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A Comparative Study on Human Cerebrocortical Cytoarchitectonics; Effects of Aging and Brain Weight Increase on Cortices of Premotor area (Brodmann's area 6) and Precortical Gyrus (Brodmann's area 4) in Human Brain†

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= Abstract =The cytoarchitectures and aging effects between summital cortex of the precentral gyrus(Brodmann's area 4) and caudal sulcal cortex of the premotor area(Brodmann's area 6; 6a) were compared in terms of comparative cytoarchitectonics in normal 418 cerebral hemispheres of 209 postnatal brains (115 of males' and 94 of females'). Statistical constancy of the relative total neuronal density in both cortices was noticed throughout the postnatal life span regardless of the aging and brain weight increase, except in 0-1 year old age group and 300-499 gm of brain weight group.

An insinuating increment of relative total glial densities were shown according to successive increase of age, and the denser values in premotor cortex were noted than that of precentral gyrus in both sex and side. In adult, the relative total neuronal density was not directly affected by the cortical thickness and aging, but the relative total glial density was so affected by the cocrtical thickness, and aging, but not by brain weight.

Key Words: ***Cytoarchitectonics, Brodmann's Area 4 and 6 of Man***

INTRODUCTION

With the development of microscope and histological technique, Meynert analyzed the layered pattern of cerebral cotex in 1868, and established the basis of cerebral cytoarchitectonics. Brodmann (1908, 1909 & 1910) presented the cytoarchitectonic nature of all the cerebral cortical layers, and classified them as 52 areas of cerebrocortical mapping. So many papers on the cerebrocortical cytoarchitectonics had been reported by Vogt and Vogt (1919), Economo and Koskinas(1925), Conel (1939, 1941, 1947), and in our department, by KJ Seoung and MB Lee *et al.* since 1963.

Recently we have tried to evaluate the relationship between functional difference and cytoarchitectural nature of Brodmann's area 4 and area 6, and the effect of aging and brain weight on cortical thickness, neuronal and glial density.

MATERIALS AND METHODS

Cerebrocortical slice materials were obtained from 143 normal brains of Korean for premotor area (males'; 81, females'; 62), for precentral gyrus from 209 brains (males'; 115, females'; 94).

After cerebral hemispheres were divided longitudinally, samples were obtained from the junctional area of the upper and the middle third of summit of the precentral gyral and premotor area at the right angle to the long axis of each gyrus. Specimens were further fixed with 10% neutral formalin followed by paraffin embedding procedure. Paraffin blocks were sectioned with a thickness of 20 μm and stained with aqueous cresyl violet and hema-

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toxylin. The thickness of each section was measured under ×10 ocular lens with an attached micrometer and ×10 objective lens.

The number of neurons or glial cells in a unit volume of cortex was computed from counts of nucleoli with the application of the Abercrombie (1946) correction. The counts were made using an eyepiece grid that enables the image of the section to be divided into a number of strips of known width(100 μ), length(100 μ) and thickness(20 μ) under ×10 ocular and ×40 objective lens, each strip being parallel to the pial surface. After the cell number in each strip with $20\times10^4\,\mu^3$ was multiplied by 5, the relative total neuronal or glial cell density (nember of neurons of glial cells/unit volume of cortex) was computed. In the present study, the unit volume of cortex was taken as 0.001 mm^3 ($10^6\,\mu^3$) (Sholl 1959).

Values, obtained by observation of precentral gyral and premotor area, were statistically processed for the biological significance (Snedecor 1956; Alder and Rossler 1960). Adult values indicate the mean values of the relative total neuronal or glial cell densities obtained from 21-50 age group, which is the stable period of the cytoarchitecture of the cerebral cortex.

RESULTS

I. Cytoarchitectural comparison of precentral gyrus and premotor area

A. Cortical thickness

1. Age related cortical thickness

Area 4 showed thicker values than that of area 6 in each age group, but otherwise there's no change, according to the sex, side, except in the age of 0-1 year, the left side of age more than 61 years, and right side of 11-15 years' group(Fig. 1).

2. Brain weight related cortical thickness

Area 4 showed thicker value than that of area 6 in each weight group. There's relatively no change in brains heavier than 900 gm, but successive increase of cortical thickness was noted in brains below 900 gm(Fig. 2).

B. Neuronal density

1. Age related neuronal density

Area 4 showed significantly denser value than that of area 6 in the age of 0-1 year group, but interestingly there's no differences in other age groups according to the sex, side. Higher neuronal densities in suckling young age of area 4 were thought probably as a parcellation effect of neurons(Fig. 3).

2. Brain weight related neuronal density

Area 4 showed denser value than area 6. In suckling young age, both areas showed successive decrease of neuronal density uentil 900 gm group. But there's relatively no change between area 4 and 6 in over 900 gm group(Fig. 4).

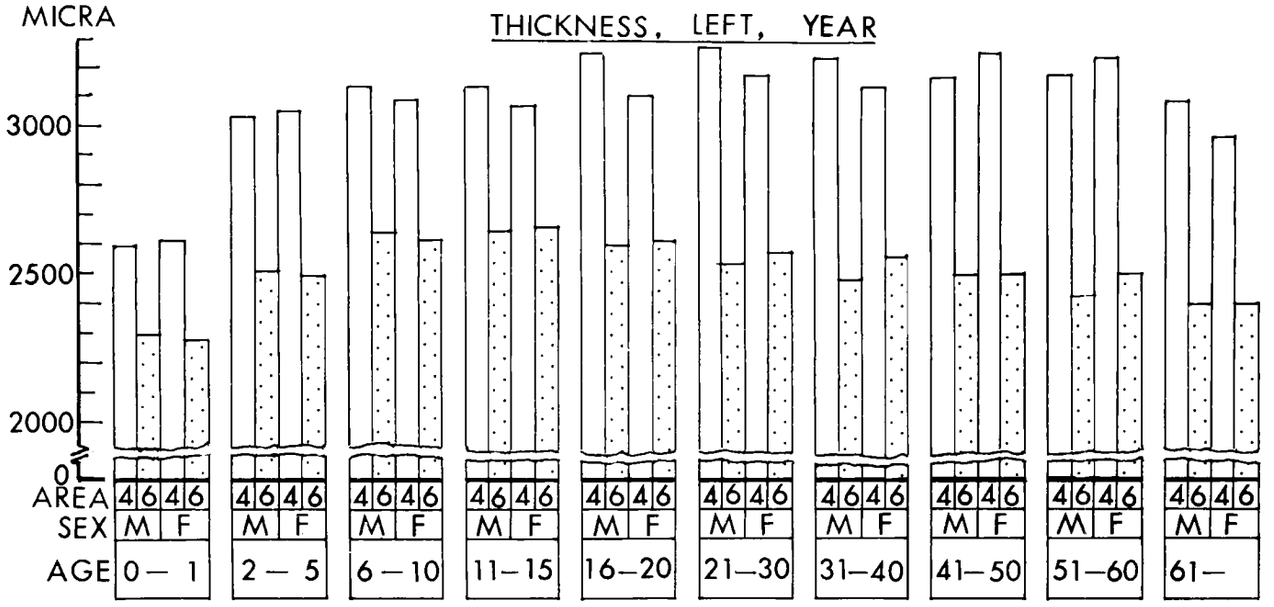

Fig. 1. Bar-graphic sets showing cortical thicknesses of precentral gyrus(open-bar: Brodmann's area 4) versus that of premotor cortex(dotted-bar: Brodmann's area 6) in both male and female sexes on each corresponding postnatal age-group of the left.

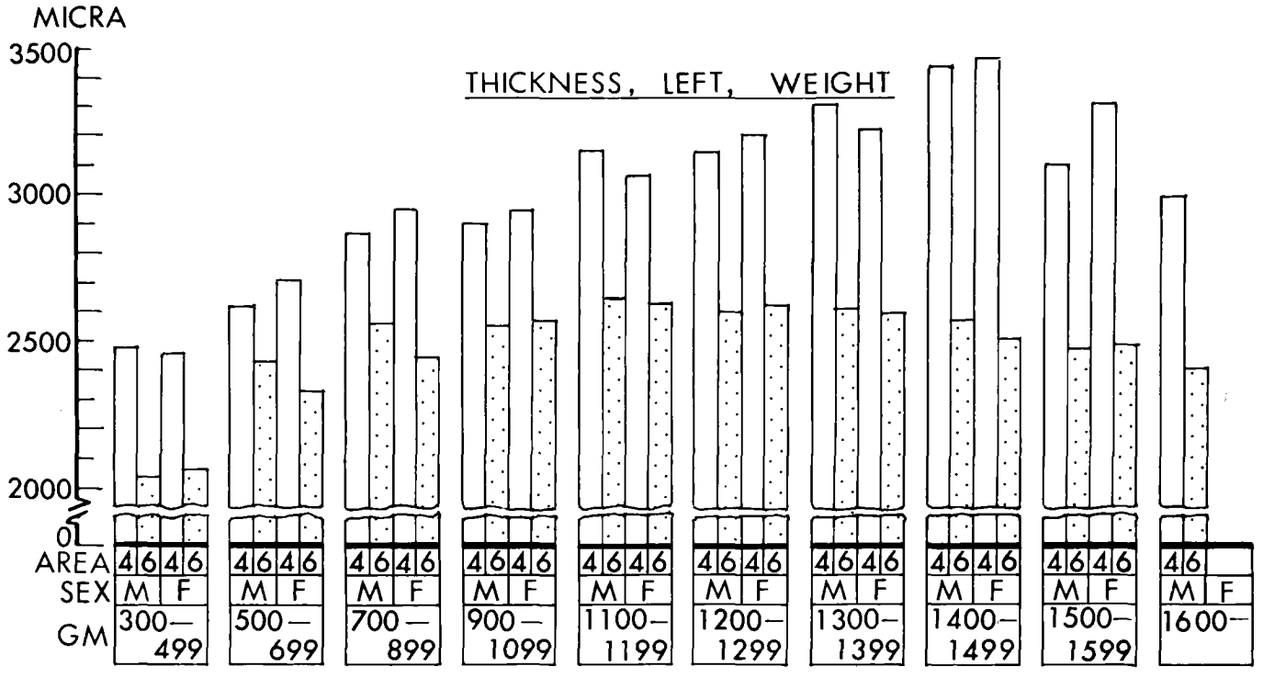

Fig. 2. Bar-graphic sets showing cortical thicknesses of precentral gyrus(open-bar: Brodmann's area 4) versus that of premotor cortex(dotted-bar: Brodmann's area 6) in both male and female sexes on each corresponding postnatal brain weight-group of the left.

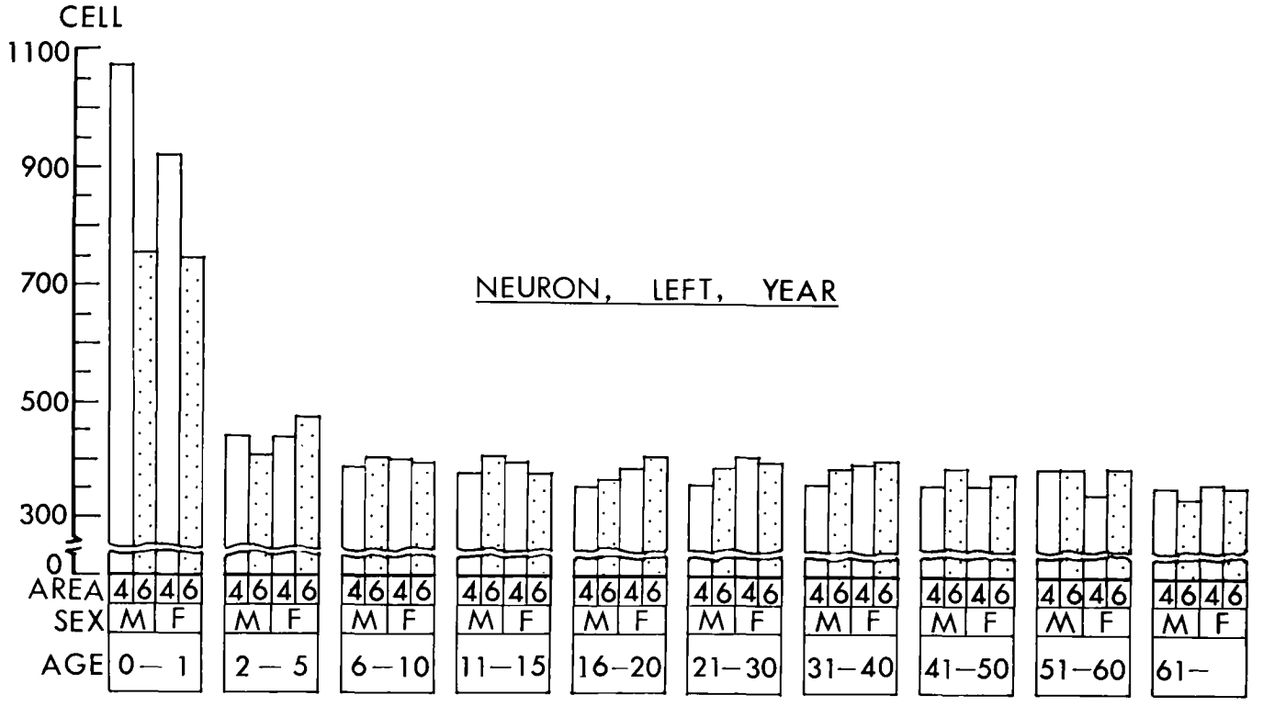

Fig. 3. Bar-graphic sets showing relative total neuronal cell densities of precentral gyrus(open-bar: Brodmann's area 4) versus that of premotor cortex(dotted-bar: Brodmann's area 6) in both male and female sexes on each corresponding postnatal age-group of the left.

C. Glial density

1. Age related glial density

In both sex and side, area 6 showed denser value than area 4. Area 6 also showed insinuating increment of relative total glial density than area 4 since the age of 2 years(Fig. 5).

2. Weight related glial density

Area 6 showed denser value than area 4 in each weight group. There was a relatively constant value in area 4, but in area 6, glial density was successively decreasing until the weight of 900 gm although higher density in area 6 was always main-

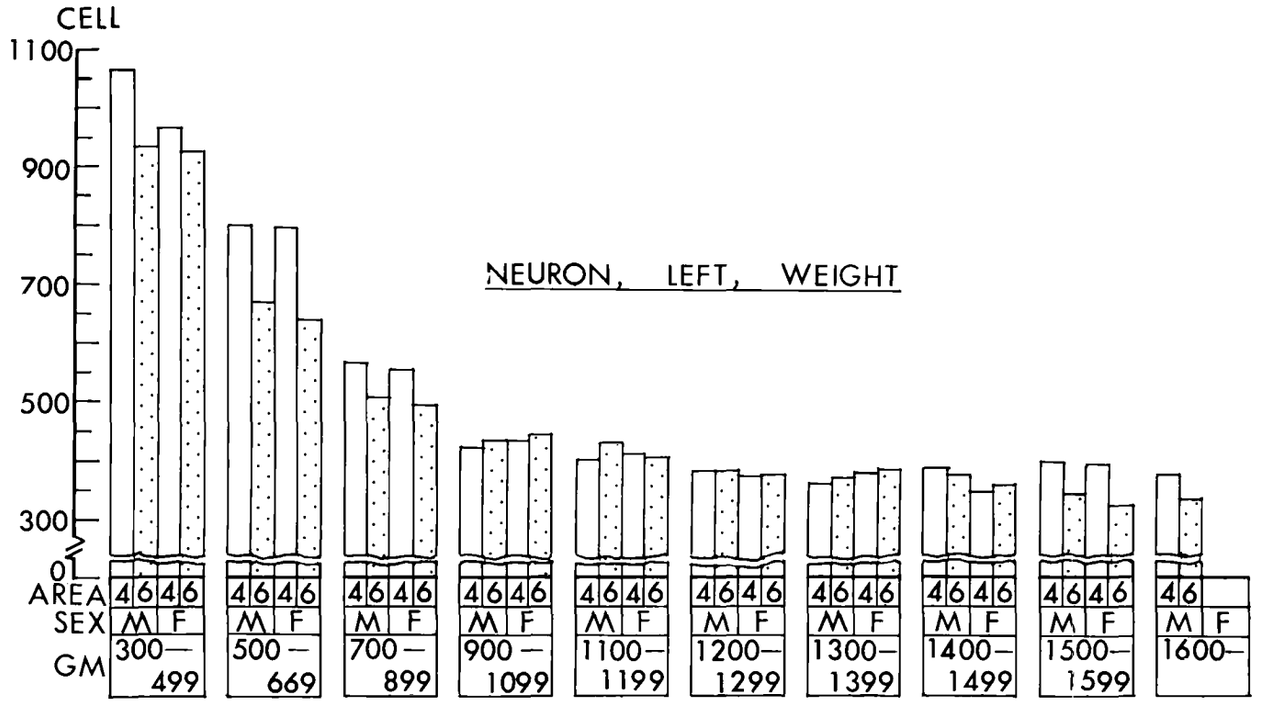

Fig. 4. Bar-graphic sets showing relative total neuronal cell densities of precentral gyrus(open-bar: Brodmann's area 4) versus that of premotor cortex(dotted-bar: Brodmann's area 6) in both male and female sexes on each corresponding postnatal brain weight-group of the left.

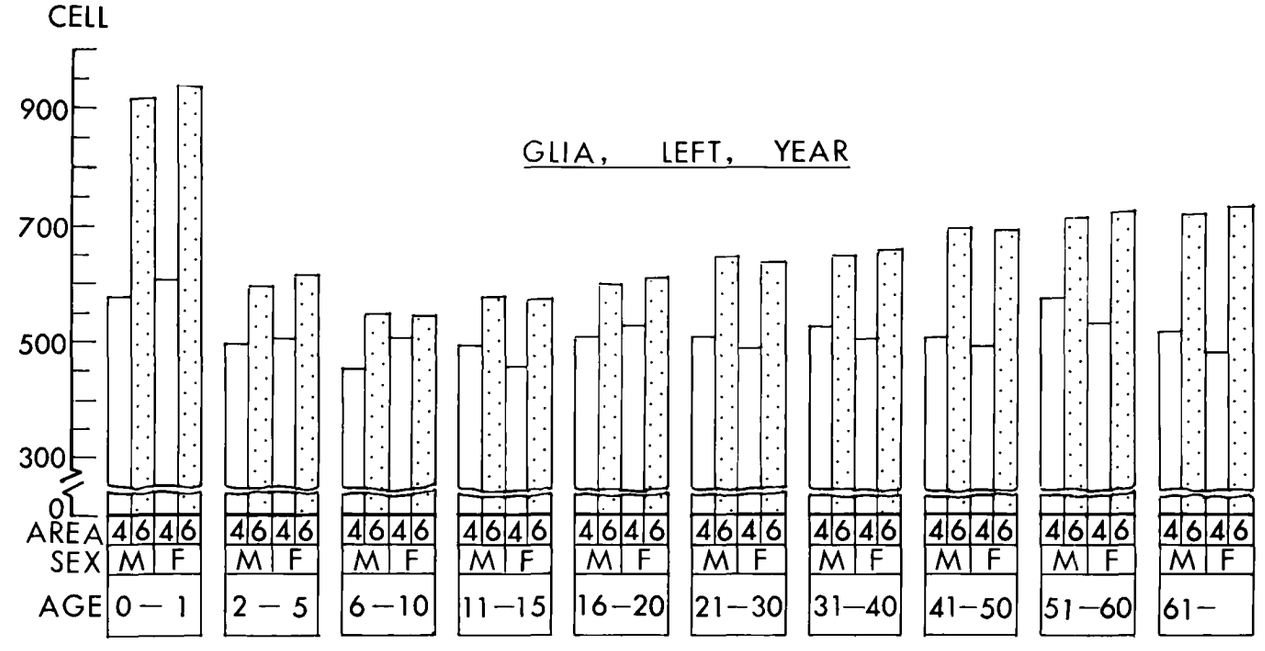

Fig. 5. Bar-graphic sets showing relative total glial cell densities of precentral gyrus(open-bar: Brodmann's area 4) versus that of premotor cortex(dotted-bar: Brodmann's area 6) in both male and female sexes on each corresponding postnatal age-group of the left.

tained(Fig. 6).

DISCUSSION

Adult values of 21-50 years old age group showed area 4 had a thicker cortical layer than area 6, but no significant difference in neuronal density between 2 areas according to aging and brain weight. Glial density of area 6 showed higher value than area 4, and also showed a successively increasing value according to increment of age.

Area 4 and area 6, named by Brodmann in his cerebral cortical map, had not a different cortical

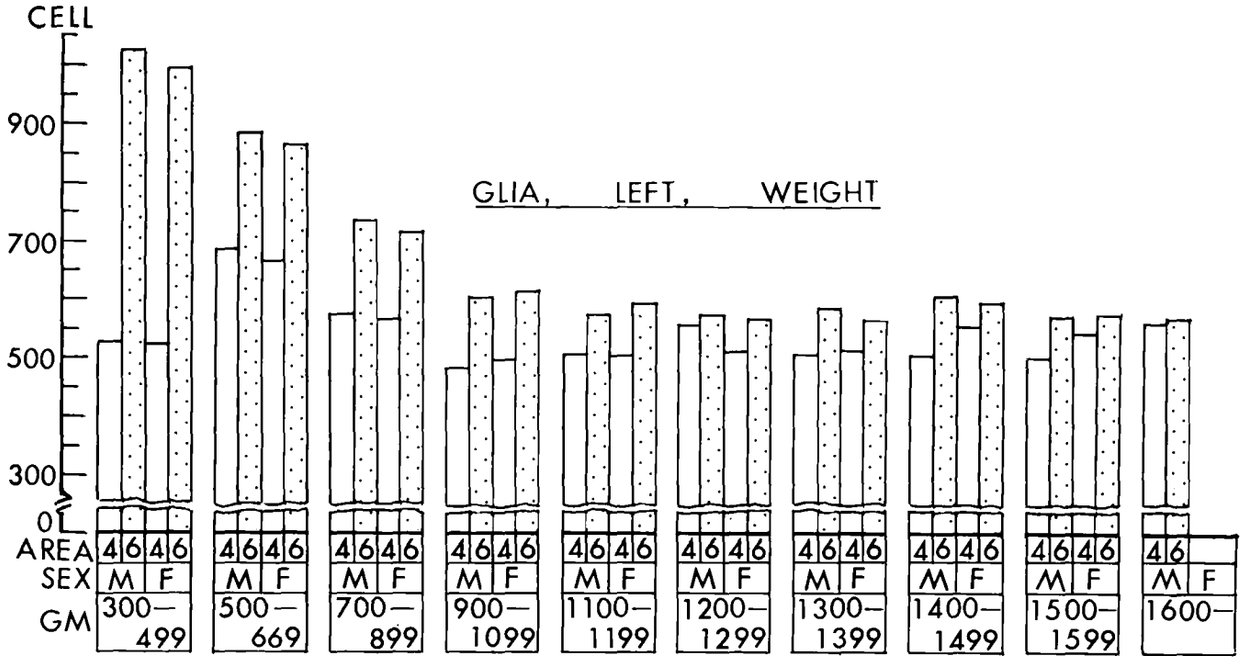

Fig. 6. Bar-graphic sets showing relative total glial cell densities of precentral gyrus(open-bar: Brodmann's area 4) versus that of premotor cortex(dotted-bar: Brodmann's area 6) in both male and female sexes on each corresponding postnatal brain weight-group of the left.

layer, but a continuous layer (Lassek and Evans 1945), except that area 4 had Betz cells, so called giant pyramidal cells (Lassek 1940). Area 6, especially posteriorly located, 6a area, had a pyramidal cell layer, which was continuous with that of area 4, and also known as an agranular cortex, and major area of extrapyramidal system.

Brody (1955) said that summital cortex of area 4 had a thickness of 3150 μm-4050 μm. Economo (1929) said that summital cortex of area 6 had a thickness of 3.2-4.0 mm. So they advocated that there're no differences in cortical thickness between area 4 and area 6. Economo(1929) said that there're differences in cortical thickness in even a same area 8(prefrontal area) according to the location of summital cortex, sulcal wall, sulcal base, such as 2.6 mm, 2.2 mm, and 1.7 mm.

Seoung and Hwang(1980 & 1981), Seoung and Lee(1982), Lee *et al.*(1983), also made a mention of such a fact. Kwun *et al.*(1984) noticed that differences in cortical thickness according to location did not affect the neuronal densities.

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= 국문초록 =

大腦皮質의 比較細胞構築學的 硏究;
加齡 및 加重의 人大腦運動前野와 中心前回 皮質에 대한 影響†

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初生兒에서 老齡에 이르는 韓人腦髓 209例(男性 115例 및 女性 94例) 418大腦半球로서 病變 혹은 奇形이 없는것을 材料로 中心前回峯部皮質(Brodmann 第4皮質分野) 및 運動前野溝壁部皮質(Brodmann 第6皮質分野) 兩皮質의 厚經 및 神經, 膠質細胞密度差를 比較하고 加齡이 兩皮質細胞構築에 미치는 影響을 追究하였다.

1. 皮質厚經은 兩分野의 同等年齡群 사이에서 男性의 左右側의 生後齡 0~1 歲群値間, 左側의 生後齡 61歲 以上 群値間 및 右于의 生後齡 11~15歲群値間을 除外하고 他 各年齡群値間에서 第4分野厚經이 第6分野의 것보다 높은 厚經을 보였으며 大體로 統計學的으로 認定할만한 加齡에 依한 厚經의 變動은 없다고 보았다.

2. 兩皮質內 相對的總神經細胞密度値間에는 男女性左右側의 것을 莫論하고 皮質間差나 加齡의 影響이 없었다.

3. 兩皮質內의 相對的總膠質細胞密度差는 男女性에서 加齡에 따라 第6分野値가 增加하여 特히 男性의 것의 右側의 것 및 女性의 左右側것에서 顯著하여 第4分野의 것과의 사이에서 生後齡 51歲 以後群에서 그러하였다.

4. 成人値의 兩皮質間의 比較에서 相對的總神經細胞密度値의 差異를 보임이 없이 그 皮質厚經 및 相對的總膠質細胞密度間에 認定할만한 差異를 보였다.

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