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ENCEPHALOMETRY ON THE MEDIAL FACE OF THE HUMAN BRAIN HEMISPHERE

A necropsy study

Paula J. Ribeiro[1], Serafim V. Cricenti V.[2] Carmen L.P. Lancellotti[3]

ABSTRACT - This study aims to evaluate the dimensions of the human brain, specifically in the frontal cortex, helping the analysis of neuroimaging. A form was made to register and describe encephalic measurements and 81 cerebral hemispheres (CH) were analyzed. Male individuals showed larger CH length; wider superior frontal gyrus in the right CH; bigger encephalic weight and corpus callosum (CC) width. The proportion of measurement from the frontal pole to the most anterior part of the CC genu, related to the CH length gets smaller with aging, whereas the average distance from the most posterior part of the splenum of the CC to the occipital pole was bigger in both male CHs and there was a tendency of decrease in this difference with aging.

KEY WORDS: neuroanatomy, brain, encephalic weight.

Encefalometria na face medial do hemisfério cerebral humano: estudo em necropsias

RESUMO - Este estudo visa avaliar as dimensões do cérebro humano, particularmente do córtex frontal, podendo colaborar para as análises de neuroimagem. Foi elaborado um formulário para registro e descrição das medidas encefálicas. A amostra foi constituída por 81 hemisférios cerebrais (HC) adultos. Os homens apresentaram maior comprimento do HC; giro frontal superior mais largo no HC direito; maior peso encefálico e largura do corpo caloso (CC). A proporção da medida do pólo frontal à parte mais anterior do joelho do CC, em relação ao comprimento do HC diminui com o avanço da idade. Já a da média da distância da parte mais posterior do esplênio do CC ao pólo occipital foi maior em ambos HC dos homens e houve tendência à diminuição desta proporção com o avanço da idade.

PALAVRAS-CHAVE: neuroanatomia, cérebro, peso encefálico.

The frontal cortex represents about one third of the whole brain. It is essential for the motor behavior, not only for mechanical action regulation, as muscle strength, but also in the decision of the proper movements to be executed in the path of a certain goal. On the lateral surface, the major part of the frontal lobe is important in the emotions and cognitive functions. The cingulate gyrus, important in the emotional functions and the corpus callosum integrates the functions of the two hemispheres[1].

The brain may suffer diverse changes, many of them related to aging, as cortical atrophy, brain weight loss and decrease of blood perfusion due to traumatic disorders or other diseases, etc[2]. The motivation of this study comes from the importance of the frontal cortex to human life. Besides that, the reports on measurements of the brain surface in the literature are rare and they can collaborate to the determination of specific neurological diseases and help in the diagnosis by imaging.

Regarding the importance of the matter, the goals of these studies were: to measure the width of the superior frontal gyrus and the cingulated gyrus on the medial part of the cerebral hemisphere (from the frontal pole to the occipital); to correlate the measurement from the most anterior part of the corpus callosum genu to the frontal pole and from the most posterior part of the corpus callosum splenum to the length of the cerebral hemisphere; to verify if there are differences in the measurements related to genre, age and sides of

Universidade Federal de São Paulo, Escola Paulista de Medicina (UNIFESP-EPM) e Faculdade de Ciências Medicas da Santa Casa de São Paulo. (FCM-SCSP), São Paulo SP, Brasil: [1]Graduanda do 3º ano do Curso de Fonoaudiologia da UNIFESP-EPM; [2]Professor Adjunto do Departamento de Morfologia da UNIFESP-EPM; [3]Professora Adjunta do Departamento de Patologia da FCM-SCSP. Apoio: CNPq/PIBIC.

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Dra. Paula J. Ribeiro - Rua Max Planck 419 - 03693-030 São Paulo SP - Brasil

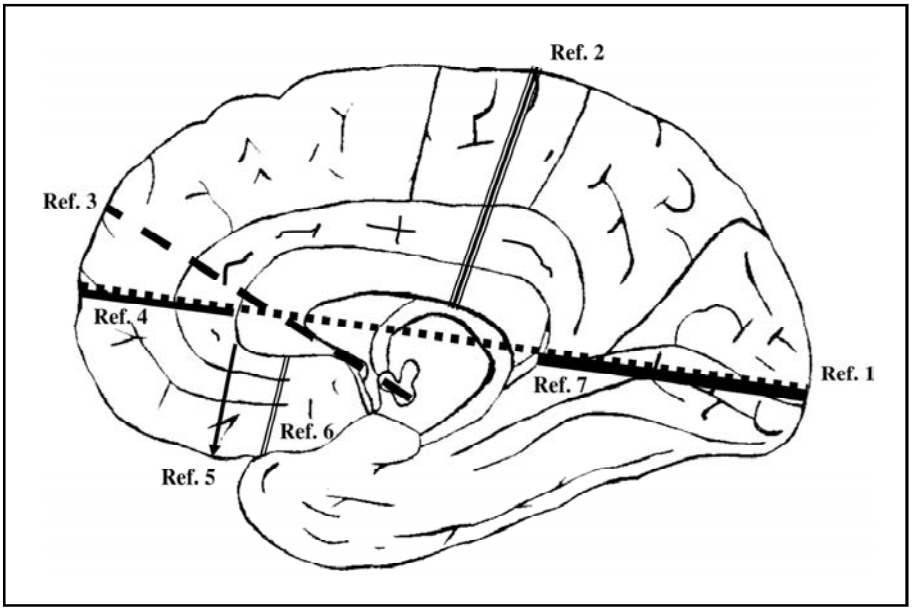


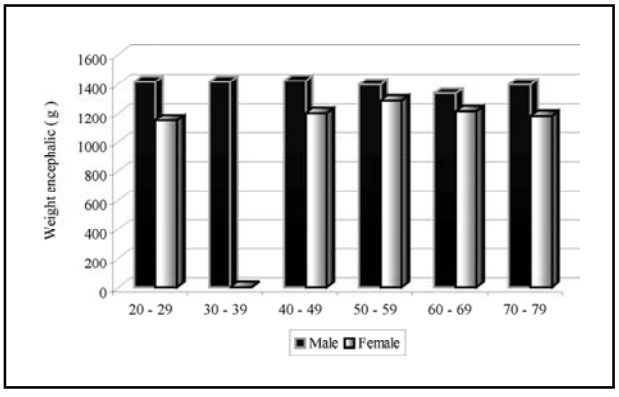
Fig 1. Encephalometry on the medial face of the human brain hemisphere. Ref. 1: Line formed by the union of the point in the most anterior part of the frontal pole to the one situated in the most posterior region of the occipital pole; Ref. 2: Perpendicular line to the line touching the point of meeting of the Central sulcus to the superior board of the cortex to the corpus callosum, F ⇒ superior frontal gyrus, C ⇒ Cingulate gyrus; Ref. 3: Line passing by the center of the mamillary body , center of the anterior commissure and reaches the superior board of the frontal córtex, F ⇒ superior frontal gyrus, C ⇒ Cingulate gyrus; Ref. 4: Line formed by the union of the point situated in the most anterior part of the genu of the corpus callosum to the most anterior part of the frontal pole, F ⇒ superior frontal gyrus, C ⇒ Cingulate gyrus; Ref. 5: Line touching the genu of the corpus callosum and crossing the Ref. 1. F ⇒ superior frontal gyrus, C ⇒ Cingulate gyrus; Ref. 6: Line crossing the most ventral part of the corpus callosum, perpendicular to Ref. 1. F ⇒ superior frontal gyrus, C ⇒ Cingulate gyrus; Ref. 7: Line that unites the point situated in the most posterior part of the splenium of the corpus callosum to the one most posterior in the occipital pole.

the cerebral hemisphere and to compare the weight of the analyzed brains to the genre and age of patients.

METHOD

This was a descriptive study, developed in the Anatomy laboratory from the Discipline of Descriptive and Topographic Anatomy of the Morphology Department of the Federal University of São Paulo (UNIFESP) - Paulista School of Medicine, with the participation of the Santa Casa Hospital Department of Pathology. The material consisted of 81 brain hemispheres, 51 male and 30 female, with an age varying from 20 to 79 years. These brain hemispheres were obtained in necropsies performed in the UNIFESP and in the Santa Casa de São Paulo, conserved in a solution of 10 % formol. Clinical data from the patients as genre, age and encephalic weight were taken from the registration book of the involved Institutions.

The method used was the one part of a protocol named "Registration of Encephalometry on the Medial face of the human brain hemisphere", which the main measurements are referred in Figure 1.



Graphic 1. Distribution of the population according to genre, age and average encephalic weight (g).

The references to the measurements effected were applied according to the preferential topography of the usual neuropathological lesions - *Ref. 1:* Line formed by the union of the point in the most anterior part of the frontal pole to the one situated in the most posterior region of the occipital pole. In this reference, one can see

the total length of the brain hemisphere. *Ref. 2:* Perpendicular line to the line touching the point of meeting of the Central sulcus to the superior board of the cortex to the corpus callosum. Through this reference, one can see the width of the superior frontal gyrus (F) and of the cingulate gyrus (C), on this level. *Ref. 3:* Line passing by the center of the mamillary body, center of the anterior commissure and reaching the superior board of the frontal cortex. Through this reference, one can see the width of the superior frontal gyrus (F) and of the cingulate gyrus (C), on this level. *Ref. 4:* Line formed by the union of the point situated in the most anterior part of the genu of the corpus callosum to the most anterior part of the frontal pole. Through this reference, one can see the width of the superior frontal gyrus (F) and of the cingulate gyrus (C), on this level. *Ref. 5:* Line touching the genu of the corpus callosum and crossing the *Ref. 1.* Through this reference, one can see the width of the superior frontal gyrus (F) and of the cingulate gyrus (C), on this level. *Ref. 6:* Line crossing the most ventral part of the corpus callosum, perpendicular to *Ref. 1*. Through this reference, one can see the width of the superior frontal gyrus (F) and of the cingulate gyrus (C), on this level. *Ref. 7:* Line that unites the point situated in the most posterior part of the splenium of the corpus callosum to the one most posterior in the occipital pole.

The statistical analysis was performed in the Department of Preventive Medicine of UNIFESP and the technique employed was the deviation analysis[2].

The Committee for Medical Ethics has analyzed and accepted the project under the number 324/99.

RESULTS

The analysis of results was done according to the following topics: characterization of the population, measurement analysis of the left and right brain hemispheres and statistical study.

Characterization of the population – 26 male and 16 female right brain hemispheres were analyzed, 25 male left and 14 female left. The population of this study was distributed under the following age groups: 20 to 29, 30 to 39, 40 to 49, 50 to 59, 60 to 69 and 70 to 79. The majority of male individuals were in the 50 to 59 group and the female individuals were mostly in the 70 to 79 group.

The smallest encephalic weigh was found in the female group - 1086, 6 g - and the biggest - 1703,3 in the male group. In Graphic 1, one can see the weight differences, according to age and genre of the studied population.

Analysis of the measurements on the right and left brain hemispheres – On the right brain hemisphere, as well as on the left, one could see that the average length of the brain hemisphere was bigger in men, as notified in Table 1. In this table, one can also see that the distance between the splenum of the corpus callosum to the occipital pole was bigger in men, not mattering which hemisphere was

Table 1. Distribution of population according to genre, age group, brain hemisphere, average, standard deviation, when related to the brain hemisphere length from the frontal to the occipital pole, and to the distance between the splenium of the corpus callosum to the occipital pole.

Age group	Right hemisphere				Left hemisphere			
	Male		Female		Male		Female	
	Average	Standard deviation	Average	Standard deviation	Average	Standard deviation	Average	Standards deviation
Brain Hemisphere length from the frontal to the occipital pole -Ref. 1- (cm)								
20 - 29	16.55	0.07	15.50	1.27	16.60	0.00	15.10	0.90
30 - 39	16.30	0.64	–	–	16.77	0.26	–	–
40 - 49	17.40	1.07	17.10	1.27	16.77	1.11	13.90	0.50
50 - 59	17.11	1.18	16.10	0.17	16.32	1.36	16.23	0.61
60 - 69	15.35	0.94	15.33	1.26	16.08	1.23	14.80	0.00
70 - 79	17.03	1.10	16.13	0.94	17.03	0.38	16.13	0.29
Distance between the splenium of the corpus callosum to the occipital pole								
20 - 29	6.05	0.15	5.20	0.57	5.80	0.00	5.20	0.28
30 - 39	5.94	0.09	–	–	5.85	0.45	–	0.00
40 - 49	6.30	0.13	6.35	0.92	5.84	0.43	5.60	0.85
50 - 59	6.04	0.19	5.20	0.36	5.60	0.54	5.40	0.40
60 - 69	5.60	0.15	4.73	1.10	5.30	0.48	4.80	0.00
70 - 79	5.90	0.39	5.35	0.44	6.03	0.50	5.52	0.47

Table 2. Distribution of population according to genre, age group, brain hemisphere, average, standard deviation, when related to the width of the superior frontal gyrus, according to the adopted reference.

Ref.	Age Grup	Right hemisphere				Left hemisphere			
		Male		Female		Male		Female	
		Average	Standard deviation	Average	Standard deviation	Average	Standard deviation	Average	Standards deviation
Average measurement of the superior frontal gyrus width (cm)									
2	20 - 29	2.85	0.92	2.50	0.00	3.50	0.00	2.35	0.49
	30 - 39	2.54	0.18	–	–	2.50	0.26	–	–
	40 - 49	2.55	0.44	2.85	0.49	2.36	0.50	2.20	0.28
	50 - 59	2.49	0.27	2.37	0.15	2.45	0.34	2.37	0.15
	60 - 69	2.17	0.24	2.37	0.25	2.35	0.10	2.50	0.00
	70 - 79	2.10	0.59	2.52	0.29	2.60	0.61	2.48	0.34
3	20 - 29	2.45	0.21	2.10	0.14	2.30	0.00	2.50	0.14
	30 - 39	2.46	0.55	–	–	2.40	0.37	–	–
	40 - 49	2.48	0.42	2.45	0.35	2.36	0.44	2.60	0.14
	50 - 59	2.46	0.51	2.00	0.40	2.58	0.24	2.00	0.00
	60 - 69	2.25	0.42	2.03	0.40	2.03	0.13	2.30	0.00
	70 - 79	1.95	0.29	2.17	0.22	2.67	0.31	2.47	0.32
4	20 - 29	2.65	0.49	2.40	0.14	2.30	0.00	2.00	0.14
	30 - 39	2.36	0.42	–	–	2.20	0.26	–	–
	40 - 49	2.35	0.31	2.35	0.07	2.54	0.42	2.60	0.14
	50 - 59	2.36	0.32	2.30	0.35	2.62	0.49	2.13	0.06
	60 - 69	2.13	0.30	1.97	0.15	2.33	0.25	2.00	0.00
	70 - 79	2.23	0.45	2.25	0.25	2.43	0.32	2.00	0.37
5	20 - 29	1.85	0.49	1.85	0.21	1.90	0.00	1.85	0.78
	30 - 39	1.60	0.12	–	–	1.30	0.29	–	–
	40 - 49	1.73	0.17	1.60	0.28	1.60	0.31	1.45	0.07
	50 - 59	1.74	0.33	1.20	0.17	1.43	0.31	1.67	0.15
	60 - 69	1.73	0.32	1.63	0.55	1.40	0.32	1.20	0.00
	70 - 79	1.80	0.36	1.77	0.39	1.57	0.25	1.63	0.14
6	20 - 29	2.10	0.28	2.00	0.57	2.20	0.00	1.65	0.49
	30 - 39	1.76	0.36	–	–	1.60	0.12	–	–
	40 - 49	2.03	0.13	1.45	0.35	1.83	0.23	1.45	0.07
	50 - 59	1.89	0.34	1.40	0.27	1.70	0.33	1.73	0.31
	60 - 69	1.95	0.19	1.57	0.23	1.58	0.57	2.00	0.00
	70 - 79	1.80	0.36	1.90	0.34	1.32	1.01	1.62	0.26

analyzed. The width of the superior frontal gyrus and the cingulated gyrus showed some difference according to genre and age, according to the studied reference, as seen in Tables 2 and 3.

As to the proportional distance between the most anterior part of the genu of the corpus callosum to the most anterior part of the frontal pole, (Ref. 4), with the BH length, we observed bigger values in the left hemisphere in both male and female and a decrease of this difference with aging, in both genres and sides. (Table 4). The proportional distance between the most posterior part of the splenium of the corpus callosum to the most posterior part of the occipital pole (Ref 7), with the BH length, we observed bigger values in the right hemisphereof men and left of women, and a tendency of decrease of this proportion with aging, not mattering the genre or brain hemisphere.

Statistical analysis – The statistical analysis was performed including all the data. There was stastical difference only when genre and age were correlated to each hemisphere, this analysis being observed in Table 5.

Table 3. Distribution of population according to genre, age group, brain hemisphere, average, standard deviation, when related to the width of cingulate gyrus, according to the adopted reference.

Ref.	Age Grup	Right hemisphere				Left hemisphere			
		Male		Female		Male		Female	
		Average	Standard deviation	Average	Standard deviation	Average	Standard deviation	Average	Standards deviation
Average measurement of the cingulate gyrus width (cm)									
2	20 - 29	1.35	0.07	1.15	0.49	1.40	0.00	1.35	0.07
	30 - 39	1.56	0.36	–	–	1.63	0.30	–	–
	40 - 49	1.35	0.39	1.45	0.07	1.46	0.34	1.75	0.07
	50 - 59	1.61	0.46	1.43	0.12	1.60	0.32	1.57	0.31
	60 - 69	1.33	0.15	1.17	0.06	1.20	0.18	1.30	0.00
	70 - 79	1.23	0.33	1.43	0.27	1.30	0.36	1.45	0.18
3	20 - 29	1.00	0.28	1.40	0.28	1.80	0.00	0.80	0.14
	30 - 39	1.24	0.38	–	–	1.25	0.21	–	–
	40 - 49	1.23	0.24	1.60	0.14	1.17	0.34	1.30	0.00
	50 - 59	1.07	0.30	1.23	0.25	1.05	0.40	0,80	0,20
	60 - 69	0.98	0.22	1.07	0.40	0.98	0.38	0.70	0.00
	70 - 79	1.30	0.47	1.08	0.38	0.93	0.31	1.05	0.34
4	20 - 29	1.00	0.00	1.25	0.21	1.10	0.00	1.40	0.20
	30 - 39	1.22	0.42	–	–	1.53	0.05	–	–
	40 - 49	1.15	0.25	1.35	0.49	0.96	0.22	1.10	0.30
	50 - 59	1.10	0.12	1.00	0.10	0.87	0.21	0.93	0.15
	60 - 69	1.13	0.33	0.93	0.42	0.98	0.10	0.80	0.00
	70 - 79	1.02	0.21	0.95	0.24	1.03	0.15	1.22	0.12
5	20 - 29	0.55	0.21	0.60	0.14	0.80	0.00	0.65	0.07
	30 - 39	0.72	0.26	–	–	0.90	0.22	–	–
	40 - 49	0.70	0.08	0.80	0.14	0.57	0.05	0.70	0.14
	50 - 59	0.67	0.18	0.80	0.36	0.65	0.19	0.67	0.12
	60 - 69	0.60	0.26	0.70	0.10	0.65	0.10	0.80	0.00
	70 - 79	0.70	0.24	0.57	0.12	0.63	0.15	0.68	0.17
6	20 - 29	0.55	0.07	0.65	0.07	0.90	0.00	0.70	0.14
	30 - 39	0.82	0.29	–	–	1.05	0.10	–	–
	40 - 49	0.88	0.15	0.95	0.21	0.66	0.11	0.80	0.28
	50 - 59	0.84	0.24	0.80	0.20	0.67	0.15	0.90	0.10
	60 - 69	0.65	0.26	0.83	0.21	0.80	0.14	0.60	0.00
	70 - 79	0.90	0.18	0.77	0.10	0.80	0.26	0.93	0.27

DISCUSSION

In the literature there are other reports on encephalic weight[4-6]. Our study revealed that average of the encephalic weight was 1395.5g in the male and 1199.2g in the female patients, with a standard deviation of 34.66g for men and 30.05g for women. This result agrees with another study in Venezuela in 1997 where it was established that the average weight of the normal adult males in Venezuela are bigger (1215 g) than the adult females (1122g)[7]. The authors have also noticed that there is a decrease of the weight in aging, in both genres, this decrease obeying the intrinsic process of brain degeneration[6]. In our case, the statistical analysis did not reveal significative correlation between the brain weight and the age of individuals, probably due to the fact that the study was not equally distributed in different ages.

Another study in 1988 verified that the brain of schizophrenic individuals and mentally challenged are smaller than those with another psychiatric illnesses, neurologic diseases or trauma. It was yet considered that there was no grand alteration of the brain weight in the maniac depressive psycho-

Table 4. Distribution of the population according to genre, age group, brain hemisphere, average and standard deviation of the measurements from the frontal pole to the genu of the corpus callosum and from the splenium of the corpus callosum to the occipital pole, related to the brain hemisphere length.

Age group	Right hemisphere				Left hemisphere			
	Male		Female		Male		Female	
	Average	Standard deviation	Average	Standard deviation	Average	Standard deviation	Average	Standards deviation
% of the measurement from the frontal pole to the genu of the corpus callosum (Ref. 4) related to the brain hemisphere length (Ref. 1)								
20 - 29	22.05	3.09	23.55	0.35	20.48	0.00	22.51	0.92
30 - 39	21.96	1.15	–	–	22.24	1.42	–	–
40 - 49	20.11	1.95	21.64	0.87	20.87	2.77	26.62	3.39
50 - 59	20.22	2.10	20.49	1.51	21.38	3.50	18.85	0.32
60 - 69	21.23	2.35	18.91	0.74	20.58	1.22	18.92	0.00
70 - 79	19.08	1.72	19.83	2.06	20.31	2.23	19.96	1.96
% of the measurement from the splenium of the corpus callosum to the occipital pole (Ref.7) related to the brain hemisphere Length (Ref. 1)								
20 - 29	36.56	1.44	33.54	0.90	34.93	0.00	34.43	1.03
30 - 39	36.52	2.61	–	–	34.88	2.58	–	–
40 - 49	36.27	1.94	37.13	2.62	34.82	2.57	40.28	8.16
50 - 59	35.35	2.39	32.29	2.56	34.31	2.36	33.27	0.32
60 - 69	36.55	2.29	30.85	7.28	32.96	3.59	32.43	0.00
70 - 79	34.64	3.83	33.16	3.02	35.40	2.22	34.22	2.50

Table 5. Statistical results related to genre and age group, when correlated to the brain hemisphere.

Reference	Genre		Hemisphere		Age		Interaction genre hemisphere	
1	0.001		Ns		Ns		Ns	
2	F	C	F	C	F	C	F	C
	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns
3	F	C	F	C	F	C	F	C
	Ns	Ns	0.095	Ns	Ns	0.068	Ns	Ns
4	F	C	F	C	F	C	F	C
	0.011	Ns	Ns	Ns	Ns	0.032	Ns	Ns
5	F	C	F	C	F	C	F	C
	Ns	Ns	0.029	Ns	Ns	Ns	Ns	Ns
6	F	C	F	C	F	C	F	C
	Ns	Ns	0.050	Ns	Ns	Ns	Ns	Ns
7	<0.001		Ns		Ns		Ns	
4/1	Ns		Ns		0.001		Ns	
7/1	Ns		Ns		0.070		0.031	
Weight	<0.001		–		Ns		-	

NS, not significant; F, superior frontal gyrus; C, cingulate gyrus.

sis. According to the authors, the average weight decreased with aging but there was no differences regarding genre[8].

When according to encephalometry, the cases related in literature are very rare[9]. Andrade[10], referred that the width of the cortical layer has been measured in different age groups and that in the first 50 years of living there was a progressive decrease of this layer, with a bigger atrophy in the elderly due to the White matter. Our study revealed differences in genres, superior frontal gyrus and cingulated gyrus widths, brain hemisphere length and in the proportion of the references 4 and 7 to 1. We observed the presence of two cases which the proportion showed a variable value range when compared to the other cases. We believe this corresponds to extreme or maybe sporadic cases, for they are not above the average. The correlation to other clinical pathological data may explain these differences. Besides that, the age is another issue to be considered, but we have already referred the difficulty when working with very distant ages.

We hope to have contributed to the correlation of our measurements to the ones obtained by imaging. Other studies are vital for human brain measurements. In future studies, we may correlate the measurements to the different neurological entities, and perhaps even correlate them to level of education and professional activity.

In conclusion, the male individuals showed bigger brain hemisphere length, in both sides; a wider superior frontal gyrus in the right hemisphere; and bigger encephalic weight. The proportion of the measurement of the distance between the frontal pole to the most anterior part of the genu of the corpus callosum, when related to the brain hemisphere length, was bigger on the left side of the male and female individuals and had a decrease with aging, not mattering the genre or brain hemisphere. The average value of the distance between the most posterior part of the splenium of the corpus callosum to the occipital pole when related to the hemispherelength showed to be bigger in the male right hemisphere and female left, with a decreasing tendency with aging.We then verified that aging has interfered in some of the references studied, but due to the fact the age groups were not proportional, a strict analysis of this specific factor could not be properly studied.

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