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RESEARCH ARTICLE

A STUDY ON VITAMIN D LEVELS IN CHILDREN WITH BRONCHIAL ASTHMA.

Dr Sekar Pasupathy and Dr Arathi Ravi Pillai.
Department of pediatrics,srm medical college hospital & research centre potheri, kattankulathur, kancheepuram district tamilnadu - 603 203.

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Abstract

Introduction: Asthma is one of the most commonly prevalent chronic illnesses among children according to the World Health Organization report. a number of studies suggested the possible role of Vitamin D in the pathophysiology of childhood asthma. Despite the overwhelming evidence linking Vitamin D and asthma, there are still insufficient studies among Asian countries, especially India. Hence, the study was conducted with the aim of establishing the relationship between vitamin D levels and asthma.

Materials And Methods: This Case control study was conducted in the Department of Pediatric, SRM Medical College, Hospital & Research Centre. Children aged 3 to 12 years Bronchial Asthma were included in the study. The data collection for the study was done from January 2017 to June 2018 for a period of 1 year & 6 months. All the eligible subjects were recruited into the study consecutively by convenient sampling till the sample size is reached. All the relevant parameters were documented in a structured study proforma. Blood samples were collected for serum vitamin D levels were taken.

Results: A total 120 people were included in the analysis. Among the people with cases group, the median age was 50 months (IQR 40 to 62) and it was 62 months (IQR 48 to 85.50) in people with control group. In cases group, 28 (46.7%) participants were male and remaining 32 (53.3%) participants were female. Among the people with control group, 30 (50%) participants were male and remaining 30 (50%) participants were female. The mean vitamin D was 15.94 ng/ml ± 4.24 in cases group and 31.01 ng/ml ± 20.25 in control group. The difference between two groups was statistically significant (P value <0.001). The mean serum calcium was 9.18 mg/dl ± 0.80 in cases group and 9.05 mg/dl ± 0.70 in control group. The difference between two groups was statistically not significant (P value 0.355).

Conclusion: In this study, the cases were younger than the controls on average and consisted of a slightly greater proportion of females. This implies the increasing burden of asthma in a predominantly younger age group. The mean serum calcium was less in cases group. This indicates the need for further research, investigating the multiple factors involved in asthma control among pediatric age group.

Corresponding Author:-Dr Sekar Pasupathy.
Address**:-**Department of pediatrics,srm medical college hospital & research centre potheri, kattankulathur, kancheepuram district tamilnadu - 603 203.

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Introduction:-

All over the world, approximately 334 million individuals are diagnosed to have bronchial asthma. Even these high estimates may be an understatement regarding the true burden of the disease. It has been reported that Asthma is one of the most commonly prevalent chronic illnesses among children according to the World Health Organization report.[1] Among the chronic diseases which cause loss of Disability Adjusted Life years among children, asthma ranks among the top 20 illnesses. Especially in the middle years of the pediatric age group, it ranks among the first ten conditions.[2]

In recent years, asthma has become increasingly common among both the childhood and adult age group. Multiple factors contribute to the increasing occurrence of childhood asthma. The increasing number of cases correlate with the increasing incidence of atopic sensitisation, and an increasing number of cases with eczema and rhinitis.[3, 4]
The prevalence of asthma in India was found to be 15%. But five decades ago in 1964, a study conducted in Delhi found that the prevalence of asthma was only 1%. Around 10% of the population were suffering from allergic rhinitis. This clearly establishes an increasing trend of allergic disorders at a global level.[7, 8]

Another commonly prevalent condition among the tropical regions such as India is the deficiency or insufficiency of Vitamin D. Studies suggest that almost 70% to 100% of the Indian population is deficient in Vitamin D. Lack of fortification of food items with Vitamin D, inadequate exposure to sunlight are some of the major reasons which contribute to the increase in Vitamin D deficiency. Furthermore, Vitamin D has also been linked to multiple chronic diseases such as epilepsy, cardiovascular diseases and cancer.[9]

In light of this data, there are a number of studies with results suggesting the possible role of Vitamin D in the pathophysiology of childhood asthma as well. The serum levels of Vitamin D among the asthmatic patients have been found to be consistently lower compared to those who never had any history of asthma. This association persisted even after adjustment for various other factors. Vitamin D has anti-inflammatory and immune-modulatory properties. Thus, it may possibly contribute to asthma which is a chronic inflammatory disorder of the airways.[10]
Additional genetic mechanisms may underlie in the pathophysiology of asthma. Gene polymorphisms have been linked to the Vitamin D status. Moreover, Vitamin D gene polymorphisms among asthmatic children require higher therapy in order to achieve better control of asthma. This indicates the multi-pronged role of Vitamin D in the pathogenesis and management of asthma.[11]

Despite the overwhelming evidence linking Vitamin D and asthma, there are still insufficient studies among Asian countries, especially India. The increasing urbanisation along with other factors has contributed to the rise in asthma incidence. In addition, a major risk factor implicated in childhood asthma is also increasingly prevalent in the Indian subcontinent. This dual burden is largely under-investigated. This lack of available evidence suggests the need for further studies investigating the potential role of Vitamin D among children with asthma in India. This study seeks to assess the same. This will help in improving the management of asthma among children thus reducing the disability due to asthma and improving the quality of life.

Aims and objectives:-

Aim:

To determine the association between vitamin D and asthma in children.

Objectives:

1. To determine serum levels of vitamin D in asthmatic children between 3-12 years age.
2. To establish correlation between serum vitamin D levels and level of asthma control**.**

Null hypothesis:

The null hypothesis of the study states that there is no association between childhood asthma and serum vitamin D level among children aged between 3 to 12 years

Alternate Hypothesis:

The alternate hypothesis states that the serum vitamin D levels may be low in children

Materials And Methods:-

Study site:
This study was conducted in the Department of Pediatrics , SRM Medical College, Hospital & Research Centre , Kattankulathur , Kanchipuram ,Tamil Nadu.

Study population:
The study population included, children diagnosed with bronchial asthma, attending the study setting with bronchial asthma

Study design:
The current study was a case control study.

Sample size:
As per recent metaanalysis by Jat K.R et al [59] the proportion of children with vitamin D deficiency among children with asthma was considered as 28.5% and among the healthy children was considered as about 8%. The sample size was calculated assuming 80% power and 5% two-sided alpha error, to detect difference between two proportions, using chi square test. STATA statistical software version IC 13 was sued for sample size assessment. As per the calculation a total of 55 subjects were needed in each of the study groups. To account for non participation rate of about 5%, it was decided to include another 3 subjects and the sample size was rounded off to 60 subjects in each group.

Sampling method:
All the eligible subjects were recruited into the study consecutively till the sample size is reached.

Study duration:
The data collection for the study was done between January 2017 to June 2018 for a period of 1 year & 6 months.

Cases:
Inclusion Criteria:
All children of 3 -12 years age with Bronchial Asthma.

Exclusion criteria:
1. Children on vitamin D supplements
2. Children were on oral steroids (less than 1-month duration)
3. Children with renal and liver pathology

Control
Inclusion Criteria:
All children in the age group 3 – 12 years.

Exclusion Criteria:
1. Children on vitamin D supplements.
2. Children with renal and liver pathology.

Ethical considerations:
Study was approved by the institutional human ethics committee. Informed written consent was obtained from all the study participants, and only those participants willing to sign the informed consent were included in the study. The risks and benefits involved in the study and the voluntary nature of participation were explained to the participants before obtaining consent. Confidentiality of the study participants was maintained.

Data collection tools:
All the relevant parameters were documented in a structured study proforma.

Methodology:-

Purpose of the study was explained to the study subjects and/or their parents. After taking informed consent, a pre-structured proforma was used to record the relevant information from individual cases selected for the study. The detailed clinical examination was conducted, and under aseptic precautions, blood was drawn for relevant investigations. Results were subjected to statistical analysis. Vitamin D was supplemented to those children who fall in the Insufficient and deficient range.

Blood samples under aseptic precautions for serum vitamin D levels were taken.

Statistical Methods:

Vitamin D, Phosphorus, urea and creatinine were considered as primary outcome variables. Study group (Cases Vs Control) was considered as a Primary explanatory variable.

All Quantitative variables were checked for a normal distribution within each category of cases and control by using visual inspection of histograms and normality Q-Q plots. Shapiro- Wilk test was also conducted to assess normal distribution. Shapiro Wilk test p value of >0.05 was considered as a normal distribution.

Descriptive analysis was carried out by mean and standard deviation for quantitative variables, frequency and proportion for categorical variables. Data was also represented using appropriate diagrams like a bar diagram, pie diagram and box plots.

For normally distributed Quantitative parameters the mean values were compared between study groups using Independent sample t-test (2 groups). For non-normally distributed Quantitative parameters, Medians and Interquartile range (IQR) were compared between study groups using the Mann Whitney U test (2 groups). Categorical outcomes were compared between study groups using Chi square.
P value < 0.05 was considered statistically significant. IBM SPSS version 22 was used for statistical analysis.[81]

Results:-

A total of 120 people were included in the analysis.

Among the study population, 60 (50%) participants were cases and remaining 60 (50%) participants were controlled. 66

Table 1:-Comparison of median age (in months) between the study group (N=120)

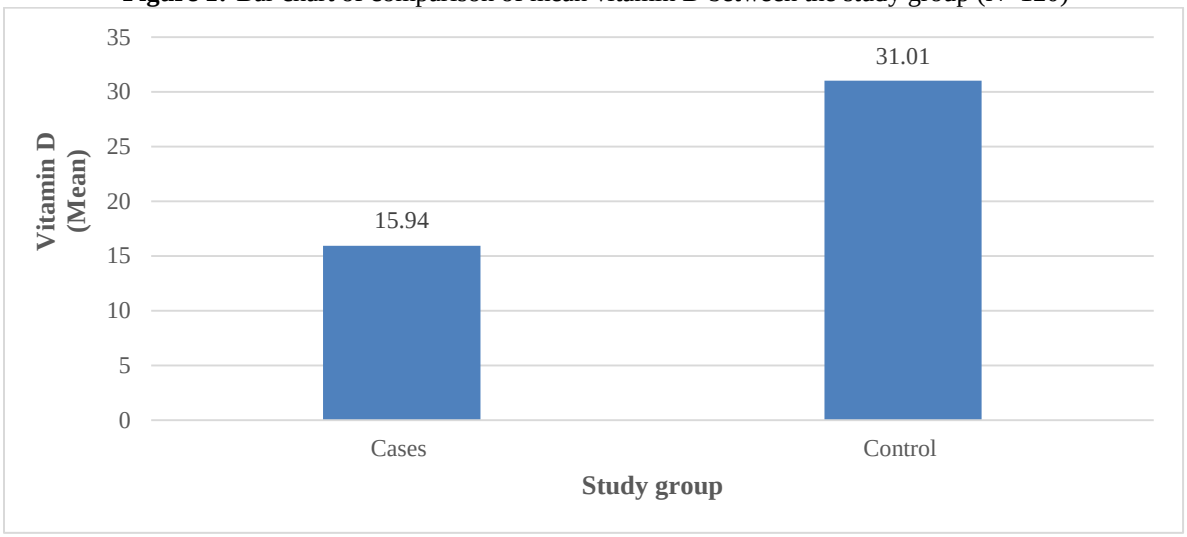
Parameter	Study group		Mann Whitney U test (P value)
	Cases (N=60)	Control (N=60)	
Age (in months) Median(IQR)	50 (40 to 62)	62 (48 to 85.50)	<0.001

Among the people with cases group, the median age was 50 months (IQR 40 to 62), and it was 62 months (IQR 48 to 85.50) in people with a control group. Indifference in the age between study groups was statistically significant (p value <0.001).

Among the people with cases group, 28 (46.7%) participants were male and remained 32 (53.3%) participants were female. Among the people with the control group, 30 (50%) participants were male and remained 30 (50%) participants were female. The difference in the proportion of gender between study group was statistically not significant (P value 0.715).

The mean vitamin D was 15.94 ± 4.24 in cases group and 31.01 ± 20.25 in the control group. The difference between the two groups was statistically significant (P value <0.001.

Figure 1:-Bar chart of comparison of mean vitamin D between the study group (N=120)



The mean serum calcium was 9.18 ± 0.80 in cases group and 9.05 ± 0.70 in the control group. The difference between the two groups was statistically not significant (P value 0.355).Among the people with cases group, the median urea was 18.90 mg/dl (IQR 16 to 29.95), and it was 21.30 mg/dl (IQR 17.05 to 33.50) in people with the control group. Indifference in the urea between study groups was statistically not significant (p value 0.213).

Among the people with cases group, the median creatinine was 0.80 mg/dl (IQR 0.60 to 0.80), and it was 0.60 mg/dl(IQR 0.40 to 0.80) in people with the control group. Indifference in the creatinine between study groups was statistically significant (p value 0.017).

Cases comparison:
A total of 60 people were included in the analysis.

Table 2:-Descriptive analysis of cases in the study population (N=60) as per GINA Assessment of Asthma Control.

Cases	Frequency	Percentages
Partially controlled	51	85.00%
Uncontrolled	9	15.00%

Among the study population, 51 (85%) participants were partially controlled and remained 9 (15%) participants were uncontrolled.

Figure 2:-Pie chart of descriptive analysis of cases in the study population (N=60)

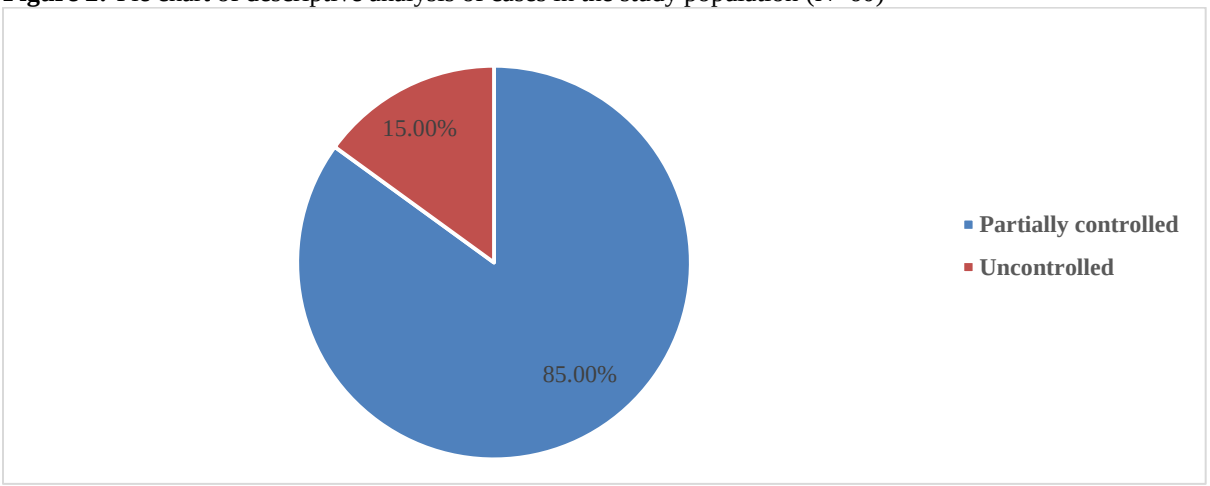


Table 3:-Comparison of median age (in months) between the cases group (N=60)

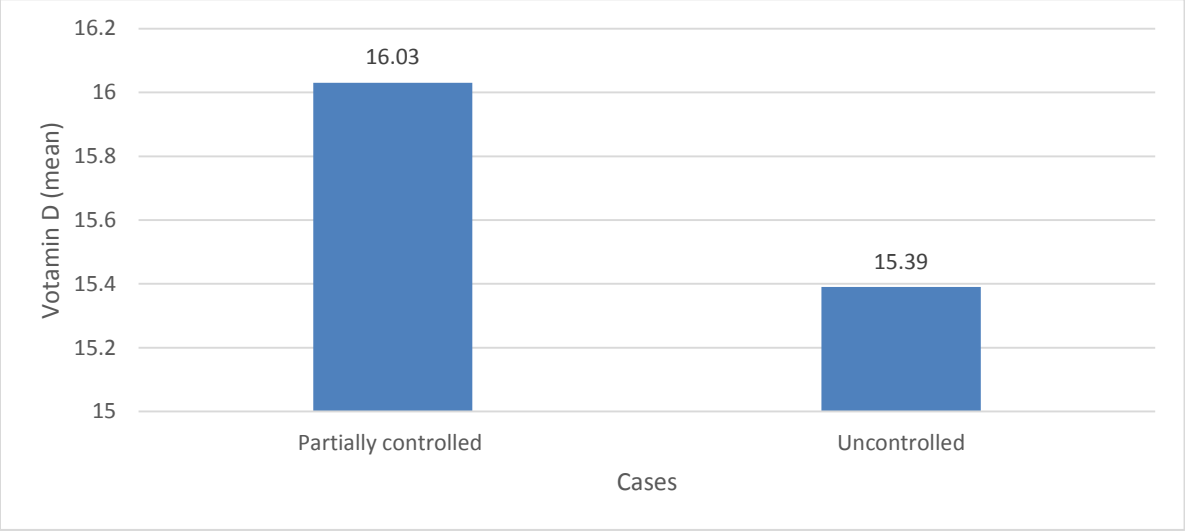
Parameter	Cases		Mann Whitney U test (P value)
	Partially controlled (N=51)	Uncontrolled (N=9)	
Age (in months) Median(IQR)	48 (40 to 60)	64 (51 to 72)	0.025

Among the people with the partially controlled group, the median age was 48 months (IQR 40 to 60) months, and it was 64 months (IQR 51 to 72) in people with the uncontrolled group. Indifference in the age between cases groups was statistically significant (p value 0.025).

Among the people with the partially controlled group, 24 (47.1%) participants were male and remained 27 (52.9%) participants were female. Among the people with the uncontrolled group, 4 (44.4%) participants were male and remained 5 (55.6%) participants were female. The difference in the proportion of gender between cases group was statistically not significant (P value 0.885).

Among the people with the partially controlled group, the median vitamin D was 14.80 (IQR 14.20 to 18.50), and it was 15 (IQR 8.40 to 19.65) in people with the uncontrolled group. Indifference in the vitamin D between cases groups was statistically not significant (p value 0.0.828).

Figure 3:-Bar chart of comparison of mean vitamin D between the study group (N=60)



The mean serum calcium was 9.14 ± 0.82 in cases group and 9.36 ± 0.67 in the control group. The difference between the two groups was statistically not significant (P value 0.444).

Among the people with the partially controlled group, the median phosphorous was 4.60 (IQR 4.20 to 5), and it was 4 (IQR 4 to 4.80) in people with the uncontrolled group. Indifference in the phosphorous between cases groups was statistically not significant (p value 0.083).

Among the people with the partially controlled group, the median urea was 18.80 mg/dl (IQR 16 to 30.60), and it was 20 mg/dl (IQR 15.50 to 30.40) in people with the uncontrolled group. Indifference in the urea between cases groups was statistically not significant (p value 0.796).

Among the people with the partially controlled group, the median creatinine was 0.70 mg/dl (IQR 0.60 to 0.80), and it was 0.70 mg/dl(IQR 0.55 to 0.08) in people with the uncontrolled group. Indifference in the creatinine between cases groups was statistically not significant (p value 0.584).

Among the people with the partially controlled group, 44 (86.3%) participants had hyperinflation and remaining 7 (13.7%) participants had normal. Among the people with the uncontrolled group, 6 (66.7%) participants had hyperinflation and remaining 3 (33.3%) participants had normal. The difference in the proportion of CXR between cases group was statistically not significant (P value 0.416).

Discussion:-

In this study, the ratio of cases to controls is 1:1. There were 60 cases and 60 controls. The distribution of genders in the current study was comparable across the cases and controls. There was a slightly lesser proportion of males compared to females among the cases, while among the controls, there was an equal number of males and females. The differences in proportion were not statistically significant. The distribution of cases and controls is not similar to the study by Aldubi et al[55] where 48% are males, and 52% females among controls and 67% are males and 33% females among cases. According to Gupta D et al.[19] boys had a higher prevalence of asthma (2.6%) compared to girls (1.9%). This is also not in agreement with the current study. Similarly, according to Jain A. et al[25] and Smith J et al[26], boys were found to have a higher prevalence of asthma compared to girls. According to Hollams E.M et al[35], male children were at an increased risk of developing bronchial hyper-responsiveness and asthma.

Table 4:-Gender comparison among cases and controls

Study	Cases		Controls	
	Males	Females	Males	Females
Current study	46.7%	53.3%	50%	50%
Aldubi et al [55](2015)	67%	33%	48%	52%
Esfandiar et al[82] (2016)	56.6%	43.4%	50.9%	49.1%

In the current study, cases were on an average of 50 months old while the mean age of controls was 62 months. The age distribution of cases and controls was similar to the studies by Bener et al[39] and Bacharier et al[14] where the average age of the cases and controls was five years. Hence age is not a limitation in the current study as the cut off levels for deficiency and insufficiency does not change with age.

In the current study, the controls had significantly higher serum levels of Vitamin D3 compared to the cases. The cases had an average serum Vitamin D3 level of 15.94 ng/mL while the controls had a serum Vitamin D3 level of 31.01 ng/mL which is almost twice the levels of the cases. The mean difference in serum Vitamin D3 levels was statistically significant. Most participants among the cases in the current study had insufficient Vitamin D levels compared to healthier controls. This finding is similar to Alyasin S et al[36] where asthmatic children were found to have significantly lower levels of Vitamin D compared to healthy controls. Similarly, according to Freishtat R J et al[45], median Vitamin D3 levels of asthmatics were lower compared to healthier individuals. The findings of the current study are similar to those by Hatami G et al[51] where among children with asthma, only 20% had sufficient levels of serum Vitamin D3. The prevalence of Vitamin D insufficiency was 24%, and the prevalence of Vitamin D deficiency was 56%. Similarly, Somasekar A.R et al[52] Aldubi et al[55] and Lautenbacher Laura et al[58] also report that serum Vitamin D3 levels among children with asthma are significantly much lower compared to the healthier controls. Similarly, Jat K.R and A. Khairwa[59] also report that among those who have asthma, 28.5% have deficient serum Vitamin D3 levels and 26.7% have deficient Vitamin D3 levels. The serum levels of Vitamin D3 are significantly lower among asthmatic children compared to healthier controls. Similarly, Kim Y.R et al[60] also report that serum Vitamin D3 among 6-14-year-olds with asthma are significantly lower compared to healthier children. In addition in the study by Xiu X.Y et al[63] the authors report that there was a statistically significant mean difference in the serum Vitamin D3 levels compared to the children with and without asthma where children with asthma have lower Vitamin D3 values.

Table 5:-Vitamin D levels between asthmatic children and healthier controls

Study	Vitamin D3 levels - Cases	Vitamin D3 - controls
Current study	15.94 ng/mL	31.01 ng/mL
Freishtat et al[45] (2010)	18.5 ng/mL	40.4 ng/mL
Searing DA et al[83] (2010)	31 ng/mL	-
Alyasin et al[36] (2011)	49.29 ng/mL	66.82 ng/mL
Bener et al[39] (2012)	17.2 ng/mL	26.8 ng/mL

Brehm et al[84] (2012)	32 ng/mL	31 ng/mL
Uysalol M et al[40] (2013)	16.6 ng/mL	28.2 ng/mL
Bose et al[50] (2013)	28 ng/mL	-
Hatami G et al[51] (2014)	20.34 ng/mL	25.39 ng/mL
Aldubi et al[55] (2015)	8.85 ng/mL	21.11 ng/mL
Kolokotroni et al[10] (2015)	21.15 ng/mL	22.90 ng/mL
Esfandiar et al[82] (2016)	14.5 ng/mL	22.4 ng/mL
Kim Y R et al[60] (2017)	16.63 ng/mL	24.24 ng/mL
Omole O et al[62] (2018)	49.2 ng/mL	51.2 ng/mL
Xiu X Y et al[63] (2018)	25 ng/mL	29 ng/mL

The findings are differing in the distribution in those who have insufficient levels compared to the study by Ulyasol et al[40] and Zhang L.L et al[29, 54] where more children among the cases were deficient in Vitamin D compared to those who had insufficient levels.

The study findings in the current study are in contrast to the study by Menon J et al[64] where the authors mention that there was no statistically significant difference in the serum levels of Vitamin D3 among asthmatic children compared to children without asthma.

In the current study, despite the differences in the serum Vitamin D3, there was no statistically significant difference in the average levels of serum calcium across the cases and controls. The serum calcium level in mg/dL in the current study was 9.18 mg/dL among the cases while it was 9.05 mg/dL among the controls. Similarly, in the study by Bener M et al[39] and Aldubi et al[55], there was no statistically significant difference in the serum levels of calcium between asthmatic children and healthier controls.

In the current study, similar to calcium levels, there was no significant difference in the median levels of serum phosphorus between the cases and controls. The cases had an average serum phosphorus level of 4.60 mg/dL while among the controls it was 4.70 mg/dL. Similarly, in the study by Bener M et al[39] Aldubi et al[55], there was no statistically significant difference in the serum levels of phosphorus between asthmatic children and healthier controls.

In the current study, there was no statistically significant difference in the serum levels of Urea between the cases and controls. The cases had a median urea level of 18.90 mg/dL while the controls had a median urea level of 21.30 mg/dL. However, in the current study, there was a statistically significant difference in the median serum creatinine levels between the cases and controls. The controls had a significantly lower level of serum creatinine (0.60 mg/dL) compared to the cases who had a median serum creatinine of 0.80 mg/dL. This is in contrast to the study by Bener et al[39] where there was no significant difference in the serum creatinine levels between the asthmatic children and healthy controls.

In the current study, with respect to the radiological findings, there was a significantly higher proportion of cases who had hyperinflation on chest X-ray (83.3%). Among the controls, a higher proportion had a normal chest X-ray. (93.3%) The difference in the proportions is statistically significant. The findings are similar to the study by Wu Ann Chen et al[48] where among asthmatic children, the presence of Vitamin D deficiency was associated with a poorer pulmonary function. Similarly, Somashekar A.R et al[52] also reports that there was a positive correlation between serum Vitamin D levels and the prevalence of asthma.

In the current study, among the cases, the majority were having partially controlled asthma (85%). Only 15% had uncontrolled asthma. There was a statistically significant difference in the ages between those who had partially controlled and uncontrolled asthma. Those who had partially controlled asthma were of a median age of 48 months, while those with uncontrolled asthma had a median age of 64 months. The children with uncontrolled asthma were of an older age compared to those who had partially controlled asthma. This is similar to the study by Aldubi et al[55] where older children had a higher prevalence of uncontrolled asthma.

In the current study, there was no statistically significant association between gender and the degree of asthma control. The distribution of males and females among the partially controlled and uncontrolled asthmatics were not statistically significant.

There was no statistically significant difference in the serum levels of Vitamin D3 between those who had partially controlled asthma and uncontrolled asthma in the current study. The mean serum Vitamin D3 among those who had partial asthma control was 16.03 ng/mL while the mean serum Vitamin D3 levels among the uncontrolled asthmatics were 15.39 ng/mL. This is in agreement to the study by Omole KO et al[62] where they report that the difference in serum Vitamin D3 levels was not correlated with the severity of asthma symptoms. Similarly, the study findings are also in concordance with the study by Menon J et al[64] where the authors report that Vitamin D levels did not correlate with asthma severity among children. Also, Krobtrakulchai W et al[66], Luo J et al[68] and Pollard S.L et al[70] also report that serum Vitamin D3 levels did not differ significantly between children with varying degrees of asthma control.

The findings of this current study are in contrast to the study by Chinellatto et al[34] where sufficient levels of serum Vitamin D3 correlated with better control of asthma. Similarly, this study also contrasts with the study by Aldubi et al[55] and Xiu X.Y et al[63] where the authors report that children with better asthma control had higher serum levels of Vitamin D3. All those who had uncontrolled asthma had deficient levels of Vitamin D3 while among those who had controlled asthma 7% had insufficient Vitamin D3 levels while the rest had deficient Vitamin D3 levels. This might explain why there was no statistically significant correlation between Vitamin D3 levels and asthma control among the cases since most of them were having only insufficient Vitamin D3 levels.

Table 6:-Serum Vitamin D and asthma control- comparison between studies

Study	Partially controlled	Uncontrolled
Current study	16.03 ng/mL	15.39 ng/mL
Krobtrakulchai et al[66] (2013)	29.2 ng/mL	27.9 ng/mL
Aldubi et al[55] (2015)	13.3 ng/mL	7.4 ng/mL
Esfandiar et al[82] (2016)	15.56 ng/mL	13.55 ng/mL

In the current study, similar to Vitamin D3 levels, there was no statistically significant difference in the serum calcium levels between those who had partially controlled and uncontrolled asthma. Those who had partially controlled asthma had a mean serum calcium level of 9.14 mg/dL while those who had uncontrolled asthma had a mean serum calcium level of 9.36 mg/dL. This is in contrast to the study by Aldubi et al[55] where partially controlled children had a significantly lower level of serum calcium compared to uncontrolled asthmatic children.

In the current study, there was no statistically significant difference in the level of serum phosphorus between the cases who had partially controlled and uncontrolled asthma. Those who had partially controlled asthma had a median serum phosphorus level of 4.60 mg/dL while those who had uncontrolled asthma had a median serum phosphorus level of 4 mg/dL. This is similar to the study by Aldubi et al[55] (2015) where there was no statistically significant difference in the serum phosphorus between children with varying degrees of asthma control.

With respect to renal function parameters, there was no statistically significant difference in the level of blood urea between the cases who had partially controlled and uncontrolled asthma in the current study. Those who had partially controlled asthma had a median blood urea level of 18.80 mg/dL while those who had uncontrolled asthma had a median blood urea level of 20 mg/dL.

Similar to blood urea levels the partially controlled and uncontrolled asthmatics had comparable levels of serum creatinine in the current study. Both the partially controlled and uncontrolled asthmatics had a median serum creatinine of 0.70 mg/dL. The difference was not statistically significant.

Among the radiological findings, the proportion of cases with hyperinflation had no statistically significant difference between the cases with partially controlled asthma and uncontrolled asthma. Among those who had partially controlled asthma, 86.3% had hyperinflation on chest X-ray, while among those who had uncontrolled asthma, 66.7% had hyperinflation on chest X-ray.

The findings of this study suggest the scope for future studies on the benefit of Vitamin D supplementation for reducing asthma attacks among children. Recent studies in the past few years such as Yadav et al[72] (2014) and Tachimoto et al[57] (2016) mention that supplementation with Vitamin D achieved better control of asthma among pediatric asthmatics. Similarly, Baris S et al[74], Martineau AR et al[78] and Joliffe DA et al[61] also conducted interventional studies where the authors report that Vitamin D supplementation decreased asthma exacerbations among children. Another recent study by Davidson D et al[80] reports that supplementation with Vitamin D3 has beneficial effects in achieving asthma control only among severely deficient individuals. But most interventional studies have been conducted only in developed countries. Further interventional studies are needed in developing countries like India for assessing the impact of Vitamin D supplementation on pediatric asthma and for prescribing guidelines regarding the optimal dose and schedule among pediatric asthma cases. This will help in reducing the morbidity due to asthma in the long term.

Conclusion:-

In this study, the cases were younger than the controls on average and consisted of a slightly greater proportion of females. This implies the increasing burden of asthma in a predominantly younger age group.

The asthmatic children had a significantly lower serum Vitamin D3 levels compared to healthier children. The asthmatic children had Vitamin D3 levels in the range of insufficiency while most healthy children were sufficient in Vitamin D3 levels. In view of the overwhelming evidence linking Vitamin D in the pathogenesis and management of asthma, this finding has multiple implications. Furthermore, this implies the greater burden of Vitamin D deficiency in a developing country like India where the premature mortality and disability due to asthma is high which is further complicated by the burden of Vitamin D deficiency.

Despite the lower levels of serum Vitamin D3, there was no significant decrease in serum phosphorus levels and calcium levels among asthmatic children compared to healthy children. This finding is in accordance with other similar studies. Furthermore, most children with asthma also had hyperinflation in chest X-rays, indicating the importance of monitoring lung function among asthmatic children.

With respect to the degree of asthma control, older children also had a higher prevalence of uncontrolled asthma. This indicates targeted efforts among older children to achieve better asthma control. However, no association was found between serum Vitamin D3 levels and the degree of asthma control. Furthermore, there was no significant difference in the hyperinflation in chest radiography between cases and controls.