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COMPRESSION OF VARIOUS PARTS OF CEREBELLUM ON HEALTHY PEOPLE BY MRI

Rajaei F[1], Roshankhah Sh[2], Jalili C[3], Salahshoor MR[4]*

1. ***Department of Anatomy, Faculty of Medicine, Qazvin University of Medical Sciences, Qazvin, Iran.***

2.3.4. Department of Anatomical Sciences, Medical School, Kermanshah University of Medical Sciences, Kermanshah, Iran.

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ABSTRACT

Background: The appearance of magnetic Resonance Imaging (MRI) method has made it possible to reply neither many questions in the field of neuroanatomy more precisely while detecting altered anatomic parts of living persons at different ages. The present study was conducted to determine and record the dimensions of various parts of the cerebellum and also to compare the values obtained for dimensions with age and sex by MRI.
Methods: The precondition for people to enter the study was the absence of any pathological lesion in brain on the basis of images obtained by MRI. The dimensions of target parts were calculated by the MRI-associated measuring system and recorded along with the age and sex of the patients. Measurements were recorded in mm based on selecting the largest size of the organ during the examination of axial, sagital, and coronal view. Results: All parts except the length of pyramid and the height of vermis are bigger in men than in women ($P<0.05$). More parts of the cerebellum in men were showing of having a significant correlation ($P<0.05$) with age changes compared with women and each part followed a specific pattern in accordance with age changes. Conclusion: More parts of cerebellum are bigger in men than in women and more correlation with age changes in men compared with women.

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Introduction

In the field of anatomy, mainly neuroanatomy, morphometric studies on many parts of the body are still not presented and this perhaps has been associated with the lack or unavailability of such equipment's to previous researchers (1). Existing data in neuroanatomy books regarding the size of different parts of the brain is restricted to major parts and usually one dimensional and little data on details of different dimensions is accessible (2 and 3). With the beginning of MRI and the possibility of creating precise images from human brain at different planes, it is now possible to answer many indistinct questions associated with the effect of several factors such as sex and age on human brain (4). As the earlier morphometric studies were performed on cadaver through open brain surgeries and because of postmortem changes particularly atrophy, and also inaccessibility to many parts of the brain in three dimensional form in a living individual, it is necessary the current information gained from a living and healthy person using new technique to be compared with previously recorded cases (5). Hence, in present study effort has been made to study different dimensions of some parts of the cerebellum in more details. This leads to generation of information associated with the size of these parts and further comparison of these values with sex and age will give rise to results which can help broadening the horizon of the science of anatomy. Since many pathologic cases, syndromes, toxic agents, and drugs can cause deviations in size of these parts (6, 7 and 8). The present study could be helpful in recognizing the racial difference regarding the size of target parts, difference in size of cerebellum in living and dead humans and finally, determining the size of different parts of cerebellum in accordance with sex and age. Previous works has mainly focused on the volume of cerebellum without reference to dimensions of various parts of this organ and only concentrated on the volume of some parts

Corresponding Author: Mohammad Reza Salahshoor, Department of Anatomical Sciences, Medical School, Kermanshah University of Medical Sciences, Kermanshah, Iran, email: reza.salahshoor@yahoo.com

of the cerebellum in men and women at different ages (9, 10, 11, 12 and 13). The sizes of various parts of pons in accordance with age and sex were reported following morphometric study by MRI (14). However there are no data on sizes of various parts of cerebellum in accordance with age and sex so far, and therefore, it seems that morphometric studies on possible relationship between dimensions of different parts of cerebellum and age and sex of individuals to be essential in revealing such information.

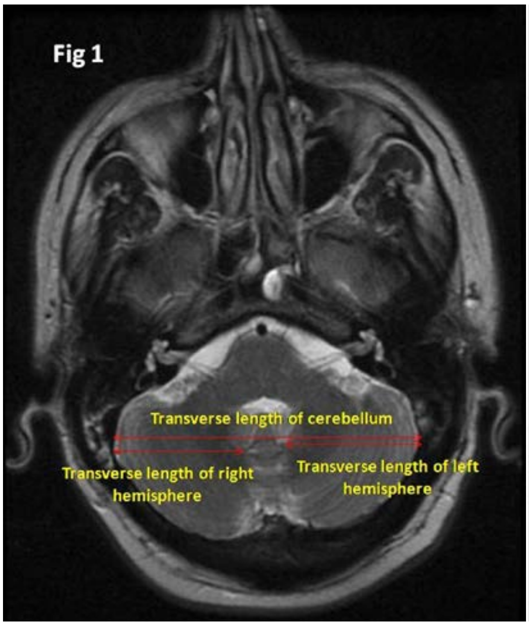
Materials and Methods

This was an experimental study carried out on 300 healthy persons including 124 males (41.3%) and 176 females (58.7%) aged between 1-100 years referred to MRI center at Imam Reza hospital in Kermanshah (Iran). The patients were divided into 9 groups based on their ages (table 1).

Table 1. Distribution of study groups based on age

Age groups (year)	1-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-100
Number	20	34	42	62	52	34	27	24	5
Percentage	6.7	11.3	14	20.7	17.3	11.3	9	8	1.7

Questionnaires were used to accumulate data from patients with requests for brain MRI. The data including sex, age, history of previous diseases particularly mental and nervous diseases, history of brain trauma, congenital diseases and syndromes. History of cardiovascular diseases especially chronic hypertension, and also the history of alcohol consumption were recorded. However, only the patients with no history of any type of diseases and with normal state of health were included in our study. After wearing special imaging cover and checking persons with metal detector to prevent artifact and occurrence of probable danger for the patients and also the instrument, the patient was placed in a supine position while the subject's chin was as close as possible to the chest and the Orbito Metal Base Line (OMBL) in a position perpendicular to bed surface. This is of prime importance to make similar investigations in different people. A head phone was placed on patient's ears to prevent the nervousness due to ultrasonic sound produced inside the equipment tunnel. Using laser lights, the patients' heads were fixed in a straight position, as a little rotation in head could decrease the accuracy of morphometric studies (14 and 15). After positioning a coil (a device to receive and boost the signals) on patient' head, the subjects were transferred into the MRI tunnel and imaging process performed. The MRI instrument used in our study was a Phillips product (Netherlands), version 2009, with an intensity of 2 Tessla, a 20-inch LCD monitor, 0.7 mm GAP, and 4mm thickness at posterior cavity. Following imaging process, morphometric studies were carried out using images with no rotation and artifacts chosen based on information obtained through questionnaires and also the report of MRI specialist on health state of brain for every patient. At next stage, following the preparation of various coronals, sagital, and axial sections, the best T1 views, based on documented researches were chosen for anatomical studies (16 and 17). Proper magnification, contrast, and density were used to increase the accuracy of measurements and also to clearly mark the edges of images (18). Using the instrument measuring system and also marking the image edges at two different points, the dimensions were measured in mm (Figure 1 and 2).



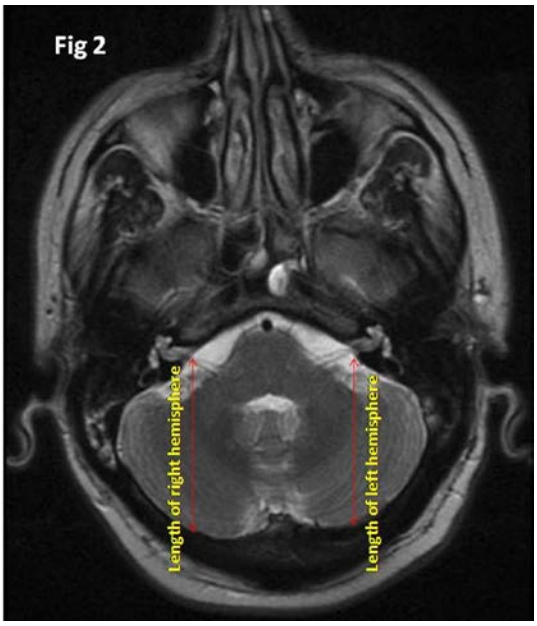


Figure. 1and 2. The axial (T1) view for measurement of the transverse length of right and left hemisphere of cerebellum, the transverse length of cerebellum (figure 1), the length of right and left hemisphere (figure 2).

Regarding the lack of symmetry and regular geometric shape in parts under study, measurements were performed at different directions and the largest value was taken as the real length (Figure 3).

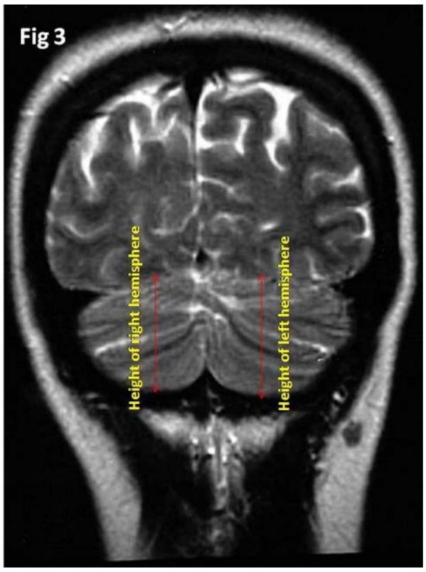


Figure.3. The coronal (T1) view for measurement of the height of right and left hemisphere of cerebellum.

Repeating this protocol on other sections gave rise in generation of values, among those, the largest ones were adopted as real length, width, and height for the organ under investigation. Efforts were made to perform the same type of study on different individuals using clear anatomical sections such as midsagital ones particularly in morphometric studies of vermis (Figure 4 and 5)

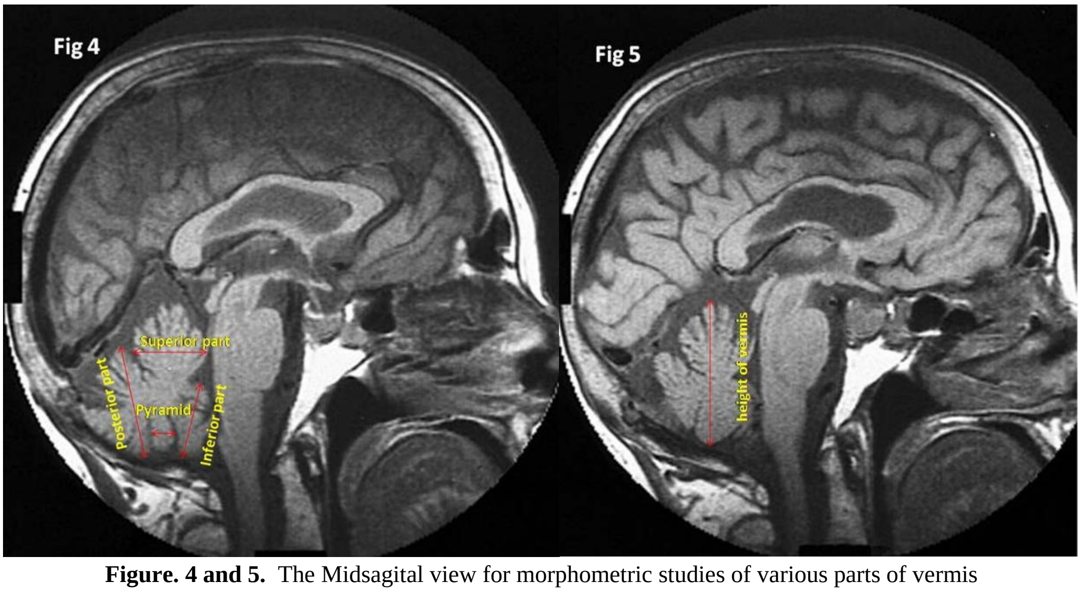


Figure. 4 and 5. The Midsagital view for morphometric studies of various parts of vermis

Considering all preconditions, the patient was allowed to be included in our study. Thus, out of 550 patients, 300 cases meeting all the requirements were included in our study. Regarding the ethical considerations, special codes were used instead of real names when filling questionnaires or studying MRI images. Moreover, all patients provided the study group with individually signed consensus forms while no obligation or extra payments were imposed.

Statistical analysis: Statistical analyses were performed by using t test, Pearson's correlation coefficient and regression. Differences between groups with P value of 0.05 or less to be considered as significant.

Results

Following the necessary investigations on study groups, the dimensions of different parts were obtained in millimeter. The size of various parts in different age groups is offered in table 2 and 3.

The data showed that, except for the height of posterior part of vermis and the length of pyramid, in other cases the dimensions of different parts of the cerebellum in men were significantly bigger than those in women (P<0.05). As seen in table 2, the dimensions of different parts of the cerebellum studied in our experiment showed a significant change in many parts of the cerebellum in men based on age increase. This change followed a particular pattern, so that the height of vermis increased in people between1-50 and decreased by age increase. The length of the right and left hemispheres of cerebellum improved in people between1-30 and then remained unchanged till 80 and decreased afterwards. The height of the right and left hemispheres of cerebellum increased in person's between1-20 and then remained unchanged till 30 and decreased between 31-50 and again increased in age group 51-60 and finally decreased by age increase. The pyramid length of vermis increased in people between 1-20, decreased till 30, unchanged towards 70 and decreased later. The length of superior part of vermis increased till 20 and then decreased afterwards. The relationship between age and size of different parts of cerebellum was investigated using the Pearson's correlation coefficient and regression.

Table 2. Dimensions of different parts in cerebellum based on gender and age groups (data in brackets stand for standard deviation).

variables	Age / Sex	1-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-100
LRCH	**M**	**56 (1.414)**	**62.07 (1.223)**	**63.73 (1.944)**	**63.42 (0.929)**	**63.17 (1.200)**	**63.07 (1.710)**	**63.29 (1.437)**	**62 (1.225)**	**62**
	F	**57.73 (1.191)**	**60 (0.882)**	**61.81 (1.331)**	**61.13 (1.018)**	**61.26 (1.746)**	**61.53 (0.964)**	**61.54 (0.877)**	**61.73 (0.905)**	**61 (1.414)**
LLCH	**M**	**56.22 (1.563)**	**62.27 (1.280)**	**64 (1.773)**	**63.42 (1.018)**	**63.22 (1.060)**	**63.07 (1.710)**	**63.26 (1.326)**	**62.92 (1.188)**	**62**
	F	**58.27 (1.348)**	**60.26 (0.733)**	**61.93 (1.269)**	**61.55 (1.058)**	**61.44 (1.353)**	**61.53 (0.905)**	**61.69 (0.751)**	**61.64 (0.924)**	**60.75 (1.500)**
HCV	**M**	**38.78 (1.922)**	**44.73 (1.438)**	**44.53 (1.060)**	**44.42 (1.666)**	**46.61 (2.682)**	**44.33 (2.469)**	**44.21 (1.626)**	**40.46 (2.602)**	**39**
	F	**42 (2.646)**	**42.58 (1.017)**	**43.11 (1.717)**	**43.29 (2.065)**	**43.12 (1.871)**	**43 (1.795)**	**41 (1.472)**	**40.27 (1.272)**	**39.5 (1.00)**
LSV	**M**	**23.56 (0.882)**	**27.07 (1.223)**	**26.93 (0.961)**	**25.92 (1.472)**	**25.94 (2.155)**	**26.07 (0.884)**	**25.71 (1.684)**	**25.69 (1.251)**	**23**
	F	**24.64 (0.896)**	**26.26 (0.653)**	**25.93 (1.072)**	**25.55 (1.155)**	**25.62 (1.326)**	**25.05 (0.621)**	**24.85 (0.987)**	**23.64 (1.027)**	**22.5 (0.577)**
HPV	**M**	**19.67 (1.936)**	**21.53 (1.407)**	**23.4 (1.920)**	**22.5 (1.769)**	**22.61 (2.593)**	**22.53 (1.356)**	**22 (1.519)**	**21.08 (1.498)**	**18**
	F	**23.09 (0.539)**	**22.16 (0.688)**	**21.59 (1.866)**	**21.61 (1.264)**	**21.59 (2.032)**	**21.32 (1.336)**	**21 (1.354)**	**21.18 (0.603)**	**22 (1.155)**
LP	**M**	**7.67 (0.707)**	**10.53 (0.640)**	**9 (1.195)**	**10 (1.383)**	**9.50 (1.20)**	**9.20 (1.014)**	**10 (0.961)**	**7.23 (0.927)**	**10**
	F	**8.45 (0.522)**	**9.471 (0.964)**	**8.96 (0.808)**	**9.34 (1.122)**	**9.47 (0.961)**	**9 (0.667)**	**8.54 (0.519)**	**8.09 (1.044)**	**7.75 (0.957)**
TLRCH	**M**	**49 (1.732)**	**50.93 (1.163)**	**51.27 (1.387)**	**50.29 (1.30)**	**50.28 (0.826)**	**50.07 (1.100)**	**50.07 (1.207)**	**49.62 (1.044)**	**48**

	F	**45.27 (2.054)**	**49.05 (1.079)**	**49.15 (1.292)**	**49.24 (1.261)**	**48.62 (1.303)**	**48.21 (0.713)**	**48.08 (0.760)**	**48.36 (0.809)**	**47.5 (1.00)**
TLLCH	**M**	**49.22 (1.202)**	**51.33 (1.234)**	**51.27 (1.280)**	**50.42 (1.316)**	**50.11 (1.079)**	**50.13 (0.990)**	**50.07 (0.997)**	**49.38 (1.044)**	**49**
	F	**45.27 (2.149)**	**48.74 (0.933)**	**49.19 (1.241)**	**49.05 (1.229)**	**48.24 (1.046)**	**48.11 (0.658)**	**48 (0.707)**	**48.73 (0.905)**	**48.25 (1.500)**
TLC	**M**	**98.56 (1.810)**	**102.27 (2.052)**	**102.47 (1.885)**	**100.58 (2.394)**	**100.28 (1.776)**	**99.93 (1.534)**	**100.21 (1.718)**	**99.08 (1.847)**	**96**
	F	**90.73 (4.292)**	**98.16 (1.740)**	**98.30 (1.772)**	**98.11 (1.737)**	**97.35 (1.873)**	**96.53 (1.124)**	**96.08 (1.320)**	**96.55 (1.572)**	**95.5 (2.380)**
LIV	**M**	**14.78 (0.972)**	**18.73 (1.163)**	**17.32 (0.90)**	**18 (1.560)**	**19.05 (1.425)**	**19.07 (1.033)**	**17 (1.177)**	**18.15 (0.801)**	**18**
	F	**17 (0.677)**	**17.58 (1.387)**	**18.19 (1.210)**	**17.32 (0.904)**	**17.29 (1.643)**	**17.05 (1.682)**	**16.62 (1.044 0**	**16 (0.894)**	**16.5 (1.00)**
HRCH	**M**	**38.11 (1.054)**	**40.93 (1.033)**	**40.13 (1.356)**	**40.04 (1.967)**	**40.89 (1.676)**	**40.87 (1.303)**	**40.36 (1.151)**	**39.38 (1.850)**	**39**
	F	**37.64 (2.541)**	**39.95 (1.393)**	**40.52 (1.122)**	**39.84 (1.305)**	**38.71 (1.528)**	**40.21 (1.273)**	**36.55 (0.934)**	**36.55 (0.934)**	**35.75 (0.50)**
HLCH	**M**	**37.78 (0.972)**	**40.8 (1.014)**	**40 (1.773)**	**40.04 (1.967)**	**40.78 (1.396)**	**40.60 (1.21)**	**39.38 (1.938)**	**39.38 (1.938)**	**39**
	F	**37.45 (2.207)**	**39.79 (1.653)**	**40.59 (1.01)**	**39.84 (1.128)**	**38.85 (1.726)**	**40.53 (1.073)**	**36.45 (0.934)**	**36.45 (0.934)**	**35.5 (0.577)**

Length of Right Cerebellar Hemisphere = (LRCH)
Length of Left Cerebellar Hemisphere = (LLCH)
Height of Cerebellar Vermis = (HCV)
Length of Superior part of Vermis = (LSV)
Height of posterior part of Vermis = (HPV)
Length of Pyramid = (LP)
Transverse Length of Right Cerebellar Hemisphere = (TLRCH)
Transverse Length of Left Cerebellar Hemisphere = (TLLCH)
Transverse Length of Cerebellum = (TLC)
Length of inferior part of Vermis = (LIV)
Height of Right Cerebellar Hemisphere = (HRCH)
Height of Left Cerebellar Hemisphere = (HLCH)

v

Table 3. Compression of means of different parts in cerebellum based on gender

different parts in cerebellum	Sex	Mean	Standard deviation	P- value
length of right hemisphere	male	.62.60	2.333	0.001
	female	61.03	1.560	
length of left hemisphere	male	62.68	2.283	0.001
	female	61.24	1.410	
height of vermis	male	43.89	2.900	0.001
	female	42.60	2.920	
length of superior part of vermis	male	25.96	1.640	0.01
	female	25.35	1.278	
height of posterior part of vermis	male	22.06	2.023	0.06 (NS)
	female	21.66	1.507	
length of pyramid of vermis	male	9.31	1.450	0.08 (NS)
	female	9.06	1.001	
ransverse length of right hemisphere	male	50.25	1.329	0.001
	female	48.55	1.526	
transverse length of left hemisphere	male	50.33	1.308	0.001
	female	48.43	1.456	
transverse length	male	00.51	2.254	0.001
	female	97.06	2.633	
length of inferior part of vermis	male	18.02	1.684	0.001
	female	17.27	1.362	
height of right hemisphere	male	40.20	1.667	0.001
	female	.14	1.907	
height of left hemisphere	male	40.08	1.675	0.001
	female	.20	1.930	

NS= not significant

The equation of regression line between age and the size of right hemisphere of cerebellum was as follows: The size of right hemisphere of cerebellum=68.61+0.04. It means that according to one year of age increase, a value of 0.04 mm will be added to size of the right hemisphere of cerebellum. Finally, the height of the posterior part of vermis increased till 30, decreased between31-40, unchanged till 60 and later decreased by age increase. Our findings were indicative of the presence of a similarity in terms of association of different parts of cerebellum and age changes among both genders, except for the height of posterior part of vermis in which no significant relationship was found. The correlation and regression coefficients obtained for those parts of the cerebellum showing a significant relationship with age, were as follows: The height of right hemisphere of cerebellum = 39.58 - 0.02 × (age); The length of right hemisphere of cerebellum = 61.68 - 0.02 × (age); The height of left hemisphere of cerebellum = 39.56-0.01 × (age); The length of left hemisphere of cerebellum = 61.83 + 0.03 × (age); The length of superior part of vermis = 25.60 - 0.02 × (age); The length of pyramid of vermis = 9.16-0.01 × (age).

Discussion

The present study which was aimed to morphometrically investigates the cerebellum and evaluating the effects of age and sex on dimensions of cerebellum. Resulted in determination of dimensions of different parts of the cerebellum among both genders and in each age group; a set of information unavailable in current reference anatomical texts so far. Moreover, except for the height of posterior part of vermis and the length of pyramid, our data indicated that other parts of the cerebellum in men were bigger than those in women and the size changes of these parts among both genders showed a particular pattern relate to age increase. Studies by using MRI and a methodology similar to those implemented in present study, on 190 and 20 healthy people to investigate the volume changes of cerebellum based on age and gender, demonstrated that the volume of cerebellum hemispheres in men are bigger in men than those in women, a finding in agreement with the results of the present study (15 and 16). Also, they showed that the volume of the superior part of vermis in men are bigger than that of women, however, the current study indicated that although the superior part of vermis is bigger in men compared to women, nevertheless this relationship at lower part of vermis is insignificant. The present research not only confirms the findings reported by Raz and et al, on study of total volume of different parts under investigation, but also could be considered as a supplementary to their work due to studying the dimensions of different parts of vermis. Tiemeier and et al showed that the age increase causes a reduction in the size of posterior part of vermis and this is supported by our data in men but not in women (19). In the same studies, the effect of age increase on reduction of the cerebellum volume was addressed whereas our findings show that the dimensions of any part of the cerebellum follow a particular pattern in relation with age increase, mentioned earlier in results section (20). In studies carried out by Courchesne and et al using MRI, was shown that no relationship between the volume of vermis, age and gender (21). while the data found in present study indicated that there is a significant relationship between the dimensions of superior and posterior parts of vermis and age increase in men and in case of women such relationship was demonstrated only for the superior part of vermis with no significant correlation between the other parts of cerebellum and age increase in both genders. Clearly, the present work contains a more detailed account on dimensions of different parts of the cerebellum compared to previous studies and thus, in addition to presenting new ideas, it could be considered as a supplement to other previous works. Our data showed that except for the transverse length of cerebellum, all other parts of the cerebellum in girls under 10 are bigger than those in boys and regarding our knowledge, such relationship has not been reported by other researchers and it seems that the reason for this relationship to be associated with early puberty in girls compared to boys (22). Considering the functions of cerebellum, it is likely that the muscular balance and coordination in girls at this age to be higher than those among boys (23). Also, described the enlargement of different parts of cerebellum following age increase in children which is consistent with the data found in our study. Other studies on volume of the cerebellum by different researchers, been focused on comparing the cerebellum volume between healthy people and the patients with pathologic lesions in cerebellum or other different psychological disorders (24 and 25). It seems that the cause of age increase-associated size changes in cerebellum among both genders to be unclear due to many uncertainties in precise function of different parts of cerebellum and thus, requires further investigations.

Conclusion

The present study showed that more parts of cerebellum are bigger in men than in women and more parts of the cerebellum in men were showing of having a significant correlation with age changes compared with women. Nevertheless, concerning many uncertainties on exact functionality of different parts of the cerebellum and also the possible relationship with various effectors, further studies are suggested.

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