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Morphometric Assessment of Cerebellum in Sudanese Population Using MRI

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Abstract

Objectives: Evaluating the influence of gender and age on cerebellum is significant for pathophysiological studies of degenerative brain disorders. This study aimed to evaluate the growth rate of the cerebellum in the normal brain in Sudanese population.

Materials and Methods: This cross-sectional descriptive study was performed at Modern Medical Center, Alia Specialist Hospital and Wad Medani Modern Medical Center, Sudan from 2017 to 2019. The data of 100 normal individuals with an age range of 3 months to 80 years old (males: 42%) were evaluated. A magnetic resonance imaging (MRI) was performed for all participants after applying the standard cerebellum protocol. Individuals with anomalies or abnormalities that may affect the posterior fossa were excluded. Measurement of all regions was performed in the screen monitor of MRI machine and statistically analyzed using SPSS Software version 16.

Results: The mean of the right hemisphere width, right hemisphere length, left hemisphere width, left hemisphere length, maximum hemisphere width, maximum hemisphere length, anteroposterior width, and anteroposterior length was 4.38, 4.88, 4.46, 4.42, 9.73, 6.42, 4.88, and 3.54, respectively, implying that the measurement variability was important.

Conclusions: There was s statistically significant correlation between cerebellum measurement with gender in left hemisphere width and maximum hemisphere width ($P=0.05$ and $P=0.07$, respectively). Also, there was a significant age-related reduction in left hemisphere width and length ($P=0.001$ and $P=0.05$, respectively).

Keywords: Cerebellum, MRI, Sudanese

Introduction

Cerebellum is one of the most vital structures of the hindbrain, situated in the posterior fossa of the cranium. The motor regulation and learning plays a crucial role, and it provides higher emotion and cognition functions. It grows over a longer period, which is one of the first brain regions to start to differentiate, but one of the last to mature (1, 2).

Some research raised questions as to whether the developmental curves between females and males are different. Studies have indicated that the brain continues to develop from childhood to maturity, with the peaks between the ages of 10 and 13 in both sexes (3).

Human brain aging is a differential process where in some regions there is a pronounced decline with relative security in others (4, 5). While this concern is shown in the cerebral cortex, it is not clear if it could be expanded to the posterior fossa structures.

Many areas tend to be more susceptible to age-related declines within the cerebellum than others. The differential aging of the cerebellar vermis involves lobules six and seven, and to some extent lobules nine to ten, but not the anterior cerebellar vermis (6, 7). Histology and computed tomography studies have documented significant loss of volume in the anterior vermis (8,9). Significant shrinkage of the posterior vermis was observed (7, 6) in magnetic resonance imaging (MRI) studies. The hemispheres also demonstrated age shrinkage (10).

In several studies, differences between males and females in gross cerebellar neuroanatomy have been observed. Males had larger cerebellar regions compared to females, although those studies did not systematically rule out the possibility that these variations may constitute gender differences of body size (7, 11-14).

Regarding the posterior fossa structures, the number of in vivo studies is limited and there is a need for normative evidence on the cerebellum. Volumetric studies are time consuming; linear measurements can be made easily without additional hardware or software. The literature includes many studies in which brain anatomical structures are quantitively measured in volume, width, and length (4, 14).

In the current prospective study, the authors investigated the variation in the size of cerebellum in different age and gender of Sudanese population. Different regions in cerebellum in axial and sagittal plane were assessed.

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Key Messages

- The manuscript discussed the role of MRI in cerebellum measurement. It showed regional gender gap and age-related atrophy in cerebellum.
- The study acts as baseline for brain volumetric regarding gender and age.
- The findings revealed that all mean measurements of cerebellar lengths and widths were higher in males than in females, but this difference was not statistically significant ($P>0.05$).

Materials and Methods

This cross-sectional descriptive analysis was conducted from 2017 to 2019 in Sudan at Modern Medical Center Alia Specialist Hospital and Wad Medani Modern Medical Center.

Samples

A data of total 150 individuals were evaluated in the current study. Fifty participants with history of clinical or MRI anomalies that affect the posterior fossa were removed. Finally, 100 healthy participants (age range: 3 months old to 80 years old) were included. Also, 42% of patients were males. All included participants were scanned using MRI of 1.5 and 0.35 Tesla (Toshiba Elan 1.5 Tesla with 63 cm aperture and Siemens Magnetom C1 0.35 Tesla) after applying the standard cerebellum protocol. Participants were selected from regions near MRI machines in Sudan. All demographic data were recorded using special designed sheet.

Technique of Measurement

Two experienced radiologists contributed to this study by making manual measured for eight 2D parameters of cerebellum. On axial plane measurement made for the following: width and length of right cerebellum hemisphere, width and length of left cerebellum hemisphere, and maximum width and length of cerebellum hemisphere. Also, measurement of the maximum width and length diameter of cerebellum on mid-sagittal plane was performed as described by Figueira *et al* (8). The age and gender of the patients were registered in the designed data collection sheet.

The Statistical Package for Social Sciences (SPSS version 16) was used for data analysis. Ethical approval was obtained from the centers (bioethical committee) that participated in this study before data collection phase.

Examination Technique Used in Measuring Cerebellum

The most regular MRI scan are T1-weighted and T2-weighted images. T1-weighted images are achieved by using both short TE and TR. T1 of tissue primarily determined the contrast and brightness of image T1 characterized by dark CSF, while T2 characterized by bright CSF.

The measurements were done in slice as follow axial T2 FSE, sagittal T2 is best visualize the cerebellum and can be measured accurately.

Axial Cerebellum Measurement Technique

First measurement was taken in axial T2 FSE in region of interest for the cerebellum at the inner borders. The cursor was positioned at the wider point in inner border of left side of cerebellum, and it was traced to another symmetrical right border of cerebellum. Then, the reading was done, and this measurement was called maximum cerebellum width at axial image. Next, the cursor was positioned from the midline and upper point and traced into lower bottom end in another symmetrical side, which was passed at midline of cerebellum and the reading was done; this was called maximum cerebellum length at axial image (3, 15, 16).

Axial Measurement of the Cerebellum for Each Hemispheres

First measurement was taken in axial T2 FSE in region of interest in the cerebellum at the inner border of cerebellum. The cursor was positioned at the middle of the right hemisphere, then traced till it reached the lower bottom end. Then the reading was done, which was called RT hemisphere length of cerebellum at axial image. Next, the cursor was transferred to the second side in the left hemisphere and the same procedure was performed to obtain LT cerebellum length hemisphere at axial image. Then, the cursor was transferred to inner border of RT hemisphere at the middle of left surface and wider area and it was drawn till it reached the midline of cerebellum; this reading was called RT hemisphere width of cerebellum at axial image. After that, the cursor was turned at the more point wider in inner border of RT surface of the left side of cerebellum; then it was drawn until midline and the measurement was taken, which was called LT hemisphere width of cerebellum at axial image (3, 15).

Sagittal Cerebellum

The image was selected where the brain stem, including the medulla oblongata and pons, appeared clearly. Then, the cursor was positioned at the most upper point and drawn till it reached the lower point in another side; this measuring was called cerebellum height at sagittal or crino caudally reading of cerebellum at sagittal image. Next, the cursor was positioned in a more wider area at RT and drawn to the symmetrical opposite side, which was called the width of cerebellum at sagittal (15, 16).

Table 1 shows the frequency and percentage of age among participants. According to the results, the age group of 1-20 years had the higher frequency (29%). Table 2 shows distribution by gender in this study.

Figure 1 shows the measurement of right and left hemisphere length and width and anterior posterior length and width of hemisphere, as well as maximum

Table 1. Distribution of Age Groups

Age (y)	No.	%
<1	8	8
1-20	29	29
21-40	24	24
41-60	25	25
>61	14	14

Table 2. Distribution by Gender

Gender	No.	%
Male	42	42
Female	58	58

Table 3. Correlation Between Age and MRI Measurement of Brain

MRI measurement	R	*P* value
Right hemisphere width	-0.027	0.860
Right hemisphere length	-0.129	0.395
Left hemisphere width	0.486**	0.001
Left hemisphere length	0.291*	0.050
Maximum hemisphere width	-0.081	0.595
Maximum hemisphere length	0.253	0.090
Anteroposterior width	0.239	0.110
Anteroposterior length	0.198	0.187

** r and *P* have strong correlation.

* r and *P* are significant.

hemisphere length and width among the samples.

As Table 3 shows, there was a significant correlation between age and left hemisphere width and length (P=0.001 and P=0.05, respectively).

Figure 2 shows the correlation of measurement for the brain among females and males. The maximum measurement was noted in female for maximum hemisphere width.

Discussion

For understanding pathological changes, normal neuroanatomic structures variability is crucial. Regarding the posterior fossa structures, the number of in vivo studies is limited and further prescriptive data are required. Volumetric studies are time-consuming for regular task; volume and area measurements are not achievable by software of some MRI scanners; linear measurements can be made rapidly without additional hardware or software, like what was done in this study. There are several studies in which length, width, and volume of the brain anatomic structure are quantitatively measured.

Evidence on the influence of aging on the cerebellum is essential, not only for explaining normal aging, but also for similar evaluation of the pathogenesis of neurological brain disorders. Therefore, this prospective study evaluated two probable induces deviation of normal regional cerebellar measurements: age and gender. The frequency and percentage of the age and gender were presented in Tables 1 and 2. Using simple linear diameter MRI method, the measurements were obtained in axial and sagittal planes (Figure 1). Our results showed that increasing age presented non-significant reduction on cerebellum hemispheres measurements; a significant reduction was seen only on width and length of left cerebellum hemisphere (P=0.001 and P=0.05, respectively) (Table 3). Previous studies justified that the histological results of the aging related cerebellum demonstrated general atrophy, as by aging loss of Purkinje cells is spread evenly through the vermis lobules as well as cerebellar hemispheres (11). Therefore, our outcomes support and extend prior reports that the cerebellum tend to be age related (12), though its volume loss is lower than that of the cerebrum. For certain subjects, the impact of age on the cerebellum was relatively small in the literature (15). Some regions tend to be more susceptible to age-related decline than others within the cerebellum. The histological results of some previous studies showed that superior lobules of the vermis demonstrated an increased cell loss (8). The vermis seems usually to be more influenced by age than the hemispheres (9). Studies of volumetric magnetic resonance in vivo yielded heterogeneous findings (17). Although some authors showed loss in cerebellar hemispheres and vermis of equal volume (10), others revealed that the hemispheres are less affected (15). Our results found that hemispheres, particularly the left hemisphere, appear to be more affected

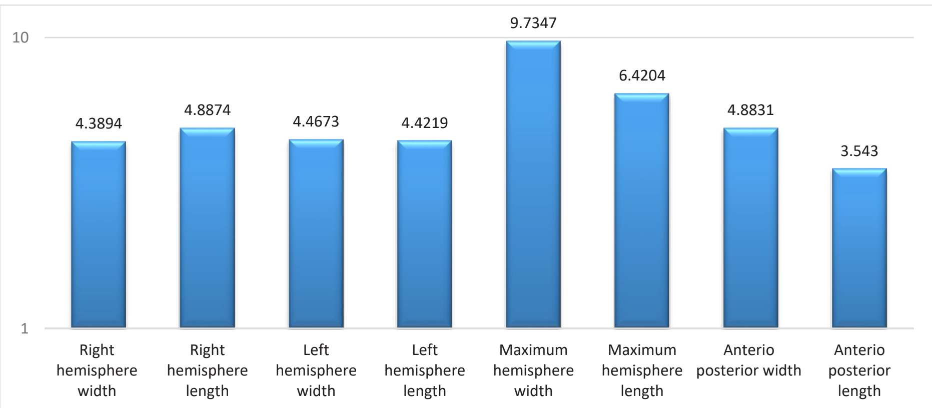

Figure 1. Measurement of Different Cerebellum Portion

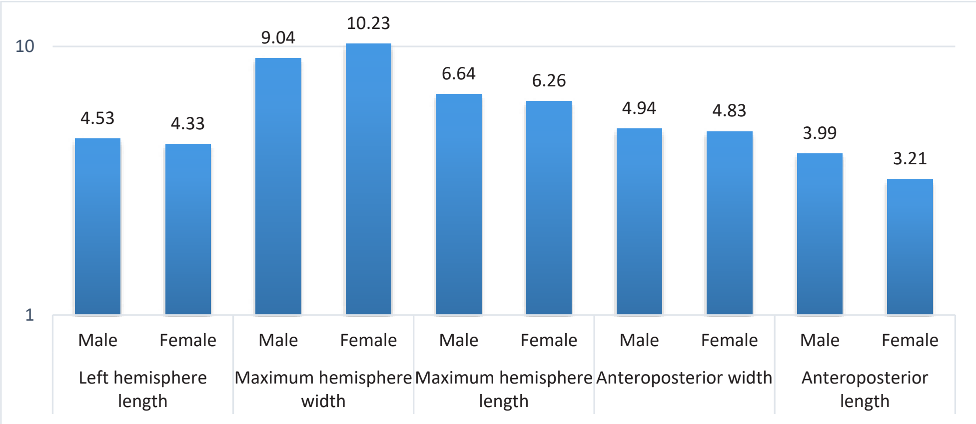

Figure 2. Correlation between Gender and MRI Measurement of Brain.

by age than other cerebellum regions. This discrepancy might be attributed to the methodological variations among the studies, particularly the concept of regions in the cerebellum. Other potential reasons for inconsistency of cerebellar volumetry are ethnic or social disparities in some samples (10). Such differences are difficult to be monitored, and vast meta-analysis studies are needed.

Gross cerebellar neuroanatomical sex variation has been noted in several studies. Males in certain studies had wider hemispheres of brain, cerebellar vermis, anterior vermis, as well as ventral pons (16, 18) in comparison to females. Consistent with overall larger brain size (13, 14, 19), our findings in showed the relation between the cerebellum measurements and gender, which positive propagation in men than women (Figure 2). The disparity among genders is substantial in some cerebellum regions such as left hemisphere length and maximum hemisphere width (P=0.05 and P=0.07, respectively). Some researchers hypothesized that cerebellar size of sexual dimorphism may be attributed to the impact of sex hormones (19, 14, 20). Escalona et al (13) revealed that females have slightly smaller volume of cerebellar than males, but showed no aging impact on cerebellar volume in both genders. Another study demonstrated that the reduction of cerebellum volume in females rather than males is due to more reduction of white matter volume in females; a major reduction of the cerebellar vermis in males after the age of 70 years was also documented (21).

Conclusions

Our findings indicated regional gender gap and age-related atrophy in cerebellum. Therefore, no age-related differences were reported in the measurements of cerebellum. The results showed that all mean measurements of cerebellar lengths and widths were higher in males than in females, though they were not significant (P>0.05), except in left hemisphere length and maximum hemisphere width (P< 0.05). Factor inherited may describe why certain regions are more susceptible than some others.

Our findings offer a valuable addition to the normative cerebellar anatomy database, in that they endorse the idea of cerebellum differential aging.

More studies are required in this area to monitor change in brain for both genders. Also, studies with larger sample sizes and different participants are needed.

The main limitations of current study included its small sample size and limited MRI machines, as there were areas far from Sudan, which were not included in the current study.

Authors' Contribution

First, third and six author planned the research and analyzed the results. First second and fifth author collect the data. Third author submit the manuscript as well as reviewing the paper.

Conflict of Interests

Authors have no conflict of interests.

Ethical Issues

The data was collected after obtaining the ethical approval from Gezira Center for diagnostic radiology (Ethical aproval No. SUD 172/2019).

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