 = significant and 3 = very significant.

Study subjects and data collection

This study was a cross-sectional, multi-centered and community-based study conducted for inpatient with stroke at the department of Circulatory Internal Medicine (CIM) in the 11 Korean Oriental Medicine Hospitals (KOMH). Data were collected by each of TKM doctors who has worked for more than three years at the department of CIM in each KOMH. A total of 105 TKM doctors were included, and the number of TKM doctors ranged from 2-25 TKM doctors at each hospital. The TKM doctors took regular training courses for standard operating procedure (SOP) twice a year to increase the objectivity of diagnosis.

Subject inclusion criteria were the following: (1) stroke patients within 30 days of the onset of their symptoms, (2) confirmed by imaging diagnosis such as computerized tomography (CT) or magnetic resonance imaging (MRI). Exclusion criteria included the following: (1) traumatic stroke patients such as subarachnoid, subdural, and epidural hemorrhage.

After receiving of informed consent from all subjects, the K-SPI-Stroke III was performed, which included general information about patients such as diagnosis, medical history, and 44 symptoms and signs that were related to Pattern Identification (PI). The patients were diagnosed as one of four patterns by two TKM doctors. Patients were considered as having an identical pattern when the pattern decision of the two TKM doctors using the K-SPI-Stroke III

were in agreement. A total of 2,905 stroke patients from September 2006 to December 2010, who have an identical pattern as a result of diagnostic decision of two TKM doctors, were analyzed in this study. This study was approved by the Institutional Review Boards of KIOM and each of the KOMHs involved.

Decision of dominant pattern for the items and factors

Dominant pattern of each items, which explain the representative characteristic of each items, was decided by these principles: to choose any two patterns (A and B) which has the most high frequency of 4 patterns (Fire-heat pattern, Dampness-Phlegm pattern, Qi deficiency pattern, Yin deficiency pattern) in each items, to compare the frequency of two patterns (A and B) by Chi-square test, to analyze the p -value of two patterns, to adopt [(A + B)] as the dominant pattern of item due to no statistical difference when the p -value is more than 0.01, to adopt [(A) or (B)] as the dominant pattern of item due to statistical difference when the p -value is less than 0.01. For instance, in case of mirror tongue which is an item in Factor 1, Yin deficiency and Fire-heat pattern were chosen as the most high frequency patterns, and the p -value between Yin deficiency and Fire-heat is less than 0.01, and frequency percentage of Yin deficiency is more than one of Fire-heat, therefore Yin deficiency was adopted as the dominant pattern of mirror tongue. In case of red tongue, Yin deficiency and Fire-heat pattern were chosen as the most high frequency patterns, and the p -value between Yin deficiency and Fire-heat is more than 0.01, therefore Yin deficiency + Fire-heat was adopted as the dominant pattern of red tongue.

Decision principles of dominant pattern in each factor are as follows:

1. When a certain factor (A) has 3 or 4 (N) items, and there are more than 2 or 3 (N-1) same dominant patterns (B), B is regarded as the dominant pattern of A factor. (Examples: factor 1, factor 2, factor 4).
2. When a certain factor (A) has 2 items, and there is the expression of 2 same dominant patterns (B), B is regarded as the dominant pattern of A factor. (Examples: factor 5, factor 7).
3. When a certain factor (A) has 2 items, and there is the appearance of 2 different dominant

Factor Analysis on Symptoms and Signs of Stroke

Table 2. Sum of Squares of Loading, Proportion of Variance, and Cumulative Variance Explained by the Loading

	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	Factor 8	Factor 9	Factor 10	Factor 11	Factor 12	Factor 13	Factor 14
SS loading	4.17552	3.10092	2.53973	1.84787	1.83053	1.68017	1.4597	1.38269	1.30433	1.16641	1.14747	1.08228	1.04553	1.00046
Proportion variance	0.0949	0.0705	0.0577	0.042	0.0416	0.0382	0.0332	0.0314	0.0296	0.0265	0.0261	0.0246	0.0238	0.0227
Cumulative variance	0.0949	0.1654	0.2231	0.2651	0.3067	0.3449	0.3781	0.4095	0.4391	0.4656	0.4917	0.5163	0.5401	0.5628

SS, sum of squares.

Table 3. Mean and standard deviation (SD) and standardized scoring coefficients in every variable

Variables	Mean ± SD	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	Factor 8	Factor 9	Factor 10	Factor 11	Factor 12	Factor 13	Factor 14
Mirror tongue	0.23 ± 0.53	0.281	-0.026	-0.009	0.018	0.018	-0.016	-0.105	0.010	0.002	0.051	0.068	0.024	0.003	-0.005
Underweight-Thin	0.41 ± 0.76	0.286	0.025	-0.014	0.115	-0.025	-0.097	-0.043	0.026	-0.091	0.107	0.070	-0.021	-0.056	0.008
Red tongue	0.73 ± 0.97	0.323	0.003	-0.002	-0.027	-0.308	-0.034	0.022	0.022	-0.093	0.004	-0.028	0.016	0.056	-0.068
Pale face and red zygomatic site	0.34 ± 0.69	0.248	-0.022	0.047	-0.030	-0.046	0.016	0.015	0.072	0.027	0.020	-0.012	0.019	-0.067	0.028
Look powerless & lazy	1.55 ± 0.63	0.017	0.411	-0.051	-0.008	-0.038	-0.006	-0.034	-0.007	-0.078	-0.022	-0.012	-0.032	-0.060	0.021
Feel powerless & lazy	1.54 ± 0.66	-0.045	0.364	-0.093	-0.015	-0.058	0.018	-0.026	0.025	0.041	-0.059	-0.053	0.039	0.007	0.020
Reluctance to speak	1.32 ± 0.58	0.028	0.355	-0.051	0.007	0.004	0.029	0.058	-0.013	-0.129	0.050	0.032	-0.039	-0.042	0.002
Weak pulse	0.76 ± 0.95	0.041	-0.029	0.369	-0.055	0.077	0.068	0.080	-0.025	-0.021	0.026	0.025	0.011	-0.020	-0.047
Fine pulse	1.19 ± 0.48	-0.001	-0.039	0.415	0.050	0.007	-0.061	0.075	-0.003	-0.049	-0.005	0.020	-0.024	0.017	0.226
Strong pulse	0.94 ± 1	0.069	0.102	-0.398	0.039	0.106	-0.025	-0.038	0.020	-0.125	0.029	-0.012	-0.020	0.057	0.072
Vexing heat in the extremities	1.01 ± 0.46	0.021	-0.018	0.001	0.397	0.055	0.102	-0.041	0.009	-0.076	0.055	0.035	0.036	-0.086	0.022
Heat in the palms and soles	1.02 ± 0.47	0.015	-0.009	-0.005	0.389	0.011	0.160	-0.020	-0.006	-0.107	-0.006	0.035	0.008	-0.087	-0.097
Aphtha or sore tongue	0.98 ± 0.41	0.029	-0.021	-0.025	0.308	-0.095	-0.105	-0.032	0.022	0.129	0.025	-0.003	0.049	0.056	-0.091
Pale tongue	0.62 ± 0.91	-0.058	-0.003	-0.042	0.068	0.419	0.001	0.048	0.050	-0.004	0.175	0.021	-0.006	-0.069	-0.038
Teeth-marked tongue	0.46 ± 0.77	-0.052	-0.062	0.039	-0.059	0.375	0.038	-0.006	-0.025	-0.130	-0.079	0.026	-0.027	0.154	0.087
Heat vexation and aversion to heat	1.5 ± 0.66	-0.081	-0.002	-0.020	0.053	0.083	0.389	0.021	-0.006	-0.082	0.025	-0.019	-0.017	0.032	0.013
Afternoon tidal fever	1.08 ± 0.36	0.013	0.012	-0.009	0.060	-0.017	0.329	-0.151	-0.029	0.076	-0.047	0.086	-0.002	-0.059	0.007
Thick fur	1.01 ± 1.02	-0.082	-0.011	0.015	-0.050	0.023	0.026	0.448	-0.063	0.011	-0.032	-0.064	-0.004	-0.061	-0.055
Fetid mouth odor	1.19 ± 0.57	0.008	-0.007	0.099	0.098	-0.091	-0.092	0.410	0.111	-0.066	0.089	0.051	-0.029	0.083	0.062
White fur	1.15 ± 1.02	0.039	-0.012	-0.038	-0.014	0.028	0.037	0.134	0.562	-0.015	-0.022	-0.032	0.021	0.010	-0.021
Yellow fur	0.75 ± 0.98	-0.024	-0.005	0.002	-0.007	0.076	-0.010	0.108	-0.535	0.033	-0.007	0.016	0.008	-0.064	-0.044
Headache accompanied by hot flush	0.31 ± 0.56	-0.053	-0.045	0.016	-0.013	-0.092	-0.054	-0.006	0.027	0.439	0.041	-0.067	-0.053	0.012	0.018
Dizziness with nausea	1.15 ± 0.46	-0.084	-0.080	0.046	-0.018	0.069	0.056	-0.034	-0.051	0.382	-0.083	0.105	0.133	0.055	0.112
Red eyes	1.53 ± 0.58	-0.010	-0.036	-0.001	-0.030	0.093	0.018	0.088	-0.029	0.086	0.530	0.009	0.029	0.010	0.009
Overweight-thick	0.6 ± 0.91	-0.090	-0.008	-0.010	-0.059	0.009	0.111	0.044	-0.010	0.067	-0.514	-0.050	0.033	-0.023	-0.010
Sallow complexion	0.77 ± 0.92	0.055	-0.033	-0.054	0.067	0.020	-0.073	-0.011	-0.048	-0.020	0.042	0.595	-0.008	0.049	-0.047
Reddened complexion	0.73 ± 0.98	0.087	-0.088	-0.056	-0.050	0.018	0.117	0.140	0.038	-0.025	0.055	-0.345	0.066	-0.041	-0.042

Factor Analysis on Symptoms and Signs of Stroke

Like to lie in spite of well-sleeping	1.02 ± 0.82	0.064	0.064	-0.042	0.030	0.029	-0.003	-0.022	0.004	0.040	-0.014	-0.003	0.550	0.027	0.023
Insomnia due to vexation	0.54 ± 0.77	0.069	0.061	-0.026	-0.031	0.037	0.031	0.002	-0.003	0.035	-0.019	-0.005	-0.518	-0.036	-0.005
Thirsty	1.39 ± 0.64	-0.052	-0.079	-0.029	-0.001	0.095	-0.012	-0.022	0.006	-0.025	0.044	0.001	0.063	0.560	-0.070
Dry mouth	1.56 ± 0.68	-0.012	0.017	-0.001	-0.037	-0.057	-0.057	0.014	0.062	0.032	-0.035	0.009	-0.014	0.513	-0.010
Rapid pulse	0.82 ± 0.97	0.130	0.012	0.051	-0.076	0.096	0.078	-0.005	0.010	-0.006	0.063	0.066	0.039	-0.054	0.571
Slow pulse	0.53 ± 0.82	0.051	0.019	-0.045	0.038	0.144	-0.012	0.052	-0.032	-0.137	0.055	0.025	-0.033	0.086	-0.529
Dry fur	0.68 ± 0.88	0.084	0.004	0.041	-0.126	-0.044	0.018	0.202	-0.012	-0.097	-0.136	0.005	0.004	0.161	0.000
Slippery pulse	1.46 ± 0.59	-0.100	0.023	-0.195	-0.013	-0.019	-0.151	0.143	0.010	0.182	-0.086	0.097	0.016	-0.042	0.060
Reversal cold of the extremities	1.04 ± 0.48	-0.081	0.003	0.112	0.198	-0.037	-0.278	0.063	-0.009	0.158	-0.053	-0.030	0.013	0.100	0.080
Surging pulse	1.07 ± 0.36	-0.114	0.075	-0.050	0.199	0.154	-0.120	0.123	-0.059	-0.132	0.036	-0.066	-0.106	0.062	0.231
Pale complexion	0.45 ± 0.78	-0.068	0.142	0.048	0.004	0.246	-0.097	-0.090	-0.077	0.057	-0.062	-0.251	-0.070	-0.032	0.033
Wheezing in throat with sputum	1.13 ± 0.62	-0.029	0.067	0.041	-0.009	-0.229	0.043	0.242	0.098	-0.079	0.119	0.019	-0.100	-0.008	-0.052
Night sweating	1.2 ± 0.47	-0.072	0.017	0.090	-0.030	-0.035	0.259	0.086	0.071	0.025	-0.137	-0.073	-0.018	0.025	0.062
Enlarged tongue	0.46 ± 0.77	0.066	-0.003	-0.049	-0.069	-0.038	-0.011	0.211	0.066	0.243	0.056	-0.011	0.040	-0.227	-0.099
Heat vexation in the chest	0.51 ± 0.77	0.091	0.029	-0.066	-0.016	-0.009	0.026	-0.066	-0.038	0.256	0.031	0.025	-0.165	-0.020	-0.051
Turbid urine	1.12 ± 0.65	0.116	-0.012	-0.045	-0.034	-0.029	0.171	-0.050	-0.021	0.197	0.210	0.000	0.161	-0.095	-0.076
Dark inferior palpebral	1.17 ± 0.4	0.039	-0.017	0.050	-0.075	-0.004	0.170	0.025	0.013	-0.002	0.037	0.296	0.032	-0.074	0.058

Bold character numbers signify factor loading higher than 0.5. SD, standard deviation.

Factor Analysis on Symptoms and Signs of Stroke

patterns (B, C), B + C is regarded as the dominant pattern in A factor. (Example: factor 6).

4. When a certain factor (A) has 2 items, and there are 2 different dominant patterns (B, B + C), B + C is regarded as the dominant pattern in A factor. (Example: factor 3, factor 13).

5. When a certain factor (A) has 2 items, and there are 2 different dominant patterns (A + B, B + C), A was excluded from pattern distribution. (Example: factor 9).

6. When some items have a negative loading in one factor (A), the negative factors were separated from positive factors. These were expressed differently from the positive factors using hyphen (A-1).

7. When a certain factor (A) has 1 item, dominant pattern of 1 item was regarded as dominant pattern of A. (Example: factor 3-1, factor 8, factor 8-1, factor 10, factor 10-1, factor 11, factor 11-1, factor 12, factor 12-1, factor 14, factor 14-1).

Statistical analysis

Continuous variables were summarized as mean \pm standard deviation (SD). For categorical variables, the percentages of patients in each category were calculated. Principal component analysis with varimax rotation was used to determine the construct validity of the Pattern Identification Questionnaire (PIQ). "Eigenvalues" reflect the amount of the variance in the data that is explained by successive numbers of factors, and the traditional "eigenvalues > 1 " rule was used as an indicator of the number of factors [8]. This was supplemented by "scree plots," in which a bend or "elbow" in the plot is assumed to indicate the level at which increasing the number of factors is only introducing noise [24, 25]. The output from factor analysis provides "factor loadings," and these show the contribution of an item to each factor; by convention, loadings < 0.50 are usually ignored as being unimportant. Also, high rank two patterns for each item were compared using the chi-square test. Results with a two-sided $P < 0.01$ were considered statistically significant. All statistical analyses were carried out using SAS version 9.1.3 (SAS Institute, Cary, NC, USA).

Results

Demographic characteristics

Table 1 summarizes characteristics of patients included. A total of 2,905 patients were interviewed. The mean age of the interviewed patients was 66.98 ± 11.55 years. The number of men and women were 1,530 (52.67%) and 1,375 (47.33%) respectively. The number of patients who had a drinking history and smoking history is much more than the number of ones who didn't. The proportion of diabetes, hyperlipidemia and hypertension accounted for 26.73%, 12.63% and 60.54% respectively. Additionally, weight, height, marriage state, anticoagulant treatment and NIHSS score are presented in **Table 1**.

Factor analysis

Figure 1 shows the eigenvalue from scree plot. The diamond dots are from actual values, making a classical scree plot. The number of diamond dots, which are "eigenvalues > 1 ", were fourteen. Therefore fourteen factors were derived from "eigenvalues > 1 " rule.

Table 2 displays a sum of squares according to the number of factors. The fourteen factors explained 56.28% of the total variance. Varimax rotation with maximum likelihood method was used to recompute these loadings on multiple factors. The results are shown in **Table 3**. There was no item loaded on more than one factors. Strong pulse, yellow fur, overweight, reddened complexion, insomnia due to vexation and slow pulse had a negative loading: -0.73 from factor 3, -0.85 from factor 8, -0.73 from factor 10, -0.54 from factor 11, -0.78 from factor 12 and -0.68 from factor 14 respectively. For instance, theoretically it may mean that increase in strong pulse correlates with decrease in factor 3 problem.

The fourteen factors accounted for 9.49%, 7.05%, 5.77%, 4.20%, 4.16%, 3.82%, 3.32%, 3.14%, 2.96%, 2.65%, 2.61%, 2.46%, 2.38% and 2.27% of the total variance respectively. Each of factors has some items ranged from 2 to 4. Description of items according to each factor was as follows: Factor 1-mirror tongue, underweight, red tongue, pale face and red zygomatic site; Factor 2-look powerless & lazy, feel powerless & lazy, reluctance to speak;

Factor Analysis on Symptoms and Signs of Stroke

Factor 3-weak pulse, fine pulse, strong pulse; Factor 4-vexing heat in the extremities, heat in the palms and soles, aphtha or sore tongue; Factor 5-pale tongue, teeth-marked tongue; Factor 6-heat vexation and aversion to heat, afternoon tidal fever; Factor 7-thick fur, fetid mouth odor; Factor 8-white fur, yellow fur; Factor 9-headache accompanied by hot flush, dizziness with nausea; Factor 10-red eyes, overweight; Factor 11-sallow complexion, reddened complexion; Factor 12-ike to lie in spite of well-sleeping, insomnia due to vexation; Factor 13-thirsty, dry mouth; Factor 14-rapid pulse, slow pulse. However, there are 11 items which don't belong to any factor: dry fur, slippery pulse, reversal cold of the extremities, surging pulse, pale complexion, wheezing in throat with sputum, night sweating, enlarged tongue, heat vexation in the chest, turbid urine and dark inferior palpebral.

Table 4 shows how the frequency, percentage and the *p*-value of Chi-square test between items and 4 patterns (Qi deficiency, Dampness-phlegm, Yin deficiency, Fire-heat) was related. In addition, the dominant pattern of each of items and each of factors was manifested.

Figure 2 displays dominant patterns for each factor in diagram form. Factor 10-1 and Factor 11 belong to Dampness-phlegm pattern, Factor 7 belongs to Dampness-phlegm + Fire-heat pattern, Factor 5 and Factor 8 belong to Dampness-phlegm + Qi deficiency. In addition, Fire-heat pattern include Factor 3-1, Factor 8-1, Factor 11-1 that are totally negative loadings, and Fire-heat + Yin deficiency include Factor 4, Factor 6, Factor 12-1, Factor 13, Factor 14. The only factor which belongs to Yin deficiency is Factor 1. Factor 3 belongs to Yin deficiency + Qi deficiency. Qi deficiency includes Factor 2, Factor 10, Factor 12, Factor 14-1. However, Factor 9 did not belong to any factor.

Discussion

Of the 44 tested items (symptoms and signs) in 2905 patients with stroke, 14 underlying factors were identified and distributed as "Yin deficiency", "Qi deficiency" and "Fire-heat", "Dampness-phlegm", "Dampness-phlegm + Fire-heat", "Dampness-phlegm + Qi deficiency", "Fire-heat + Yin deficiency", "Yin deficiency + Qi deficiency". Each of four patterns was defined

by World Health Organization as follows [26]: "Qi deficiency" is a pattern leading to decreased visceral functions and lowered body resistance. "Dampness-phlegm" is a pattern due to accumulation of dampness phlegm in the lung, marked by cough with profuse expectoration, heaviness sensation of the limbs, feeling of stuffiness in the chest, reduced food intake, stickiness of the mouth, white slimy tongue coating and slippery pulse. "Yin deficiency" is a pattern resulting from deficiency of yin fluid and essence, incapable of restraining yang and usually manifested by emaciation, dizziness, tinnitus, dryness of the mouth and throat, constipation, dark-colored urine, afternoon tidal fever, malar flush, night sweating, reddened tongue with scanty coating and rapid fine pulse. "Fire-heat" is a pattern of heat and fire, either contracted externally or engendered internally.

Because there is no overlapped area between Dampness-phlegm and Yin deficiency, and between Qi deficiency and Fire-heat, it could be interpreted that their relation is mutually exclusive in terms of pathophysiology. However, Dampness-phlegm is partly overlapped with Qi deficiency and Fire-heat considering each of areas such as factor 5, 8 and factor 7. Similarly Yin deficiency is partly associated with Qi deficiency and Fire-heat regarding each of areas such as factor 3 and factor 4, factor 6, factor 13, factor 14.

Some items of the heat condition such as red tongue, heat in the palms and soles, aphtha or sore tongue, headache accompanied by hot flush, insomnia due to vexation, thirsty and rapid pulse were expressed as Yin deficiency + Fire-heat within the framework of dominant items. Although the pathological causes and their treatments of Yin deficiency and Fire-heat are so different each other, external symptoms and signs of Yin deficiency and Fire-heat are similarly expressed as heat condition, so it is thought that TKM doctors have had difficulties to identify the difference of external expressions between two patterns. Because these difficulties were reflected to TKM doctors clinically, it was supposed that the domain of Yin deficiency + Fire-heat including factor 4, factor 6, factor 13 and factor 14 were generated. Therefore, it was recommended that clinically exclusive factors that represent Fire-heat or Yin deficiency are requisite to draw a sharp line between Fire-heat and Yin deficiency.

Factor Analysis on Symptoms and Signs of Stroke

Table 4. Decision of dominant pattern

Factor	Variables	P-value	Qi deficiency (630)	Dampness-phlegm (1037)	Yin deficiency (407)	Fire-heat (831)	Total (2905)	Dominant Pattern	
Factor 1	Mirror tongue	<.0001	17	9	60	28	114	Y	Y
			2.7	0.87	14.74	3.37			
	Underweight-Thin	0.0003	85	64	94	123	366	Y	
			13.49	6.17	23.1	14.8			
	Red tongue	0.8767	109	203	194	400	906	FY	
17.3			19.58	47.67	48.13				
Pale face and red zygomatic site	<.0001	30	62	138	85	315	Y		
		4.76	5.98	33.91	10.23				
Factor 2	Look powerless & lazy	<.0001	473	413	226	263	1375	Q	Q
			75.08	39.83	55.53	31.65			
	Feel powerless & lazy	<.0001	419	430	211	287	1347	Q	
66.51			41.47	51.84	34.54				
Reluctance to speak	<.0001	308	234	117	154	813	Q		
		48.89	22.57	28.75	18.53				
Factor 3	Weak pulse	<.0001	380	232	151	110	873	Q	QY
			60.32	22.37	37.1	13.24			
	Fine pulse	0.4587	256	99	156	54	565	QY	
			40.63	9.55	38.33	6.5			
Strong pulse*	<.0001	110	420	100	516	1146	F	F	
		17.46	40.5	24.57	62.09				
Factor 4	Vexing heat in the extremities	0.0008	30	98	30	120	278	F	FY
			4.76	9.45	7.37	14.44			
	Heat in the palms and soles	0.8841	26	87	58	121	292	FY	
			4.13	8.39	14.25	14.56			
Aphtha or sore tongue	0.5116	19	56	30	53	158	FY		
		3.02	5.4	7.37	6.38				
Factor 5	Pale tongue	0.1505	227	338	59	112	736	DQ	DQ
			36.03	32.59	14.5	13.48			
	Teeth-marked tongue	0.0269	135	177	37	84	433	DQ	
21.43			17.07	9.09	10.11				
Factor 6	Heat vexation and aversion to heat	<.0001	211	383	176	476	1246	F	FY
			33.49	36.93	43.24	57.28			
	Afternoon tidal fever	<.0001	39	60	73	82	254	Y	
6.19			5.79	17.94	9.87				
Factor 7	Thick fur	0.9655	149	469	87	375	1080	DF	DF
			23.65	45.23	21.38	45.13			
	Fetid mouth odor	0.0210	84	234	63	226	607	DF	
13.33			22.57	15.48	27.2				
Factor 8	White fur	0.2816	377	648	165	320	1510	DQ	DQ
			59.84	62.49	40.54	38.51			
	Yellow fur*	<.0001	106	300	95	381	882	F	F
16.83			28.93	23.34	45.85				
Factor 9	Headache accompanied by hot flush	0.3729	21	21	19	49	110	FY	Exclusion
			3.33	2.03	4.67	5.9			
	Dizziness with nausea	0.4787	89	197	64	115	465	DY	
14.13			19	15.72	13.84				

Factor Analysis on Symptoms and Signs of Stroke

Factor 10	Red eyes	0.0007	367	500	196	410	1473	Q	Q
			58.25	48.22	48.16	49.34			
Factor 11	Overweight-Thick*	<.0001	72	347	52	190	661	D	D
			11.43	33.46	12.78	22.86			
Factor 11	Sallow complexion	<.0001	147	538	83	117	885	D	D
			23.33	51.88	20.39	14.08			
Factor 12	Like to lie in spite of well-sleeping	0.0006	63	186	97	527	873	F	F
			10	17.94	23.83	63.42			
Factor 12	Insomnia due to vexation*	0.1595	230	216	107	151	704	Q	Q
			36.51	20.83	26.29	18.17			
Factor 13	Thirsty	0.3053	40	91	60	149	340	FY	FY
			6.35	8.78	14.74	17.93			
Factor 13	Dry mouth	<.0001	167	288	159	350	964	FY	FY
			26.51	27.77	39.07	42.12			
Factor 14	Rapid pulse	0.2264	292	431	260	417	1400	Y	
			46.35	41.56	63.88	50.18			
Factor 14	Slow pulse*	<.0001	115	322	165	367	969	FY	FY
			18.25	31.05	40.54	44.16			
Non-groupable Items	Dry fur		198	199	51	75	523	Q	Q
			31.43	19.19	12.53	9.03			
Non-groupable Items	Slippery pulse		89	155	131	210	585		
			14.13	14.95	32.19	25.27			
Non-groupable Items	Reversal cold of the extremities		135	746	97	323	1301		
			21.43	71.94	23.83	38.87			
Non-groupable Items	Surging pulse		109	123	58	62	352		
			17.3	11.86	14.25	7.46			
Non-groupable Items	Pale complexion		17	61	14	154	246		
			2.7	5.88	3.44	18.53			
Non-groupable Items	Wheezing in throat with sputum		272	80	40	37	429		
			43.17	7.71	9.83	4.45			
Non-groupable Items	Night sweating		88	237	79	180	584		
			13.97	22.85	19.41	21.66			
Non-groupable Items	Enlarged tongue		94	141	102	156	493		
			14.92	13.6	25.06	18.77			
Non-groupable Items	Heat vexation in the chest		98	219	41	102	460		
			15.56	21.12	10.07	12.27			
Non-groupable Items	Turbid urine		56	96	65	136	353		
			8.89	9.26	15.97	16.37			
Non-groupable Items	Dark inferior palpebral		129	210	96	208	643		
			20.48	20.25	23.59	25.03			
			15.71	21.7	12.78	10.35			

*; indicates items which had a negative loading. Bold character numbers signify that P-values were calculated by chi-square test between high rank two patterns for each item is lower than 0.01. Q: Qi deficiency, D: Dampness-phlegm, Y: Yin deficiency, F: Fire-heat, DY: Dampness-phlegm and Yin deficiency, QY: Qi deficiency and Yin deficiency, FY: Fire-heat and Yin deficiency, DF: Dampness-phlegm and Fire-heat, DQ: Dampness-phlegm and Qi deficiency.

Factor 7 which has thick fur and fetid mouth odor were found out to belong to Dampness-phlegm + Fire-heat. In pathophysiology having

congested the flow of Qi and Blood for a long time, Dampness-phlegm tends to generate heat and often be combined with heat for itself

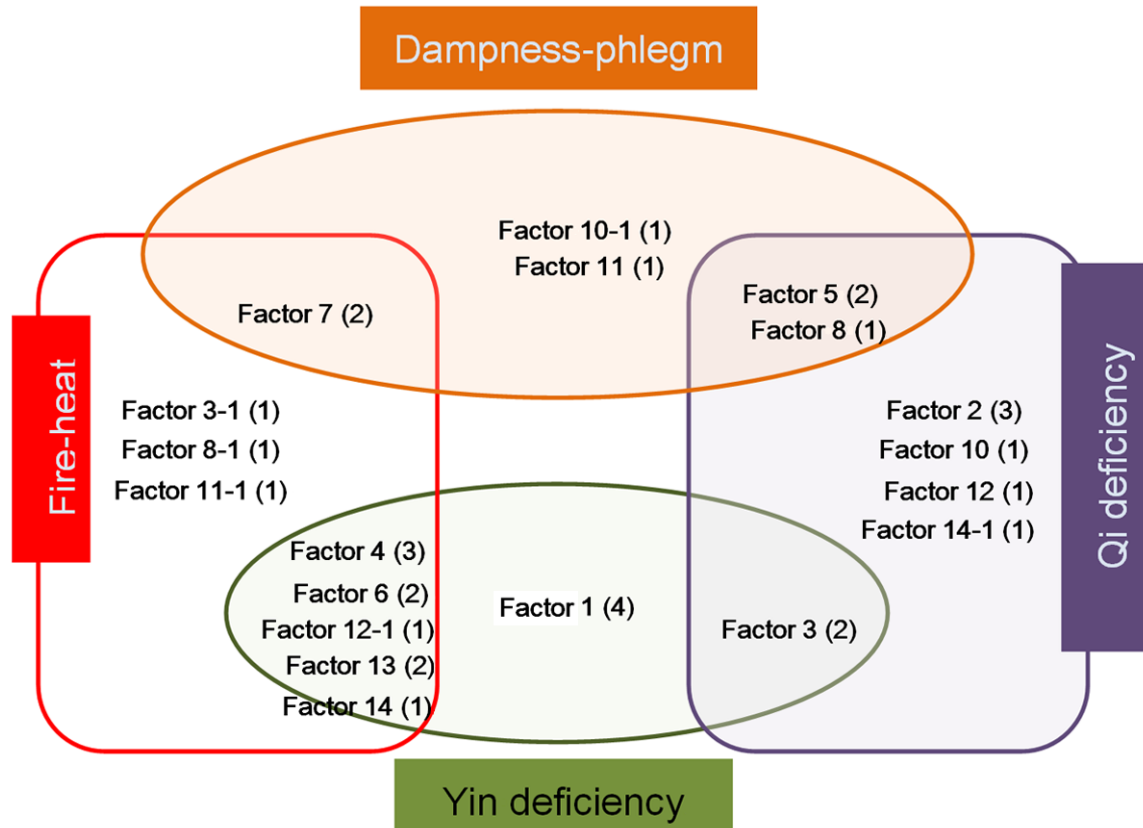


Figure 2. Classification of factors into each pattern.

[27]. For this reason, it was thought that the overlapped area of Dampness-phlegm and Fire-heat exists. Therefore exclusive factors that represent Dampness-phlegm or Fire-heat are requisite to distinguish Dampness-phlegm from Fire-heat. Additionally heat-typed Taeum constitution in Sasang Constitution Medicine which is originated from only Korea [28] would clinically be able to be recommended as representative type of Dampness-phlegm + Fire-heat.

Factor 3 including weak pulse and fine pulse were expressed as Qi deficiency + Yin deficiency. Pulse indicators from Yin deficiency or Qi deficiency have in common in that they all belong to Deficiency pattern. However, the differentiation between Qi which is power to boost pulse and Yin which is a volume of pulse is not quite easy clinically, indicating that exclusive clinical factors from Qi deficiency and Yin deficiency are essential for us to tell Qi deficiency from Yin deficiency.

Factor 5 including pale tongue and teeth-marked tongue, and Factor 8 which has white

fur were expressed as Qi deficiency + Dampness-phlegm. Further consideration of the reasons why the area of Qi deficiency + Dampness-phlegm generates is below: Lowering the speed of metabolism; discharging waste from a body and charging nutrition into a body, Qi deficiency induces the formation of Dampness-phlegm in human body [12]. Therefore exclusive factors that represent Qi deficiency or Dampness-phlegm are requisite to differentiate Qi deficiency from Dampness-phlegm. In addition, cold-typed Taeum constitution in Sasang Constitution Medicine [28] would clinically be able to be suggested as representative type of Dampness-phlegm + Qi deficiency.

Conclusion

Fourteen factors were detected among 44 items (symptoms and signs) for stroke. 11 items were non-groupable. Dominant patterns of each factor were manifested, constructing 8 classification areas: Yin deficiency, Qi deficiency, Fire-heat, Dampness-phlegm, Dampness-phlegm + Fire-heat, Dampness-phlegm + Qi

Factor Analysis on Symptoms and Signs of Stroke

deficiency, Yin deficiency + Fire-heat, Yin deficiency + Qi deficiency. Therefore, it was statistically investigated that there are inter-relationship between Dampness-phlegm and Qi deficiency, between Dampness-phlegm and Fire-heat, between Fire-heat and Yin deficiency, and between Yin deficiency and Qi deficiency for stroke patients.

Acknowledgements

We are grateful to TKM doctors in the study from 11 oriental medical hospitals. This study was supported by a grant from the Korea Institute of Oriental Medicine (K13130 and K14281).

Disclosure of conflict of interest

None.

Address correspondence to: Dr. MyeongSoo Lee, Division of Medical Research, Korea Institute of Oriental Medicine, 461-24 Jeonmin-dong, Yuseong-gu, Daejeon 305-811, Republic of Korea. Tel: +82-42-868-9266; Fax: +82-42-863-9299; E-mail: drmslee@gmail.com

References

- [1] World Health Organization. Chronic diseases and health promotion. <http://www.who.int/chp/en/>. Accessed 12 Sept, 2014.
- [2] World Health Organization. Health topics; Stroke, Cerebrovascular accident. http://www.who.int/topics/cerebrovascular_accident/en/. Accessed 12 Sept, 2014.
- [3] Shah SH, Engelhardt R and Ovbiagele B. Patterns of complementary and alternative medicine use among United States stroke survivors. *J Neurol Sci* 2008; 271: 180-185.
- [4] Shin YI, Yang CY, Joo MC, Lee SG, Kim JH and Lee MS. Patterns of using complementary and alternative medicine by stroke patients at two university hospitals in Korea. *Evid Based Complement Altern Med* 2008; 5: 231-235.
- [5] Lloyd-Jones D, Adams RJ, Brown TM, Carnethon M, Dai S, De Simone G, Ferguson TB, Ford E, Furie K, Gillespie C, Go A, Greenlund K, Haase N, Hailpern S, Ho PM, Howard V, Kissela B, Kittner S, Lackland D, Lisabeth L, Marelli A, McDermott MM, Meigs J, Mozaffarian D, Mussolino M, Nichol G, Roger VL, Rosamond W, Sacco R, Sorlie P, Stafford R, Thom T, Wasserthiel-Smoller S, Wong ND, Wylie-Rosett J; American Heart Association Statistics C and Stroke Statistics S. Executive summary: heart disease and stroke statistics-2010 update: a report from the American Heart Association. *Circulation* 2010; 121: 948-954.
- [6] Division of Statistical Analysis in the Institute of Health Insurance Policy. The status of health insurance benefits of the inpatients frequent diseases on classified subdivision of diseases in Traditional Korean Medicine 2009. Seoul: The National Health Insurance Corporation; 2010.
- [7] Xiong G, Virasakdi C, Geater A, Zhang Y, Li M and Lerkiatbundit S. Factor analysis on symptoms and signs of chronic low-back pain based on Traditional Chinese Medicine theory. *J Altern Complement Med* 2011; 17: 51-55.
- [8] Hayton JC, Allen DG and Scarpello V. Factor retention decisions in exploratory factor analysis: a tutorial on parallel analysis. *Organizational Research Methods* 2004; 7: 191-205.
- [9] Norris M and Lecavalier L. Evaluating the use of exploratory factor analysis in developmental disability psychological research. *J Autism Dev Disord* 2010; 40: 8-20.
- [10] Kim J, Seol I, Lee I, Jo HK, Yu B and Choi S. Report on the Korean standard differentiation of the symptoms and signs for the stroke-1. *Korean J Orient Physiol Pathol* 2006; 20: 229-234.
- [11] Association of Traditional Korean Medicine for Cardiovascular System. The traditional Korean medical textbook on the cardiovascular system. Seoul: Seowondang; 1995.
- [12] Association of Traditional Korean Medicine Pathology. Traditional Korean Medicine pathology. Seoul: Iljoongsa; 2002.
- [13] Huh J. Dongeuibogam. Seoul: Namsandang; 2004.
- [14] Lee BK and Lim TH. Traditional Korean Medicine diagnostics. Seongnam, Korea: Seongbosa; 2004.
- [15] Moon SJ. The traditional Korean medical textbook on the digestive system. Seoul: Iljoongsa; 1988.
- [16] Shin SS, Shin MK and Yang KS. A study of standardization of diagnoses and diagnostic requirements in traditional Korean Medicine III. Seoul: Korea Institute of Oriental Medicine; 1997.
- [17] The collaboration group of encephalopathy emergency of state administration of traditional Chinese medicine. Guideline for diagnosis and therapeutic effect evaluation of stroke. *J Beijing Univ TCM* 1996; 19: 55-56.
- [18] Traditional Medicine Research Institute. Pattern identification diagnostics. Seoul: Seongbosa; 1995.
- [19] Wang XZ. Traditional Chinese medicine for encephalopathy. Beijing: People's Medical Publishing House; 2004.
- [20] Yang K. A study of standardization of diagnoses and diagnostic requirements in traditional

Factor Analysis on Symptoms and Signs of Stroke

- Korean Medicine II. Daejeon, Korea: Korea Institute of Oriental Medicine; 1996.
- [21] Go H, Kim Y and Kang B. Report on the Korean standard differentiation of the symptoms and signs for the stroke-2. Korean J Orient Physiol Pathol 2006; 20: 1789-1791.
- [22] Lee J, Park TY, Lee J, Moon TW, Choi J, Kang BK, Ko MM and Lee MS. Developing indicators of pattern identification in patients with stroke using traditional Korean Medicine. BMC Research Notes 2012; 5: 136.
- [23] Lee J, Kim SY, Kang BK, Ko MM, Kim JC, Oh DS, Kim YS, Lee I, Cho KH, Chen CY, Han CH and Bang OS. A review of static blood pattern in stroke pattern diagnosis. Korean J Orient Int Med 2009; 30: 813-820.
- [24] Fayers PM and Machin D. Quality of life: the assessment, analysis and interpretation of patient-reported outcomes. Chichester, UK: Wiley; 2007.
- [25] Nunnally JC, Bernstein I. Psychometric theory. 3rd edition. New York: McGraw-Hill; 1993.
- [26] World Health Organization. WHO International standard terminologies on traditional medicine in the western pacific region. Manila: WHO Western Pacific Region; 2007.
- [27] Park Y and Kim T. Pattern identification diagnostics. Seoul: Sung-bo-sa; 1995.
- [28] Lee KR and Kim KY. A study on the Cold and Heat syndromes in Dongyi-Soose-Bowon. J Sasang Constitutional Med 1999; 11: 79-102.