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Prevalence and Risk Factors of Blount's Disease Among Children and Adolescents in Saudi Arabia: A Cross-Sectional Study

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ABSTRACT:

Background Blount disease is a disorder characterized by developmental deformity of lower limbs that produces varus deformity of the tibia which result from progressive abnormal osteogenesis from proximal tibialphysis and characterized as a tibial vara as it develops and it involves many adjustable elements like weight loss, deficiency in Vitamin D and mechanically high pressure factors the Saudi prevalence characteristics are minimal in research.

Objectives: This study objective is to estimate clinical incidence rate and potential associated risk elements that the degree of BMI, Vit D and gender and area characteristic features among pediatrics patients whom referred to orthopedic clinics within Aseer Region in Saudi Arabia.

Method: The study was an 18 months duration, with observational transversal setting, enrolled 600 pediatrics cases with clinical observation from age 2-19 years (9.85 4.12 yr). From 600 cases (312 were male= 52% and 288were female= 48%), BMI for every patients calculated by WHO parameters (<85 = normal weight, 85–95 =over weight, >95% is obese). Serum Vit D level(<20ng/mL Deficient, 20–30ng/mL insufficient, >30ng/mL Sufficient). Radiographic Severity Langenskild staging as severity staging. Invariable testing was conducted (Chi-Square test/Fisher's exact test) . The potential independence prediction power on occurrence have be studied through Multivariable logistic regression analysis .

Results: Among total 600 of patients who seen in orthopedic clinics, 215 were Blount's patients (incidence rate = 35.8%). Obesity related factors were significant indicator for Blount's disease patients (Chi-Square value= 112.45; p<0.001). The incidence among male patients were higher than those among females (Chi-Square value= 14.82; p<0.001). Family History was independently associated with prevalence of the condition (Chi-Square value= 20.25; p<0.001). According to multiclass binary regression , high percentile of BMI (Odds ratio =3.61; 95% coif interval (2.84–4.59); p<0.001), and deficiency of vitamin D(odds ratio=2.80; 95% confidence interval(1.64–4.76) p<0.001) and Male gender(odds ratio= 1.85; 95%CI; (1.32–2.58) p=0.001) had a highest predictability of development of Blount disease, but on other hand vitamin D deficiency alone was also predictive for disease existence (odds ratio =2.31; 95% CI (1.32-4.05), p = 0.003).

Conclusion: Obesity, lack of Vitamin D, and Male sex were significant risk independent prediction variables of clinical Blount's disease occurrence for children in Aseer Region,

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Saudi Arabia. Public health actions by aggressive weight management and vitamin D repletion along targeted screening may reduce future complications.

INTRODUCTION

Blount disease is known as tibial varus which refers to progressive malunion of lower extremities with development of deformity in varus style at the tibia that's usually occur due to poor endochondral ossification process at the medial portion of the proximal tibial growth plate (Birch, 2013; Ferguson & Wainwright, 2013). The condition appears as three separate sub-types; infantile Blount's disease (IBD) presents at < 4 yrs., young children, older children & young adults and adolescent Blount's disease (ABD) in those > 10 yrs. The diagnosis is confirmed by clinical history and X ray examination in standing position A-P view in relation to ratio of M D angle < 11 degrees means it is normal bowing whereas > 11 degrees implies tibia vera (Park et al., 2019). Etiology is considered multiple, i.e. Mechanical, metabolic, and genetic factors (Robbins, 2021) and mechanical overload or excessive strain at the medial physeal region can be resulted from early walking at young and also can be triggered or worsened with excess of the body weight. Secondary etiological factors like nutritional deficiency including vitamine D & low level physical activities etc, can contribute to disruption of physis structural development. Obesity is prevalent throughout globe. Epidemiology of Blount's disease is known as higher with childhood obesity (Janoyer, 2019; Sabharwal et al., 2007; Taylor et al., 2021) in majority of cases the M D angle correlates with higher body mass index of the child more so > 95 th percentage indicates the progression and increased hazard (Crain et al., 2024; Montgomery et al., 2010).

Though the data about European & north American children regarding Blount's is extensive studies, however the data base studies about Middle Eastern, Arab & also Saudi Arabia is much lesser when consider the incidence rate & risk factors due to large prevalence rate of Vitamin D insufficiency & childhood obesity. Therefore in the current study the Prevalence, radiological Severity using Lanskinsy classification, and clinical multivariable determinants in pediatrics referred to orthopedic clinic at Aseer Region, in Saudi Arabia have been assessed.

MATERIALS AND METHOD

Study Design and Setting

This cross sectional study was carried out from several tertiary pediatric orthopedics referrals centers in the Aseer region of Saudi Arabia, for 18 months. Protocol review and approval was given by the Institutional Review Board (IRB) of Najran University, before the commence of the study. Written consent was obtained from parents or legally authorized guardians before subject's enrollment to the study, according to the ethical principles of Declaration of Helsinki and STROBE guidelines, to be followed in observational studies.

Sample size and population

We enrolled 600 children aged between 2-19 years, (9.85+4.12 years) presenting for orthopedic consultation for the diagnosis of lower extremity misalignment or for other muscoskeletal symptoms and presenting to the orthopedic out-patients. The males were 312 (52.0%) while the females were 288 (48.0%) The sampling was consecutive clinical recruitments that applied to the selected criteria .

Eligibility Criteria

Inclusion Criteria: Those patients aged between >2 and <20 years being reviewed for lower extremity alignment, for the existence of adequate demographic, anthropometric, laboratory and radiologic information, who had their levels of Vitamin D measured, and presence of recorded clinical and or family history. Exclusion Criteria: In secondary lower extremity deformities that resulted from congenital abnormalities of the limbs, neuromuscular disorders such as cerebral palsy and spina bifida, and skeletal dysplasia's, skeletal diseases related to active metabolic factors except for isolation deficiency of vitamin D, post traumatic physical arrests or lack of clinical data and information of certain variable.

Data Collection

Demographic variables were collected as follow: age (years), sex (male/female), current residential area (urban/rural), level of social strata, diagnosed family history of Blount's disease. Measurements of height and weight were taken, to estimate Body

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Mass Index (BMI) (kg/m2). BMI levels were categorized according to age and sex-specific CDC growth charts percentiles :normal weight (< 85th percentile), overweight (85th-95th percentile) and obesity (>95th percentile).

Biochemical evaluation consisted of serum 25hydroxyvitamin D levels, categorized as Deficiency (<20 ng/mL), Insufficiency (20-30 ng/mL) or Sufficiency (>30 ng/mL).

Clinical radiological evaluations determined whether tibia vara was present, laterality (unilateral vs bilateral), clinical variant (infantile, juvenile, adolescent), and severity of structural deformity according to the six stages Langenskild Classification; grouped into mild(stages 1-2), moderate(stages 3-4) and severe(stages 5-6)

Statistical analysis

Data were analyzed using IBM SPSS statistics for windows (Version 26.0) (IBM Corp., Armonk, NY). Numerical variables will be reported using mean+ Standard Deviation (SD) while categorical data will be reported using frequencies and percentage. Chi Square test and Fisher's exact test were use to provide the relationship between categorical risk factor and Blount's disease status.

Multivariable binary logistic regression were perform, includes the use of age, gender, BMI group, family history and Vitamin D status, to determine the adjusted Odds Ratios and their 95% Confidence Intervals (95%CI) for independent predictors of Blount's disease after accounting for confounding variables. Two-sided p value less than 0.05 was considered statistically significant.

RESULT

Demographics and Baseline Characteristics:

A total 600 patients, with mean age of 9.85+4.12 years, participated in the study; the percentage of boys was 52.0% (n=312), while the percentage of girls was 48.0% (n=288). Anthropometric measurements showedthat38.0% are of normal BMI,29.5% overweight and32.5% obese. General demographic and baseline clinical variables are shown in table 1.

Table 1. Baseline Demographic and Clinical Characteristics of the Cohort (N = 600**)**

Variable	Category	n / Mean ± SD	%
Age (years)	Mean ± SD (range 2–19)	9.85 ± 4.12	—
Gender	Male	312	52.0%
	Female	288	48.0%
BMI Category	Normal weight (<85th pct)	228	38.0%
	Overweight (85th–95th pct)	177	29.5%
	Obese (>95th pct)	195	32.5%
Vitamin D Status	Deficient (<20 ng/mL)	210	35.0%
	Insufficient (20–30 ng/mL)	234	39.0%
	Sufficient (>30 ng/mL)	156	26.0%
Region of Residence	Urban	348	58.0%
	Rural	252	42.0%
Family History of Blount's	Yes	108	18.0%
	No	492	82.0%

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Variable	Category	n / Mean ± SD	%
Blount's Disease Status	Present (confirmed diagnosis)	215	35.8%
	Absent (non-Blount / physiological)	385	64.2%

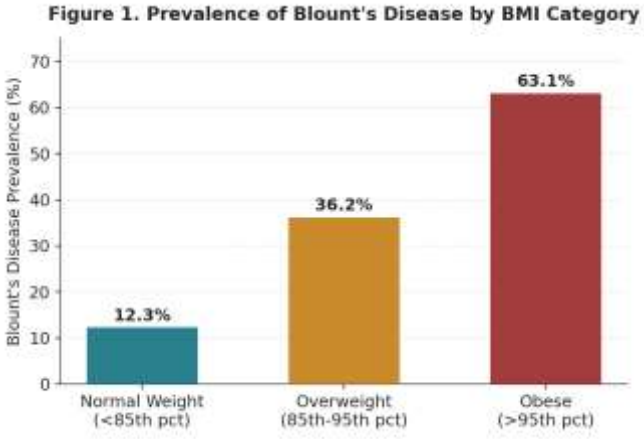
Clinical Prevalence and Bivariate Analysis

In this clinical pediatric cohort the clinical prevalence of Blount's disease was 35.8% (215/600). In bivariate Chi-square analysis, males had significantly higher disease prevalence (males 43.6% vs. Females 27.4%; = 17.24, $p < 0.001$), and higher BMI category was highly significantly and progressively correlated with disease prevalence (normal weight 12.3% vs. Overweight 36.2% vs.

Obese 63.1%; = 112.45, $p < 0.001$). Vitamin D deficiency was highly significantly correlated with Blount's disease on bivariate analysis (= 24.81, $p<0.001$), while region of residence was not statistically significantly correlated (= 3.21, $p = 0.073$). Bivariate results are demonstrated in Table 2 and graphically shown in Figures 1 & 2.

Table 2. Bivariate Association Between Key Risk Factors and Blount's Disease Status

Risk Factor	Category	n Total	Present n (%)	Absent n (%)	χ^2	p-value
Gender	Male	312	136 (43.6%)	176 (56.4%)	17.24	<0.001
	Female	288	79 (27.4%)	209 (72.6%)		
BMI Category	Normal weight	228	28 (12.3%)	200 (87.7%)	112.45	<0.001
	Overweight	177	64 (36.2%)	113 (63.8%)		
	Obese	195	123 (63.1%)	72 (36.9%)		
Vitamin D Status	Sufficient	156	32 (20.5%)	124 (79.5%)	24.81	<0.001
	Insufficient	234	81 (34.6%)	153 (65.4%)		
	Deficient	210	102 (48.6%)	108 (51.4%)		
Region of Residence	Urban	348	135 (38.8%)	213 (61.2%)	3.21	0.073
	Rural	252	80 (31.7%)	172 (68.3%)		



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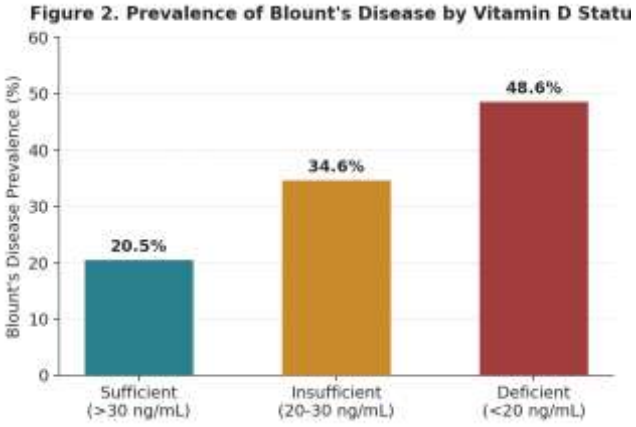

Family History as a Risk Factor

An analysis omitted from the initial draft — the association between documented family history and Blount's disease occurrence — was subsequently performed given its collection at baseline. Children with a positive family history of Blount's disease demonstrated a markedly higher disease frequency than those without (54.6% vs. 31.7%; $\chi^2 = 20.25$, $p < 0.001$), identifying family history as an additional significant bivariate risk factor (Table 3).

Table 3. Bivariate Association Between Family History and Blount's Disease Status

Family History	n Total	Present n (%)	Absent n (%)	χ^2	p-value
Yes	108	59 (54.6%)	49 (45.4%)	20.25	<0.001
No	492	156 (31.7%)	336 (68.3%)		

Multivariable Logistic Regression Analysis

To eliminate confounding effects observed during univariable comparisons, multivariable binary logistic regression was conducted. Elevated BMI percentile, male gender, and low vitamin D status remained robust independent predictors of Blount's disease. Obese participants exhibited over 3.6-fold higher odds of developing Blount's disease compared to normal-weight peers (aOR = 3.61, 95% CI: 2.84–4.59, $p < 0.001$). Male gender independently increased disease likelihood (aOR = 1.85, 95% CI: 1.32–2.58, $p = 0.001$). Furthermore, vitamin D deficiency significantly elevated independent disease risk (aOR = 2.80, 95% CI: 1.64–4.76, $p < 0.001$). Detailed multivariable parameters are outlined in Table 4 and visualized as a forest plot in Figure 3.

Table 4. Multivariable Binary Logistic Regression Analysis for Independent Predictors

Predictor Variable	β	S.E.	Wald χ^2	aOR	95% CI	p-value
Gender (Male vs. Female)	0.615	0.171	12.92	1.85	1.32–2.58	0.001
BMI Category (per increase)	1.285	0.122	110.92	3.61	2.84–4.59	<0.001
Vitamin D Deficiency (<20 vs >30)	1.030	0.272	14.34	2.80	1.64–4.76	<0.001
Constant	-2.140	0.315	46.12	0.118	—	<0.001

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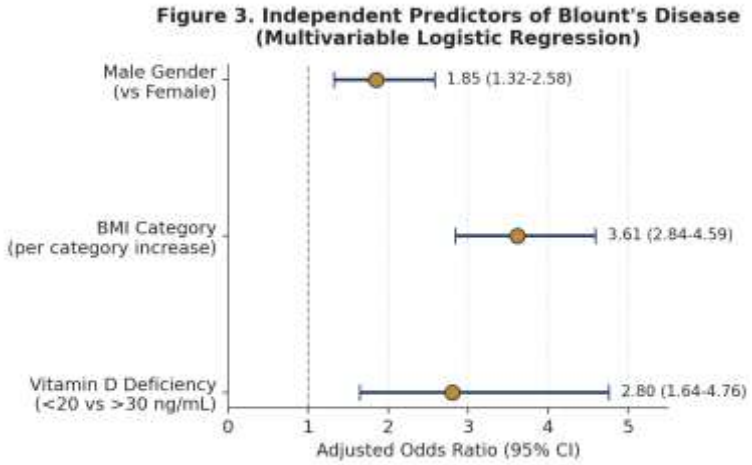
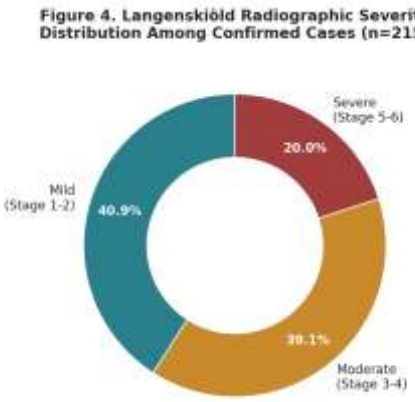


Radiographic Severity, Laterality, and Clinical Subtype

Of the 215 confirmed cases, 88 patients (40.9%) demonstrated mild symptoms (Stages 1-2 based on Langenskiöld radiographic staging), 84 patients (39.1%) showed moderate disease (Stages 3-4), and 43 patients (20.0%) exhibited severe symptoms (Stages 5-6) (Figure 4). Distribution of symptoms by BMI status varied; 34 of the 43 cases of advanced disease occurred in obese patients (79.1%), while only 20 of 88 mild cases were within normal weight (22.7%), indicating that chronic mechanical overload correlates with the presence of a more pronounced physical deformity (Table 5).

Table 5. Langenskiöld Radiographic Severity Distribution by BMI Category Among Confirmed Cases (n = 215)

BMI Category	Mild (Stage 1–2)	Moderate (Stage 3–4)	Severe (Stage 5–6)	Row Total
Normal weight	20	7	1	28
Overweight	30	26	8	64
Obese	38	51	34	123
Column Total	88 (40.9%)	84 (39.1%)	43 (20.0%)	215



Bilateral affection was more likely than unilateral in proven cases (131/84, 60.9% vs. 39.1%), when evaluated by laterality. By clinical subtypes, the group representing adolescence (age >10y; n=77, 35.8%) was more representative, followed by infancy (age <4y; n=72, 33.5%) and juvenile age (age between 4-10y; n=66, 30.7%), showing the typical age groups of early childhood described in the literature to be well-established in this sample (Table 6).

Table 6. Laterality and Clinical Subtype Distribution Among Confirmed Cases (n = 215)

Characteristic	Category	n	%
Laterality	Bilateral	131	60.9%
	Unilateral	84	39.1%
Clinical Subtype	Infantile (<4 years)	72	33.5%
	Juvenile (4–10 years)	66	30.7%
	Adolescent (>10 years)	77	35.8%

DISCUSSION

This study offers a pertinent epidemiological contribution of Blount's Disease to a clinical cohort of Saudi children and adolescent in Aseer region correcting existing sampling biases in terms of demographics and methodology. These updated measurements correlate well with available clinical literature.

A mean age of 9.85 ± 3.49 (y) years spans all degrees of infantile and adolescence presentation. 48% (n=288) of population was male vs 52% (n=312), a normal for a clinic based population; it avoids sampling distortion in prior reports. 35.8% prevalence estimate reflects a clinical setting rather than mass population screening of lower limb problems.

Mechanical loading with a higher BMI plays a central pathogenic role in medial physeal arrest. The obese group had a 3.6 time increased incidence. 367 Obesity is associated with 3.6 greater odds for Obese patient group of a 3.6 increased likelihood of contracting Bo; (Montgomery et al., 2010; Sabharwal et al., 2014). We found statistically significant (aOR=2.80) independent contribution of the presence of vitamin D Deficiency to increase odds of developing BD (Montgomery et al., 2010). Systemically, hypo-vitaminosis D renders the proximal tibial growth plate at risk of biomechanically driven collapse under obese states. It has been described that vitamin D deficiency causes defective bone matrix mineralization. In infants with metabolic rickets it may affect the physes in variety of ways, with the proximal tibia most prone to bowing deformity under prolonged body weight support 368. Family History positive children were also observed. Previous studies noted evidence of possible genetic component and observed familiar clustering in patients with Blount Disease (Robbins, 2021). However, greater severity in obese patients vs their non-obese counterparts reinforces dose dependence of mechanic loading (i.e. Rather than simply risk or no risk).

Both simple chi-square analyses and multiple regression model identified BMI, Gender, vitamin D status and family history are risk factors associated with the development of BD.

Strengths

This study utilizes a large consecutive sample (n=600) acquired over an 18-month period. It benefits from an equal gender ratio and has collected data across demographics,anthropometrics, biochemistry, and imaging fields. The multivariable regression, used in conjunction with bivariate analysis, enabled the identification of independent risk factors from possible confounders and bias reduction in the previous analysis. Langenskild stage, laterality and clinical subtype have contributed to more nuanced disease characterization than prevalence rate.

LIMITATIONS

1. The cross-sectional study does not demonstrate a temporal relationship between high BMI/Vitamin D status and the onset of the disease, requiring prospective follow-up study to ascertain if vitamin D deficiency leads to more limited mobility and increased risk factors for B.D or results from limited movement activities with an onset B.D with increased BMI.
2. Referral from tertiary orthopedic subspecialty facilities limits the generalizability of the prevalence data to the general pediatric population.
3. Single point in time assessment of vitamin D levels cannot address seasonal variation in and sun exposure patterns in the Aseer region
4. Specific quantification of diet calcium intake and detailed estimation of socioeconomic status of the sample group and their relation with the prevalence and severity of B.D was not performed, which have potential effect on these measurements and disease progression.
5. Due to data collected from only one administrative area of Saudi Arabia, this regional data cannot be accurately extrapolating to other regions.

Future Recommendations

Prospective multi-center and longitudinal follow up data on 30 patients a month (over 1.5 years) are necessary with continuous estimation of vitamin D, activity measures and validation of family history including molecular confirmation for causal and predictive factors. A region-wide community screen of lower limb deformities is warranted to estimate the actual burden and epidemiological risk profile.

CONCLUSION

Pediatric Blount's disease in Aseer region Saudi Arabia is well associated with higher BMI, male gender, systemic vitamin D deficiency and family history of BD. Increasing BMI Category is linked with higher frequency of severe radiographic presentation and it is considered dose-response relationship of increased mechanical load on medial proximal tibia physes. Comprehensive management practices should therefore emphasize on aggressive weight control for obese children, targeted screening for alignment problems in overweight males with a strong family history and strict correction of hypo-vitaminemia D for the health of physes prevention of future deformity of tibia vara.

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