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Original Research Article

The Effect of Age, Sex and Sport Practice on the Measurements of the Frontal Lobe of the Brain

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ABSTRACT

Background: The frontal lobes make up two-thirds of the human brain, and their functions have long remained unclear.

Aim of the work: measuring cortical thickness and volume in various parts of the frontal lobe in athletic football players and non-athletes, as well as age-related changes in both sexes, using high-resolution MRI.

Subjects and methods: A 40 volunteers were divided into two groups: non-football players (20 each, 10 males and 10 females) and 60 non-athletes of various ages (10-20, 20-30, and 30-40) (10 participants from each gender for each group).

Results: The height, weight and BMI are increased in sport male and female groups, The medial orbitofrontal, the pars orbitalis, the superior frontal and the frontal pole in the right frontal lobe in females in the sport group, the pars orbicularis and pars triangularis in the left frontal lobe is increased significantly in the sport group, The medial orbitofrontal and pars triangularis are increased significantly in the left frontal lobe in the male group aged 10-20 years, The caudal middle frontal, the medial orbitofrontal, the paracentral, the pars triangularis, the pars orbicularis and superior frontal gyrus are increased significantly in the female aged 10-20 years in the right frontal lobe while the lateral orbitofrontal and the frontal pole increased significantly in the female aged 20-30 years and medial orbitofrontal and paracentral in female aged 10-20 years in the left frontal lobe.

Conclusion: age, gender and physical exercise can affect different parameters of the frontal lobe of the brain

KEY WORDS: volumetric, frontal lobe, exercise, High-resolution MRI.

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INTRODUCTION

The frontal lobes make up two-thirds of the human brain, and their functions have long remained unclear. Aside from their well-known function in motor control and language, little was previously known about the functions of the frontal lobes [1].

According to the literature on ageing, the brain undergoes widespread morphological and physiological changes, especially in the prefrontal cortex (PFC). These changes are due to a reduction in executive and sensorimotor functions as people get older [2].

When studying variations between adult males and females with Autism Spectrum Disorders, major differences in regional grey and white matter neuroanatomy was found [3].

The volumetric assessment and measurement of cortical thickness have been validated against histological analysis and manual measurements [4].

Regional brain volume studies have provided insight into the pathology and pathophysiology of a variety of neurological and psychiatric disorders, such as Alzheimer's disease [5], schizophrenia [6], disorder of post-traumatic stress [7] and repeated injuries to the head [8].

Females can have poorer outcomes following traumatic brain injury; this is due to sex or other individual differences [9].

Sex and sport-specific behaviors have an effect on perceptual-motor and verbal fluency activities. In order to predict the outcome of traumatic brain injury among athletes, it is important to understand the differences and similarities between sports and gender in various neurocognitive measures [10].

In people subjected to repetitive head trauma, volumetric brain examination is especially relevant because there is evidence that repetitive head impacts can contribute to regional brain atrophy [11].

Volumetric studies of neuroimaging regularly use freely accessible automatic segmentation methods such as Free-Surfer [12].

The effects of physical activity on executive functions mediated by the frontal lobe over the adult life span are less well understood.

The aim of this study is to see how age, gender, and sports activity affect brain frontal lobe measurements.

MATERIALS AND METHODS

Participants: A total of 80 healthy volunteers with no apparent/ diagnosed health problems (40 males and 40 females) were selected and divided into 4 groups:

Group I (Control group): the group consists of 20 volunteers (20 males and 20 females). All are healthy, non-athletes with age ranges 20: 30 years

Group II (Athletic group): the group consists of 20 volunteers (20 males and 20 females). All are healthy, football players playing in Smouha sporting and Alexandria sporting clubs with age ranges 20: 30 years.

Group III (Younger age group): the group consists of 20 volunteers (20 males and 20 females). All are healthy, non-athletes with age ranges 10: 20 years

Group IV (Older age group): the group consists of 20 volunteers (20 males and 20 females). All are healthy, non-athletes with age ranges 30: 40 years.

All particpants were proved to be healthy according to history taken from them and a written consent to participate in the study was taken from all of them.

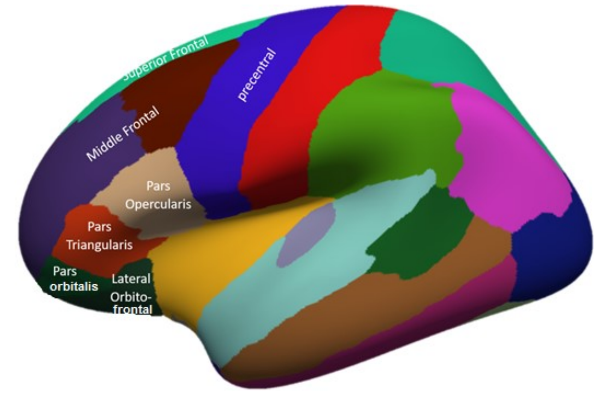

Fig. 1: Different areas of the frontal lobe assessed by free surface-based imaging study (superolateral surface).

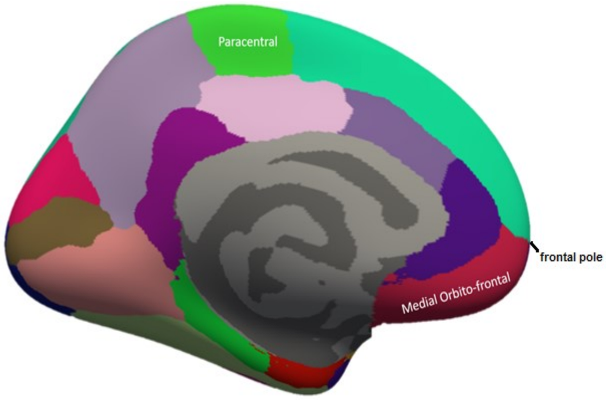

Fig. 2: Different areas of the frontal lobe assessed by free surface-based imaging study (inferomedial surface).

Study design:

I. Anthropometric Measurements:

Height (Ht) in cm, weight (Wt) in kg and body mass index (BMI) were measured for every participant.

B. MRI volumetry was used to assess the frontal lobe areas on both sides as follows:

On superolateral surface (figure 1)

- Superior frontal gyrus
- Middle frontal gyrus (rostral and caudal)
- Inferior frontal gyrus (pars opercularis, pars orbitalis and pars triangularis)
- Pre central gyrus.

On inferomedial surface (figure 2)

- Lateral orbito frontal.
- Medial orbito frontal.
- Paracentral lobule.
- Frontal pole

Imaging assessment:

MRI acquisition protocol:

A 3 Tesla General Electric (GE) Discovery MR 750 device was used for the MRIs (GE Discovery, Madison, WI). The following sequence was used to obtain MR images: T1-weighted 3D fast spoiled gradient-echo (FSPGR) sequences were acquired in an axial plane and reconstructed in coronal and sagittal planes.

MRI data analysis:

Free-surfer image processing for brain volumetric evaluation:

Cortical reconstruction and volumetric segmentation of the acquired 3D fast spoiled gradient-echo (FSPGR) T1-weighted sequences was carried out by Voxel-Based Morphometry (VBM) using the Free-surfer image analysis suite, which is well-documented and freely downloadable on the internet (http://surfer.nmr.mgh.harvard.edu/) [13].

The following are the technical aspects of these procedures in short:

1. Motion correction and averaging of multiple volumetric T1 weighted images (when more than one is available).

2. Removal of non-brain tissue using a hybrid watershed/surface deformation procedure, automated Talairach transformation.

3. Segmentation of the subcortical white matter and deep gray matter volumetric structures (including hippocampus, amygdala, caudate, putamen, ventricles).

4. Intensity normalization, tessellation of the gray matter-white matter boundary, automated topology correction, and surface deformation following intensity gradients to optimally place the gray/white and gray/cerebrospinal fluid borders at the location where the greatest shift in intensity defines the transition to the other tissue class.

5. Once the cortical models are complete, a number of deformable procedures can be performed for further data processing and analysis including surface inflation, registration to a spherical atlas which is based on individual cortical folding patterns to match cortical geometry across subjects, parcellation of the cerebral cortex into units with respect to gyral and sulcal structure, and creation of a variety of surface based data including maps of curvature and sulcal depth. (Figure 3) [13].

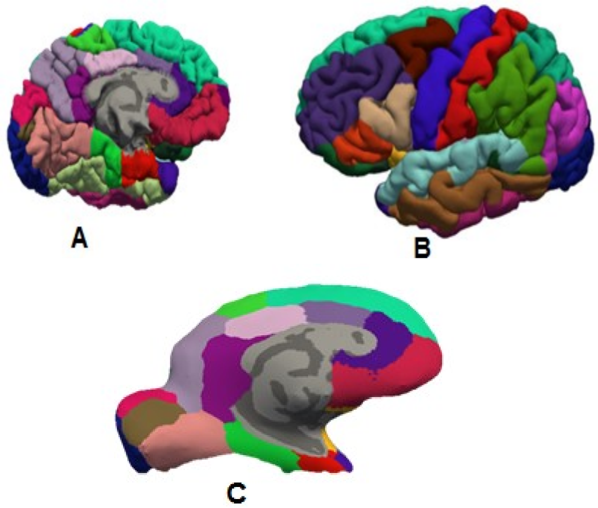

Fig. 3: Free surface based imaging analysis showing segmented medial surface (A), supero lateral surface (B) and inflated brain images (C) (13).

Free-surfer image analysis suite uses both intensity and continuity information from the entire three dimensional MR volumes in segmentation and deformation procedures to produce representations of cortical thickness, calculated as the closest distance from the gray/white boundary to the gray/CSF boundary at each vertex on the tessellated surface. **(Figure 4)**

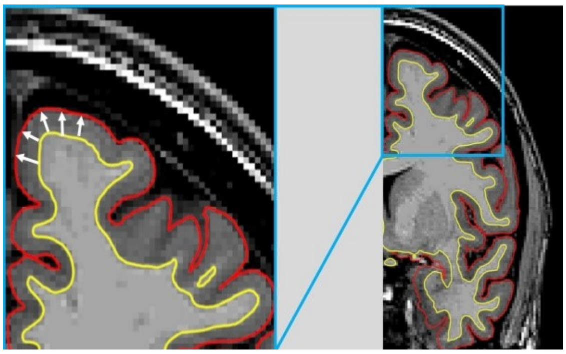

Fig. 4: Free surface based imaging analysis showing cortical thickness measurement [13].

Statistical analysis of the data: Data were fed to the computer and analyzed using IBM SPSS software package version 20.0. (Armonk, NY: IBM Corp**).** The Kolmogorov- Smirnov test was used to verify the normality of distribution of variables,**). Student t-test** was used to compare two groups for normally distributed quantitative variables. **F-test (ANOVA)** was used for normally distributed quantitative variables. Significance of the obtained results was judged at the 5% level (14).

RESULTS

The height, weight and BMI are increased in sport male and female groups compared to the control group and this was statistically significant ($p \leq 0.05$) (table (1).

Table 1: Comparison between the two studied groups according to demographic data.

Demographic data	Male		Female	
	Control (n=10)	Sport (n=10)	Control (n=10)	Sport (n=10)
Age (years)	24.2 ± 3.4	24.6 ± 3.1	25.2 ± 3.4	25.2 ± 3.2
Height (cm)	172.2 ± 1.8	178 ± 1.5	170.1 ± 2.5	177.5 ± 2
Weight (kg)	69.6 ± 2.2	58.5 ± 1.3	71.1 ± 1.7	58 ± 1.8
BMI (kg/m^2)	23.5 ± 0.9	18.5 ± 0.3	24.6 ± 0.8	18.4 ± 0.3

Data was expressed in mean ± SD : Student t-test p: p value for comparing between the two studied groups
*: Statistically significant at $p \leq 0.05$.

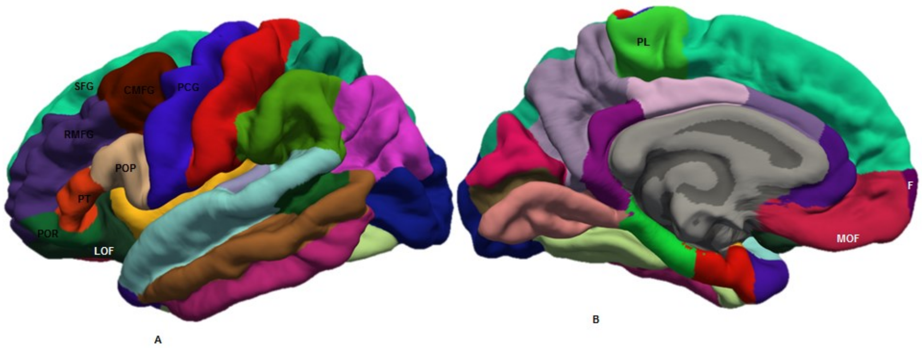

Fig. 5: Volumetric measurements of different areas of the frontal lobe are shown in figure 5.

Figure (5) Different areas of the frontal lobe assessed by free surface-based imaging study; superolateral (A) and inferomedial (B) surfaces. SFG: superior frontal gyrus, CMFG: caudal middle frontal gyrus, RMFG: rostral middle frontal gyrus, POP: pars opercularis, PT: pars triangularis, POR: pars orbitalis, LOF: lateral orbitofrontal, MOF: medial orbitofrontal, F: frontal pole, PL: paracentral lobule.

The pars triangularis in the right frontal lobe in males in the control group is increased significantly compared to the study group while other parameters show no significant difference (Table 2, Figure 6).

The medial orbitofrontal, the pars orbitalis, the superior frontal and the frontal pole in the right frontal lobe in females in the sport group isincreased significantly compared tothe control while the pars orbicularis and pars triangularis in the left frontal lobe is increased significantly in the sport group compared to the control (table 3, figure 7).

The medial orbitofrontal and pars triangularis are increased significantly in the left frontal lobe in the male group aged 10-20 years while other parameters in the left and right frontal lobes showed no statistical significant difference (table 5, figure 9).

Table 2: Comparison between the two studied groups according to Brain parameters in male group.

Brain parameters	Right frontal lobe		Left frontal lobe	
	Control (n=10)	Sport (n=10)	Control (n=10)	Sport (n=10)
Caudal middle frontal	2.7 ± 0.1	2.6 ± 0.1	2.7 ± 0.2	2.7 ± 0.1
t (p)	**1.457 (0.167)**		**0.288 (0.822)**	
Lateral orbito frontal	2.7 ± 0.2	2.7 ± 0.1	2.7 ± 0.1	2.8 ± 0.1
t (p)	**1.380 (0.184)**		**1.247 (0.228)**	
Medial orbito frontal	2.6 ± 0.2	2.6 ± 0.2	2.5 ± 0.1	2.6 ± 0.2
t (p)	**0.282 (0.781)**		**1.872 (0.088)**	
Paracentral	2.5 ± 0.1	2.5 ± 0.1	2.5 ± 0.1	2.5 ± 0.1
t (p)	**0.174 (0.864)**		**0.078 (0.939)**	
Pars opercularis	2.7 ± 0.2	2.6 ± 0.2	2.7 ± 0.2	2.7 ± 0.1
t (p)	**1.604 (0.126)**		**0.059 (0.953)**	
Pars orbitalis	2.8 ± 0.2	2.8 ± 0.2	2.8 ± 0.2	2.7 ± 0.2
t (p)	**0.402 (0.692)**		**0.140 (0.890)**	
Pars triangularis	2.6 ± 0.2	2.4 ± 0.1	2.5 ± 0.2	2.5 ± 0.1
t (p)	**2.753* (0.013*)**		**0.005 (0.996)**	
Pre central	2.6 ± 0.1	2.6 ± 0.1	2.7 ± 0.1	2.6 ± 0.1
t (p)	**0.850 (0.406)**		**1.767 (0.094)**	
Rostral middle frontal	2.5 ± 0.2	2.5 ± 0.1	2.5 ± 0.2	2.5 ± 0.1
t (p)	**0.421 (0.679)**		**0.641 (0.530)**	
Superior frontal	2.8 ± 0.2	2.8 ± 0.2	2.8 ± 0.1	2.9 ± 0.1
t (p)	**0.189 (0.852)**		**1.322 (0.203)**	
Frontal pole	3 ± 0.4	2.9 ± 0.3	2.8 ± 0.3	2.9 ± 0.3
t (p)	**0.415 (0.683)**		**0.826 (0.419)**	

Data was expressed in mean ± SD t: Student t-test

p: p value for comparing between the two studied groups

*: Statistically significant at $p \leq 0.05$

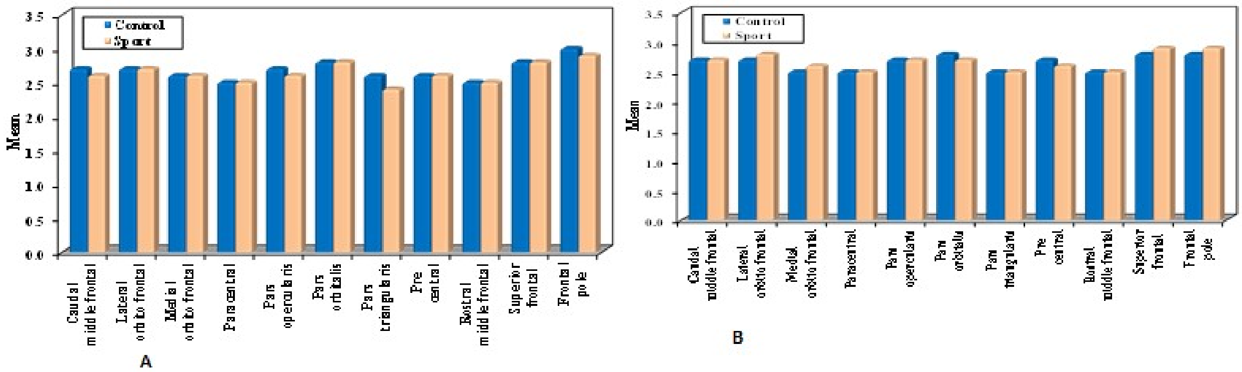

Fig. 6: Comparison between the two studied groups according to brain parameters in males. A: Right frontal lobe, B: left frontal lobe

Table 3: Comparison between the two studied groups according to brain parameters in female group.

Brain parameters	Right frontal lobe		Left frontal lobe	
	Control (n=10)	Sport (n=10)	Control (n=10)	Sport (n=10)
Caudal middle frontal	2.6 ± 0.1	2.7 ± 0.1	2.7 ± 0.1	2.8 ± 0.2
t (p)	**0.889 (0.386)**		**0.825 (0.420)**	
Lateral orbito frontal	2.7 ± 0.1	2.8 ± 0.2	2.8 ± 0.2	2.8 ± 0.1
t (p)	**1.534 (0.142)**		**0.900 (0.380)**	
Medial orbito frontal	2.5 ± 0.1	2.7 ± 0.2	2.6 ± 0.2	2.6 ± 0.1
t (p)	**3.696* (0.002*)**		**0.939 (0.360)**	
Paracentral	2.5 ± 0.2	2.5 ± 0.2	2.5 ± 0.1	2.5 ± 0.2
t (p)	**0.100 (0.921)**		**0.009 (0.993)**	
Pars opercularis	2.7 ± 0.1	2.6 ± 0.2	2.8 ± 0.1	2.7 ± 0.1
t (p)	**1.453 (0.170)**		**3.439*(0.003*)**	
Pars orbitalis	2.7 ± 0.1	2.9 ± 0.1	2.9 ± 0.2	2.9 ± 0.2
t (p)	**2.948* (0.009*)**		**0.194 (0.849)**	
Pars triangularis	2.5 ± 0.1	2.5 ± 0.2	2.6 ± 0.2	2.5 ± 0.2
t (p)	**0.761 (0.457)**		**2.291*(0.034*)**	
Pre central	2.6 ± 0.1	2.6 ± 0.1	2.7 ± 0.2	2.7 ± 0.1
t (p)	**0.154 (0.879)**		**0.019 (0.985)**	
Rostral middle frontal	2.4 ± 0.1	2.5 ± 0.1	2.6 ± 0.2	2.6 ± 0.1
t (p)	**0.640 (0.530)**		**0.222 (0.827)**	
Superior frontal	2.7 ± 0.1	2.9 ± 0.1	2.9 ± 0.2	2.9 ± 0.1
t (p)	**2.852*(0.011*)**		**0.671 (0.511)**	
Frontal pole	**2.9 ± 0.1**	3.1 ± 0.4	3 ± 0.3	3 ± 0.2
t (p)	**2.255* (0.044*)**		**0.113 (0.912)**	

Data was expressed in mean ± SD

t: Student t-test

p: p value for comparing between the two studied groups

*: Statistically significant at $p \leq 0.05$

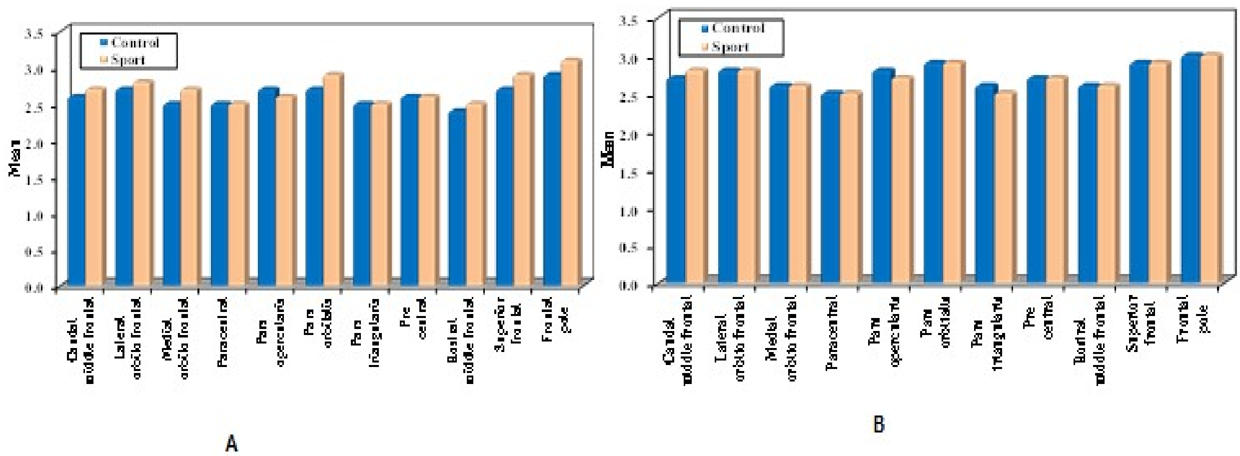

Fig. 7: Comparison between the two studied groups according to brain parameters in females. A: Right frontal lobe, B: left frontal lobe In both frontal lobes, there are no gender differences in the measurements of various brain parameters (table 4, figure 8).

Table 4: Comparison between Male and Female according to brain parameters in Sport group.

Brain parameters	Right frontal lobe		Left frontal lobe	
	Male (n=10)	Female (n=10)	Male (n=10)	Female (n=10)
Caudal middle frontal	2.6 ± 0.1	2.7 ± 0.1	2.7 ± 0.1	2.8 ± 0.2
t (p)	0.961 (0.349)		1.542 (0.140)	
Lateral orbito frontal	2.7 ± 0.1	2.8 ± 0.2	2.8 ± 0.1	2.8 ± 0.1
t (p)	0.846 (0.413)		0.109 (0.914)	
Medial orbito frontal	2.6 ± 0.2	2.7 ± 0.2	2.6 ± 0.2	2.6 ± 0.1
t (p)	1.685 (0.109)		0.097 (0.924)	
Paracentral	2.5 ± 0.1	2.5 ± 0.2	2.5 ± 0.1	2.5 ± 0.2
t (p)	0.236 (0.816)		0.025 (0.980)	
Pars opercularis	2.6 ± 0.2	2.6 ± 0.2	2.7 ± 0.1	2.7 ± 0.1
t (p)	0.318 (0.754)		0.411 (0.686)	
Pars orbitalis	2.8 ± 0.2	2.9 ± 0.1	2.7 ± 0.2	2.9 ± 0.2
t (p)	2.041 (0.056)		2.037 (0.057)	
Pars triangularis	2.4 ± 0.1	2.5 ± 0.2	2.5 ± 0.1	2.5 ± 0.2
t (p)	0.912 (0.374)		0.558 (0.584)	
Pre central	2.6 ± 0.1	2.6 ± 0.1	2.6 ± 0.1	2.7 ± 0.1
t (p)	0.547 (0.591)		1.541 (0.141)	
Rostral middle frontal	2.5 ± 0.1	2.5 ± 0.1	2.5 ± 0.1	2.6 ± 0.1
t (p)	0.356 (0.726)		1.212 (0.241)	
Superior frontal	2.8 ± 0.2	2.9 ± 0.1	2.9 ± 0.1	2.9 ± 0.1
t (p)	0.930 (0.365)		0.950 (0.355)	
Frontal pole	2.9 ± 0.3	3.1 ± 0.4	2.9 ± 0.3	3 ± 0.2
t (p)	1.431 (0.170)		0.836 (0.414)	

Data was expressed in mean ± SD

t: Student t-test

p: p value for comparing between the two studied groups

*: Statistically significant at $p \leq 0.05$

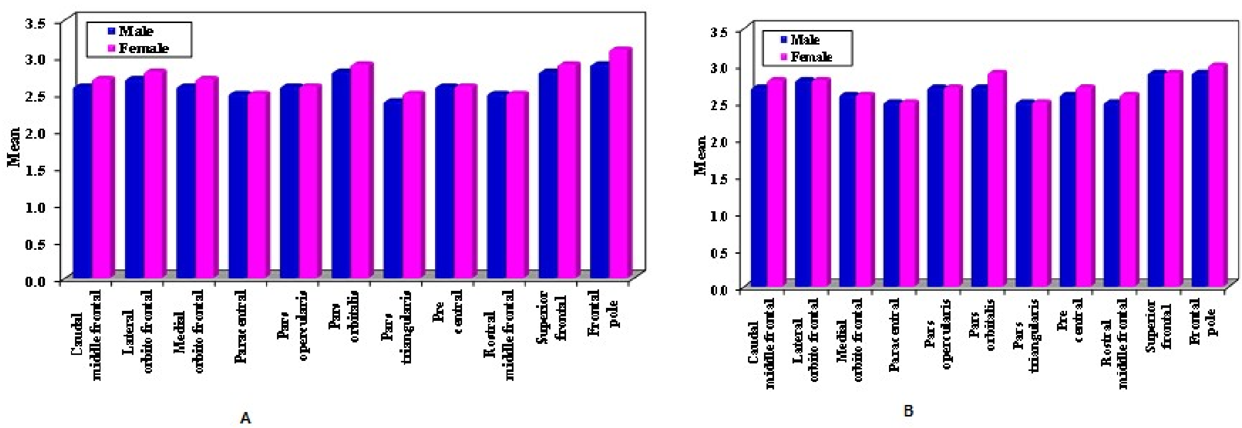

Fig. 8: Comparison between brain parameters in the males and females of the sport group. A: Right frontal lobe, B: left frontal lobe

The medial orbitofrontal and pars triangularis are increased significantly in the left frontal lobe in the male group aged 10-20 years while other parameters in the left and right frontal lobes showed no statistical significant difference (table 5, figure 9).

Table 5: Comparison between different age changes according to brain parameters in males.

Brain parameters	Right frontal lobe Age 10 – 20 (n = 10)	Right frontal lobe Age 20 – 30 (n = 10)	Right frontal lobe Age 30 –40 (n = 10)	Left frontal lobe Age 10 – 20 (n = 10)	Left frontal lobe Age 20 – 30 (n = 10)	Left frontal lobe Age 30 –40 (n = 10)
Caudal middle frontal	2.7 ± 0.2	2.7 ± 0.1	2.6 ± 0.1	2.7 ± 0.2	2.7 ± 0.2	2.7 ± 0.1
F (p)		1.573 (0.226)			0.154 (0.858)	
Lateral orbito frontal	2.8 ± 0.2	2.7 ± 0.2	2.7 ± 0.2	2.8 ± 0.2	2.7 ± 0.1	2.8 ± 0.2
F (p)		0.978 (0.389)			1.808 (0.183)	
Medial orbito frontal	2.7 ± 0.2	2.6 ± 0.2	2.5 ± 0.1	2.6 ± 0.1	2.5 ± 0.1	2.5 ± 0.1
F (p)		3.056 (0.064)			6.865* (0.004*)	
Paracentral	2.6 ± 0.2	2.5 ± 0.1	2.4 ± 0.1	2.6 ± 0.2	2.5 ± 0.1	2.5 ± 0.1
F (p)		2.135 (0.138)			1.791 (0.186)	
Pars opercularis	2.7 ± 0.3	2.7 ± 0.2	2.7 ± 0.2	2.7 ± 0.2	2.7 ± 0.2	2.8 ± 0.1
F (p)		0.405 (0.671)			0.578 (0.568)	
Pars orbitalis	2.8 ± 0.1	2.8 ± 0.2	2.8 ± 0.2	2.9 ± 0.2	2.8 ± 0.2	2.8 ± 0.2
F (p)		0.074 (0.929)			1.148 (0.332)	
Pars triangularis	2.6 ± 0.2	2.6 ± 0.2	2.5 ± 0.2	2.7 ± 0.1	2.5 ± 0.2	2.5 ± 0.1
F (p)		0.705 (0.503)			6.422* (0.005*)	
Pre central	2.6 ± 0.1	2.6 ± 0.1	2.6 ± 0.2	2.7 ± 0.1	2.7 ± 0.1	2.6 ± 0.2
F (p)		0.435 (0.652)			0.442 (0.648)	
Rostral middle frontal	2.5 ± 0.2	2.5 ± 0.2	2.4 ± 0.2	2.5 ± 0.1	2.5 ± 0.2	2.5 ± 0.1
F (p)		0.548 (0.584)			0.214 (0.808)	
Superior frontal	2.9 ± 0.2	2.8 ± 0.2	2.8 ± 0.2	2.9 ± 0.2	2.8 ± 0.1	2.9 ± 0.2
F (p)		0.381 (0.687)			0.560 (0.578)	
Frontal pole	3 ± 0.3	3 ± 0.4	2.7 ± 0.3	2.9 ± 0.3	2.8 ± 0.3	2.9 ± 0.3
F (p)		2.483 (0.102)			1.016 (0.375)	

Data was expressed in mean ± SD F: F for ANOVA test
p: p value for comparing between the age changes *: Statistically significant at $p \leq 0.05$

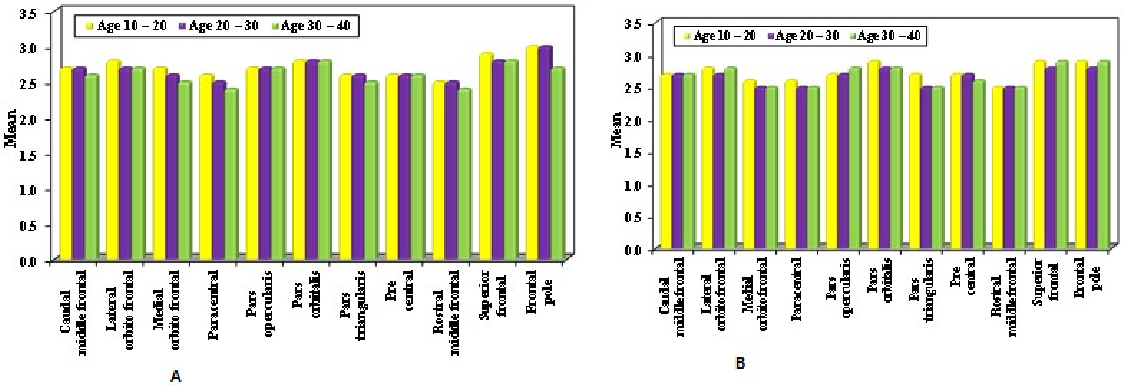

Fig. 9: Comparison between brain parameters in different age groups males. A: Right frontal lobe, B: left frontal lobe

Table 6: Comparison between different age changes according to brain parameters in females.

Brain parameters	Right frontal lobe Age 10 – 20 (n = 10)	Right frontal lobe Age 20 – 30 (n = 10)	Right frontal lobe Age 30 –40 (n = 10)	Left frontal lobe Age 10 – 20 (n = 10)	Left frontal lobe Age 20 – 30 (n = 10)	Left frontal lobe Age 30 –40 (n = 10)
Caudal middle frontal	2.8 ± 0.1	2.6 ± 0.1	2.5 ± 0.2	2.6 ± 0.2	2.7 ± 0.1	2.6 ± 0.1
F (p)		7.907* (0.002*)			3.304 (0.052)	
Lateral orbito frontal	2.8 ± 0.2	2.7 ± 0.1	2.7 ± 0.2	2.8 ± 0	2.8 ± 0.2	2.7 ± 0.1
F (p)		2.469 (0.104)			4.941* (0.015*)	
Medial orbito frontal	2.7 ± 0.2	2.5 ± 0.1	2.5 ± 0.1	2.7 ± 0.1	2.6 ± 0.2	2.5 ± 0.1
F (p)		7.624* (0.002*)			7.445* (0.003*)	
Paracentral	2.7 ± 0.2	2.5 ± 0.2	2.4 ± 0.1	2.8 ± 0.1	2.5 ± 0.1	2.4 ± 0.1
F (p)		8.665* (0.001*)			17.645* (<0.001*)	
Pars opercularis	2.9 ± 0.1	2.7 ± 0.1	2.7 ± 0.2	2.8 ± 0.1	2.8 ± 0.1	2.7 ± 0.2
F (p)		6.314* (0.006*)			3.314 (0.052)	
Pars orbitalis	3 ± 0.3	2.7 ± 0.1	2.7 ± 0.2	2.9 ± 0.2	2.9 ± 0.2	2.7 ± 0.2
F (p)		3.851* (0.034*)			3.920* (0.032*)	
Pars triangularis	2.7 ± 0.1	2.5 ± 0.1	2.6 ± 0.2	2.7 ± 0.2	2.6 ± 0.2	2.6 ± 0.2
F (p)		5.411* (0.011*)			1.466 (0.249)	
Pre central	2.7 ± 0.2	2.6 ± 0.1	2.5 ± 0.2	2.7 ± 0.1	2.7 ± 0.2	2.6 ± 0.2
F (p)		2.866 (0.074)			0.662 (0.524)	
Rostral middle frontal	2.5 ± 0.2	2.4 ± 0.1	2.4 ± 0.1	2.4 ± 0.2	2.6 ± 0.2	2.5 ± 0.1
F (p)		1.263 (0.299)			1.856 (0.176)	
Superior frontal	2.9 ± 0.1	2.7 ± 0.1	2.7 ± 0.2	2.9 ± 0.2	2.9 ± 0.2	2.7 ± 0.1
F (p)		6.621* (0.005*)			3.354* (0.049*)	
Frontal pole	3 ± 0.3	2.9 ± 0.1	2.8 ± 0.3	2.6 ± 0.2	3 ± 0.3	2.6 ± 0.4
F (p)		1.659 (0.209)			4.046* (0.029*)	

Data was expressed in mean ± SD
F: F for ANOVA test
p: p value for comparing between the age changes
*: Statistically significant at $p \leq 0.05$

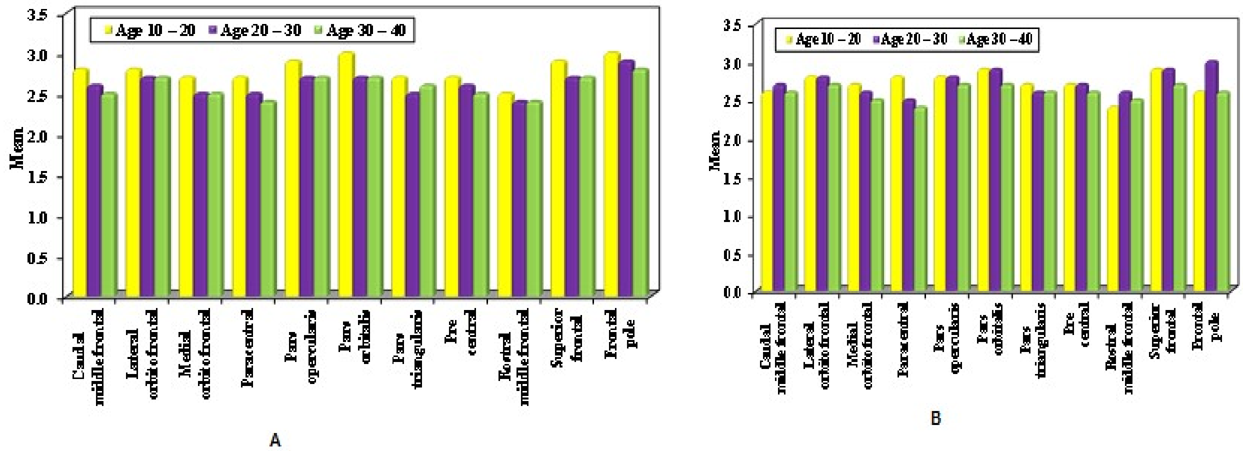

Fig. 10: Comparison between brain parameters in different age groups females.
A: Right frontal lobe, B: left frontal lobe

The caudal middle frontal, the medial orbitofrontal, the paracentral, the pars triangularis, the pars orbicularis and superior frontal gyrus are increased significantly in the female aged 10-20 years in the right frontal lobe while the lateral orbitofrontal and the frontal pole increased significantly in the female aged 20-30 years and medial orbitofrontal and paracentral in female aged 10-20 years in the left frontal lobe (table 6, figure 10).

DISCUSSION

Although the clinical literature has long recognised that exercise has an effect on general health and brain function, little is known about the benefits of physical exercise on executive functions over the course of an adult's life [2].

In the present research, the height, weight and BMI are increased in sport male and female groups compared to the control group and this was statistically significant.

Contrary to the present study, Taki et al revealed that, the regional grey matter volume of the bilateral inferior frontal gyri, frontal lobe, and precuneus showed significant negative correlations with BMI in men [15]. This may be explained by the fact that the study's participants are athletes, and the rise in BMI is attributed to increased muscle mass rather than fat.

In the present work, The pars triangularis in the right frontal lobe in males in the control group is increased significantly compared to the study group. According to Iwashiro's study, the increased volume of the pars opercularis and pars triangularis is due to their functions in language processing and interpersonal awareness [16].

In this study, the medial orbitofrontal, pars orbitalis, superior frontal, and frontal pole in the right frontal lobe of females in the sport group were significantly increased compared to the control group, while the pars orbicularis and pars triangularis in the left frontal lobe were significantly increased in the sport group compared to the control group.

Best et al, revealed in their research that, larger lateral prefrontal cortex volume, especially the left middle frontal gyrus, predicted greater exercise class attendance independent of intracranial volume, age, education, body structure, mobility, depressive symptoms, and general cognitive functioning. as well as the likelihood of potential exercise compliance [17]. Exercise compliance is responsible for the increased volume of these areas in the current report.

In this research, the male population aged 10-20 years, the medial orbitofrontal and pars triangularis was significantly increased in the left frontal lobe, while other parameters in the left and right frontal lobes showed no statistically significant difference.

Reduced cortical surface area in right frontal regions, according to Nissim et al, can explain age-related declines in working memory function [18]. The caudal middle frontal, the medial orbitofrontal, the paracentral, the pars triangularis, the pars orbicularis and superior frontal gyrus are increased significantly in the female aged 10-20 years in the right frontal lobe while the lateral orbitofrontal and the frontal pole increased significantly in the female aged 20-30 years and medial orbitofrontal and paracentral in female aged 10-20 years in the left frontal lobe.

The rostral middle frontal gyrus, the pars opercularis, the postcentral gyrus, the caudal middle frontal gyrus, and the superior frontal gyrus all had significant leftward asymmetries, according to Koelkebeck et al [19].

Conflicts of Interests: None

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