

## Original Research Article

# Extraocular muscle diameter in Makurdi, North Central Nigeria: what is normal?

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## ABSTRACT

**Background:** Establishing normal values of extra ocular muscle (EOM) diameter is essential in a given population. Factors including race, region, gender and environment affect the normal diameter of the EOM. The aim of the study was to determine the normal sizes of the EOM in a population in the North Central part of Nigeria using computed tomography (CT).

**Methods:** One hundred and eighty-three CT images of patients who underwent craniofacial imaging for other conditions and who met the inclusion criteria were evaluated. The maximum diameters of the EOMs on coronal reformatted CT images which are the superior group (SG) (superior rectus and the levator palpebral), inferior rectus (IR) medial rectus (MR) and lateral rectus (LR) were assessed.

**Results:** The mean values±SD obtained were 3.65±1.13, 3.93±0.94, 3.40±0.67, 3.43±0.92 for SG, IR, MR, and LR muscles respectively on the right and 3.61±1.07, 3.86±0.92, 3.34±0.70, 3.42±0.08 for SG, IR, MR and LR muscles respectively on the left. The order IR>SR>MR>LR of average muscle diameter was obtained. The females in this region showed slightly higher mean values of the diameter of the EOM than the males; however, this was not statistically significant. By age, there was no consistent correlation.

**Conclusions:** The established normal values of the EOM may serve as a reference point for ophthalmologist and for cosmetic surgeons and also will add to the pool of the existing knowledge for academic purposes.

**Keywords:** EOM, Normal values, CT

## INTRODUCTION

The orbit contains the eyeball (globe) and the retrobulbar space. Within the retrobulbar space are six extra-ocular muscles (EOMs) responsible for the synchronous movement of the eyeballs and eyelids, they include: the superior, inferior, medial, and lateral recti; and the superior and inferior oblique muscles.<sup>1</sup> Together, the EOMs form a

muscular cone with its base at the posterior globe and its apex at the superior orbital fissure. This cone divides the retrobulbar space into extraconal and intraconal spaces.<sup>2</sup>

The EOMs could be enlarged in different disease conditions including primary neoplasm, non-specific inflammation, metastatic tumor, vascular malformation, infection, acromegaly and trauma, as well as Graves'

ophthalmopathy, the most common cause.<sup>3-5</sup> In diagnosing or differentiating these diseases, it is therefore important to know the normal diameters of the extraocular muscles.<sup>6</sup>

Various reports of normative measurements of orbit show some variation in the measurements of EOM based on race, age, region, gender, and ethnicity; therefore, normal reference data for extra-ocular muscle diameter are needed to define abnormality for specific populations.<sup>7,8</sup>

Various imaging modalities could be employed for the evaluation of the extra-ocular muscle including ultrasonography, CT and magnetic resonance imaging (MRI), however the authors choose CT for this study due to available of data in CT archives and its quantitative ability in its EOMs assessment compared with USS which is operator dependent.<sup>9-12</sup> The objective of the study was to generate baseline values of the extra-ocular muscles by computerized tomography to act as a benchmark against which diseased states can be evaluated and also to establish racial and regional local values for academic reference.

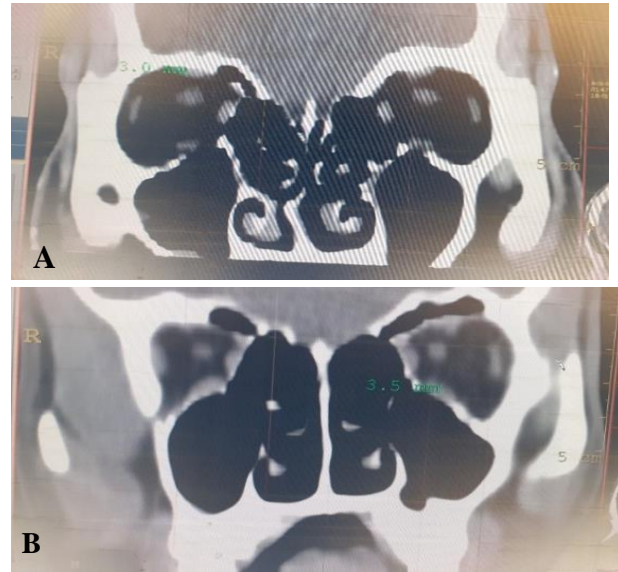
**METHODS**

This was a retrospective study. Non-contrast CT images of patients who underwent skull, brain or paranasal sinus studies in the department of radiology, Benue State University Teaching Hospital Makurdi, middle belt Nigeria between March 2019 to December 2019 were reviewed. Ethical clearance for this study was approved by the research review board of the institution. Patients who had facial congenital anomalies, orbital pathologies, fractures from acute head injury or known endocrine disease were excluded from the study. The CT images with any form of asymmetry were also excluded.

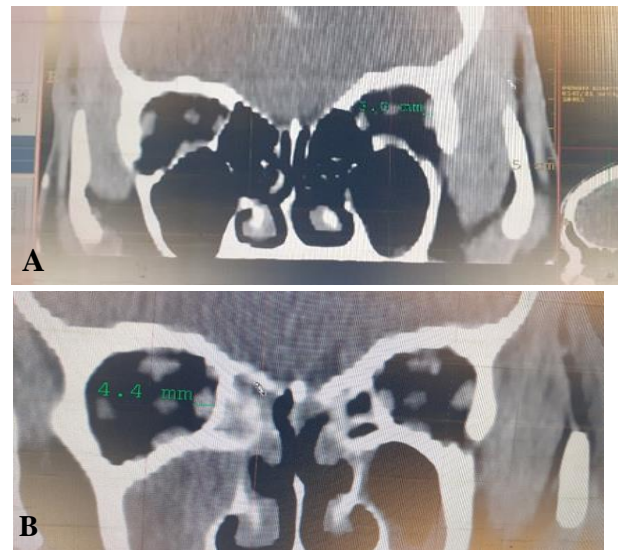
CT images were acquired with Philip Brilliance 16. The axial images were acquired as a volumetric data set parallel to the orbito-meatapl lane. Coronal reformats of the volumetric data were subsequently generated. Only non-contrast images of the reformatted coronal images were evaluated for the study using simple random sampling technique. As a technical factor, every change in the window level and width settings on CT scanning may result in different values with respect to the muscle size even when the extraocular muscles are normal. This means that window settings should be the same to accurately compare the muscle sizes both between different patients and between different CT examinations.<sup>13</sup> For accuracy of this study therefore, the same magnification factor and constant window settings were used using windows width and level of 350 and 50 HU respectively as compared to studies done elsewhere and a magnification factor of 5X.

The superior rectus and the levator palabrae muscles termed the superior muscle group were measured together as a single muscle group because it is unreliably difficult to distinguish one from another from their origin before they became separate with a fat plane between them (Figure 1A). The inferior rectus muscle as well as the

medial and lateral recti muscles were measured independently (Figure 1B, 2 A-B respectively).



**Figure 1: Measurement of maximal vertical diameter of the superior group and inferior rectus muscle (A) Superior group of muscles; (B) inferior rectus muscle.**



**Figure 2: Measurement of maximal vertical diameter of the superior group and inferior rectus muscle (A) Medial rectus muscles; (B) Lateral rectus muscle.**

Each muscle was measured at its point of maximum diameter perpendicular to the orbital wall. Vertical diameters were used for the superior muscle group and inferior rectus muscle while horizontal diameters were used for the medial and lateral recti muscles.

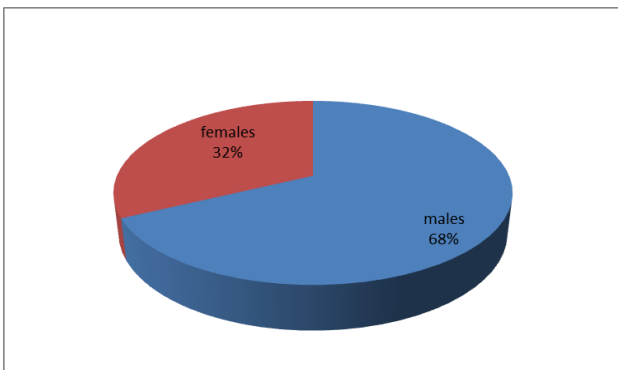
The measurement caliper was operated with a single mouse click at either end of the distance to be measured.

The start and end point of the measurement was the diameter of the muscle. The measurements were taken on 3 consecutive images to determine the maximal diameter of each of the muscle using the measurement calipers. The calipers could measure up to a tenth of a millimetre. Both right and left sides were measured.

The data obtained was analysed using SPSS for windows version 16. Sample t-test was used to compare data and relationship was calculated using Pearson’s correlations. A p-value of <0.05 was considered statistically significant.

**RESULTS**

One hundred and eighty-three (183) CT were reviewed in this study; there were 124 (68%) males and 59 (32%) females (Figure 3).



**Figure 3: Sex distribution in the study.**

The mean values and ranges of the diameters of the extra ocular muscles is given in Table 1.

**Table 1: Normal measurements of extra ocular muscles as seen on CT (N= 183).**

Extra ocular muscles	Mean (mm)	Mean±2 SD (mm)	Normal range (mm)
<b>Right</b>			
SG	3.65	3.65±1.13	1.10-7.60
IR	3.93	3.93±0.94	1.40-7.50
MR	3.40	3.40±0.67	1.70-5.40
LR	3.43	3.43±0.92	1.50-6.60
<b>Left</b>			
SG	3.61	3.61±1.07	1.10-6.80
IR	3.86	3.86±0.92	1.90-7.30
MR	3.34	3.34±0.70	1.10-6.00
LR	3.42	3.42±0.88	1.50-7.00

SG- superior muscle group, IR- inferior rectus, MR- medial rectus, LR- lateral rectus

Comparison of the mean extra ocular muscles diameters and the mean difference between the right and left sides is given in Table 2. In the present study, the mean sum was

14.3 mm and 14.2 mm right and left respectively with a difference of 0.1 mm.

**Table 2: Comparison of the mean extra ocular muscle diameters between the right and left sides.**

Muscle	Side Right (mm)	Left (mm)	MD	SD	P value
SG	3.65	3.61	0.04	0.03	0.000
IR	3.93	3.86	0.07	0.01	0.000
MR	3.40	3.34	0.06	0.03	0.000
LR	3.43	3.42	0.01	0.00	0.000

SG- superior muscle group, IR- inferior rectus, MR- medial rectus, LR- lateral rectus, SD- standard deviation

**Table 3: Comparison of the mean diameters of the extra ocular muscles by sex.**

Muscle	Male (mm)	Female (mm)	Mean difference	P value
<b>SG</b>				
Right	3.71	3.53	0.81	0.63
Left	3.73	3.40	0.33	0.47
<b>IR</b>				
Right	3.93	3.96	-0.03	0.95
Left	3.85	3.90	0.05	0.27
<b>MR</b>				
Right	3.40	3.40	0.00	0.55
Left	3.33	3.37	0.04	0.69
<b>LR</b>				
Right	3.39	3.51	-0.12	0.06
Left	3.43	3.45	0.00	0.31

SG- superior muscle group, IR- inferior rectus, MR- medial rectus, LR- lateral rectus.

**Table 4: Correlation between the extra ocular muscle and age.**

Extra ocular muscles	Pearson’s correlation (r)	P value
<b>Right</b>		
SG	0.01	0.05
IR	0.05	0.59
MR	0.06	0.36
LR	0.01	0.12
<b>Left</b>		
SG	0.00	0.52
IR	0.14	0.80
MR	0.05	0.91
LR	0.07	0.12

SG- superior muscle group, IR- inferior rectus, MR- medial rectus, LR- lateral rectus

They all showed statistically significant differences in their mean sizes on both sides with p=0.000.

By gender, the mean diameter of the extraocular muscles were slightly higher in the female group except the

superior group of muscles bilaterally which were slightly larger in the female group, however they did not show any significant difference in the mean diameter between the male and female gender ( $p>0.05$ ) (Table 3).

In relation to age, there was no consistent correlation with the mean diameters of the single extraocular muscles.

## DISCUSSION

Extraocular muscle thickness is increased in many pathological conditions and usually the inferior rectus muscle is the first and most commonly involved.<sup>14</sup> To decide whether a muscle is enlarged or not, it is imperative to have the baseline measurements of these muscles.

In this study, the mean diameter of inferior rectus muscle and superior complex muscles was 3.9 mm and 3.6 mm respectively, the medial and lateral recti were both 3.4 mm while the mean sum of the diameters of the EOM was 14.2 mm. In most studies previously described elsewhere on the dimensions of EOM, the pattern of muscle thickness found was to be inferior>superior>medial>lateral.<sup>1</sup> This study had corroborated with such following the same pattern; though on independent eye side, the LR slightly edged the MR but on average they are same. This study collaborated with the work of Lee et al in Korean population and Lerdelum *et al* in that the IR is the thickest of the EOM measured.<sup>15,16</sup> However similar works done by Sacca et al and Gupta et al and local studies in the south western region of our environment by Ogboole et al are at variance with this study in the order of the sequence of EOM diameter and have attributed the variance to ethnic, socioeconomic and nutritional factors.<sup>1,7,17</sup>

Differences between diameters of healthy contralateral extraocular muscles may also be helpful. The total mean sum of 14.2 mm was not much different from Lee et al (14.0 mm) and Sukalaya et al (15.0 mm) but little lower than that of Ogboole et al (18.0 mm) in a different region of the country and in the western population (16.9 mm and 19.7 mm). This variance could be as a result of ethnic, regional and socioeconomic factors.

With reference to the mean diameters of the extraocular muscles in the present study, aside from the superior group of muscles which were marginally larger in the males, the IR, MR and the LR all slightly larger in the females but not statistically significant. Similar previous studies however reviewed the mean diameters of all the EOM to be slightly larger in the males and attributed such to the larger head size of the male forks compared to the females.<sup>1,6</sup> The authors in this study imagined similar or even larger head sizes and/or larger orbits with accompanying EOMS sizes in the female forks in this environment and proposed to study the orbital diameter and head circumference in this to unravel reason(s) for this variation.

In relation to age, there was also no significant correlation with the mean diameters of the single extraocular muscles and the sum of all four muscles.

## Limitations

For accurate assessment of EOM diameters, patient were instructed to maintain forward gaze and gentle close their eyes during CT scan to preventing extraocular muscle contraction. However, this was not done because the images used for this study were not primarily to study EOM but images of patients who underwent cranial, craniofacial or paranasal sinus studies in the department of radiology for other conditions.

Also, the clinical history may be misleading or inaccurate therefore Biochemical and hormonal profile of patients were needed to evaluate for evidence of endocrine disorder especially thyroid ophthalmopathy.

## CONCLUSION

It has been established that there are differences in the extraocular muscle diameters between races, ethnic and geographic zones. These normative values obtained in this study may be used by both, radiologists and Ophthalmologist as reference values for assessment of changes in size and enlargement of EOM in our environment and also add to the pool of existing knowledge.

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