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The Evaluation of Cerebellum Gross Morphometric Measurements in Subjects Having Migraine, Ataxia, Dementia and Vertigo

Evaluación de las Medidas Morfométricas Macroscópicas del Cerebelo en Sujetos con Migraña, Ataxia, Demencia, Vértigo

Mahmut Öksüzler[1]; Yasemin Öksüzler[2]; Mahmut Tunç[3]; Sema Polat[3]; Duygu Vurallı[3] & Pinar Göker[3]

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SUMMARY: This paper was aimed to determine the morphometric measurements of cerebellum using MRI in subjects having migraine, ataxia, dementia and vertigo. Three hundred twenty six (326 subjects; 80 migraine subjects; 85 vertigo subjects; 83 dementia subjects; 78 ataxia subjects) subjects ranging from 20 up to 85 years were included in this study. Cerebellum morphometric measurements were taken from subjects having brain MRI in the Radiology Department. The means and standard deviations of the measurements were: Sagittal section cerebellum superior inferior length, 56.21±5.16 mm; sagittal section cerebellum anteroposterior length, 86.36 ±5.36 mm; axial section cerebellum antereoposterior length, 66.53±5.41 mm; axial section bi-cerebellar length, 100.48±5.14 mm; coronal section cerebellum supero-inferior length,53.60±3.84 mm; coronal section bi-cerebellar length, 99.77±6.24 mm in subjects with migraine, whereas the corresponding values were 62.33±8.66 mm; 93.31±9.89 mm; 60.26±7.98 mm; 99.89±6.41 mm; 54.35±4.64 mm; 85.58±14.74 mm in subjects with vertigo, respectively. The same values were found as 58.82±8.34 mm; 86.74±13.22 mm; 58.93±8.89 mm; 97.93±6.07 mm; 50.66±4.92 mm; 84.96±14.93 mm in patients having dementia, respectively, while the same measurements were as 60.83±8.59 mm; 92.18±9.12 mm; 57.76±7.85 mm; 97.71±5.82 mm; 52.48±4.85 mm; 81.49±14.38 mm in ataxia patients, respectively. Also, ages were divided into seven groups as decades. There were found significant difference in all parameters according to *sex* and ages ($p<0.05$). The cerebellum morphometry provides important and useful knowledge in terms of comparison of abnormalities clinicians and data will be valuable for the determination of pathologies for clinical disciplines.

KEY WORDS: Age and sex differences of cerebellum; Cerebellum morphometry; Cerebellum lengths.

INTRODUCTION

The cerebellum is called as 'little brain' in Latin and located in the posterior cranial fossa. The cerebellum has a critical role in the regulation of posture, motor coordination, balance, motor learning, emotion and cognition, memory function and psychiatric diseases. The cerebellum consists of a midline region referred to as the vermis, a narrow paravermal area immediately adjacent to the vermis, and large hemispheres on either side (Rapoport *et al.*, 2000; Gottwald *et al.*, 2004; Hopyan *et al.*, 2010; Ding *et al.*, 2012; Arıncı & Elhan, 2020; Jimsheleishvili & Dididze, 2021; Unverdi & Alsayouri,2021). In the embryological period, the central nervous system (CNS) that develops from the ectoderm begins to shape at the 3rd week whereas neural tube (NT) development is completed in the 4th week. Then, NT differs in the rostral area to constitute the cerebrum and cerebellum. Development of the cerebellum starts in days forty-forty five and continues to puberty. It reaches to the highest level between 10-13 years and it is the one of the last to mature. The cerebellar fissures and folia of cerebellum appear in the cerebellum at the end of the 4th month. Its volume represents approximately 10% of brain, but it has more than 50% of all neurons (Susan *et al*., 2008; Sadler, 2011; Kosar *et al*., 2012; Ayhan *et al*., 2015; Arıncı & Elhan, 2020; Jimsheleishvili & Dididze, 2021; Unverdi & Alsayouri, 2021). Previous studies investigated age and sex related changes in the cerebellum. In that studies results of age and sex related differences in cerebellum may give different results in general (Ellis *et al*., 1920; Nishimiya,

[1] Adana Medline Hospital, Department of Radiology, Adana, Turkey.
[2] Ortadogu Hospital Department of Radiology, Adana, Turkey.
[3] Çukurova University Faculty of Medicine, Department of Anatomy, Adana, Turkey.

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1988; Hayakawa *et al*., 1989; Schaefer *et al*., 1991; Shah *et al*., 1991; Raz *et al*.,1992; Murshed *et al*., 2003). Also, the cerebellum linear measurements with MRI are inadequate in Turkish healthy population (Mushed *et al*., 2003). The linear measurements can be performed more quickly, are practical (Raininko *et al*., 1994).

Posterior fossa structures' evaluation , specifically vermis of cerebellum, may be fundamental for understand, evaluate pathological changes in neoplastic and many neurodegenerative diseases and recognize the congenital malformations (Koehler *et al*., 1985; Raininko *et al*., 1994; Ahmed *et al*., 2017). For this reason, to understand the pathologies of cerebellum structures and the effects of some diseases on cerebellum, the cerebellum reference data should be well known. Therefore, in this study, it was aimed to determine the age, sex and diseases related changes or differences of cerebellum structure subjects with migraine, ataxia, dementia and vertigo using MRI.

MATERIAL AND METHOD

This study was carried out from the three hundred twenty six (326 subjects; 80 migraine subjects; 85 vertigo subjects; 83 dementia subjects; 78 ataxia subjects) aged 20-85 years between January 2017 and 2021. Moreover, inclusion criteria for subjects were diagnosed of migraine, dementia, spino cerebellar ataxia and vertigo.

MRI was performed using a 1.5 T MRI system (Siemens; Essenza, Erlangen, Germany). Brain MRI protocol including axial T2-weighted turbo spin echo (TR:3600, TE:87 ms; slice thickness 5 mm; gap 1.5 mm) and sagittal T2-weighted spin echo (TR:3600, TE: 87 ms; slice thickness 5 mm; gap 1.5 mm) was used. The measurements were performed from digital MRI images on a hospital using caliper function with x2 magnification. Using the axial, sagittal and coronal images, the following parameters of cerebellum linear measurements were evaluated (Hwang *et al*., 2013). The measurements were made on the computer screen with an electonic caliper and estimations were expressed as millimeters.

ASCAPL: Anteroposterior length of cerebellum on axial section,
ASBCL: Bi-cerebellar length of cerebellum on axial section,
CSCSI: Supero-inferior length on coronal section,
CSBCL: Bi-cerebellar length of cerebellum on coronal section,
SSCSI: Supero-inferior length of cerebellum on sagittal section.
SSCAPL: Anteroposterior length of cerebellum on sagittal section.

The data were divided into four groups as migraine, ataxia, demantia and vertigo (Table I to 3). Furthermore, the data were divided also into seven groups according to age; subjects aged between 20-30 years for Group 1; 31-40 years for Group 2; 41-50 years for Group 3; 51-60 years for Group 4; and 61-70 years for Group 5; 71-80 years for Group 6; and 81-90 years (Table IV and V). Also, this study was approved by the Institutional Review Ethics Committee at Çukurova University (2021/110-25).

Statistical Analysis. The SPSS 21.0 program was used for statistical analysis of the measurement results. The means, standard deviations (SD), minimum (min.) and maximum (max.) values were calculated; In all statistical analyses; p value under 0.05 was considered statistically significant. Also, the significance was evaluated ANOVA and A post hoc test was used to found whether is there any significance between decades.

RESULTS

The aspect of the cerbellum parameters in sagittal/coronal/axial MR images were shown in Figure 1. Infact, superior-inferior, anteroposterior, and right-to-left maximum distance of the posterior cranial fossa on axial, coronal, and sagittal section. Especially, in sagittal section SSCAPL and in coranal section CSBCL terms were used whereas these dimensions involve the pons and some posterior fossa structures, respectively. However, we prefered to use the abbreviation below. The value of minimum, maximum, mean and standard deviation of the ASCAPL: Anteroposterior length of cerebellum on axial section; ASBCL: Bi-cerebellar length of cerebellum on axial section; CSCSI: Supero-inferior length on coronal section; CSBCL: Bi-cerebellar diameter of cerebellum on coronal section; SSCSI: Supero-inferior length of cerebellum on sagittal section; and SSCAPL: Sagittal section length of the serebellum anterior posterior length were measured in the three hundred twenty four (324 subjects; 80 migraine subjects; 85 vertigo subjects; 83 dementia subjects; 78 ataxia subjects) aged 20-85 years and were shown in Tables I to V.

The means and standard deviations of the measurements were: sagittal section cerebellum superior inferior length, 56.21±5.16 mm; sagittal section cerebellum anteroposterior length, 86.36 ±5.36 mm; axial section cerebellum antereoposterior length, 66.53±5.41 mm; axial

section bi-cerebellar length, 100.48±5.14 mm; coronal section cerebellum supero-inferior length, 53.60±3.84 mm; coronal section bi-cerebellar length, 99.77±6.24 mm in subjects with migraine, whereas the corresponding values were 62.33±8.66 mm; 93.31±9.89 mm; 60.26±7.98 mm; 99.89±6.41 mm; 54.35±4.64 mm; 85.58±14.74 mm in subjects with vertigo, respectively. The same values were found as 58.82±8.34 mm; 86.74±13.22 mm; 58.93±8.89 mm; 97.93±6.07 mm; 50.66±4.92 mm; 84.96±14.93 mm in patients having dementia, respectively, while the same measurements were as 60.83±8.59 mm; 92.18±9.12 mm; 57.76±7.85 mm; 97.71±5.82 mm; 52.48±4.85 mm; 81.49±14.38 mm in ataxia patients, respectively (Table I). Also, there were found significant difference in all measurements ($p<0.05$) and the significance were evaluated between all diseases (i.e; migraine and vertigo; mgraine and dementia; migraine and ataxia; vertigo and demantia; vertigo and ataxia; dementia and ataxia) (Table II). Moreover, the cerebellum linear measurements of subjects having migraine, vertigo, dementia and ataxia in axial, coronal and sagittal section according to sex were given in Table III. Furthermore, the cerebellum linear measurements and Post Hoc test results of subjects having migraine, vertigo, dementia and ataxia in axial, coronal and sagittal section according to age groups were shown in Tables IV and V. According to these results; the significance was found between decades ($p<0.05$).

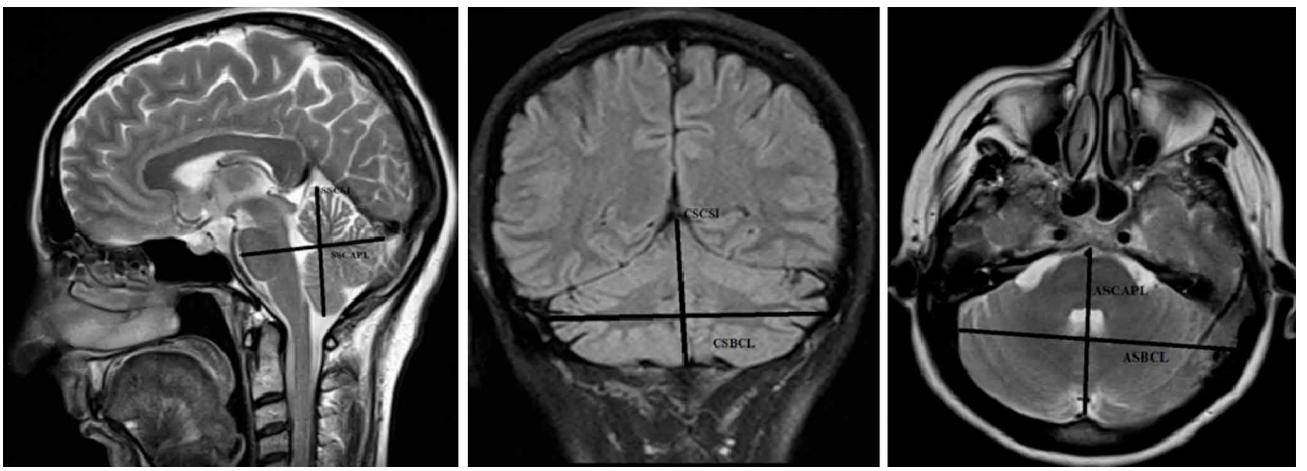

Fig. 1. Demonstration of the maxium diameters of posterior fossa measurements on MRI and the cerebellum superior inferior and anterior posterior lengths on sagittal section, the bi-cerebellar length and cerebellum anterior posterior lengths on coronal and axial section.

Table I. Cerebellum linear measurements of subjects having migraine, vertigo, dementia and ataxia in axial, coronal and sagittal images.

Measurements	Subjects with migraine (n=80)				Subjects with vertigo (n=85)				Subjects with dementia (n=83)				Subjects with ataxia (n=78)			
	Mean	SD	Min.	Max.	Mean	SD	Min.	Max.	Mean	SD	Min.	Max.	Mean	SD	Min.	Max.
SSCSI	56.21	5.16	48.00	84.90	62.33	8.66	45.70	77.00	58.82	8.34	43.90	76.30	60.83	8.59	41.90	75.00
SSCAPL	86.36	5.36	78.00	114.90	93.31	9.89	75.70	111.00	86.74	13.22	49.00	108.20	92.18	9.12	71.90	110.00
ASCAPL	66.53	5.41	50.00	83.80	60.26	7.98	46.00	81.80	58.93	8.89	44.00	78.50	57.76	7.85	44.00	72.00
ASBCL	100.48	5.14	89.00	111.00	99.89	6.41	81.30	112.00	97.93	6.07	86.80	115.00	97.71	5.82	84.10	108.00
CSCSI	53.60	3.84	43.20	61.00	54.35	4.64	43.00	69.00	50.66	4.92	39.90	61.00	52.48	4.85	39.50	66.00
CSBCL	99.77	6.24	67.00	112.00	85.58	14.74	64.00	111.00	84.96	14.93	61.00	115.00	81.49	14.38	62.00	107.50

SD: Standard deviation: Min.: Minimum; Max.: Maximum; SSCSI: Supero-inferior length of cerebellum on sagittal section; SSCAPL: Anteroposterior length of cerebellum on sagittal section; ASCAPL: Anteroposterior length of cerebellum on axial section; ASBCL: Bi-cerebellar length of cerebellum on axial section; CSCSI: Supero-inferior length on coronal section; CSBCL: Bi-cerebellar diameter of cerebellum on coronal section

Table II. Post Hoc Test of the Cerebellum linear measurements of subjects having migraine, vertigo, dementia and ataxia.

Measurements	P value (between all diseases)	Migraine - Vertigo	Migraine –Dementia	Migraine - Ataxia	Vertigo-Dementia	Vertigo-Ataxia	Dementia-Ataxia
	<0.001	<0.001	0.035	<0.001	0.004	0.223	0.105
SSCSI	<0.001	<0.001	<0.804	<0.001	<0.001	0.466	0.001
SSCAPL	<0.001	<0.001	<0.001	0.001	0.264	0.038	0.330
ASCAPL	0.004	0.519	0.006	0.003	0.032	0.019	0.807
ASBCL	<0.001	0.294	<0.001	0.126	<0.001	0.010	0.012
CSCSI	<0.001	<0.001	<0.001	<0.001	0.758	0.048	0.095

SSCSI: Supero-inferior length of cerebellum on sagittal section; SSCAPL: Anteroposterior length of cerebellum on sagittal section; ASCAPL: Anteroposterior length of cerebellum on axial section; ASBCL: Bi-cerebellar length of cerebellum on axial section; CSCSI: Supero-inferior length on coronal section; CSBCL: Bi-cerebellar diameter of cerebellum on coronal section; p value: Significance level.

Table III. Cerebellum linear measurements of subjects having migraine, vertigo, dementia and ataxia in axial, coronal and sagittal section according to sex.

Measurements	Sex	Migraine (n=80; males, 25; females 55)		Vertigo (n=85; males, 38; females, 47)		Dementia (n=83; males, 45; females, 38)		Ataxia (n=78; males, 42; females, 36)	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD
SSCSI	Males	57.74	4.34	62.72	7.01	58.96	8.09	61.75	8.37
	Females	55.52	5.39	62.01	9.85	58.64	8.74	59.75	8.84
	P value	0.074		0.707		0.863		0.308	
SSCAPL	Males	87.42	3.81	94.02	8.76	86.24	11.58	93.54	9.04
	Females	85.87	5.90	92.72	10.77	88.96	14.89	90.58	9.08
	P value	0.233		0.550		0.262		0.155	
ASCAPL	Males	66.92	7.27	61.64	7.85	60.55	8.86	55.87	7.35
	Females	66.35	4.39	59.13	7.99	57.02	8.66	57.62	8.50
	P value	0.661		0.150		0.072		0.890	
ASBCL	Males	103.82	5.61	101.19	6.22	99.96	6.54	99.74	5.00
	Females	98.96	4.14	98.83	6.43	95.54	4.47	95.33	5.87
	P value	<0.001		0.091		0.001		0.001	
CSCSI	Males	54.68	3.98	55.28	3.87	51.52	5.21	53.16	5.10
	Females	53.10	3.70	53.59	5.09	49.64	4.40	51.68	4.47
	P value	0.087		0.095		0.083		0.179	
CSBCL	Males	102.29	8.73	86.33	16.52	84.91	15.11	82.74	15.38
	Females	98.62	4.32	84.97	13.28	80.27	13.46	80.02	13.19
	P value	0.014		0.675		0.008		0.409	

SD: Standard deviation; SSCSI: Supero-inferior length of cerebellum on sagittal section; SSCAPL: Anteroposterior length of cerebellum on sagittal section; ASCAPL: Anteroposterior length of cerebellum on axial section; ASBCL: Bi-cerebellar length of cerebellum on axial section; CSCSI: Supero-inferior length on coronal section; CSBCL: Bi-cerebellar diameter of cerebellum on coronal section

Table IV. The determination of the cerebellum linear measurements of subjects having migraine, vertigo, dementia and ataxia in axial, coronal and sagittal section according to age groups.

Measurements	P value	Decade 1 (n=42)	Decade 2 (n=57)	Decade 3 (n=36)	Decade 4 (n=36)	Decade 5 (n=71)	Decade 6 (n=61)	Decade 7 (n=23)
SSCSI	<0.001	59.10±6.11 (50.00-75.40)	59.94±8.17 (49.00-77.00)	62.58±7.76 (50.50-75.00)	61.00±8.13 (46.60-75.00)	60.42±8.65 (46.20-84.90)	58.71±8.53 (41.90-76.30)	52.30±4.67 (43.90-58.30)
SSCAPL	0.010	89.75±7.11 (80.00-108.20)	89.08±9.65 (50.00-108.50)	93.52±8.99 (80.50-107.30)	89.48±13.34 (49.00-106.00)	90.81±10.49 (52.00-114.90)	89.22±11.64 (52.00-110.00)	82.77±4.76 (73.90-89.00)
ASCAPL	<0.001	66.68±6.02 (50.00-83.80)	63.33±6.54 (50.00-78.00)	61.45±8.15 (50.00-78.50)	57.52±9.36 (45.00-78.40)	58.24±7.83 (44.00-74.80)	58.36±8.83 (44.00-81.80)	63.14±7.17 (46.00-73.50)
ASBCL	<0.001	102.58±6.08 (88.30-115.00)	101.06±4.79 (90.00-112.00)	101.06±5.21 (89.10-109.10)	96.75±5.56 (86.80-106.00)	97.65±5.01 (88.00-110.90)	96.85±6.11 (82.00-108.00)	97.70±7.52 (81.30-113.00)
CSCSI	<0.001	55.23±3.36 (48.00-61.00)	55.09±4.22 (48.00-69.00)	54.34±4.35 (45.00-61.00)	51.76±4.46 (42.40-59.00)	52.34±4.11 (43.00-61.00)	50.69±5.09 (39.50-66.00)	48.57±4.67 (39.90-55.60)
CSBCL	<0.001	98.30±11.07 (67.00-115.00)	92.87±14.40 (64.00-112.00)	85.44±16.09 (61.00-110.00)	81.06±13.75 (63.00-106.00)	85.01±13.32 (64.00-109.00)	81.80±14.26 (62.00-107.50)	96.58±9.05 (69.00-110.80)

DISCUSSION

In present study, the means of axial anteroposterior and bi-cerebellar diameter in cerebellum were measured as 66.53±5.41 mm and 100.48±5.14 mm in migraine subjects. The same measurements were 60.26±7.98 mm and

Table V. Post Hoc Test of the cerebellum linear measurements of patients having migraine, vertigo, dementia and ataxia in axial, coronal and sagittal section according to age groups.

Measurements and Decades	SSCSI	SSCAPL	ASCAP	ASBCU	CCCSI	CCBCU
Decade 1-Decade 2	0.600	0.744	0.036	0.182	0.879	0.050
Decade 1-Decade3	0.052	0.102	0.003	0.233	0.370	<0.001
Decade1-Decade 4	0.288	0.906	<0.001	<0.001	0.001	<0.001
Decade 1-Decade 5	0.389	0.589	<0.001	<0.001	0.001	<0.001
Decade 1-Decade 6	0.808	0.793	<0.001	<0.001	<0.001	<0.001
Decade 1-Decade 7	0.001	0.008	0.081	0.001	<0.001	0.626
Decade 2-Decade 3	0.115	0.040	0.256	0.999	0.417	0.011
Decade 2-Decade 4	0.527	0.853	0.001	<0.001	<0.001	<0.001
Decade 2-Decade 5	0.730	0.335	<0.001	0.001	<0.001	0.001
Decade 2-Decade 6	0.400	0.940	0.001	<0.001	<0.001	<0.001
Decade 2-Decade 7	<0.001	0.012	0.918	0.016	<0.001	0.270
Decade 3-Decade 4	0.393	0.091	0.033	0.001	0.012	0.172
Decade 3-Decade 5	0.180	0.192	0.045	0.003	0.026	0.876
Decade 3-Decade 6	0.020	0.044	0.060	<0.001	<0.001	0.202
Decade 3-Decade 7	<0.001	<0.001	0.418	0.026	<0.001	0.002
Decade 4-Decade 5	0.720	0.518	0.649	0.434	0.511	0.156
Decade 4-Decade 6	0.168	0.903	0.608	0.934	0.243	0.796
Decade 4-Decade 7	<0.001	0.014	0.007	0.530	0.006	<0.001
Decade 5-Decade 6	0.215	0.366	0.933	0.414	0.030	0.176
Decade 5-Decade 7	<0.001	0.001	0.009	0.975	<0.001	<0.001
Decade 6-Decade 7	<0.001	0.010	0.013	0.539	0.047	<0.001

SSCSI: Supero-inferior length of cerebellum on sagittal section; SSCAPL: Anteroposterior length of cerebellum on sagittal section; ASCAPL: Anteroposterior length of cerebellum on axial section; ASBCL: Bi-cerebellar length of cerebellum on axial section; CSCSI: Supero-inferior length on coronal section; CSBCL: Bi-cerebellar diameter of cerebellum on coronal section

99.89±6.41 mm in subjects having vertigo; 58.93±8.89 mm and 97.93±6.07 mm in subjects with dementia; and 57.76±7.85 mm and 97.71±5.82 mm in ataxia subjects, respectively. A significant difference was found between migraine and vertigo; migraine and dementia; migraine and ataxia in ASCAPL measurements ($p<0.05$). A significant difference was in ASBCD between migraine and dementia; migraine and ataxia; vertigo and dementia; and vertigo and ataxia ($p<0.05$). Both of axial anteroposterior and bi-cerebellar diameter measurements were higher in subjects having migraine than subjects having vertigo, dementia and ataxia. In a study with 12 symptomatic Chiari Malformation Type 1 patients and 24 healthy control subjects performed by Hwang *et al*. (2013) the mean lengths of axial antero-posterior aspect and bicerebellar diameter in cerebellum were found as 32.01 mm and 50.30 mm and 86.93 mm and 98.83 mm in CMI group and healthy Korea subjects, respectively. In this study both of measurement were lower in CMI groups than healthy control subjects (Hwang *et al*., 2013). The coronal supero-inferior diameter and bi-cerebellar diameter in cerebellum were reported as 58.02 mm and 52.30 mm ($p<0.05$); and 103.29 mm and 100.36 mm ($p>0.05$) in subjects with CMI and healthy subjects, respectively. The means of sagittal supero-inferior aspect and anteroposterior diameter in cerebellum were reported as 61.51 mm and 53.89 mm; and 35.62 mm and 49.21 in CMI group and healthy subjects, respectively (Hwang *et al*., 2013). In present study, the means of coronal supero-inferior diameter and bi-cerebellar diameter were found as 53.60±3.84mm and 99.77±6.24 mm in subjects with migraine; 54.35±4.64mm and 85.58±14.74mm in vertigo patients; and 50.66±4.92mm and 84.96±14.93mm in dementia subjects; and 52.48±4.85 mm and 81.49±14.38mm in subjects having ataxia, respectively. The means of sagittal supero-inferior aspect and anteroposterior diameter in cerebellum were 56.21±5.36mm and 86.36±5.36mm in subjects with migraine; 62.33±8.66 mm and 93.31±9.89 mm in subjects with vertigo; 58.82±8.34 mm and 86.74±13.22 mm in dementia patients; and 60.83±8.59 mm and 92.18±9.12 mm in ataxia patients, respectively.

No age related differences were noticed in measurements including the axial bi-cerebellar diameter, cerebellum supero-inferior length and cerebellar vermis anteroposterior diameter on sagittal view ($p>0.05$). Also, the axial bi-cerebellar diameter and vermis of cerebellum anteroposterior diameter were smaller in females than in Sudanese healthy males, whereas the cerebellum supero-inferior length was longer in Sudanese healthy females than in Sudanese healthy males. Additionally, the cerebellum hemisphere maximum width was affected significantly by sex ($p=0.040$) while the cerebellum height ($p=0.705$) and AP vermian width ($p=0.330$) were not significantly correlated with sex (Ahmed *et al*., 2017). In present study, age related diffences were found in all cerebellum measurements including coronal, axial and sagittal view ($p<0.05$). Also, the lowest values of both cerebellum measurements on sagittal view were obtained in decade 7 (age 70 and higher), whereas the highest values of the same measurements were in decade 3 (between 40 and 49 years). The anteroposterior length and bi-cerebllar diameter measurements on axial view were lower in decade 4. Also, the values of cerebellum supero-inferior length on coronal view was highest in decade 1 (18-29 years), while the lowest value was obtained in decade 7 (70 ages above). Additionally, the bi-cerebellar diameter on coronal section was highest in decade 1, the lowest value was in decade 4 (Table III).

The cerebellum is one of the most important structures and responsible for coordinating the sensory and motor input from the brain to spinal cord properly. It directly effects the motor neurons of the braimstem and cortex. Cerebellar lesions have clinical problems such as ataxia, vertigo, eye movement disorders (Blumenfeld *et al*., 2002; Tumeh *et al*., 2007). It was known that the relationship between cerebellar atrophy and neuropsychiatric symptoms. Also, the cerebellum was known to be involved in such diseases as autism, fragile X-syndrome, alcoholism, and ataxia (Koller *et al*., 1981; Ramos *et al*., 1987; Torvik *et al*., 1987; Courchesne *et al*., 1988; Murakami *et al*., 1989). Many studies examined the effect of age on the cerebellum reported that cerebellar volume decreases with age (Sawle *et al*., 1990; Escalona *et al*., 1991; Raz *et al*., 1998; Jernigan *et al*., 2001; Walhoyd *et al*., 2005). In a study examined with normal healthy subjects aged between 30 to 99 years, studied with MRI by Jernigan *et al*. (2001) study, age related loses in the hippocampus happen earlier than in gray matter loses of brain. Also, increase in white matter signal hyperintensity takes place. After, occuring loss of cerebral and cerebellar white matter is present in elderly healthy subjects. Walhovd *et al*. (2005) examined the effect of age across 16 automatic segmented brain volumes in 73 healthy subjects aged between 20 and 88 years. Also, significant age effects were found for all volumes except pallidum and the 4th ventricle (Walhoyd *et al*.,2005). In Escalona *et al*. (1991) study performed with 37 healthy subjects (females, 21; males, 16) aged between 24-79 years, results in the study of cerebellar volumes showed that males had a significantly larger cerebellar volume than females and age was not a significant predictor of cerebellar volume Age related changes also remained speculative.

In a study examined to determine the effects of age and sex on the size of the cerebellar hemispheres, the cerebellar vermis, and the pons in 146 healthy adults, 18 to 77 years by Raz *et al*. (1998) a significant age-related decrease in the volume of the hemisphere of cerebellum and in the total area of the vermis of cerebellum was found. Also, the areas of lobules VI and VII and of the posterior vermian lobules (VIII–X) decreased significantly with age, whereas the anterior vermis (I–V) showed no significant age-related reduction. The hemisphere of cerebellum volume and anterior vermis area were larger in male (Raz *et al.*, 1998; Rapoport *et al.*, 2000). With aging, a decrease in Purkinje cell layer and dorsal vermis region was found and the functions performed by cerebellum could be affected to some extent (Rapoport *et al*., 2000). Cerebellar diseases can be localized by their clinical features. Lesions in flocculonodular lobe are seen to cause disequilibrium with ataxic gait, a wide based stance, and nystagmus; lesions in anterior lobes are seen to cause impaired gait and abnormal coordinates movements of the lower limbs; lesions of the lateral posterior lobes are associated with hypotonia, dysmetria, dysarthric speech and dysdiadochokinesia (Ghez & Fahn, 1985; Rapoport, 2000).

When the studies about cerebellum were investigated, the research related the impact of age, sex and diseases on the cerebellum measurements are few and it was declared that there was a need for normative data (Hwang *et al*., 2013; Ahmed *et al*., 2017). In a study of Ahmed *et al*. (2017) performed with Sudanese population, there was no reduction or changing with age. Also, it was reported the observed patterns of discrepancy to aging were follows as;

1. The histologic findings of the aging cerebellum are presence of atrophy, as purkinje cells' age related decrease is evenly divided from vermian lobules and the hemisphere of cerebellum. The aging and many diseases are the most crucial reason of the changes of cerebellar lobules (VI-VII) (Ellis *et al*., 1920; Courchesne *et al*., 1987; Ciesielski *et al.*, 1994; Raz *et al*.,1998).

2. There are two different opinions: An association can be between blood supply and aged related changes (Baloh

et al., 1984) or the significant age related reduction in blood flow, oxygen consumption, and glucose metabolism is no found in cerebellum (Kushner *et al.*, 1987; Raz *et al.*, 1998).

The aims of this study were to qualify the cerebellum by measuring the linear measurements of cerebellum on axial, coronal and sagittal view, using MRI, as well as to determine the impact of age and sex on the measurements of migraine, vertigo, dementia and ataxia subjects. Knowledge on the neuroanatomic measurements including cerebellum, cerebrum, brainstem etc. may be essential for understanding pathologic changes. The results of the present study provide an important reference data of cerebellum in both healthy Turkish subjects and diseases regarding cerebellum such as vertigo, demantia and ataxia. Also, many diseases progress with cerebellar atrophy and hypoplasia. Cerebellum dimensions measurements for assessment of changes in cerebellum size will be of considerable use in clinical practice and appropriate for measurement value standardization, and form the reference and normative data. We think that this will allow easier interpretetation of findings, together with more accurate diagnosis or a decrease in delays caused by false diagnosis. In conclusion, this is the first study considering cerebellum lengths of subjects having migraine, ataxia, dementia and vertigo according to age related changes and sex differences. Our study give important knowledge and reference data related posterior cranial fossa measurements in terms of clinical. These presented findings which includes the age and sex related normal values changes will provide an evaluation opportunity to data regarding age and sex related cerebellum gross morphometry studies and will shed light on patients with migraine, ataxia, dementia and vertigo and in aging process.

ÖKSÜZLER, M.; ÖKSÜZLER,Y.; TUNÇ, M.; POLAT, S.; VURALLI, D. & GÖKER, P . Evaluación morfométrica macroscópicas del cerebelo en sujetos con migraña, ataxia, demencia y vértigo. *Int. J. Morphol., 40(4)*:1067-1074, 2022.

RESUMEN: Este trabajo tuvo como objetivo determinar las medidas morfométricas del cerebelo mediante resonancia magnética en sujetos con migraña, ataxia, demencia y vértigo. Trescientos veintiseis sujetos (80 con migraña; 85 con vértigo; 83 con demencia y 78 con ataxia) entre los 20 y los 85 años de edad se incluyeron en este estudio. Se tomaron medidas morfométricas del cerebelo de sujetos sometidos a resonancia magnética en el Departamento de Radiología. Las medias y desviaciones estándar de las medidas fueron: sección sagital longitud superoinferior del cerebelo, 56,21±5,16 mm; sección sagital longitud anteroposterior del cerebelo, 86,36 ±5,36 mm; sección axial longitud anteroposterior del cerebelo, 66,53±5,41 mm; sección axial longitud bicerebelosa, 100,48±5,14 mm; sección coronal longitud superoinferior del cerebelo, 53,60±3,84 mm; longitud bicerebelosa de la sección coronal, 99,77±6,24 mm en sujetos con migraña, mientras que los valores correspondientes fueron 62,33±8,66 mm; 93,31±9,89mm; 60,26±7,98 mm; 99,89±6,41 mm; 54,35±4,64 mm; 85,58±14,74 mm en sujetos con vértigo, respectivamente. Se encontraron los mismos valores para pacientes con demencia 58,82±8,34 mm; 86,74±13,22 mm; 58,93±8,89 mm; 97,93±6,07 mm; 50,66±4,92 mm; 84,96±14,93 mm , respectivamente, mientras que las mismas medidas fueron de 60,83±8,59 mm; 92,18±9,12 mm; 57,76±7,85 mm; 97,71±5,82 mm; 52,48±4,85 mm; 81,49±14,38 mm en pacientes con ataxia, respectivamente. Las edades se dividieron en siete grupos, cada uno en década. Se encontraron diferencias significativas en todos los parámetros según sexo y edad ($p<0,05$). La morfometría del cerebelo proporciona un conocimiento importante y útil en términos de comparación de anormalidades clínicas y los datos serán valiosos para la determinación de patologías para las disciplinas clínicas.

PALABRAS CLAVE: Diferencias de edad y sexo; Morfometría del cerebelo; Longitud del cerebelo.

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Corresponding author:
Research Assistant Mahmut Tunç
Department of Anatomy
Adana
TURKEY

E-mail: fzt.mtunc@gmail.com

Mahmut Öksüzler	Orcid ID:0000-0002-3730-5487
Yasemin Öksüzler	Orcid ID:0000-0002-1789-9628
Mahmut Tunç	Orcid ID:0000-0003-1373-4700
Sema Polatb	Orcid ID:0000-0001-7330-4919
Duygu Vuralli	Orcid ID:0000-0002-8213-6387
Pınar Göker	Orcid ID:0000-0002-0015-3010