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RESEARCH ARTICLE

QUANTITATIVE ASSESSMENT OF MITRAL VALVE APPARATUS IN HIGH ALTITUDE POPULATION BY ECHOCARDIOGRAPHY

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ABSTRACT

Introduction: Mitral valve (MV) apparatus is a vital structural component of the heart. The defective structure and function of any one or more components of mitral valve apparatus can lead to mitral valve dysfunction. Present study is an attempt to establish the normal reference value of mitral valve apparatus that would help in differentiating normal from diseased valve in borderline situation in clinical practice.
Methods: All eligible subjects underwent detailed echo study of MV on Philips IE33 echo machine using phased array broad band 2-4 MHZ and 4-6 MHZ. The data of MV structure was analyzed in relation to predefined age groups & gender wise.
Result: Mean and range of Mitral annular diameter in minor axis plane in diastole and systole was 2.3(1.4-3.0) v/s 2.2(1.5-2.9)cms recorded in Parasternal long axis (PSLAX) view, 2.3(1.6-3.5) v/s 2.2(1.6-2.9)cms in Apical four chamber (A4C) view and 3.4(2.2-4.8) v/s 2.5(1.4-3.7)cms in major axis.The mean and range of Mitral annular area during end diastole and end systole was 6.2(3.0-9.4) v/s 4.4(2.3-7.8) cm². In overall groups mean and range of Anterior mitral leaflet (AML) and Posterior mitral leaflet (PML) length was 1.7(1.1-2.6) v/s .8(.4-1.2) cms in A4C view, 1.8(1.2-2.6) v/s .9(.5-1.3)cms in PSLAX view and 1.6(.4-2.2) v/s .8(.2-1.4) cms in Apical two chamber (A2C) view respectively, thickness of AML and PML(mean and range) was .2(.1-.4) v/s .3(.1-.5)cms respectively and chordae tendinae length attached to AML was 1.5(1.0-2.2)cms and of PML1.3(.7-1.9)cms.
Conclusion: This study will help in finding the correct size of prosthesis for annuloplasty in population from hilly region.

INTRODUCTION

Mitral valve apparatus (MV) is a vital structural component of the heart that allows blood to flow from atria to ventricle unimpeded and prevents regurgitation of blood back into left atrium during systole by ensuring effective closure of the atrio-venticular communication. This vital function of the heart is accomplished by coordinated and concerted participation of various components of the mitral valve apparatus namely anterior and posterior mitral leaflets, mitral annular ring, chordae tendinae, two papillary muscles.

Nordblom P *et al* in 2007 carried out the transthoracic 2D Echocardiographic study on 38 individuals, in order to know the reference values describing the normal mitral valve apparatus and the position of the papillary muscle. Michael h. Crawford *et al* in 2001 carried out the echocardiographic study of quantitative assessment of valve thickness in normal subjects.

Recent studies using color Doppler Transthoracic Echocardiography or Transoesophageal Echocardiography in apparently healthy subjects, have reported a prevalence of up to 40% of mild Mitral Valve regurgitation (Lavie *et al*.,1993, Choong *et al*.,1989, Roldan *et al*.,1996). In case of mitral regurgitation, various changes occur in mitral apparatus depending upon various diseases causing it. Infectious endocarditis involving mitral valve can cause regurgitation by leaflet destruction, leaflet perforation, or chordal rupture. Large vegetation can cause inappropriate closure of leaflets, healed lesions can lead to valvular fibrosis and deformity. An accurate Echocardiographic evaluation of the normal mitral annular diameter, leaflet length, thickness and chordae length is therefore essential.

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Previous Transthoracic Echocardiographic studies have shown that age, sex and body surface area had a significant effect on the dimension of the heart (Trizuli *et al.*,1984; Valdez *et al.*,1979; Gardin *et al.*,1979; Henry*et al.*,1980; Knutsen *et al.*,1989; Gerstenblith *et al.*,1977). Besides this, the other factors including conditioning (Roy *et al.*,1988; Mac Farlane *et al.*, 1991) and heredity (Hinderliter *et al.*, 1992) also have bearing on the size of the heart. Therefore, the present study was conducted on the population from hilly region to study whether high altitude, harsh topographic and climatic condition and different eating habits have any bearing on various parameters of mitral valve apparatus.

MATERIALS AND METHODS

Present hospital based prospective study was conducted after obtaining approval by the Hospital Ethics Committee. Hundred and one subjects referred to echocardiography laboratory and found to have normal echocardiographic findings and good echogenicity were included in the study.

Figure1.tif

Echocardiographic Apical four chamber(A4C) view of Mitral Apparatus in diastole showing Right Ventricle(R.V.),Right Atrium(R.A.),Left Ventricle(L.V.) and measurement of Anterior Mitral Leaflet(A.M.L.) length from annulus to tip of leaflet.

Table 1 A Measurement of Mitral Valve Apparatus Components according to Age Groups(Cms).

	MADFC		MADPSAX		MADPSLAX		MLLFC		MLLTC		MLLPSLAX	
	DIASTOLE	SYSTOLE	Diastole	Systole	Diastole	Systole	Ant. Leaflet	Post.Leaflet	Ant. Leaflet	Post.Leaflet	Ant. Leaflet	Post.Leaflet
Age groups	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD
5-9years	1.9±.2	2.0±.3	2.9±.5	2.2±.4	1.9±.3	1.9±.3	1.4±.3	.7±.1	1.3±.3	.6±.1	1.5±.2	.7±.1
10-14years	2.2±.3	2.2±.3	3.1±.5	2.3±.4	2.1±.3	2.0±.2	1.5±.2	.7±.1	1.5±.1	.7±.1	1.7±.2	.8±.2
15-19years	2.3±.3	2.3±.3	3.7±.4	2.8±.5	2.4±.3	2.3±.3	1.7±.3	.9±.2	1.8±.2	.9±.2	1.8±.2	.9±.2
20-24years	2.4±.3	2.4±.2	3.4±.4	2.5±.3	2.4±.3	2.4±.2	1.8±.2	.8±.1	1.7±.2	.7±.2	1.9±.3	1.0±.1
25-29years	2.4±.5	2.2±.4	3.5±.5	2.5±.5	2.3±.3	2.1±.4	1.8±.3	.9±.2	1.7±.2	.8±.2	1.8±.4	1.2±.1
30-34years	2.4±.2	2.4±.2	3.6±.5	2.5±.4	2.4±.4	2.3±.2	1.7±.3	.8±.2	1.7±.3	.8±.1	1.9±.3	.9±.1
35-39years	2.3±.2	2.1±.2	3.3±.4	2.5±.3	2.3±.2	2.2±.2	1.8±.3	.9±.1	1.7±.2	.7±.1	1.9±.3	.9±.1
40-44years	2.4±.3	2.2±.3	3.4±.3	2.5±.4	2.4±.2	2.3±.1	1.7±.3	.8±.2	1.7±.1	.8±.2	1.9±.3	.9±.1
45-49years	2.4±.3	2.3±.3	3.4±.3	2.5±.3	2.3±.1	2.1±.3	1.8±.2	.9±.2	1.7±.3	.8±.1	2.0±.3	.9±.1
>50years	2.6±.2	2.0±.4	3.5±.4	2.7±.2	2.3±.1	2.3±.3	1.8±.2	1.1±.1	1.6±.4	1.0±.4	1.7±.2	1.0±.1

Values are mean ± SD. **MADFC=**Mitral Annular Diameter Four Chamber, **MADPSAX=**Mitral Annular Diameter Parasternal Short Axis, **MADPSLAX=**Mitral Annular Diameter Parasternal long Axis, **MLLFC=**Mitral leaflet length Four chamber, **MLLTC=**Mitral leaflet length Two Chamber, **MLLPSLAX=**Mitral leaflet length Parasternal long Axis.

Table 1B Measurement of Mitral Valve Apparatus Components according to Age Groups (Cms)

	AMLTPSLAX	PMLTPSLAX	CTLAML	CTLPML
Age groups	Mean±SD	Mean±SD	Mean±SD	Mean±SD
5-9years	.2±.03	.2±.03	1.3±.2	1.0±.2
10-14years	.2±.04	.2±.05	1.3±.2	1.2±.2
15-19years	.2±.02	.2±.02	1.8±.3	1.5±.3
20-24years	.2±.04	.3±.04	1.5±.2	1.2±.2
25-29years	.2±.04	.3±.09	1.5±.4	1.4±.1
30-34years	.2±.05	.2±.05	1.5±.2	1.3±.2
35-39years	.2±.05	.2±.04	1.5±.3	1.3±.2
40-44years	.2±.02	.2±.04	1.6±.2	1.3±.2
45-49years	.2±.02	.3±.02	1.7±.3	1.4±.3
>50years	.3±.1	.3±.1	1.6±.4	1.3±.3

Values are mean ± SD. **AMLTPSLAX=**Anterior Mitral Leaflet thickness Parasternal Long Axis, **PMLTPSLAX=**Posterior Mitral Leaflet Thickness Parasternal Long Axis, **CTLAML=**Chordae Tendinae Length to Anterior Mitral Leaflet, **CTLPML=**Chordae Tendinae Length to Posterior Mitral Leaflet.

Mitral valve (MV)apparatus was defined as normal if found to have no apparent thickening of valves, thickening and or shortening of chordae tendinae, visually normal movements of mitral leaflets, normally positioned two papillary muscles, absence of mitral annular calcification and no Doppler evidence of valvular dysfunction. The subjects with abnormal echocardiographic findings, hypertension and/ or diabetes, renal failure, not willing to participate and poor echogenicity were excluded.

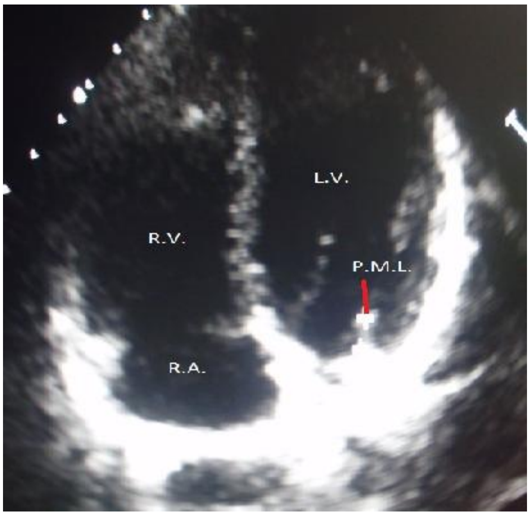

Figure2.tif

Echocardiographic Apical four chamber(A4C) view of Mitral Apparatus in diastole showing Right Ventricle (R.V.),Right Atrium(R.A.),Left Ventricle(L.V.) and measurement of length of Posterior Mitral Leaflet(P.M.L.) from annulus to tip of leaflet.

All eligible subjects underwent detailed echo study of MV after obtaining informed consent on Philips IE33 echo machine using phased array broad band 2-4 MHZ and 4-6 MHZ for adults and children respectively in supine left lateral position.

Gain settings and depth of 2D images were optimized to ensure good quality images. All the parameters related to each component of mitral valve apparatus were measured in three consecutive frames obtained at predefined phases of cardiac cycle and average of the three was taken as the representative value for each parameter.

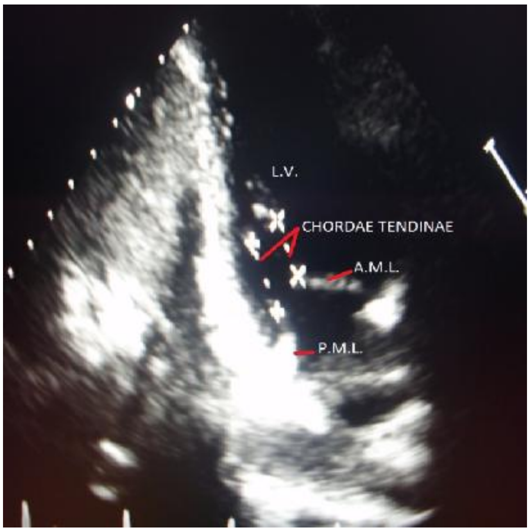

Figure 3 tif

Echocardiographic Apical Two chamber (A2C) view of Mitral Apparatus showing Anterior Mitral Leaflet (A.M.L.), Posterior Mitral Leaflet (P.M.L.) and measurement of Chordae Tendinae length from papillary muscle tip to Posterior Mitral Leaflets and Anterior Mitral Leaflet.

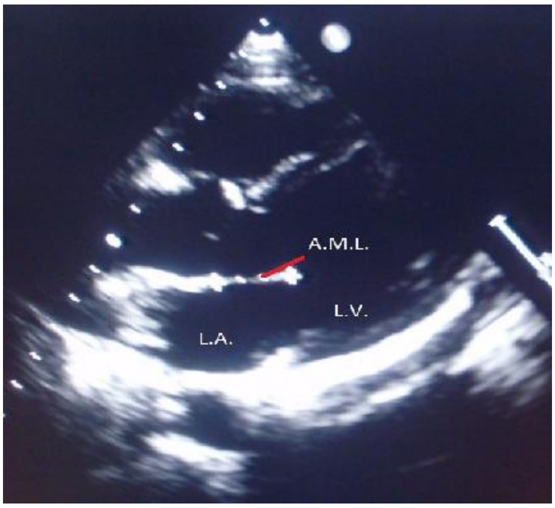

Figure 4.tif

Echocardiographic Parasternal Long Axis (PSLAX) view of Mitral Apparatus showing Left Atrium(L.A.),Left Ventricle(L.V.) and measurement of Anterior Mitral Leaflet(A.M.L.) length from annulus to tip of leaflet.

All observations were noted by the same observer for all the subjects. Mitral valve structural components that were studied are Mitral annular diameter, Antero-medial leaflet, Postero-lateral leaflet and Chordae Tendinae. Length of Anteromedial and Posterolateral leaflets was measured by measuring distance from annulus to tip of respective leaflets in PSLAX (Figure 4.and Figure 5.), Apical 4 chamber (Figure 1.and Figure 2.) and Apical 2 chamber views. Thickness of leaflets was measured by recording images of mitral valve obtained in PSLAX view at Middle 3rd of both leaflet in diastole (Figure 8.). The Mitral Annulus was evaluated by taking measurement of antero-posterior minor axis in PSLAX and apical 4-chamber view, measurement of commissure to Commissure (CC) long axis of mitral annulus in diastole and systole (Figure 6 and Figure 7.). Mitral annular area was calculated at the peak of P wave in ECG and at end systole using formula for elliptical structure (3.14×CC long axis × AP minor axis in apical four chambers). Cordae tendinae length was measured by measuring the distance between Papillary muscle tip and point of attachment to leaflet in modified 2C view where the papillary muscle, chordae and leaflet are profiled (Figure 3.).

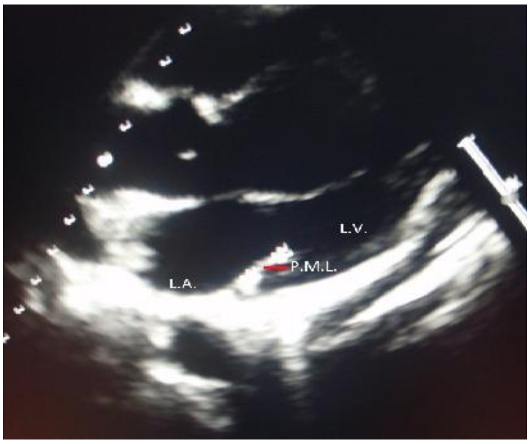

Figure 5.tif

Echocardiographic Parasternal Long Axis (PSLAX) view of Mitral Apparatus showing Left Atrium (L.A.), Left Ventricle (L.V.) and measurement of Posterior Mitral Leaflet (P.M.L.) length from annulus to tip of leaflet.

Figure 6.tif

Echocardiographic view of Mitral Apparatus during diastole showing measurement of Commissure to Commissure long axis of Mitral Annulus (M.A.).

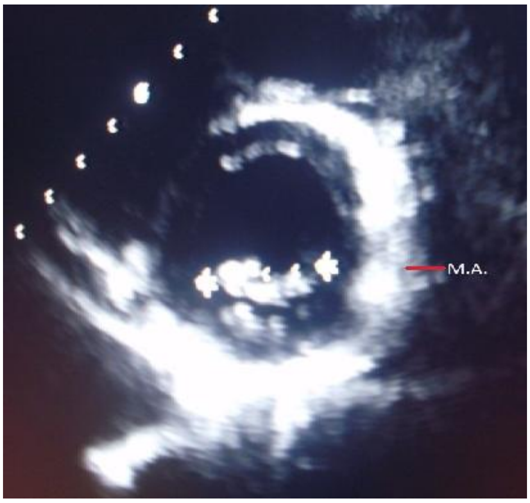

Figure7.tif

Echocardiographic view during systole showing measurement of Commissure to Commissure long axis of Mitral Annulus (M.A.).

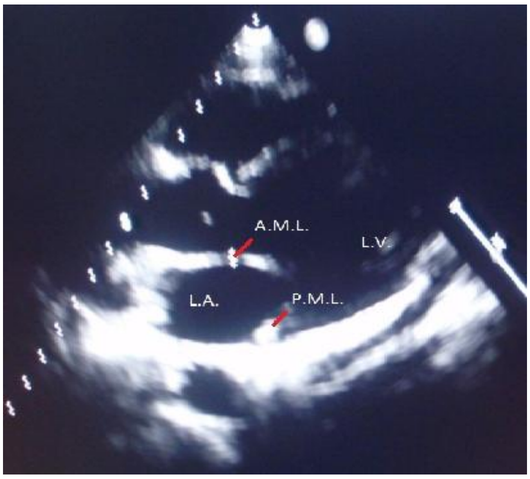

Figure 8.tif

Echocardiographic view of Mitral Apparatus in Parasternal Long Axis (PSLAX) during diastole showing Posterior Mitral Leaflet (P.M.L.) and measurement of Anterior Mitral Leaflet (AML) thickness.

related to various components of MV structure was also analyzed in relation to predefined age groups and gender wise. The values recorded for each component of MV apparatus was recorded as range and mean (95%confidence interval). Correlation of values of MV apparatus with age and weight was correlated using Pearsons correlation. The statistical analysis of the data was done using Epi Info statistical software Version 3.4.3 and Epi Info statistical software Version 7.

RESULT

The results of the present echocardiography based study are tabulated in table 1-3.

DISCUSSION

The structural components of MV apparatus functions in a coordinated fashion in such a way that it facilitates filling of ventricle during diastole without imposing any resistance to ventricle inflow and prevents back flow into left atrium during systole by ensuring complete cooptation of anterior and posterior mitral leaflet which is also facilitated by decrease in mitral annular area during systole.

There are various disease processes which affect the structural integrity of the components of MV apparatus directly or indirectly. In order to gain insights about mechanisms of MV apparatus dysfunction establishing normal reference values of its components is of paramount importance. Furthermore, such values help in mechanistic understanding and to assess the feasibility and planning the mitral valve repair strategies.

Table 2 Significant Value of Mitral Valve Apparatus Components in Reference to Height, Weight, and Body surface Area, Age and Sex.

	M.A.D.D	M.A.D.S	A.M.L.L	P.M.L.L	A.M.L.T	P.M.L.T	CTLAML	CTLPML
	P Value	P Value	P Value	P Value	P Value	P Value	P value	P value
HEIGHT	.0001	.0001	.0001	.0001	.0001	.0001	<.0001	<.0001
WEIGHT	.0001	.0001	.0001	.0001	.0001	.0001	.0151	.0038
B.S.A.	.0001	.0001	.0001	.0001	.0001	.0001	.0033	.0004
AGE	.0008	.0843	.0002	.0001	.0001	.0006	.0085	.0109
SEX	.0601	.0705	.0340	.0857	.3340	.6827	.0072	.0031

MADD=Mitral annular diameter diastole, **MADS=**Mitral annular diameter systole, **AMLL=**Anterior mitral leaflet length, **PMLL=**Posterior mitral leaflet length, **AMLT=**Anterior mitral leaflet thickness**, PMLT=**Posterior mitral leaflet thickness, **CTLAML=**Chordae Tendinae Length to Anterior Mitral Leaflet, **CTLPML=**Chordae Tendinae Length to Posterior Mitral Leaflet, **B.S.A** = Body Surface Area.

Table 3 Demographic profile of participants including Male and Female according to age group for Echocardiographic study.

Age groups	Male	Female	Total Population
5-9years	5(10.6%)	5(9.3%)	10(9.9%)
10-14years	5(10.6%)	5(9.3%)	10(9.9%)
15-19years	6(12.8%)	6(11.1%)	12(11.9%)
20-24years	5(10.6%)	5(9.3%)	10(9.9%)
25-29years	5(10.6%)	6(11.1%)	11(10.9%)
30-34years	5(10.6%)	6(11.1%)	11(10.9%)
35-39years	5(10.6%)	7(13.0%)	12(11.9%)
40-44years	5(10.6%)	7(13.0%)	12(11.9%)
45-49years	5(10.6%)	6(11.1%)	11(10.9%)
>50years	1(2.1%)	1(1.9%)	2(2.0%)

Table 4 Comparison of Mitral valve apparatus with other studies

Haritha *et al*.,(2003)(61±15years)(10 individuals)			**Present Study (2013)(28.77±13.18 Years) (101 individuals)**	
Mitral annular diameter	End diastole	End systole	End diastole	End systole
PSLAX	3.0±0.3(2.4-3.4)cms	2.8±0.2(2.2-3.1)cms	2.3±.3(1.4-3.0)cms	2.2±.3(1.5-2.9)cms
A4C	3.4±0.4(2.9-3.9)cms	2.9±0.4(2.2-3.5)cms	2.3±.3(1.6-3.5)cms	2.2±.3(1.6-2.9)cms
Petrus *et al*., (2007)(51±9years)(38 individuals)				
Mitral annular diameter	End diastole	End systole	End diastole	End systole
PSLAX	2.9±0.4(2.4-3.5)cms	3.3±0.3(2.8-4.0)cms	2.3±.3(1.4-3.0)cms	2.2±.3(1.5-2.9)cms
A4C	3.0±0.3(2.4-3.5)cms	3.5±0.3(2.6-4.2)cms	2.3±.3(1.6-3.5)cms	2.2±.3(1.6-2.9)cms
PSAX	3.7±0.4(3.0-5.1)cms	………..	3.4±.5(2.2-4.8)cms	2.5±.4(1.4-3.7)cms
Mitral annular area	8.7±1.7(5.6-12.6)cms^2	………..	6.2±.1(3.0-9.4)cms^2	4.4±.1(2.3-7.8)cms^2
Michal *et al*., (2001)(35±8years)(78 individuals)				
	Anterior leaflet thickness	Posterior leaflet thickness	Anterior leaflet thickness	Posterior leaflet thickness
	.1±.05(.08-.03)cms	.1±.05(.07-.3)cms	.2±.04(.1-.4)cms	.3±.06(.1-.5)cms

Values are mean±SD(range). **PSLAX**= Parasternal long axis, **A4C**=Apical four chamber, **PSAX** =Parasternal short axis.

Statistical Analysis

The categorical characteristics were expressed as percentages and continuous variables were recorded as Mean±SD. The data

Mean annular diameter in minor axis plane in diastole and systole was 2.3 (1.4-3.0) v/s 2.2 (1.5-2.9) cms recorded in PSLAX view and 2.3(1.6-3.5) v/s 2.2 (1.6-2.9) cms in A4C view. The mean annular diameter recorded in diastole and systole in major axis was 3.4 (2.2-4.8) v/s 2.5 (1.4-3.7) cms. The mean mitral annular area during end diastole and end systole was 6.2 (3.0-9.4) v/s 4.4 (2.3-7.8) cm².

The mitral annular area decreases during systole and mean percent change in annular area during cardiac cycle was 28.71±11.56% and this measurement is in close agreement with 26.44±3.00% (mean±SD) which is reported by Ormiston *et al*., 2001. Furthermore, we found strong positive correlation of mitral annular area with height, weight and body surface area and similar thing has been reported by Carolin Sonne *et al* in their study that mitral valve area increases with body surface area, height and age. Poutanen, *et al* in there echocardiographic study also reported that mitral valve area increases with body surface area. In overall groups mean and range of AML and PML length was 1.7 (1.1-2.6) v/s.8 (.4-1.2) cms in A4C view, 1.8 (1.2-2.6) v/s.9 (.5-1.3) cms in PSLAX view and 1.6 (.4-2.2) v/s .8 (.2-1.4) cms in A2C view respectively,thickness of AML and PML (mean and range) was .2 (.1-.4) v/s.3 (.1-.5) cmsrespectively and chordae tendinae length attached to AML was1.5(1.0-2.2) cms and of PML1.3(.7-1.9) cms.

In this study we found strong correlation of AML and PML thickness in PSLAX with age (Table 2) and the same thing was reported by the anatomic study of Sahasakul *et al* that mitral valves thickness increase with age. Besides this we found strong correlation of AML and PML thickness in PSLAX with height, weight and body surface area (Table 2). All the reference values of MV apparatus observed to be increasing with increasing age, indicating growth of heart and its components. Thus the mean value of the MV apparatus varies amongst different age groups. Therefore, this study establishes reference value for various mitral apparatus structures in 10 different age groups ranging from 5to 56 years of age (Table 1A and 1B and Table 3). However, there was no significant difference in the mean reference values between genders (Table 2).

Moreover, we found that reference values in relation to mitral annular diameter and area are less and values related mitral anterior and posterior leaflet thickness are more as compared to the value found in previous study of European population (Table 4) and this can be due to lean body of people of hilly region as result of harsh topographic and environmental conditions and different eating habits of people of hilly region and this has also been indicated in previous studies that conditioning (Roy *et al*.,1988; Mac Farlane *et al*., 1991) and heredity (Hinderliter *et al*., 1992) have effect on various parameters of heart. Besides, we have also calculated the length of anterior and posterior mitral leaflet (Table1A), chordae tendinae length from tip of papillary muscle to anterior and posterior leaflet (Table 1B), which has been ignored by previous studies. Collectively, these parameters should provide a framework for comprehensive evaluation of the mitral valve apparatus in patients suffering from various heart diseases and differentiating the borderline cases of heart disease from normal heart. The present study will help in finding the correct size of prosthesis for a valve replacement which will accurately fit in the mitral valve orifice in hilly region population. Vander Spuy found that thorough anatomical and functional features are essential in the construction of an entirely anatomical whole mitral valve from autogenous tissue (Vander *et al*., 1964), thus the data collected by us can be used for manufacture of various MV apparatus components.

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