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Correlation between psychological factors and the cerebellar volume of normal young adults[1]

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ABSTRACT. This study analyzed the relationship between the cerebellar volume of normal adults in the third decade of life (20-29 years) and various psychological factors. The cerebellar volume of 118 subjects (mean age, 23 ± 2.6 years), including 58 males (mean age, 24 ± 2.8 years) and 60 females (mean age, 21.9 ± 2.1 years), was measured using magnetic resonance imaging (MRI). The following tests were performed on all subjects: the Symptom Checklist-90-R (SCL-90-R), the Component of Type A Behavior, the State Anxiety Inventory from Korean YZ, the Sixteen Personality Factor (16PF), and the Self-rating Depression Scale (SDS). Using linear regression analysis, the relationship between cerebellar volume and psychological factors was analyzed. Without considering gender differences, as the tendency toward type A personality increased and the state of anxiety and superego strength increased, cerebellar volume decreased. As ego strength increased, cerebellar volume increased. When considering gender differences, as male phobic anxiety and ambition increased, cerebellar volume decreased. As female hostility, tenseness, and the state of anxiety increased, cerebellar volume decreased.

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KEYWORDS. Psychological tests. Cerebellar volume. Volumetry. MRI. *Ex post facto* study.

RESUMEN. Este estudio analiza la relación entre el volumen del cerebelo de adultos normales en la tercera década de la vida (20-29 años) y varios factores psicológicos. El volumen del cerebelo de 118 sujetos (media de edad 23 ± 2,6 años), incluyendo 58 varones (media de edad 24 ± 2,8 años) y 60 mujeres (media de edad, 21,9 ± 2,1 años), fue medido utilizando la imagen por resonancia magnética (IRM). Todos los participantes completaron los siguientes tests: Cuestionario de 90 Síntomas (SCL-90-R), Cuestionario de Personalidad de Tipo A, El cuestionario de Ansiedad Estado *Korean* YZ, El Cuestionario de 16 Factores de la Personalidad (16PF), y la Escala Autoadministrada de Depresión (EAD). Utilizando regresión linear, se analizó la relación entre el volumen del cerebelo y factores psicológicos. Sin considerar las diferencias entre géneros, en cuanto crecía la tendencia hacia la personalidad tipo A y se incrementaba el estado de ansiedad y la fuerza del superego, disminuía el volumen del cerebelo. Cuando se incrementaba la fuerza del ego, se incrementaba el volumen del cerebelo. Cuando se consideraban las diferencias de género, cuando incrementaba la ansiedad fóbica y ambición en varones, disminuía el volumen del cerebelo. En mujeres, cuando incrementaba la hostilidad, tensión y la ansiedad estado, disminuía el volumen del cerebelo.

PALABRAS CLAVE. Tests psicológicos. Volumen del cerebelo. Volumetría. IRM. Estudio *ex post facto.*

Cerebellum has become known to be generally related with motor control and has not caught attention about emotional and psychological matters. It has recently been known that cerebellum is involved in motor control as well as is necessary structure which is related with emotion, cognition, and psychological factors such as personality, anxiety, mood, and perception (Konarski, McIntyre, Grupp, and Kennedy, 2005; Papez, 1937; Schmahmann, 1991, 2000; Schmahmann and Sherman, 1998).

A number of studies regarding the relationship between the cerebellar volume and psychological diseases have been conducted (Rapoport, van Reekum, and Mayberg, 2000). There is a report that alcohol abuse and manic-depressive psychosis induce the size of the cerebellum or the cerebellar vermis to shrink (Glaser *et al.,* 2006). Hill *et al.* (2007) have reported that the cerebellar volume of children born from alcoholic parents is decreased. There have been reports that the cerebellar volume of children and adults with attention deficit hyperactivity disorder (ADHD) is smaller than that of normal subjects (Berquin, Castellanos, Giedd, Hamburger, and Rapoprt, 1998; Hill *et al.,* 2003; Glaser *et al.,* 2006). Brambilla *et al.* (2003) reported that the cerebral and cerebellar volumes of patients with autism are increased. Studies regarding the cerebellar volume of schizophrenia have also been performed. The cerebellar volume of schizophrenic patients is smaller than that of normal subjects (Bottmer *et al.,* 2005; Joyal *et al.,* 2004), and there is a gender difference in the variation of cerebellar volume (Szeszko *et al.,* 2003). Shin *et al.* (2005) reported that when the first episode of schizophrenia occurred

in patients with auditory hallucinations, they had a smaller cerebellar volume than when the first episode of schizophrenia occurred in patients without auditory hallucinations. Barkataki, Kumari, Das, Taylor, and Sharma (2006) also reported that the cerebellar volume of patients with schizophrenia or antisocial personality disorder (ASPD) is smaller than that of normal subjects.

Cerebellum has become known to be related with psychological factors (Allin *et al.,* 2001; Jeremy and Janet, 1998; Leroi *et al.,* 2002; Riklan, Marisak, and Cooper, 1974). Generally psychological factors such as anxiety, depression, impulsiveness, and offensiveness are symptoms which are required for diagnosis of psychological diseases. There have been a number of studies concerning the relationship between cerebellar volume and various psychological diseases, such as alcohol abuse, manic-depressive psychosis, attention deficit hyperactivity disorder (ADHD), autism, schizophrenia, and ASPD. Therefore this study assumed that even normal people can have diverse range (or level) of points of psychological factors, thus there might be a relationship between this and cerebellar volume. Through this study it was assumed that cerebellar volume or changes in cerebellar volume could be one of parameters which can diagnose the possibility of psychological diseases closely related with psychological factors.

Therefore, this ex post facto study (Montero and León, 2007; Ramos-Álvarez, Moreno-Fernández, Valdés-Conroy, and Catena, 2008) measured the cerebellar volume of normal subjects in their third decade of life (20-29 years of age) with magnetic resonance imaging (MRI) and investigated the basic relationship between cerebellar volume and various psychological factors.

Method

Participants

Korean subjects who did not have any previous brain damage or head injuries and did not have any medical problems, as confirmed by neurospecialists, were selected for this study. One hundred eighteen subjects (mean age, 23 ± 2.60 years), consisting of 58 males (mean age, 24 ± 2.80 years) and 60 females (mean age, 21.90 ± 2.10 years) were enrolled. The overall procedure was explained to all subjects, who gave consent prior to testing.

Image acquisition and volumetry

A MRI scan was conducted using a 3.0-T FORTE machine (ISOL Technology, Korea) equipped with whole-body gradients and a quadrature head coil. T1-weighted brain images were obtained with a three-dimensional, magnetization-prepared, rapid-gradient echo sequence (TR/TE/TI=10/4/100 ms; slice thickness, 1.5 mm; field of view, $220 \times 192 \times 192$ mm^3; number of slices, 128; slice gap, 0; matrix size, $256 \times 224 \times 128$; and number of excitations, 2). These MRI data have been used to analyze the effects of age, gender, and weight on the cerebellar volume of Korean adults (Chung *et al.,* 2005).

A Brain Voyager 2000 instrument (Brain Innovation BV, Germany) was used for separation of the cerebellar regions and their volume measurements. An inhomogeneity

correction, based on the brightness of white matter, was carried out for all axial, sagittal, and coronal planes. Sigma filtering, which is similar to the standard Gaussian smoothing filter and which can remove impulse noise, was used to increase image contrast. After these two pre-processing routines, a region-growing algorithm based on image brightness was carried out for automatic segmentation. Finally, manual segmentation was carried out by one of the authors who has sufficient knowledge in neuroanatomy to process boundary and detailed regions properly. It was easy to divide the left and right parts of the cerebellum in the axial image, and the cerebellum was extracted by excluding cerebellar peduncles, the brainstem, and the medullary vela regions. After measuring the regions of interest, the total cerebellar volume was calculated by summation of the cerebellar volume in each slice, obtained by multiplication of the areas by the slice thickness.

Psychological tests

Age, gender, handedness, height, and weight of each subject were measured. The Symptom Checklist-90-R (SCL-90-R; Caparrós-Caparrós, Villar-Hoz, Juan-Ferrer, and Vinas-Poch, 2007; Derogatis, 1983), the Component of Type A Behavior (Eysenck and Fulker, 1983), the State Anxiety Inventory from Korean YZ (Hahn, Lee, and Chon, 1996), the Sixteen Personality Factor (16PF; Kalat, 2002), and the Self-rating Depression Scale (SDS; Zung, 1965) were performed.

The SCL-90-R is classified into 9 lower ranks (*Somatization, Obsessive-compulsive, Interpersonal sensitivity, Depression, Anxiety, Hostility, Phobic anxiety, Paranoid ideation,* and *Psychoticism*) and consists of 90 problems. Each problem represents a single typical psychological symptom and calculates 5 point scales from 1 (*do not have*) to 5 (severe). The Component of Type A Behavior consists of 4 lower ranks (*tenseness, ambition, activity,* and *unrepressed*) and has 34 yes-or-no problems. As the total points increases, the type A character becomes stronger. The State Anxiety Inventory from Korean YZ consists of 20 problems and each problem has a 4 point scale from 1 (*never*) to 5 (*always*) to calculate the level of anxiety. A high score indicates high anxiety. As shown in Table 1, 16PF consists of 16 personality factors and 165 problems and has a 5 point scale from 1 (*never*) to 5 (*agreed well*) to calculate each personality score. Based on 16 first-order factors, the score of 6 second-order factors (*Extraversion, Anxiety, Tough Poise, Independence, High superego strength,* and *Creativity*) is calculated. The SDS consists of 20 problems related to depression and 4 point scales from 1 (*never*) to 4 (*always*) are used to calculate the score.

TABLE 1. Factors of Sixteen Personality Factor (16PF) (Kalat, 2002).

		High score	*Low score*
First-Order Factor	A Factor	Warmth	Coolness
	B Factor	High Intelligence	Low Intelligence
	C Factor	High Ego Strength	Low Ego Strength
	E Factor	Dominance	Submissiveness
	F Factor	Impulsivity, Surgency	Desurgency
	G Factor	HigherSuperego Strength	Lower Superego Strength
	H Factor	Boldness	Shyness
	I Factor	Tender-Mindedness	Tough-Mindedness
	L Factor	Suspiciousness	Trustfulness
	M Factor	Autia	Praxernia
	N Factor	Shrewdness	Nüivete
	O Factor	Guilt Proneness	Untroubled Adequacy
	Q1 Factor	Radicalim	Conservatism
	Q2 Factor	Self-Sufficiency	Group Dependence
	Q3 Factor	Self-Control	Undiciplined Self-Conflict
	Q4 Factor	Tension, Anxiety	Relaxation
Second-Order Factor	Extraversion	Extraversion	Introversion
	Anxiety	High Anxiety	Low Anxiety
	Tough Poise	Tough Poise	Emotion Sensitivity
	Independence	Independence	Subduedness
	High Superego Strength	High Superego Strength	Low Superego Strength
	Creativity	High Creativity	Low Creativity

Linear regression analysis, using SPSS (version 12.0), was carried out by setting each psychological factor score as an independent variable and cerebellar volume as a dependent variable. The combined analysis of each psychological factor was done without distinguishing gender difference, and then the analysis was carried out distinguishing males and females.

Results

As shown in Table 2, when gender differences were not considered, there was not any relationship between cerebellar volume and the 9 lower ranks of the SCL-90-R. By distinguishing males and females, male phobic anxiety increased ($p < .018$) and female hostility increased ($p < .027$), with a decrease in cerebellar volume.

TABLE 2. Coefficient of regression for factors of Symptom Checklist-90-R (Caparrós-Caparrós *et al.,* 2007; Derogatis, 1983) from linear regression analysis.

	Factors	*Unstandardized coefficients*		*Standardized coefficients*	*t*	*Sig.*	
		B	*Std. Error*	*Beta*			
Male	(constant)	155859.13	19872.71		7.84	.00	$R^2 = .20$
	Somatization	238.19	467.12	.11	.51	.61	$F = 1.05$ $p < .42$
	Obsessive-Compulsive	39.75	536.96	.02	.07	.94	
	Interpersonal Sensitivity	496.26	575.87	.26	.86	.39	
	Depression	198.13	671.35	.10	.30	.77	
	Anxiety	110.56	681.34	.05	.16	.87	
	Hostility	100.41	564.45	.05	.18	.86	
	Phobic Anxiety	-1321.31	539.49	-.51	-2.45	.02	
	Paranoid Ideation	95.04	592.60	.04	.16	.87	
	Psychoticism	-251.70	578.49	-.15	-.44	.67	
Female	(constant)	128613.65	12492.74		10.30	.00	$R^2 = .24$
	Somatization	345.51	331.25	.29	1.04	.30	$F = 1.37$ $p < .228$
	Obsessive-Compulsive	-53.79	358.41	-.05	-.15	.88	
	Interpersonal Sensitivity	-226.78	319.37	-.21	-.71	.48	
	Depression	444.75	391.16	.33	1.14	.26	
	Anxiety	-160.85	486.13	-.12	-.33	.74	
	Hostility	-746.46	326.19	-.56	-2.29	.03	
	Phobic Anxiety	384.75	381.77	.23	1.01	.32	
	Paranoid Ideation	-178.66	368.72	-.15	-.49	.63	
	Psychoticism	199.59	449.02	.14	.45	.66	
Male+ Female	(constant)	165413.75	10759.67		15.37	.00	$R^2 = .29$
	Gender	-13291.15	2719.05	-.45	-4.89	.00	$F = 3.57$ $p < .000$
	Somatization	225.22	258.09	.13	.87	.39	
	Obsessive-Compulsive	129.60	305.86	.08	.42	.67	
	Interpersonal Sensitivity	-88.26	287.16	-.06	-.31	.76	
	Depression	232.97	346.80	.13	.67	.50	
	Anxiety	84.99	394.72	.04	.22	.83	
	Hostility	-545.25	291.36	-.29	-.19	.06	
	Phobic Anxiety	-376.43	312.44	-.16	-1.21	.23	
	Paranoid Ideation	-69.24	310.87	-.04	-.22	.82	
	Psychoticism	194.08	337.04	.02	.58	.57	

As shown in Table 3, for the Component of Type A Behavior, when gender difference were not considered, there was no relationship between cerebellar volume and the 4 lower ranks; however as the type A personality became stronger, *i.e.,* the total score increased ($p < .049$), the cerebellar volume decreased. As male ambition increased ($p < .024$) and female tenseness increased ($p < .033$), cerebellar volume decreased.

TABLE 3. Coefficient of regression for factors of the Component of Type A Behavior (Eysenck and Fulker, 1983) from linear regression analysis.

	Factor	*Unstandardized coefficients*		*Standardized coefficients*	*T*	*Sig.*	
		B	*Std. Error*	*Beta*			
Male	(constant)	148198.90	6532.16		22.69	.00	$R^2 = .13$ $F = 1.84$ $p < .138$
	Tenseness	299.30	678.45	.07	.44	.66	
	Ambition	-2842.66	1214.96	-.38	-2.34	.02	
	Activity	-1009.94	1819.67	-.11	-.56	.58	
	Unrepressed	1679.11	1726.26	.20	.97	.34	
	Total	-429.99	321.44	-.18	-1.34	.19	
Female	(constant)	36868.20	5511.67		24.83	.00	$R^2 = .12$ $F = 1.58$ $p < .196$
	Tenseness	-1400.92	637.64	-.34	-2.20	.03	
	Ambition	1025.04	1098.45	.17	.93	.36	
	Activity	-916.58	1193.12	-.15	-.77	.45	
	Unrepressed	123.57	1559.64	.02	.10	.94	
	Total	-368.94	246.56	-.21	-1.50	.14	
Male+ Female	(constant)	162255.17	5447.60		29.79	.00	$R^2 = .28$ $F = 7.67$ $p < .000$
	Gender	-13392.48	2580.02	-.46	-5.19	.00	
	Tenseness	-622.67	468.43	-.13	-1.33	.19	
	Ambition	-919.17	815.77	-.12	-1.13	.26	
	Activity	-950.50	1048.19	-.11	-.91	.37	
	Unrepressed	1113.56	1138.19	.13	.98	.33	
	Total	-396.67	199.19	-.17	-1.99	.05	

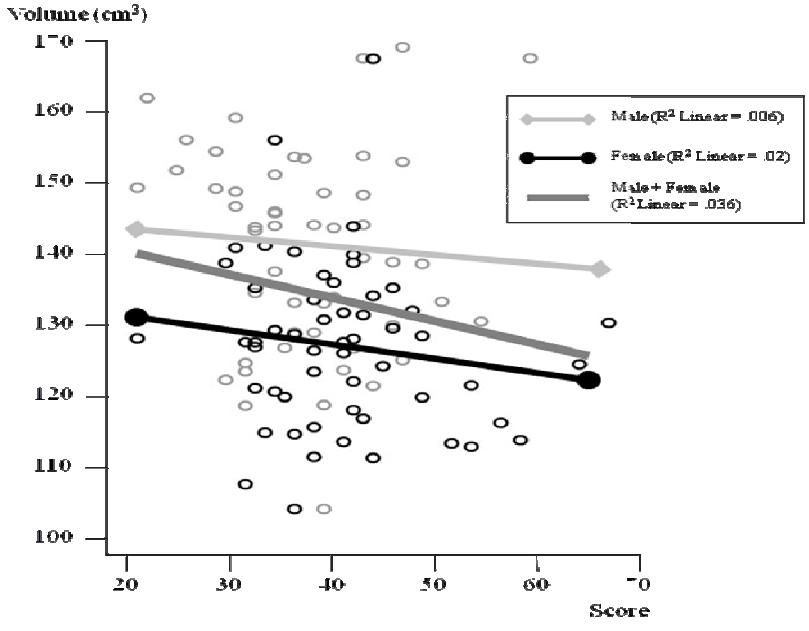
As shown in Table 4 and Figure 1, when gender differences were not considered, there the cerebellar volume decreased as the state of anxiety increased ($p < .006$). When gender differences were considered, as the state of anxiety increased ($p < .006$), the cerebellar volume decreased for females only.

TABLE 4. Coefficient of regression for the State Anxiety Inventory (Hahn *et al.,* 1996) from linear regression analysis.

	Factor	*Unstandardized coefficients*		*Standardized coefficients*	*T*	*Sig.*	
		B	*Std. Error*	*Beta*			
Male	(constant)	139156.83	10585.18		13.15	.00	R^2 = .04 F = 1.02 p <.368
	sf-sa	-443.04	337.92	-.26	-1.31	.20	
Female	(constant)	24301.68	7978.46		15.58	.00	R^2 = .15 F = 4.51 p <.016
	sf-sa	-791.56	274.44	-.60	-2.88	.01	
Male+ Female	(constant)	15111.22	7023.88		21.51	.00	R^2 = .28 F = 13.21 p < .000
	Gender	-12762.34	2509.54	-.44	-5.09	.00	
	sf-sa	-600.68	214.88	-.36	-2.80	.01	

Note. sf-sa = STAI form-State Anxiety.

FIGURE 1. Correlation between score of State Anxiety Inventory (Hahn *et al.,* 1996) and cerebellar volume.



As shown in Table 1, the 16PF was divided into first-order and second-order factors. Six second-order factors are the linear combination of part of 16 first-order factors, thus second-order factors show a perfect relation with the summed score of part of the first-order factors. Therefore, linear regression analysis was carried out by using only 16 first-order factors. As shown in Table 5, for the 16PF, when gender differences were not considered, the cerebellar volume increased as ego strength increased ($p <$ .033), and cerebellar volume decreased as superego strength increased ($p <$ .022). When gender differences were considered, there were no factors related to cerebellar volume. There was no relation between the results of SDS and cerebellar volume.

TABLE 5. Coefficient of regression for factors of Sixteen Personality Factor (Kalat, 2002) from linear regression analysis.

	Factor	*Unstandardized coefficients*		*Standardized*	*T*	*Sig.*	
		B	*Std. Error*	*Beta*			
Male+ Female	(constant)	103950.25	16715.19		6.22	.00	$R^2 = .46$ $F = 3.95$ $p < .000$
	Gender	-12234.43	2548.23	-.42	-4.8	.00	
	Warmth-Coolness	-245.42	1152.35	-.03	-.21	.83	
	Intelligence	1083.17	926.89	.11	1.17	.24	
	Ego Strength	2569.88	1184.55	.30	2.17	.03	
	Dominance-Submissiveness	-1544.63	1067.50	-.19	-1.45	.15	
	Surgency-Desurgency	-274.96	1109.05	-.04	-.25	.08	
	Superego Strength	-2307.14	984.62	-.32	-2.34	.02	
	Boldness-Shyness	772.23	1206.37	.10	.64	.52	
	Mindedness	1210.71	793.19	.16	1.53	.13	
	Suspiciousness-Trustfulness	712.66	940.34	.09	.76	.45	
	Autia-Praxernia	-1399.95	1228.88	-.20	-1.14	.25	
	Shrewdness-Nüivete	359.69	968.33	.05	.37	.71	
	Guilt Proneness-Untroubled	2052.90	1167.85	.26	1.76	.08	
	Radicalim-Conservatism	1387.52	832.91	.16	1.67	.10	
	Self Sufficiency-Group Dependence	1263.81	923.37	.14	1.37	.17	
	Self Conflict-Undiciplined Self	1480.81	1086.44	.17	1.36	.17	
	Tension-Relaxation	913.88	1056.31	.12	.87	.39	

Discussion

Most published studies compare the cerebellar volume of patients with psychological diseases, such as alcohol abuse, manic-depressive psychosis, ADHD, autism, schizophrenia, and ASPD, with normal subjects (Barkataki *et al.,* 2006; Berquin *et al.,* 1998; Bottmer *et al.,* 2005; Brambilla *et al.,* 2003; Glaser *et al.,* 2006; Hill *et al.,* 2003; Hill *et al.,* 2007; Joyal *et al.,* 2004; Shin *et al.,* 2005; Szeszko *et al.,* 2003). The current study, however, analyzed the relationship between cerebellar volume of normal young adults and various psychological factors.

Patients with schizophrenia show higher anxiety and hostility compared with normal subjects (Ritsner *et al.,* 2004). Some 41.50% of schizophrenia patients have an anxiety disorder, and schizophrenia patients with anxiety disorders show severe degrees of schizophrenia as compared to schizophrenia patients without anxiety disorders (Braga, Mendlowicz, Marrocos, and Figueira, 2005). Schizophrenia patients sometimes have social phobia (Cosoff and Hafner, 1998; Pallanti, Quercioli, and Hollander, 2004), and show various symptoms, such as hostility, auditory and visionary hallucinations, and delusions (Kasper, 2006; Ritsner *et al.,* 2004; Tibbo, Swainson, Chue, and LeMelledo, 2003). Of adults with ASPD, 54.30% have anxiety disorders (Goodwin and Hamilton, 2003), accompanied with symptoms of anxiety (Hatzitaskos, Soldatos, Kokkevi, and Stefanis, 1999). There is a report that ASPD is related to social phobia and post-traumatic stress disorder (PTSD), and specific phobia, social phobia, PTSD, and generalized anxiety disorder are factors that increase the possibility of ASPD (Goodwin and Hamilton, 2003). The frequency of occurrence of generalized anxiety disorders and social phobias are greater for patients with ADHD than for normal subjects (Biederman *et al.,* 1994; Fischer *et al.,* 2007; Pliszka, 1998; Shekim, Asarnow, Hess, Zaucha, and Wheeler, 1990).

In this study, when gender difference was not considered, as anxiety in all subjects, phobic anxiety in male subjects, and hostility in female subjects increased, the cerebellar volume decreased. It is believed that this is a meaningful result when compared with the published results that cerebellar volume of patients with schizophrenia, ASPD, and ADHD decreased, due to the psychological factors, such as anxiety, phobia, and hostility (Barkataki *et al.,* 2006; Berquin *et al.,* 1998; Bottmer *et al.,* 2005; Glaser *et al.,* 2006; Hill *et al.,* 2003; Joyal *et al.,* 2004; Shin *et al.,* 2005; Szeszko *et al.,* 2003). When gender differences were not considered, superego strength and cerebellar volume had a negative relationship, which is a meaningful result since superego strength is closely related to anxiety.

Eysenck and Fulker (1983) reported that as the tendency for type A behavior became higher, ambition and tenseness became higher, and this tendency had a static relationship with neurotic tendencies. Wiles *et al.* (2006) reported that neurotic tendencies are important factors for symptoms of schizophrenia. The cerebellar volume in schizophrenia is smaller than that of normal subjects (Barkataki *et al.,* 2006; Bottmer *et al.,* 2005; Joyal *et al.,* 2004). These published studies support the result of this study that when gender differences were not considered, the type A personality became stronger and as male ambition increased and female tenseness increased, cerebellar volume decreased.

Lamb (1982) reported that ego strength and autistic tendencies had a static relationship, and Brambilla *et al.* (2003) reported that the cerebellar volume of patients with autism increased. These published studies support the results of this study that when gender differences were not considered, ego strength and cerebellar volume had a positive relationship.

Patients with cerebellar diseases such as cerebellar tumor, stroke, cerebellar atrophy have difficulties in control of behavior and personal characteristics, show impulsive behaviors or have difficulties in concentration, and also have compulsive personality disorders (Grafman *et al.,* 1996; Laakso *et al.,* 2001; Leroi *et al.,* 2002; Parker *et al.,* 2008;

Schutter and Honk, 2005; Tiihonen *et al.,* 2008). Cerebellar volume was measured for those who were very preterm group (VTP) and term-born group (control group) during their juveniles and adulthood and 12-item General Health Questionnaire (GHQ-12) was also performed for verifying cognitive function test, psychological pain, and social function disorder. Cerebellar volume of VPT group in adulthood was 3.11% less than that of juvenile due to cerebellar atrophy, and that of control group in adulthood increased .44%. VPT group showed the negative relationship between cerebellar volume and concentration, feeling useful, decision-making capability, overcoming difficulties, feeling confident and feeling worthless among GHQ-12 (Parker *et al.,* 2008). As shown this, partial studies concerning behavior and personal characteristics, psychological, cognitive, and social functional disorders that are related with cerebellar diseases and cerebellar developmental deterioration have been carried out, but there is no comprehensive neurophysiological model which can explain structural and functional disorders of cerebellum concerning major neurological diseases. However since cerebellum is connected with cingulate, medial and dorsolateral prefrontal cortex through thalamus, the hypothesis that cerebellum has an effect on cognitive processing as well as psychological factors such as anxiety, personality, mood, and cognition has been generally accepted (Schmahmann, 2004). Even though this study did not perform the relation concerning functional aspects of cerebellum for normal subjects, the result which showed the relationship between cerebellar volume and various psychological factors strongly supports above hypothesis. Further researches are necessary to study why there is a relationship between psychological factors and cerebellar volume. Even the normal subjects can have minor cerebellar development deterioration or increase and cerebellar atrophy due to inherited and other factors, this can be one of the causes which explains that cerebellar volume is related with psychological factors.

There have been no studies about the relationship between cerebellar volume and various psychological factors for normal subjects. Further studies are necessary to clarify that the tendency of schizophrenia, ASPD, ADHD, and autism for normal subjects has similar results as those of patients. It is believed that studies about cerebellar volume as well as cerebral volume, and the relationship between functional and structural changes in cerebellum and cerebrum and various psychological factors are necessary. This study showed that there was a gender difference in the relationship between cerebellar volume and psychological factors. The cause of gender differences in relationship between cerebellar volume and psychological factors is unclear and may be attributed to internal (such as sex hormones) and external factors (such as smoking and drinking) (Chung *et al.,* 2005). This issue needs to be further explored. Considering that boundaries of the cerebellum are sometimes hard to establish because of partial volume effects or mixed vessels, it had been more reliable to use an inter-rater approach in the manual segmentation of the cerebellum. However, this study showed interesting results that for even normal young adults, there exists a possible relationship between various psychological factors and cerebellar volume. This study also indicated that cerebellar volume or changes in cerebellar volume could be one of parameters which can diagnose the possibility of psychological diseases.

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