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RESEARCH

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Regular Islamic prayers have different corpus callosum: a shape analysis study

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Abstract

Background Religious practices and experiences are thought to involve a variety of thoughts and behaviors, and various studies hypothesize the relationship between religion and changes in the brain. The aim of this study was to evaluate the corpus callosum (CC) of prayers by statistical shape analysis (SSA) and compare it with healthy ones who did not.

Methods The study group consisted of 13 healthy people who pray regularly and the control group consisted of 14 healthy people who did not pray. Participants were scanned with a 1.5 T scanner and a high-resolution structural image of the entire brain was obtained with sagittal 3D spiral fast spin echo. In mid-sagittal images of each individual, the CC was marked using landmarks. The mean of 'Procrustes' points was calculated and shape deformations were evaluated using thin plate spline analysis.

Results There was no significant difference between the CC area of prayers and controls. Maximum CC deformation was observed in the body and rostrum region markings during prayers. There was no significant difference in the other parameters of the individuals who performed regular prayers compared to the controls.

Conclusions Corpus callosum analysis with SSA revealed differences between prayers and healthies. The study findings highlighted the abnormal distribution of white matter in the CC and the variable subregional nature of CC in prayers. The study findings showed that shape analysis could be a useful technique to show variations in the corpus callosum using MRI images.

Keywords Religion and science, Islam, Corpus callosum, Image processing, Computer-assisted, Magnetic resonance imaging

Introduction

For over a century, research on different religious groups has suggested that religious practices and experiences are thought to involve a variety of thoughts and behaviors, and various studies of the relationship between religion and changes in the brain hypothesize that religious experiences may be similar [15, 18, 36]. Yet little is known about the relationship between religion, spiritual experiences, and brain structure and activity, and in fact, a large number of neuroimaging studies (especially meditation studies) in recent years have provided important information about the beneficial effects of such activities on the physical health and psychology [1, 10, 17]. Both cross-sectional and longitudinal imaging studies have shown that meditation is associated with differences when assessing its effect on brain structure changes [13, 38, 40]. Although there is limited research on monotheistic religions; In terms of traditional meditation, polytheistic religions, and secular experiences, there are neuroimaging studies that show variation in brain regions, such as the hippocampus, insular cortex, inferior temporal gyrus, anterior cingulate cortex, amygdala, somatomotor

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cortex, ventrolateral prefrontal cortex, temporopolar region, medial prefrontal cortex, temporal–parietal junction, and precuneus [2, 16, 22, 27, 29, 32, 38]. Although brain imaging studies have been conducted for various psychiatric diseases in Muslim societies, the level of religiosity, the presence and effects of Islamic prayer have not been investigated [3, 5] apart from a neurophysiological study [33]. Religious practices and experiences can cause changes in any part of the brain and cause changes in texture, size and shape (plasticity). It is inevitable that these changes will lead to changes in size and shape by causing changes in the structure of the corpus callosum (CC), which is the main white matter structure that connects the brain hemispheres, provides interhemispheric integration and transmits sensory information [9, 31]. It is known that structural changes in CC are associated with neuropsychiatric symptoms [6, 35].

In the last decades, statistical shape analysis (SSA) has been widely used in medicine to examine various structures of interest to determine morphometric features of abnormalities of an organ associated with a particular condition or disease. Offering many different methods for measuring anatomical brain structures, SSA has become a growing interest, particularly in neuroimaging. These studies often rely on measurements of volume and area, which are quantitative features that can predict the progression of disease-induced atrophy or dilation. However, structural changes occurring in certain locations may not be adequately reflected in these volume and area measurements, because it is possible for two different individuals to have the same organs in the same volume and area dimensions, but with differences in shape. Today, with technical developments, imaging views and shapes of organs or tissue structures are widely used as photographic input data. With these data, geometric shape changes in any organ or textural structure can be statistically analyzed using certain signs. SSA is a modern geometric–morphometric analysis method that can be used to evaluate the effects of demographic factors, environmental influences or diseases on growth and allometry and compares body shapes with specific anatomical features using static landmarks. This method is a form of analysis that gives more objective results with multivariate and integrated data on morphological shapes compared to analyzes using classical linear measurements. SSA is increasingly used in medicine to examine various structures to identify morphometric abnormalities associated with a particular condition or disease that can aid diagnosis and treatment [20, 26, 28, 34].

Since differences in texture parameters have been shown previously in CCs of prayers [4, 5], the aim of this study is to evaluate the corpus callosum by SSA using T1-weighted sagittal MRI images of regular prayers and compare them with healthy controls based on this information.

Materials and methods

The criteria of the study were determined as being between 20 and 50 years of age, having no psychiatric diagnosis, no mental retardation, no neurological or physiological disease, no history of alcohol or substance use in the last year, and no contraindications for MRI examinations. Local Ethics Committee approval was obtained (date: 08 Dec 2015, session: 21, decision: 06). All participants signed an informed consent form. All study procedures were carried out in accordance with the 1983 revised version of the 1975 Helsinki Declaration.

Study population

According to the study criteria, 27 healthy volunteers with similar age and gender distribution were selected, 13 of whom regularly prayed at community standards, 14 of whom did not pray at all and did not engage in any other spiritual activity. All of the participants had similar characteristics in terms of education level, socioeconomic status and usual activities.

Imaging process

A 1.5 T General Electric Signa Excite scanner (GE, Milwaukee, Wisconsin, USA) with an 8-channel HR brain coil was used for MRI. High resolution structural T1-weighted sagittal 3D fast spin echo MRI images were obtained. Anteroposterior commissure line and interhemispheric fissure were used to align the brains of all individuals in a standard position in MRI examinations.

Analysis of images

Obtaining two-dimensional landmarks

Mid-sagittal T1-weighted two-dimensional digital MRI images of each individual, most clearly showing the cerebral aqueduct, corpus callosum, and superior colliculus, were selected. Corpus callosum was marked with TpsDig2 version 2.32 software on each selected image using standardized anatomical landmarks [8, 34] and data were collected [37].

Statistical deformation analysis

The mean of 'Procrustes' landmark points was calculated and shape deformations were evaluated using thin plate spline (TPS) analysis with Past version 4.10 [19]. Areas that show the greatest expansion or contraction as a result of this analysis are marked using different colors to indicate deformations. The homogeneity of the variance–covariance matrices was examined using the Box–M test [11, 19]. Because of the non-homogeneous matrices, the James FJ test based on a resampling procedure was used to compare the shapes of the corpus callosum between the control and prayer groups [11, 41]. In addition, the root mean square of Kendall's Riemann distance rho was compared with the mean shape to obtain overall shape variability measures for the controls and prayer groups. Allometric evaluation was performed using multivariate regression analysis of centroid sizes and tangent coordinates. Model significance was assessed using the Wilks' lambda test. Assessment of model fit was performed based on the mean square error (MSE) and the coefficient of determination (R^2) [20, 28].

Statistical analysis

Shapes version 1.2.6 package with the R version 4.2.0, PAST version 4.10 were used for the statistical shape analysis [11, 19]. Data were expressed as mean ± standard deviation. According to normal distribution analysis (One Sample Kolmogorov–Smirnov test) of variables, Student's *t* test were used to compare the groups for other data. All statistical analyses were made with IBM® SPSS® Statistics (SPSS for Windows version 25, IBM Corporation, Armonk, New York, USA). p value of < 0.05 was considered statistically significant.

Results

The mean age of the prayer's group was 32.46 ± 5.06 and the mean age of the control group was 34.93 ± 8.27. The individuals consisted of eight men and five women who performed the Islamic pray and eight men and six women who did not. There was no significant difference between the groups based on age ($p = 0.363$) and gender ($p = 0.816$).

There was no significant difference between the corpus callosum area in the mid-sagittal images of the patients diagnosed with prayers and controls (6.0 ± 0.76 cm^2 and 5.67 ± 0.68 cm^2, respectively; $p = 0.250$).

As the Box–*M* test identifies inhomogeneous matrices ($F = 11.295$, $p < 0.001$), the James FJ test was applied and corpus callosum shapes of prayer patients were found to be significantly different from controls ($T^2 = 1447.596$, $p < 0.001$) (Fig. 1). The root mean square of Kendall's Riemann distance (rho) to main shape was 0.07689575 for controls, 0.07879347 for prayers, and 0.04027745 for all (Fig. 2).

The effect of size-dependent shape changes and deformations in the mean shape on graphs (shrinkage) was demonstrated and compared between controls and prayer patients using TPS (Fig. 3). Maximum deformation was observed at marked points (landmarks) in the posterior region of the CC (6, 13, 8, 16, 15, 3, 11, 10, 4, 2, 9, 12, 5, 7, 14, and 1 in descending order of landmarks) (Table 1).

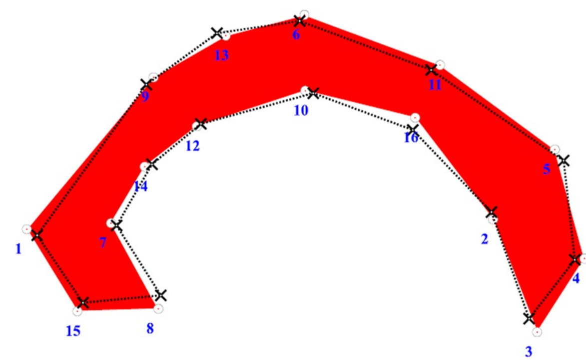

Fig. 1 Procrustes mean shape of the CC landmarks of the control (red dot circle) and prayer groups (X)

Cubic growth model was chosen as the most suitable model for CC and it was seen that centroid size in prayer group decreased with increasing age in contrast to the increase in control group for CCs (Fig. 4).

Multivariate regression test was used for the relationship between size and shape in the evaluation of allometry and a statistically significant model ($p = 6.41E{-}40$, $R^2 = 0.297$, $MSE = 0.02594$ and Wilks' lambda = 2.559E−151) was obtained for CC.

Discussion

It should be underlined that this study is the first to evaluate brain region imaging changes in individuals who regularly pray. In this sense, it is thought that the results of the present study will shed light and guide the future studies in this field. The data of this study observe that the corpus callosum in prayers differs from healthy controls who do not perform pray, suggesting that regular practice of Islamic pray is associated with altered corpus callosum shape.

It should be noted that previous studies of cortical plasticity in animals and humans have shown that when a task is required, constant attention should be paid to a behaviorally relevant sensory, and it has been shown that relaxation accelerates the learning process based on cortical plasticity [7, 15, 23, 38].

The corpus callosum provides integration between the hemispheres by connecting the relevant cerebral cortex regions in the brain [9, 31]. Furthermore, the association of white matter, including CC, with psychogenic conditions has been investigated in many studies, and empirical evidence from neuroimaging studies suggests that the corpus callosum plays an important role in mood states, but structural neuroimaging fails to extract information about its functionality [30, 39, 42, 44].

Statistical shape analysis has received more attention recently for its potential to demonstrate morphological

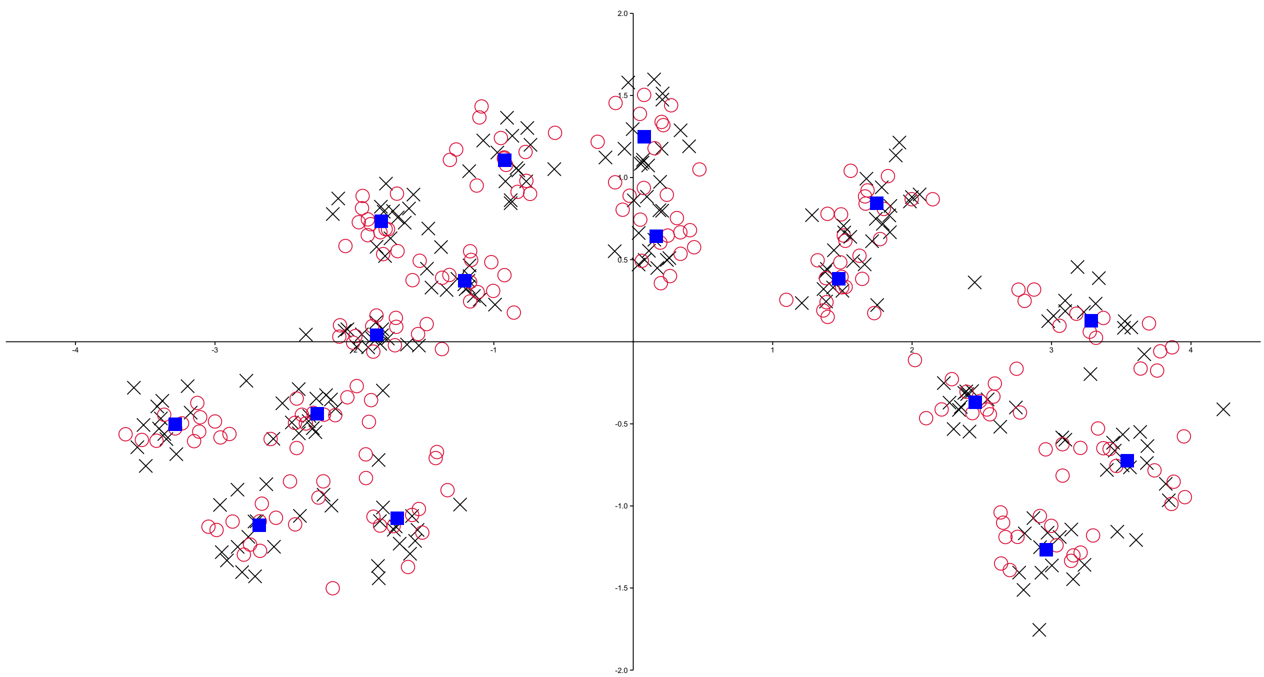

Fig. 2 Landmarks scatter plot with overall mean (blue square), controls (red circle) and prayers (X)

changes, but relatively few medical studies have analyzed the shape of CC to investigate of psychology [24, 28].

As the assessment of general form differentiation using neuroanatomical landmarks was considered most appropriate, analyzes were performed using the traditional landmark-based TPS method to examine the shape abnormalities of CC in prayers in this study. To our knowledge, this study was the first to use landmark-based SSA methods to analyze CC abnormalities in prayers, and local shape comparison had not been performed before.

In present study, no significant difference was found between prayers and controls in terms of CC areas in cross-sectional images, but when examined with SSA, the corpus callosum shape of the prayers was different from that of controls.

Some studies using shape analysis have reported significant findings about various CC subdivisions. Regional distribution differences of CC injury should result from variable regional fiber amounts associated with different neuroanatomical regions [20, 25, 43].

In this study, it was determined that the maximum deformation was located in the superior–anterior edge of the body, inferior splenium and region of rostrum of the CC. The first region is the connecting regions of precentral and second region is parietal activation cortical areas (landmarks = 6 and 13, and 16, respectively). These are also predominantly tactile, motor and auditory areas. As the other region, the rostrum is the connecting regions of the prefrontal cortex and premotor cortex areas, which they associate with cognitive information (landmarks = 8 and 15) [12, 14, 21]. This shows that possible basic mechanisms can also be applied to Islamic prayers. However, the exact reason for this cannot be explained as there is not enough research as of now, and therefore, there is no possibility to compare Islamic prayer and meditation. It is also not possible to assess whether differences in attributes will have an effect.

Limitations

The present study had certain limitations. Since there were no previous studies that analyzed CC with SSA in prayers, we were not able to compare the study findings. The small sample size of group members was another limitation of the study. Although morphological evaluation with 3D data may seem difficult now, it is certain that it will give results that are more accurate in the morphological analysis of organs in spatial dimensions. In addition, manual tracing methods were used to describe the corpus callosum, so some errors may have been made in the measurement. Last, the current study is a cross-sectional design and longitudinal studies are needed to assess change.

Conclusion

In this study, CC analysis with SSA and using MRI images revealed significant differences between prayers and controls. The study findings highlighted the abnormal distribution of white matter in the corpus callosum and the

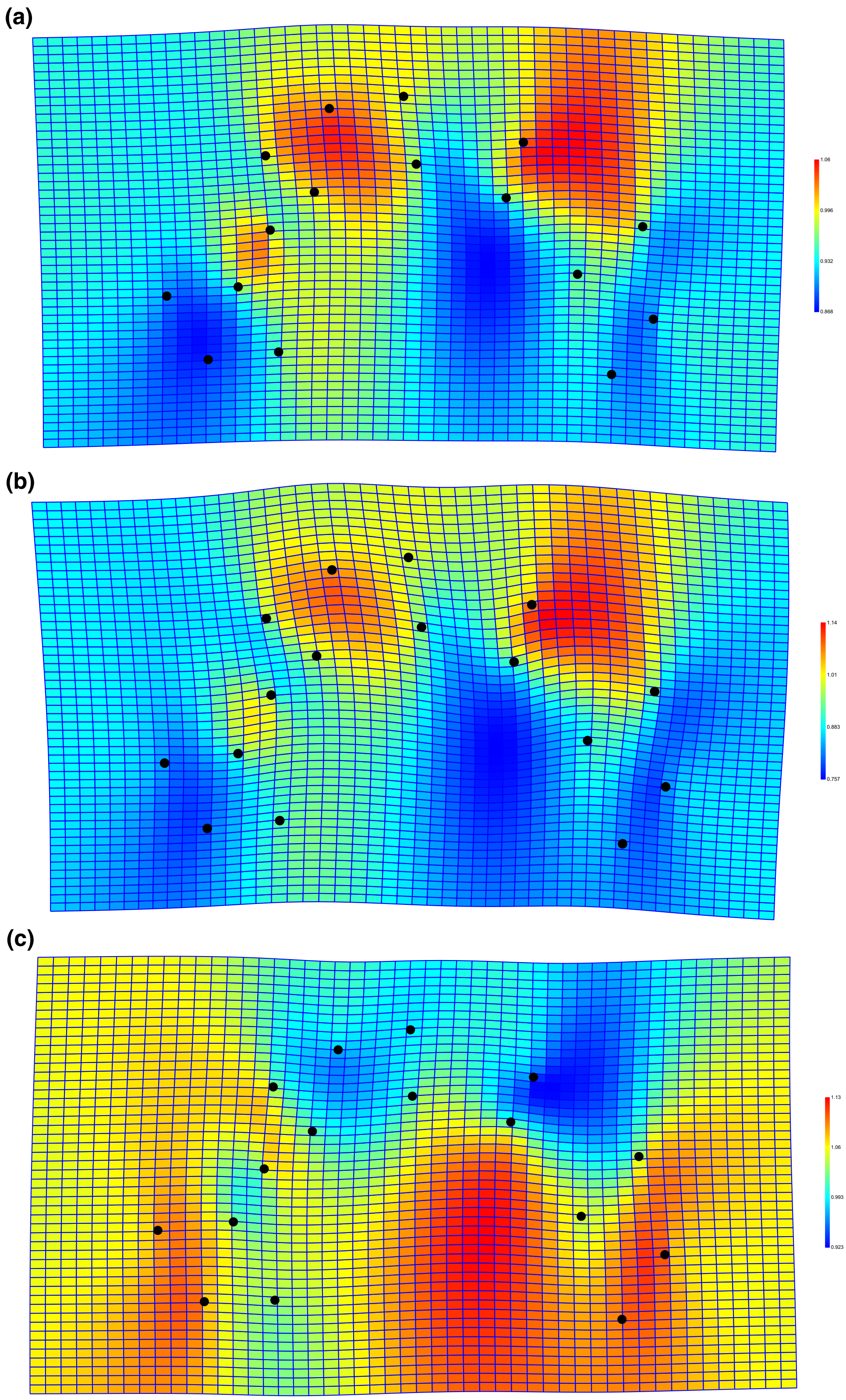

Fig. 3 Thin-plate spline transformation grid with expansion factors of the transformation from the overall mean to the control group (**a**), from the overall mean to the prayer group (**b**) and from the prayer group to control group (**c**)

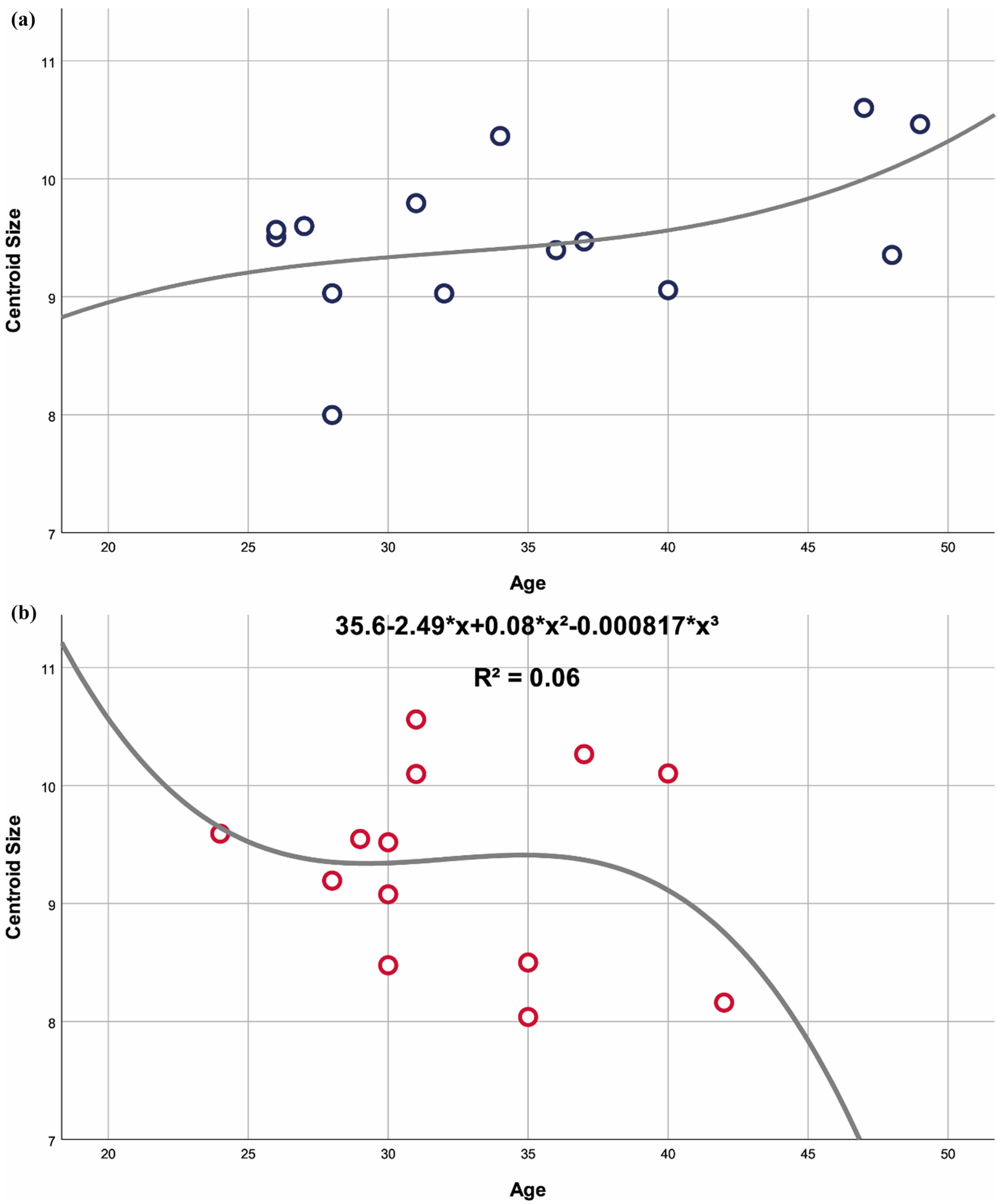

Fig. 4 Growth curves between the size of the CC's centroid size and age for controls (**a**) and prayers (**b**)

Table 1 Average dissimilarity values and contribution percentages of landmarks

Landmark	Average dissimilarity	Contribution %	*p*
1	− 1.45E+06	1.33	0.0372
2	− 4.81E+06	4.40	
3	− 8.15E+06	7.47	
4	− 5.62E+06	5.15	
5	− 3.61E+06	3.30	
6	− 15.16E+06	13.89	
7	− 2.63E+06	2.41	
8	− 12.13E+06	11.11	
9	− 4.40E+06	4.04	
10	− 5.65E+06	5.18	
11	− 7.13E+06	6.53	
12	− 4.09E+06	3.75	
13	− 12.35E+06	11.33	
14	− 2.58E+06	2.36	
15	− 8.41E+06	7.71	
16	− 10.95E+06	10.04	

variable subregional nature of CC in prayers. In conclusion, the available data in present study suggest that regular Islamic pray appears to be associated with altered corpus callosum shape compared to non-prayer controls. Future longitudinal studies with larger samples may contribute to further elucidation of these findings. This study may assist future studies in terms of the effects of prayer.

Abbreviations

CC Corpus callosum
SSA Statistical shape analysis

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Author contributions
MB (writing, data collecting, design), SB (data collecting, design), MA (supervising, design)

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No.

Declarations

Ethical approval and consent to participate

Yes.

Consent for publication

Yes.

Competing interests

No.

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