사상체질의학회지 2010;22(3):87-97
J of Sasang Constitutional Medicine
Vol. 22, No. 3, 2010:87-97
http://www.esasang.com

사상체질 판별을 위한 2단계 의사결정 나무 분석

진희정 · 이혜정 · 김명건 · 김홍기* · 김종열

한국한의학연구원
*충남대학교

Abstract

Two-Stage Decision Tree Analysis for Diagnosis of Personal Sasang Constitution Medicine Type

Hee-Jeong Jin, Hae-Jung Lee, Myoung-Geun Kim, Hong-gie Kim*, Jong-Yeol Kim
Korea Institute of Oriental Medicine
*Chungnam National University

1. Objectives

In SCM, a personal Sasang constitution must be determined accurately before any Sasang treatment. The purpose of this study is to develop an objective method for classification of Sasang constitution.

2. Methods

We collected samples from 5 centers where SCM is practiced, and applied two-stage decision tree analysis on these samples. We recruited samples from 5 centers. The collected data were from subjects whose response to herbal medicine was confirmed according to Sasang constitution.

3. Results

The two-stage decision tree model shows higher classification power than a simple decision tree model. This study also suggests that gender must be considered in the first stage to improve the accuracy of classification.

4. Conclusions

We identified important factors for classifying Sasang constitutions through two-stage decision tree analysis. The two-stage decision tree model shows higher classification power than a simple decision tree model.

Key Words : Sasang constitution, Sasang Diagnosis, classification, 2-stage decision tree analysis

• 접수일 2010년 05월 12일; 심사일 2010년 05월 14일;
승인일 2010년 06월 05일
• 교신저자 : Kim Jong Yeol
Division of Constitutional Medicine Research, Korea Institute of Oriental Medicine
Tel : +82-42-868-9489 Fax : +82-42-861-5800
E-mail : ssmed@kiom.re.kr
• 교신저자 : Kim Hong gie
Department of Information and Statistics, Chungnam National University
Tel : +82-42-868-9489 Fax : +82-42-861-5800
E-mail : honggiekim@cnu.ac.kr
• 연구비 지원기관 : the Korea Science and Engineering Foundation (KOSEF)

Ⅰ. Introduction

SCM was systematically theorized by Jae-Ma Lee in his book 『Donguisusebowon』[1] in 1894. He explained the individual differences of disease susceptibility and drug response according to each constitution. He classified human bodies into four constitution types, Taeyangyin (TY type), Tae-eumin (TE type), Soyangyin (SY type), and Soeumin (SE type), by body shape, character, skin, response to herb, and so on. In particular, the response to herb is a distinguishing mark of SCM compared to other attributes. In the clinic, SCM treatment accompanied by type-matched herbal medicine offers patients favorable medical care. If a type-mismatched herb is offered, there will be an adverse side effect.

The personal SCM type must be determined accurately ahead of any Sasang treatments. The personal SCM type is determined based on the attributes described in Dong-Yi Su-Se Bo-Won, which include the external appearance and somatotype, personality, general health condition and symptoms, and reactions to medications. However, until the herbal effect in confirmed, there is a risk that a person may be diagnosed as a different constitution type, depending on which oriental doctor he or she visits. Therefore, many researchers have attempted to diagnose the SCM type. Lee et al.[2] and Huh et al.[3] focused on somatotype measurements[2,3], while Koh et al.[4] and Cho et al.[5] tried to diagnose the SCM type using head and face measurements and biochemical analysis, respectively. Cho et al.[6] and Choi et al.[7] analyzed SCM types genetically. Kim et al.[8] analyzed the SCM type using diagnostic equipment and Chae et al.[9] evaluated psychological and physical characteristics of SCM types from the perspective of personality theory. In this paper, we analyzed attributes of Dong-Yi Su-Se Bo-Won to develop a diagnostic tool for SCM typing using a “two-stage decision tree analysis” method.

Ⅱ. Materials

1. Case Report Form

The Case Report Form (CRF) is a self-report questionnaire for a study for standardization of the SCM in KIOM (Korea Institution of Oriental Medicine). Each question in the CRF was designed by SCM experts with reference to Donguisusebowon. It has since been updated and revised to change subjective questions to objective ones; the third version is currently in use. However, in order to include sample subjects obtained before the revision of CRF, the first version was used in this study.

The CRF consists of 7 parts: general information, external appearance, somatotype, personality, general health condition, symptoms, and reaction to medication. The general information consists of personal information such as name and address. And some part of the reaction to medication is subjective opinions written by an oriental medical doctor. Therefore, in this research, we used the other 5 parts of the CRF. We did, however, consider gender in the general information category. Kim et al.[10] studied the relationship between relativeness in four constitution type shown in personality pattern and ordinary symptom pattern of the CRF using 877 samples. In this paper, Cronbach's α of the personality pattern and symptom pattern was 0.801 and 0.598, respectively.

2. Sample Collection and Selection

We recruited samples from 5 centers: 4 Korean Colleges of Oriental Medicine (KyungHee, KyungWon, Dong-Eui, WooSuk) and KIOM. The collected data were from subjects whose response to herbal medicine was confirmed according to Sasang constitution. 515 respondents agreed to this study. However, we used only 390 sample subjects in the analysis. We excluded 125 subjects because of lack of information on body measurement which was not precisely determined on initial period of this study.

Among our subjects, the gender distribution was 164 males (42.1%) and 226 females (57.9%) with an average

Table 1. Constitution and Gender Distribution*

	Total	Male	Female
TE type	175(47%)	76(46.34%)	99(43.81%)
SE type	96(23%)	34(20.73%)	62(27.43%)
SY type	119(30%)	54(32.93%)	65(28.76%)
Total	390	164	226

*There were 175 (44.9%) TE type, 96 (24.6%) SE type, and 119 (30.5%) SY type.

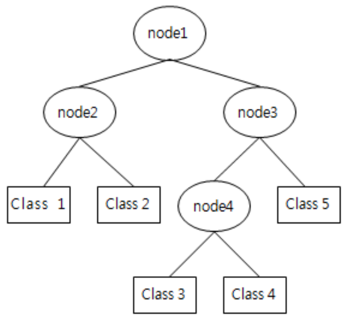


Fig. 1. Example of a decision tree*

*the decision tree consists of 3 parts – nodes, branches and classes.

age of 47.26±6.1 among the males and 48.69±13.51 among the females. According to SCM classification, 175 (44.9%) were TE type, 96 (24.6%) were SE type, and 119 (30.5%) were SY type. We didn't consider TY type since the proportion of TY type is very low in the Korean population. We can see the constitution and gender distribution. (Table 1).

In clinical fields of data, we used 142 items consisting of 13 continuous items related to somatotype and 129 discrete (42 non-binary and 87 binary variables) items associated with personality, external appearance, general health condition, and symptoms. The responses to personality questions were on a scale from one to five. We converted the five-level scale to a three-level scale because there were few respondents with extreme responses (1 or 5). The missing values were processed as missing. All experiments were conducted in accordance with the Institutional Review Board at the Korea Institute of Oriental Medicine. (I-2008/010-001)

Ⅲ. Method

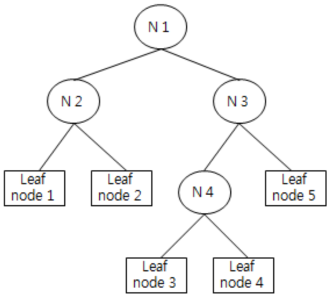
In the Korean traditional medicine society, there have been several recent efforts to establish diagnostic tools using the decision tree method[11]. In this paper, we use a modified decision tree method for Sasang constitution classification to reduce the error rate and increase the accuracy rate at the same time. The modified decision tree method is named "two-stage decision tree analysis".

A decision tree consists of nodes, branches and classes. Figure 1 shows a result from a typical decision tree. The nodes are tested attributes, and the branches of each node correspond to all of the possible outcomes of the test at the node. Leaf nodes assign classes according to the relative frequency of each class in the decision tree.[11] The each node of the split has the smallest p-value that is above the split samples. For example, there are 100 samples with 10 clinical information $\{i_1, i_2, ..., i_{10}\}$. and each constitution. If 100 samples are the most well classified into 4 groups according to 4 constitution by i_3, the i_3 denotes a node of the decision tree. And then,

Table 2. Variables Used to Construct Trees*

	No.	Question	
Male	[1]	Axillary	Circumference
	[2]	Are	you broad-minded or delicate?
	[3]	Neck	Circumference
	[4]	How	much do you perspire?
	[5]	Are	you quick or slow?
	[6]	Which	do you hate cold or heat?
	[7]	Iliac	Width
	[8]	Head	Circumference
	[9]	Upper	Abdomen Circumference
Female	[1]	Chest	Circumference
	[2]	Which	do you hate cold or heat?
	[3]	Are	you active or passive?
	[4]	Rib	angle
	[5]	Waist	Circumference
	[6]	Axillary	Width
	[7]	Neck	Circumference
	[8]	How	much do you perspire?
	[9]	Urine:	color/thickness

* In the case of male, 9 variables were used to make decision tree that were mostly related to somatotype. 9 variables were used to construct trees for female.



Leaf node	Probability of each constitution	class
1	TE: 71%, SE:10%, SY:19%	TE
2	TE: 2%, SE:60%, SY:38%	U
3	TE: 14%, SE:10%, SY:76%	SY
4	TE: 62%, SE:20%, SY:18%	U
5	TE: 90%, SE:5%, SY:5%	TE

* N: node, U : Undeclared node

Fig. 2. Example of undeclared nodes and undeclared sample subjects*

*If a given f is less than 70%, those nodes are undeclared. Leaf nodes 2 and 4 are undeclared nodes and sample subjects in these leaf nodes are undeclared sample subjects.

in each group, we can find a node such as i_3.

We used the following rule. Generally, all sample subjects within a leaf node are declared to be the class with the maximum relative frequency. We define a "relative frequency of declaration" f given by user, an "undeclared node" and an "undeclared sample subject" as follows. If the maximum relative frequency within a leaf node is lower than f, sample subjects within the leaf node will not be assigned to any class. We call this leaf node an undeclared node and sample subjects within this leaf node are undeclared sample subjects. We collect undeclared sample subjects and reconstruct a second decision tree using undeclared ones.

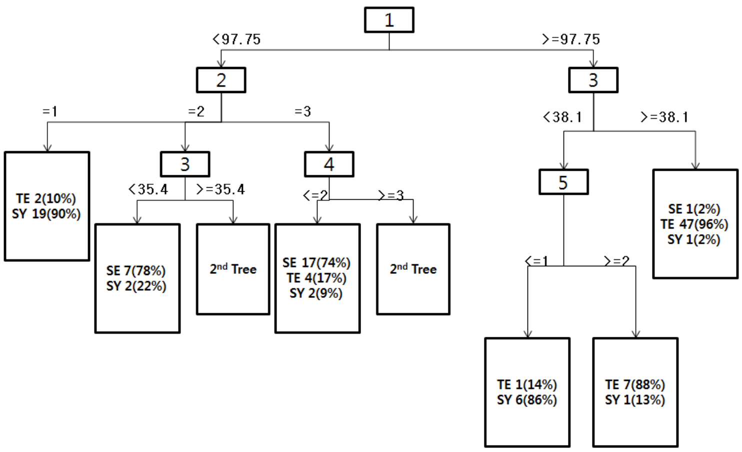
Generally, the decision tree method is a good approach for classifying large, complex datasets. In our collected sample, there were 129 discrete variables and 13 continuous variables, and each variable had a various response scale. Thus we employed a tree-structured analysis. The treestructure analysis was extended into “two-stage” based on the assumption that the whole group of sample subjects could be divided into two groups, one with typical SCM type and the other with non-typical SCM type.

Figure 2 shows an example of the first-stage of the decision tree analysis. We can see undeclared nodes and undeclared sample subjects in Figure 2. If f is 70%, leaf nodes 1, 3 and 5 are declared to be TE type, SY type and TE class, respectively. However, leaf nodes 2 and 4 are not assigned as any class because their maximum relative frequencies (50% and 62%, respectively) are less than f. Thus, leaf nodes 2 and 4 are undeclared nodes and the sample subjects belonging to these are undeclared sample subjects. We collect the sample subjects from leaf nodes 2 and 4 and construct a second decision tree using these sample subjects.

Ⅳ. Results

The collected 390 sample subjects were analyzed using the two-stage decision tree method with f = 70%. In previous research for QSCC, the accuracy was 65.0% [12]. We set a larger value for f than the accuracy. According to Size Korea[20], the difference of each body dimension

(a) The first tree for male



(b) The second tree for male

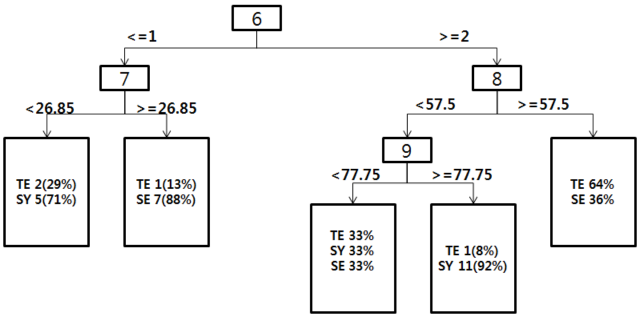
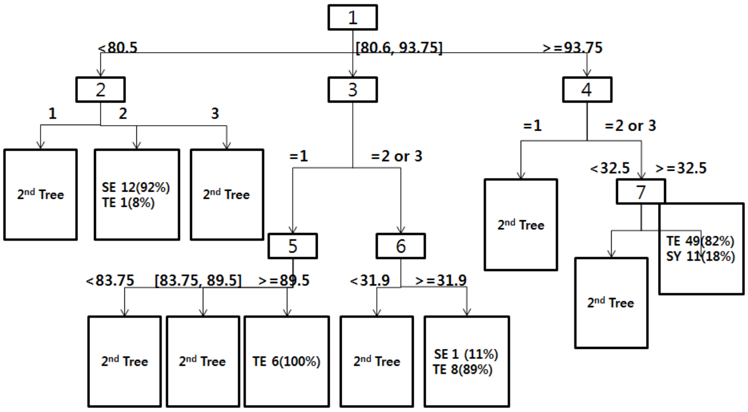


Fig. 3. Result of two-stage analysis using male sample subject

*In the first tree for males, 5 variables were used and there were 54 undeclared sample subjects within 2 undeclared nodes. In the second tree, 4 variables were used and there were 19 undeclared sample subjects within 2 undeclared nodes. The total accuracy was 87.6%.

(a) The 1st Tree for female



(b) The 2nd Tree for female

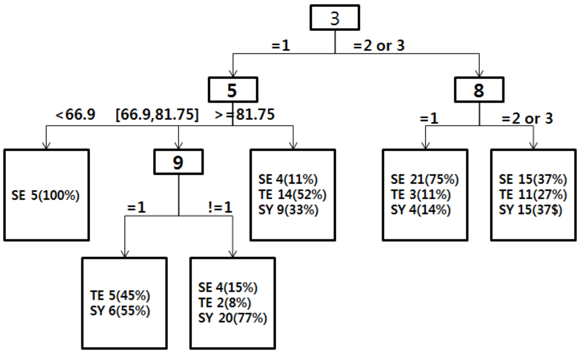


Fig. 4. Result of two-stage analysis using female sample subjects

*In the first tree for female, 7 variables were used and there were 138 undeclared sample subjects within 6 undeclared nodes. In the second tree, there were 79 undeclared sample subjects within 3 undeclared nodes. The total accuracy was 79.2%.

between gender is large. In addition, somatotype in SCM is an important measure in diagnosing constitution. According to Donguisusebowon, TY type has a developed nape of the neck and a slender waist and SY type has a developed chest and a small hip. TE type has a thick waist and a weak nape of the neck and SE type has a developed hip and a weak chest. For example, in the case of obesity, several reports have demonstrated distinct susceptibilities to obesity among subjects with different SCM types.[13] However, there is a huge difference in somatotype between male and female. Therefore, we analyzed male and female separately. In addition to, age and BMI are important variables but we could not consider these variables because, our sample size is small. These will be considered in our future work. We also checked that the distributions of constitutions were similar within each gender group, which enabled us to perform separate analysis. (Table 1) Figure 3 and 4 show the results of male and female groups after applying the two-stage decision tree analysis and Table 2 shows the variables used in constructing decision trees.

In the case of male, the variables used were mostly related to somatotype. (Fig. 3, Table 2) In the first tree for male, the variable "axillary circumference" yielded

Table 3 Classification Accuracy of Declared Sample Subjects and the Number of Undeclared Sample Subjects

	N	Classification Accuracy	# of Undeclared Sample Subjects in the 1st Decision Tree	# of Undeclared Sample Subjects in the2nd Decision Tree
Male	164	87.6%	54(32.9%)	19(11.6%)
Female	226	82.3%	138(61.1%)	79(35.0%)

* # : frequency

two branches with two nodes. At the left node, three nodes were separated by "personality", which was characterized as "broad-minded", "neutral", or "delicate". The node represented by broad-minded included 90% SY type. So, it was declared to be SY type as a terminal node. The group represented by neutral needed another variable, "neck circumference", to split. The node with smaller neck circumference was declared to be SE type and the node with larger neck circumference was classified as undeclared. At the third level at the node for delicate, the variable "amount of perspiration" allowed us to declare the "less perspiration" node as SE and the "more perspiration" node as undeclared. Going back to the right node at the second level of the tree with larger axillary circumference, the variable "neck circumference" produced a terminal node declared as TE type corresponding to large neck circumference and an intermediate node at smaller neck circumference, where "fast reaction" led to a terminal node for SY type and "slow reaction" led to a terminal node for TE type.

In the second tree for male, the first variable used to split the tree was "sensitivity to cold and hot". The node with sensitive to cold was divided into two terminal nodes by the variable "iliac width". The node for smaller iliac width was declared as SY type and the node with larger iliac width was declared as SE type. At the second level of the second tree, the node corresponding to non-sensitive to cold required the variable "head circumference" to split. The node with larger head circumference was undeclared since the maximum relative frequency did not meet our threshold value. The node with smaller head circumference was split using the variable "upper abdomen circumference." The node with larger upper abdomen circumference was declared as SY type, but the node with smaller upper abdomen circumference was undeclared as a terminal node.

In the case of female, the first variable considered was "chest circumference"(Fig. 4, Table 2). This variable generated three sub nodes, a left node for small chest circumference, in which the variable "sensitivity to cold and hot" produced a terminal node declared as SE type corresponding to non-sensitive to cold and hot. The other node was undeclared. Further explanations of the tree are left to the reader since the tree diagram should be self-explanatory.

Table 3 shows the classification accuracy of declared sample subjects and the number of undeclared sample subjects in the first and the second decision tree, respectively. We calculated the classification accuracy using sample subjects, excluding the undeclared sample subjects. The classification accuracies for male and female were 87.6% and 82.3%, respectively. Among males, the numbers of undeclared sample subjects in the first and the second decision trees were 54 and 19, respectively. Among females, the numbers of undeclared sample subjects in the first and the second decision trees were 138 and 79, respectively. Thus the number of undeclared sample subjects after the second decision tree was much lower than that in the first decision tree.

We applied this two-stage decision tree to a different data set that was obtained from the same sources at which we collected training data. These sampls were not used at constructing a decision tree. Among males, the classification accuracy was 76.0% and the proportion of

Table 4 Classification Accuracy and the Number of Undeclared Sample Subjects of Test Data

	N	Classification Accuracy	# of Undeclared Sample Subjects
Male	56	76.0%	6(10.7%)
Female	105	61.5%	40(38.1%)

undeclared subjects was 10.7%. Among females, they were 61.5% and 38.1%, respectively. (Table 4)

Ⅴ. Discussion

1. Test result

Among males, the slightly lower classification accuracy, 76%, is due to a general decrease from the training set to the test set. The proportion of undeclared sample subjects was similar to that in the training set. We saw relatively low classification accuracy, 61.5%, and a relatively high proportion of undeclared sample subjects, 38.1%, in the female group. To find a reason for the low classification accuracy and the high proportion of undeclared sample subjects among females, we calculated the accuracies and the numbers of undeclared sample subjects within the first and second decision trees for the male and female groups. (Table 5)

TE types were classified mainly by somatotype variables in the first tree. In the second tree, variables about personality and general health condition were used to separate SE and SY types. (Table 5) In both male and female training data sets, most of the unclassified TE types in the first trees were not classified in the second trees, either. We can therefore describe several tendencies.

① TE types are classified mainly by somatotype.

② Differences of personality and general health conditions between SE and SY types are fairly obvious.

③ TE types with skinny bodies are difficult to distinguish from other constitutions and act as a disturbance factor in our analysis.

Based on these tendencies, we assume that we obtained low classification accuracy and high proportion of undeclared sample subjects among females for the following reasons.

① Females tend to change somatotype due to pregnancy, childbirth, or nursing. In addition, they tend to keep their figures slender. Therefore, fewer somatotype variables are used to classify constitutions in the female group. For this reason, there are more undeclared sample subjects in the female group than in the male group in the first tree. Especially, the proportion of undeclared TE types in the female group, 35.4% (35/99), in the first tree is larger than that in the male group, 19.7% (15/76). Therefore, since there are more unclassified TE types in the female group than in the male group, the female group has more disturbance factors.

② The second tree is more data-oriented than the first tree. Generally, this induces data-oriented errors when applying test data. In the female group, there may be more undeclared sample subjects and errors in the second tree due to the number of remaining unclassified sample subjects in the first tree. However, interestingly, in the male group, since a few sample subjects were used to construct the second tree, this data-oriented tendency influenced the test to obtain high accuracy.

Therefore, when we apply test data, there may be many errors and undeclared sample subjects due to the data-oriented tree in the female group. To overcome this problem, other characteristics, excluding somatotype, need to be added in the female case. For this, we are considering to supplement variables of general health condition and symptoms for female in CRF and try to find factors related with SCM types in female group.

2. Two-stage decision tree analysis

Sample subjects can be classified into 2 types - typical

Table 5. Accuracy and the Number of Undeclared Sample Subjects Within Each Constitution according to Training and Test Data.

(a) Training Data of Male Group

		SY	SE	TE	Total(accuracy)	# of U
1st tree	SY	25	4	2	31(80.65%)	23
	SE	0	24	1	25(96.00%)	9
	TE	3	4	54	61(88.52%)	15
	Total	28	32	57	117	47
2nd tree	SY	16	0	0	16(100%)	7
	SE	0	7	0	7(100%)	2
	TE	3	1	0	4(0.00%)	11
	Total	19	8	0	27	20
	Total	47	40	57	144	20

(b) Test Data of Male Group

		SY	SE	TE	Total(accuracy)	# of U
1st tree	SY	3	0	3	6(50.00%)	5
	SE	1	0	0	1(0.00%)	8
	TE	3	1	26	30(86.67%)	6
	Total	7	1	29	37	19
2nd tree	SY	3	0	0	3(100%)	2
	SE	0	6	0	6(100%)	2
	TE	1	3	0	4(0.00%)	2
	Total	4	9	0	13	6
	Total	11	10	29	50	6

(c) Training Data of Female Group

		SY	SE	TE	Total(accuracy)	# of U
1st tree	SY	0	0	11	11(0.00%)	54
	SE	0	12	1	13(92.31%)	49
	TE	0	1	63	64(98.44%)	35
	Total	0	13	75	88	138
2nd tree	SY	20	4	0	24(83.33%)	30
	SE	4	26	0	30(86.67%)	19
	TE	2	3	0	5(0.00%)	30
	Total	26	33	0	59	79
	Total	26	46	75	147	79

(d) Test Data of Female Group

		SY	SE	TE	Total(accuracy)	# of U
1st tree	SY	0	1	8	9(0.00%)	27
	SE	0	0	2	2(0.00%)	25
	TE	0	0	24	24(100.00%)	18
	Total	0	1	34	35	70
2nd tree	SY	5	4	0	9(55.56%)	18
	SE	4	11	0	15(73.33%)	10
	TE	0	6	0	6(0.00%)	12
	Total	9	21	0	30	40
	Total	9	22	34	65	40

* # of U : # of undeclared sample subjects

SCM type and non-typical SCM type. Sample subjects with the non-typical SCM type tend to have their personality and body shape changed by environment or occupation, etc. Therefore, when these sample subjects are classified into SCM types, the classification accuracy may be low and the number of undeclared sample subjects may be large. In this study, we employed the two-stage decision tree method to classify sample subjects with non-typical SCM type.

We found that the variables used to classify constitutions in the first decision tree were different from those used in the second tree regardless of gender. Thus the criteria for classifying subjects in the first and the second decision trees were different. It is well known that somatotype measurements are a criterion to classify TE type and that personality is used to distinguish SY and SE. The tree in this study complied with the general theory regarding constitution classification. If a subject is a typical SCM type, we can find his/her Sasang constitution using the variables shown in the first decision tree. However, if one is a non-typical subject, he/she may be classified through the second decision tree.

3. SCM's view about constructed trees

In this study, somatotype and personality are shown to be important factors for diagnosing SCM type. According to the 『Donguisusebowon』, most TE types have well developed skeletons and most SE types have small frames. In the case of similar frames, SY types have well developed shoulders and breasts, TE types have well developed waists, and SE types have well developed hips. These tendencies were statistically proven in previous studies (14-19). Six and five somatotype variables were used in male and female groups, respectively. These results also support those tendencies.

SE types are still and internal-oriented, whereas SY types are active and external-oriented. TE types fall between SE and SY types. These results were shown in the 『Donguisusebowon』 and in previous studies using personality tests such as MBTI (Meyers-Briggs Type Indicator).[10)]

Generally, although subjects may be of the same constitution, general health condition varies depending on body conditions. The consistency is lacking in this category compared with that of somatotype or personality. In our trees, “sensitivity to hot and cold” and “amount of perspiration” were used in both the male and female groups, and “color/thickness of urine” was used in the second tree for the female group. SY types are sensitive to hot and SE types are sensitive to cold. Although there have been no clear studies regarding this, we can presume this from the theory about strength and weakness of internal organs according to constitutions. In the 『Donguisusebowon』, SE types have weak digestive systems, and SY types have strong digestive systems. “Sensitivity to hot and cold” is determined initially by caloric intake. We can confirm this interpretation with our statistical analysis, which shows that SY types eat more than SE types (χ^2=8.8, df=3, p-value=0.032).

We can see that TE types perspire more than SE types, and SY types are in between. According to the 『Donguisusebowon』, if TE types are in good health, they perspire more. On the other hand, SE types perspire less. Most of the sample subjects in our study are in good health, so our result for “amount of perspiration” supports the description in the 『Donguisusebowon』.

In “color/thickness of urine”, the urine of SY types is clearer than that of TE types. We cannot explain this result. However, this may be caused by different amounts of perspiration. SY types perspire less than TE types (χ^2=10.1, df=3, p-value=0.018).

Ⅵ. Conclusion

In this paper, we classified clinical sample subjects into Sasang constitutions by means of two-stage decision tree analysis. We identified important factors for classifying Sasang constitutions through this method. The two-stage decision tree model shows higher classification power than a simple decision tree model. This study also suggests that gender must be considered first to improve the classification accuracy.

Ⅶ. Acknowledgements

This work was supported by the Korea Science and Engineering Foundation (KOSEF) grant funded by the Korea government(MEST) (No.20090084121).

Ⅷ. References

1. Lee J. Longevity & life preservation In Oriental Medicine. Seoul: Kyung Hee University Press 1996.
2. Lee MH, Hong SY. A study on the correlation between Lee Jae-ma's four types of essential physical constitution and physical from index. J Sasang Constitut Med. 1990;2:71-86. (Korean)
3. Huh MH, Song JM, Kim DR, Koh BH. A study on the morphological diagrammings of four constitutions. J Sasang Constitut Med. 1992;4:107-148. (Korean)
4. Koh BH, Song IB, Cho YJ, Choi CS, Hong SC, Lee EJ, et al. A morphologic study of head and face for Sasang constitution. J Sasang Constitut Med.1996;8. (Korean)
5. Cho HS, Ji SE, Lee EJ, Hong SC, Koh BH, Gwon GH, et al. The studies on the objectification of Sasang constitution by biochemistry lab. J Sasang Constitut Med. 1997;9:147-162. (Korean)
6. Cho DW, Lee CS, Koh BH, Cho HS. Genetic analysis study of Sasang constitution classification by DNA fingerprinting methods. J Sasang Constitut Med. 1996;8:151-164. (Korean)
7. Choi SH, Yim YB, Rhee JW, Kim HY, Kang CH. Relationship between the Sasang constitution and ACE polymorphism. J Sasang Constitut Med. 1998;10:283-290. (Korean)
8. Kim JR, Kim DR. The study of verification bi-digital O-ring test by gaugus. J Sasang Constitut Med. 1995;7:69-102. (Korean)
9. Che H, Lyoo IK, Lee SJ, Cho SH, Bae HS, Hong MC, et al. An Alternative way to individualized medicine: Psychological and physical traits of Sasang typology. J Altern Complement Med. 2003;9:519-528.
10. Kim MG, Lee HJ, Jin HJ, Yoo JH, Kim JY. Study on the relationship between personality and ordinary symptoms from the viewpoint of Sasang Constitution and cold-hot. J Sasang Constitut Med. 2008;22:6. (Korean)
11. Kantardzic M. Data mining concepts, models, methods, and algorithms: Wiley-Interscience 2002.
12. Lee SG, Kwak CK, Lee EJ, Koh BH, Song IB. The study on the upgrade of QSCC (Ⅱ). J of Sasang Constitutional Medicine. 2003;15:39-49. (Korean)
13. Yoo JH, Kim JW, Kim KK, Kim JY, Koh BH, Lee EJ. Sasangin diagnosis questionnaire: test of reliability. J Altern Complement Med 2007;13:111-122.
14. Huh MH, Koh BH, I.B S. A study about morphological diagram of Sasang Constitution. J Sasang Constitut Med. 1989;1:29-40. (Korean)
15. Huh MH, Song JM, Kim DR, B.H. K. A Study about morphological diagram of Sasangin. J Sasang Constitut Med. 1992;4. (Korean)
16. Huh MH, Koh BH, I.B S. The Body measuring method to classify Sasang Constitutions. J Sasang Constitut Med. 2002;14:51-66. (Korean)
17. Hong SC, Lee SK, Lee EJ, Han GH, Chou YJ. A study on the morphologic characteristics of each constituion's trunk. J Sasang Constitut Med. 1998;10:101-114. (Korean)
18. Lee EJ, Lee JK, Kim JY, Song JM. The study on the biomechanical body segment parameters of korean adults with reference to sasang constitutional medicine. J Sasang Constitut Med. 1998;10:140-160. (Korean)
19. Lee EJ, Koh BH, Song IB. A morphologic study of sasang constitution. J Sasang Constitut Med. 1998;10:181-220. (Korean)
20. Size Korea. The study of Korean human dimension. 2004. (Korean)