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Original Research Article

Prevalence and determinants of acanthosis nigricans among adolescents: a school based cross sectional study in Southern Kerala

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ABSTRACT

Background: Acanthosis nigricans (AN) is a dermatologic condition that may be associated with various underlying medical conditions and is increasingly seen in obese children and adolescents. Assessing AN in adolescents is crucial as it can serve as an early indicator of underlying insulin resistance and metabolic disorders.
Methods: This cross sectional study was conducted among class eleven higher secondary students in public and aided sector in Thiruvananthapuram district of Kerala. A total of 1832 students were recruited using multistage cluster sampling procedure. The participants were examined and neck grading for acanthosis was recorded. Anthropometric readings along with blood pressure, perceived stress levels, family history of diseases as well as life style habits were also evaluated. The female participants were examined for symptoms of anovulation and hyperandrogenism.
Results: A total of 1832 students participated in the study of which 66% were girls and 34% were boys. About 26% were found to have AN. Prevalence of Acanthosis was higher in girls (30.3%) compared to boys (18%). Hypertension (OR: 2.83, 95% CI: 2.25-3.55), overweight or obesity (OR: 10.67, 95% CI: 8.26-13.78) and high levels of perceived stress (OR: 1.55, 95% CI: 1.05-2.30) were found to be significantly associated with acanthosis.
Conclusions: The findings suggest that AN neck grading can serve as a useful tool for non-communicable disease screening in schools, enabling the identification of students who may require further evaluation and intervention.

Keywords: Acanthosis nigricans, Adolescents, Blood pressure, Kerala

INTRODUCTION

Acanthosis nigricans (AN) is a dermatologic condition that has been recognized for more than a century and may be associated with various underlying medical conditions.[1] Obesity is the leading cause of AN, and is increasingly seen in obese children and adolescents.[2] Although majority of AN have been found to be associated with obesity and other metabolic syndromes, drug-and malignancy-related etiologies have also been described.[3-5] The role of insulin, insulin-like growth factors (IGFs), and other biochemical factors in the skin changes seen in AN has been well-documented.[5-8] These changes are closely linked to metabolic and physiological risk factors for NCDs like obesity, elevated blood pressure, dyslipidemia, and insulin resistance, suggesting a potential early onset of non-communicable diseases (NCDs) and an increased risk of related health complications.[6-12] Consequently, AN, when associated with metabolic and physiological risk factors for NCDs, can serve as an important indicator for early intervention.[6-12] This condition thereby underscores the importance of lifestyle modifications aimed at preventing or delaying the onset of NCDs and their complications, particularly in children and adolescents. Referring to systemic disorders, early identification of AN is crucial, as it can also be, in rare cases, suggest the presence of internal malignancies.[2]

In adolescent development, the age range of 14 to 17 years is categorized as middle adolescence, while 17 to 21 years is considered late adolescence.[13] This transitional pre-adulthood period is crucial for chronic disease prevention, as this is when most behavioral risk factors are often acquired. They represent key opportunities for implementing NCD screening programs aimed at timely detection and management of risk factors, ultimately reducing the burden of adult non communicable diseases as individuals' age. In this background, the present study was conceived with the objective to explore the prevalence and determinants of AN among middle-late adolescents in the capital district of Kerala.

METHODS

This cross-sectional study was conducted as part of a larger school-based study which assessed the NCDs risk factors among class eleven higher secondary students in public and aided sector in Thiruvananthapuram district of Kerala from July to September 2019. The sample size was calculated using the least prevalence of NCD risk factors obtained from a higher secondary school-based pilot study conducted by the researchers themselves. A total of 1832 students were recruited using multistage cluster sampling procedure. Five schools each were selected from each of the three educational sub-districts of Thiruvananthapuram district. From each of the five schools science, humanities and commerce divisions of class eleven were randomly selected. Students who belonged to the selected divisions between the ages of 15-18 years and whose parents gave consent to participate in the study were included. Children who were severely sick or with problems like mental retardation, learning disabilities or absent on the day of data collection were excluded. Students in the selected divisions were recruited for the study with informed consent of guardians as well as the students' assent.

Measures

The socio-demographic details along with family history of diseases as well as life style habits of the students were assessed using a pre-validated self-administered questionnaire. The participants were examined and neck grading for acanthosis was recorded by a trained physician using Burke et al qualitative grading of acanthosis as follows: 0: not visible; grade 1: present: clearly present on close visual inspection; extent not measurable; grade 2: limited to the base of the skull, does not extend to the lateral margin of the neck; grade 3: extending to the lateral margins, not visible from the front; grade 4: extending anteriorly.[14]

Height and weight of the students were recorded using a pre-calibrated portable stadiometer and a digital weighing scale respectively. The body mass index (BMI) was calculated based on the Indian academy of pediatrics standard growth charts.[13] Blood pressure was measured using pre-calibrated mercury sphygmomanometer by the physician and the average of two readings taken ten minutes apart was calculated and categorized based on the latest American academy of pediatrics guidelines.[15] Perceived stress levels of the students were assessed using a ten-item perceived stress questionnaire by Cohen et al.[16] The female participants were examined for symptoms like amenorrhea/oligomenorrhea and hyperandrogenism features like hirsutism and acne.[17]

Statistical analysis

Levels of different grades of acanthosis were estimated and associations derived using bivariate analysis with chi square tests and logistic regression to calculate the odds ratios for the association between AN and various risk factors. The analysis was done using IBM SPSS version 25.

Ethical considerations

The study was conducted after obtaining clearance from the institutional ethics committee. Assent of the students and written informed consent of parents were obtained prior to recruiting the students for the study.

RESULTS

A total of 1832 students participated in the study of which 1209 (66%) were girls and 623 (34%) were boys. The median age of participants was 16 years. About 26% were found to have AN. Prevalence of acanthosis was higher in girls (30.3%) compared to boys (18%). Grade 1 acanthosis was found in 274 (15%) students, grade 2 in 92 (5%) students, grade 3 in 72 (3.9%) students and grade 4 was found in 41 students (2.2%) (Table 1).

The factors associated with AN are presented in Table 2. Higher odds of acanthosis in all grades were found in girls (OR: 1.96, 95%CI: 1.54-2.49). Hypertension (OR: 2.83, 95% CI: 2.25-3.55), overweight or obesity (OR: 10.67, 95%CI: 8.26-13.78) and high levels of perceived stress (OR: 1.55, 95% CI: 1.05-2.30) were found to be significantly associated with acanthosis. Those with family history of obesity (OR: 1.45, 95% CI: 1.05-2.01), hypertension (OR: 1.34, 95% CI: 1.06-1.68) and hypercholesterolemia (OR: 1.26, 95% CI: 1.02-1.55) reported significant increase in acanthosis. Higher odds for grade 4 acanthosis were found in students with history of diabetes mellitus (OR: 2.11, CI: 1.00-4.47) in the immediate family. We found that individuals who engage in moderate physical activity three or more days per week have lower odds of experiencing grade 1 acanthosis. (OR: 0.7, CI: 0.52-0.96) compared to those who do not engage in this level of activity. However, no association was found between acanthosis and family history of malignancies (Table 2).

The mean body weight was 49.12 (±9.06) kilograms and BMI 18.7 (±2.73) kg/m^2 in students without AN, while

59.66 (±13.57) kg and 23. 2 (±4.34) kg/m^2 respectively in students with acanthosis. The mean body weight and BMI was found to increase with progressive grades of acanthosis. The mean systolic blood pressure for students with AN was 118.25 (±14.92) mmHg, and those without acanthosis was 112.99 (±14.21) mmHg. The mean diastolic blood pressure of students with acanthosis was 83.95 (±9.40) mmHg while in non-acanthotic students, 73.49 (±8.09) mmHg. The mean systolic and diastolic blood pressure was also found to increase with higher grades of acanthosis. We found significant difference in blood pressure, BMI and body weight between students with acanthosis and those without. The mean perceived stress score for students without AN was 17.42 (±5.76), and those with acanthosis was 18.26 (±5.65). The PSS scores among students with different grades of acanthosis was significantly different among girls (p=0.012), but not in boys (p=0.54) (Table 3).

Features of anovulation and/or hyperandrogenism were present in 22.4% of the girls with acanthosis condition. Proportion of girls with hyperandrogenism features were found to increase significantly with progressing grades of acanthosis (Table 4).

Table 1: Distribution of AN among the study population.

AN (grading)	Boys, (n=623) (%)	Girls, (n=1209) (%)	Total, (n=1832) (%)
AN grade 1	80 (12.8)	194 (16)	274 (15.0)
AN grade 2	17 (2.7)	75 (6.2)	92 (5.0)
AN grade 3	8 (1.3)	64 (5.3)	72 (3.9)
AN grade 4	8 (1.3)	33 (2.7)	41 (2.2)
Total	113 (18.13)	366 (30.3)	479 (26.0)

Table 2: Factors associated with AN in the study population.

Characteristic	Category	AN, N (%)		OR (95% CI)
		Present	Absent	
Gender	Female	366 (30.3)	843 (79.7)	1.96 (1.54-2.49)**
	Male	113 (18.14)	510 (81.8)	
BMI (kg/m^2)	Overweight or obese	252 (66.32)	128 (33.6)	10.67 (8.26-13.78)**
	Not overweight	226 (15.58)	1225 (84.42)	
Blood pressure (mmHg)	Hypertension	187 (42.79)	250 (57.21)	2.83 (2.25-3.55)**
	Normal blood pressure	292 (20.93)	1103 (79.07)	
Perceived stress	High	41 (34.75)	77 (65.25)	1.55 (1.05-2.30)*
	Low-moderate	438 (25.55)	1276 (74.45)	
Moderate intensity physical activity	3 or more days a week	59 (13.47)	379 (86.53)	0.70 (0.52-0.96)*
	Less than 3 days a week	214 (18.1)	968 (81.9)	
Hypertension in the immediate family	Yes	337 (28.04)	865 (71.96)	1.34 (1.06-1.68)*
	No	138 (22.56)	473 (77.44)	
Hypercholesterolemia in immediate family	Yes	238 (28.47)	598 (71.53)	1.26 (1.02(1.55)*
	No	234 (24.07)	738 (75.93)	
Obesity in the immediate family	Yes	61 (32.97)	124 (67.03)	1.45 (1.05-2.01)*
	No	413 (25.29)	1220 (74.71)	
Diabetes in the immediate family	Yes	32 (3.67)	841 (96.3)	2.11 (1.00-4.47)*
	No	9 (1.77)	500 (98.3)	

*p<0.05, **p<0.001

Table 3: Comparative analysis of anthropometric measurements, blood pressure, and stress perception in students with varying grades of AN.

Characteristic, mean (SD)	AN-grading					
	Nil	Grade 1	Grade 2	Grade 3	Grade 4	P
Weight (kg)	49.12 (9.06)	56.51 (11.62)	58.96 (12.18)	66.44 (14.73)	70.31 (13.87)	<0.001
BMI (kg/m^2)	18.7 (2.73)	1.81 (3.58)	23.27 (3.94)	26.23 (4.74)	27.20 (4)	<0.001
Systolic BP (mmHg)	11.99 (14.21)	116.13 (14.7)	116.5 (13.3)	124.38 (14.43)	125.61 (15.79)	<0.001
Diastolic BP (mm Hg)	73.49 (8.09)	75.97 (9.18)	77.18 (8.71)	81.94 (10.61)	83.95 (9.40)	<0.001
Perceived stress score	17.42 (5.76)	18.34 (5.87)	18.02 (5.72)	18.75 (4.98)	17.46 (5.18)	≤0.05

Table 4: Grade wise distribution of features of hyperandrogenism and anovulation among females with AN.

AN (grading)	N (%)	X^2	P value
Nil. (n=833)	10 (1.20)	400	<0.001
Grade 1, (n=194)	23 (11.90)		
Grade 2, (n=75)	11 (14.70)		
Grade 3, (n=64)	31 (48.40)		
Grade 4, (n=33)	17 (51.50)		

DISCUSSION

The present school-based study aimed to determine the prevalence and determinants of AN among adolescents. The study looked into behavioural, biological as well as psycho-social risk factors for NCDs and explored their association with AN.

The prevalence of AN in our study was found to be 26% of which majority belonged to grade 1 category. In a similar study conducted in North Kerala, the prevalence of this condition was found to be 39.5%.[18] The levels of acanthosis in this pre-adult population raises concern in the backdrop of the rising NCD burden in the state. However, in a study done in Central Kerala the overall prevalence of acanthosis was found to be 14.5%.[19] The differences could be due to the grading or body site used in the study.

In this study males had significantly lower odds of presenting with AN compared to females. Individuals who were overweight or obese exhibited a markedly higher risk of this condition. Those with hypertension had increased odds of developing AN. Higher perceived stress was associated with a greater likelihood of the condition. Engaging in moderate-intensity physical activity for less than three days a week was associated with lower odds of acanthosis. Family history of hypertension, hypercholesterolemia, obesity, and diabetes showed significant associations with AN, indicating potential genetic or environmental factors influencing the condition. Correspondingly, in a study done in North Kerala significant association was found between AN and insulin resistance and when the condition was combined with high BMI, the incidence of insulin resistance was found to be 80%.[18]

Various studies have established associations between AN with BMI, blood pressure and diabetes.[1,8,12,17,20] The present study further explored these relationships across adolescents with varying grades of acanthosis. Acanthosis grades showed strongest positive correlation with BMI, and moderate-weak correlation with body weight and blood pressure. The mean BMI for acanthosis grades three and four was found to be more than 25 kg/m^2, the cut-off for adult overweight.[21] The average blood pressure of the study participants was found to progress into the elevated blood pressure category, from grade 3 level of acanthosis. Simple screening and the grading of the acanthosis could thus indicate overweight/ hypertension in such older adolescents, and such students may be referred for further evaluation.

Studies on psychosocial comorbidities in people with acanthosis has been rare. Girls, in the present study exhibited stronger and more significant correlation between perceived stress levels and acanthosis grades. Increased prevalence of depression symptoms has been reported in obese patients with acanthosis [22-23] This could be attributed to the cosmetic impact and its effect on self-esteem, along with presence of issues like overweight and obesity, or associated hormone mediated inflammatory processes in the skin.[22-23] Timely intervention can significantly reverse obesity-related AN. Therefore, screening adolescents for acanthosis and implementing appropriate interventions and preventive measures could be beneficial. Features of hyperandrogenism in girls could point towards poly cystic ovarian syndrome (PCOS), which has been strongly associated with acanthosis.[24] Progressively higher proportion of girls with advanced acanthosis in the present study were found to have hirsutism, amenorrhea/oligomenorrhea, and acne suggestive of PCOS, which is a risk factor for other NCDs like type 2 diabetes mellitus, as well as a particularly important cause of preventable infertility. This points to the need for statewide screening of adolescent girls as a preventive approach.

Previous studies have found associations between AN, and non-communicable disease risk factors.[17-20] The present study has explored these associations and has attempted to quantitatively categorize the physiological risk factors for NCDs with progressing severity of AN among middle-late adolescents which indicate a practical utility in NCD screening programmes for adolescents. We also explored the relation between perceived stress levels and AN. This study however did not include invasive measures, and hence other factors like blood sugar and lipid levels could not be assessed, which might have given insights into metabolic syndrome and advanced grades of acanthosis.

CONCLUSION

Progressively higher levels of BMI, blood pressure, stress levels and features suggestive of PCOS with advancing grades of AN among middle adolescents have been observed in this study. Assessing AN in adolescents is important because it can serve as an early indicator of insulin resistance and metabolic syndrome, the conditions

that increase the risk of type 2 diabetes and other health issues. Early detection allows for timely interventions, including lifestyle modifications and monitoring, which can significantly improve long-term health outcomes. Additionally, recognizing acanthosis can help healthcare providers educate adolescents and their families about the importance of maintaining a healthy weight and making informed dietary choices. This would facilitate early detection and management of risk factors in children and adolescents at higher risk for NCDs.

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