ORIGINAL RESEARCH

Hypertension and its association with anthropometric indices among Nigerian adolescents

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Abstract

Background

Hypertension has become increasingly common among adolescents such that it poses a significant health concern. To develop effective prevention and management strategies, it is essential to understand the association between hypertension and various factors. This study therefore sought to investigate the prevalence of hypertension and its association with anthropometric indices among Nigerian adolescents.

Methods

A cross-sectional study was conducted among Nigerian adolescents aged 10-19 years in 2022, using a multi stage sampling method. Anthropometric measurements were obtained using mobile stadiometer, bathroom weighing scale, measuring tape, and personal body fat caliper while blood pressure was determined using digital blood pressure monitor. Statistical analysis was performed using IBM Statistical Product for Service Solution, version 23 and significance was accepted at $p < 0.05$.

Results

A total of 455 respondents (58.5% females & 41.5% males) with mean age of 14.7±2.3 years participated in the study. Their mean weight (kg), height (cm) and BMI (kg/m2) were 55.1 ± 11.5, 162.7±71.3, and 21.5±3.1, respectively. More females than males had hypertension (19.9% vs. 12.7%), whereas more males than females had pre-hypertension (19.0% vs. 17.7%). Obese adolescents had significantly ($p = 0.000$) higher prevalence of hypertension (18.2%) compared to pre-hypertension (1.2%). Adolescents who had abnormal triceps and sub-scapular skinfold thicknesses also had significantly ($p = 0.000$) higher prevalence of hypertension (11.7% vs. 7.8%) compared to pre-hypertension (4.8% vs. 3.6%) and normal blood pressure (2.4% vs. 0.3%). No significant ($p > 0.05$) association was observed between the waist-hip ratio and blood pressure.

Conclusion

Blood pressure showed positive correlation with anthropometric indices except for waist- hip ratio, which had no significant association with blood pressure. Regular screening for hypertension among at-risk adolescents and early initiation of treatment for affected individuals should be conducted to prevent potential complications in later life.

Keywords: Adolescents, hypertension, prevalence, obesity, overweight, body mass index, skinfold thickness, Nigeria.

Introduction

Non-communicable diseases (NCDs) are seen as "lifestyle diseases" leading to the assumption that adolescents are generally immune to such diseases. Consequently, there have been limited efforts to evaluate their overall well-being in relation to adopting healthier lifestyles and preventing NCDs. Hypertension, classified as a NCD, is a prevalent condition characterized by persistently elevated blood pressure. It is primarily influenced by lifestyle factors, genetic predisposition and other underlying medical conditions. It significantly increases the risks of heart disease, brain disease, kidney disease and other diseases. The foundations of hypertension are laid during childhood and adolescence thereby contributing to increased risk of cardiovascular complications in adulthood. The earlier the age of onset of hypertension, the greater the morbidity and mortality rate if the condition remains untreated[1]. Most studies conducted on high blood pressure globally have focused on middle-aged and elderly individuals, giving rise to the perception that hypertension primarily affects these age groups.

Previous studies have shown that the development of hypertension has an association with overweight or obesity, in which those who were overweight, with an unhealthy waist circumference and waist-to-hip ratio and unhealthy body fat were more prone to hypertension[2]. This is further supported by another study[3], that an increase in body mass index is associated with a greater risk of developing hypertension. Studies investigating the correlation between hypertension and body weight have predominantly targeted adult populations. Despite the growing prevalence and potential risks of hypertension in adolescents, its diagnosis is often overlooked. This oversight is due to the perception that adolescents are generally healthy.

Understanding the association between hypertension and anthropometric indices can provide an easy and cost effective way of reducing the disease burden. This study aimed to determine the prevalence of hypertension and its associations with anthropometric indices among Nigerian adolescents. It is hoped that this study will provide policymakers with valuable evidence that can inform efforts towards improving

https://dx.doi.org/10.4314/mmj.v37i1.6

the health status of adolescents in Nigeria and other regions.

Methods

Study area

The study was carried out in Nsukka town between August, 2022 and February, 2023. Nsukka town is sometimes referred to as University town because it harbors the University of Nigeria Nsukka. Nsukka town is made up of three prominent communities namely; the Nkpunanor community, the Ihe n'Owerre community and the Nru Nsukka community. With a population projection of 444,100 in 2022,[4] the town shares a common border with Edem, Opi, Ede-Oballa, Obimo, Eha-Alumona, Alo-Uno and Obukpa. The town is home to members of the Igbo ethnic group who are mostly farmers, traders, civil servants and artisans. The common foods consumed by the people are cassava, maize, yam, cocoyam, bambara groundnut (okpa), pigeon pea, and rice.

Study design

A descriptive cross-sectional survey design was adopted for this study.

Study population and sample size

The study population consisted of adolescents aged 10 – 19 years who attends secondary schools in the three communities (Nkpunano, Nru and Ihe/Owerre) in Nsukka town.

The sample size for the study was calculated using Cochran's formula:

$$n = \frac{z^2 p(1-p)}{d^2}$$

Where n = sample size required; z = critical value which is 1.96; p = estimated prevalence of hypertension among adolescents which is 12.7%[5]; and d = absolute sampling error that was tolerated in this study and was fixed at 5%. The sample size was calculated based on design effect of 2.0 with an increase of 10% for contingencies. The calculated minimum sample size of 341 was obtained. However, a total of 455 adolescents who gave consent for the study were recruited to increase the power of the study.

Sampling techniques

A multi-stage sampling technique was used for the study. In the first stage, 30% (9) of secondary schools in the three (Nkpunanor, Nru and Ihe/Owerre) communities were randomly selected from the total of thirty-three (33) secondary schools in Nsukka town[6]. That is three schools were randomly selected from each of the communities. In the second stage, proportionate sampling was used to determine the number of students to be selected from each school, according to the number of students in the school. In the third stage, random sampling by balloting without replacement was used to select adolescents who gave consent from each of the nine schools until the required number was achieved.

Methods of Data Collection

Data were collected using semi-structured validated questionnaire, anthropometric measurements, and digital blood pressure monitor. The questionnaire with a reliability index of 0.79 was used to elicit information on socio-economic background, dietary habits, and lifestyles of the respondents. It was self-administered and the filling was supervised by the researchers with thorough explanation of items of the questionnaire in the language the respondents understand.

Anthropometric measurements

The respondents' weight was measured using Hanson's bathroom weighing scale, expressed in kilograms with a capacity of 120kg. The measurement was carried out with the respondents wearing minimum clothing. The respondents were made to stand at the centre of the platform of the weighing scale without touching or leaning on anything. With head held erect and arms hanging by the sides, reading was taken to the nearest 0.1kg. A height meter expressed in centimetres was used for height measurement. Respondents' height was taken without their shoes; both feet parallel to each other and with the heels, buttocks, shoulders and back of head touching the height meter. The head was comfortably erect while the height measurement was read to the nearest 0.1cm.

The Body mass index (BMI) was calculated by dividing each respondent's weight in kilograms by the square of their height in meters (kg/m2). In adolescents, body mass index is age and gender specific and is often referred to as BMI-for-age. The calculated BMI and corresponding age was compared with z-scores using the WHO reference data for children and adolescents[7]. Obesity, overweight and underweight were classified as >+2SD, >+1SD and <-2SD, respectively[7].

Waist-to-hip ratio (WHR) measurement was conducted following the WHO STEP protocol[8]. Waist circumference was measured to the nearest 0.5cm with a non-elastic measuring tape at midway between the lower rib margin and the iliac crest at the end of expiration with the subject standing upright, feet together, arms at the sides and wearing light clothing. Hip circumference was measured at the maximum circumference over the buttocks. Measurement was taken to the nearest 0.5 cm using a non-elastic measuring tape.

Waist-to-hip ratio (WHR) was calculated using the formula;

$$\text{WHR} = \frac{\text{Waist circumference(cm)}}{\text{Hip circumference(cm)}}$$

WHR above 0.90 for males and above 0.85 for females were considered as abdominal obesity[9].

Skinfold thickness (triceps & subscapular) was measured in millimeter using personal body fat caliper with a precision of 0.1 mm. For the triceps skinfold measurement, the mid-acromiale radiale line on the posterior surface of the right arm was identified using a tape rule and then marked with a marker. The caliper was applied at this point, and the measurement was taken. The subscapular skinfold measurement was taken at the inferior angle of the right scapula after identifying and marking the point. The two measurements were taken at the sites and the average recorded. The measurement was repeated if paired measurements varied by more than 1 mm. The triceps and subscapular skinfold thickness percentile reference values 10 was used to classify subjects as overweight or obese. Subject was categorized as underweight for below the 50^{th} percentile, normal for 50^{th} to 85^{th} percentile, overweight for $>85^{th}$ to 90^{th} percentile, or obesity for above 90^{th} percentile for the

https://dx.doi.org/10.4314/mmj.v37i1.6

Table 1: Socio-economic information of the respondents

Variables	Frequency (n=455)	Percent (%)
Gender		
Males	189	58.5
Females	266	41.5
Age group		
10-13 years	150	33.0
14-16 years	183	40.2
17-19 years	122	26.8
	Mean age of respondents = 14.7 ± 2.3 years	
Class		
Junior	234	51.4
Senior	221	48.6
Ethnicity		
Igbo	447	98.2
Yoruba	7	1.5
Hausa	1	0.3
Religion		
Christianity	447	98.2
Islam	4	0.9
Traditional	4	0.9
Father's educational level		
No formal education	24	5.3
Primary education	48	10.5
Secondary education	183	40.2
Tertiary education	200	44.0
Mothers' educational level		
No formal education	16	3.5
Primary education	30	6.6
Secondary education	213	46.8
Tertiary education	196	43.1

Table 2: Chi-square analysis of behavioural lifestyle of the respondents according to gender

Variables	Male (n=189) F(%)	Female (n=266) F(%)	Total (n=455) F(%)
Alcohol consumption status			
Current drinker	149 (78.8)	211 (79.3)	360 (79.1)
Abstainer	40 (21.2)	55 (20.7)	95 (20.9)
	χ^2=0.016	df=1	p=0.495
Smoking habit			
Smoker	9 (4.8)	6 (2.3)	15 (3.3)
Non-smoker	180 (95.2)	260 (97.7)	440 (96.7)

Table 2 Cont.....

	χ^2=2.177	df=1	p=0.114
Inhale smoke from cigarette smokers (n=440)			
Yes	107 (59.4)	114 (43.8)	221(50.2)
No	73 (40.6)	146 (56.2)	219 (49.8)
	χ^2=2.365	df=1	p=0.065
Reason for smoking (n-15)			
Pleasure	2 (22.2)	-	2 (13.3)
Habit	1 (11.1)	-	1 (6.7)
Highness	1 (11.1)	-	1 (6.7)
No reason	5 (55.6)	6 (100.0)	11 (73.3)
	χ^2=3.636	df=3	p=0.304
Engagement in physical activity			
Yes	118 (62.4)	163 (61.3)	281 (61.8)
No	71 (37.6)	103 (38.7)	174 (38.2)
	χ^2=0.062	df=1	p=0.440

Table 3: Chi-square analysis of anthropometric indices and blood pressure classification by gender

Variables	Male (n=189) F(%)	Female (n=266) F(%)	Total (n=455) F(%)
Body mass index (BMI-for-age)			
Underweight	4(2.1)	2(0.8)	6(1.3)
Normal	140(74.1)	181(68.0)	321(70.6)
Overweight	42(22.2)	71(26.7)	113(24.8)
Obesity	3(1.6)	12(4.5)	15(3.3)
	χ^2=5.884	df=3	p=0.117
Waist-hip ratio			
Normal WHR	175(92.6)	233(87.6)	408(89.7)
Abnormal WHR	14(7.4)	33(12.4)	47(10.3)
	χ^2=2.981	df=1	p=0.084
Triceps skinfold thickness			
Underweight	45(23.8)	142(53.4)	187(41.1)
Normal	125(66.1)	106(39.8)	231(50.8)
Overweight	6(3.2)	11(4.2)	17(3.7)
Obese	13(6.9)	7(2.6)	20(4.4)
	χ^2=43.360	df=3	p=0.000*
Sub-scapular skinfold thickness			
Underweight	44(23.3)	109(41.0)	153(33.6)
Normal	137(72.5)	143(53.7)	280(61.6)
Overweight	4(2.1)	8(3.0)	12(2.6)
Obese	4(2.1)	6(2.3)	10(2.2)
	χ^2=16.930	df=3	p=0.001*
Blood pressure classification			
Normal	129(68.3)	166(62.4)	295(64.9)
Prehypertension	36(19.0)	47(17.7)	83(18.2)
Hypertension	24(12.7)	53(19.9)	77(16.9)
	χ^2 = 4.107	df = 2	p = 0.128

F = frequency, % = percentage, * = statistically significant ($p < 0.05$).
Mean weight: 55.1 ± 11.5 kg; Mean height: 162.7±71.3cm; Mean BMI: 21.5±3.1kg/m^2

Table 4: Chi-square analysis of respondents' anthropometric indices and blood pressure classification

Variables	Normal BP F(%)	Prehypertension	Hypertension F(%)	Total F(%)
Body mass index (BMI-for-age)				
Underweight	6(2.0)	0(0.0)	0(0.0)	6(1.3)
Normal	256(86.8)	35(42.2)	30(38.9)	321(70.6)
Overweight	33(11.2)	47(56.6)	33(42.9)	113(24.8)
Obesity	0(0.0)	1(1.2)	14(18.2)	15(3.3)
Total	295(100.0)	83(100.0)	77(100.0)	455(100.0)
	χ^2=163.189	df=6	p=0.000*	
Waist-hip ratio				
Normal WHR	267(90.5)	75(90.4)	66(85.7)	408(89.7)
Abnormal WHR	28(9.5)	8(9.6)	11(14.3)	47(10.3)
Total	295(100.0)	83(100.0)	77(100.0)	455(100.0)
	χ^2=1.568	df=2	p=0.457	
Triceps skinfold thickness				
Underweight	142 (48.1)	16(19.3)	29(37.7)	187(41.1)
Normal	144(48.8)	54(65.1)	33(42.8)	231(50.8)
Overweight	2(0.7)	9(10.8)	6(7.8)	17(3.7)
Obese	7(2.4)	4(4.8)	9(11.7)	20(4.4)
Total	295(100.0)	83(100.0)	77(100.0)	455(100.0)
	χ^2=51.995	df=6	p=0.000*	
Sub-scapular skinfold thickness				
Underweight	126(42.8)	7(8.4)	20(26.0)	153(33.6)
Normal	165(55.9)	68(82.0)	47(61.0)	280(61.6)
Overweight	3(1.0)	5(6.0)	4(5.2)	12(2.6)
Obese	1(0.3)	3(3.6)	6(7.8)	10(2.2)
Total	295(100.0)	83(100.0)	77(100.0)	455(100.0)
	χ^2=56.182	df=6	p=0.000*	

F=frequency, %=percentage, * = statistically significant ($p < 0.05$).

Table 5: Bivariate correlation of blood pressure with anthropometric indices of the respondents

Variables		SBP	DBP
Body mass index-for-age	r-value	0.633**	0.314**
	P-value	0.000	0.000
	N	455	455
Waist-hip ratio	r-value	0.055	0.026
	P-value	0.245	0.582
	N	455	455
Triceps skinfold thickness	r-value	0.311**	0.139**
	P-value	0.000	0.003
	N	455	455
Subscapular skinfold thickness	r-value	0.329**	0.182**
	P-value	0.000	0.000
	N	455	455

SBP= Systolic blood pressure, DBP= diastolic blood pressure,
**= Correlation is significant at $p < 0.01$

age and gender.

Blood pressure measurement

Blood pressure was measured using digital blood pressure monitor (MOTECH® model: BPU500, Germany). Measurement was performed two times (1-3 min interval) and the average recorded. Respondents with systolic blood pressure of < 120 mmHg and diastolic blood pressure of < 80 mmHg were classified as having normal blood pressure. Elevated blood pressure (prehypertension) was defined as systolic blood pressure of 120-129 mmHg and diastolic blood pressure of < 80 mmHg and hypertension was defined as systolic blood pressure of ≥ 130 mmHg and/or diastolic blood pressure of ≥ 80 mmHg11.

Ethical consideration

Ethical approval (NHREC/05/01/2008B) was obtained from the Ethics and Research committee of the University of Nigeria Teaching Hospital Ituku/Ozalla, Enugu State, Nigeria. The schools' management also granted approval for the study. Written informed consent was also obtained from the parents/caregivers of the students after a thorough explanation of the study objectives and procedures, with an assurance of confidentiality.

Statistical analysis

Data obtained were statistically analyzed using the IBM Statistical Product for Service Solution (SPSS), version 23. Descriptive data was presented as frequencies, percentages, means and standard deviation. Chi-square analysis was employed to analyze the categorical indicators in relation to gender. The normality of continuous variables (blood pressure and anthropometric indices) was assessed using the Shapiro-Wilk-test. Since the data were normally distributed, Pearson's correlation analysis was used to assess the strength and direction of the relationship between blood pressure and anthropometric indices (BMI, WHR and skinfold measurement). Statistical significance was accepted at p value of < 0.05.

Results

More than half of the adolescents were female (58.5%) and in the junior class (51.4%). Respondents in their early adolescence stage were 33.0% while those in their mid-adolescence stage were 40.2%. The majority of them identified as Christians (98.2%) and belong to the Igbo ethnic group (98.2%). Only few fathers (5.3%) and mothers (3.5%) had no formal education compared to those who had attained tertiary education (44.0% and 43.1%, respectively) [Table 1].

Majority of both male (78.8%) and female (79.3%) respondents were current drinkers while few of them reported being smokers (4.8% and 2.3%, respectively). The chi-square analysis showed no significant association between gender and the respondents' alcohol consumption (p = 0.495) and smoking habit (p=0.114). About 57.1% of the respondents reported inhaling smoke from cigarette smokers. A higher percentage of male respondents (61.4%) inhaled cigarette smoke compared to the female respondents (54.1%). However, the association between gender and inhalation of cigarette smoke was statistically not significant (p = 0.075). The respondents reported various reasons for smoking; 22% of male smokers mentioned pleasure while 11.1% reported habit and highness. More male (62.4%) than female (61.3%) respondents engaged in physical activity, however, no significant difference (p = 0.440) was observed between gender and physical activity [Table 2].

The prevalence of overweight and obesity among the respondents were 24.8% and 3.3%, respectively. No significant association (p = 0.117) between gender and BMI-for-age classification was observed. The result showed that 12.4% and 7.4% of the female and male respondents had abnormal WHR, respectively. The chi-square analysis suggests no significant association in WHR distribution between males and females (p = 0.084). The triceps skinfold thickness measurement showed that among the male respondents, 3.2% and 6.9% were classified as overweight and obese, respectively. In contrast, 4.2% and 2.6% of the female respondents were overweight and obese, respectively. The sub-scapular skinfold thickness measurement also revealed that more females than males were overweight and obese. These relationships were statistically significant (p < 0.05); revealing gender-specific variations in skinfold measurements. The prevalence of prehypertension and hypertension among the respondents were 18.2% and 16.9%, respectively. The chi-square analysis revealed no significant association in blood pressure between the male and female respondents (p = 0.128) [Table 3].

The relationship between respondents' anthropometric indices and blood pressure is shown in Table 4. There was significant association in the distribution of BMI-for-age (p = 0.000), triceps skinfold thickness (p = 0.000), and sub-scapular skinfold thickness (p = 0.000) with blood pressure classification. However, no significant association between WHR and blood pressure was observed [Table 4].

There was a positive correlation of BMI-for-age with SBP (r=0.633, p=0.000), and DBP (r=0.314, p=0.000), indicating that as BMI-for-age increases, blood pressure tends to increase as well. Triceps skinfold (r=0.228, p=0.000) and subscapular skinfold (r=0.275, p=0.000) thickness were also positively correlated with blood pressure, revealing that higher thickness is linked to elevated blood pressure. No significant correlation (r=0.052, p=0.269) was observed between WHR and blood pressure measurement of the respondents [Table 5].

Discussion

A significant portion of the respondents were within 14-16 years, comprising 40.2% of the total population. Most of the respondents had consumed alcohol in the 12 months preceding the study and it was notable that more males than females were current smokers. Despite the official drinking age in Nigeria being 18 years, it is worrisome that the adolescents, many of whom are just 14 years old, already have access to alcoholic drinks and tobacco. This issue had been previously highlighted in studies conducted in the same area, which raised concern about the easy accessibility of alcohol even in the rural communities[12]. Drinking excessive alcohol is considered one of the most common causes of raised blood pressure. Consequent on the alcohol consumers, the effect of alcohol consumption on weight gain has been reported[13]. It is even more worrisome to discover that majority of the adolescents who smoke do so without any clear reason. This observation directly underscores the perilous influence of peer pressure, a phenomenon well-documented in studies focusing on adolescence[14].

This study also showed that less than half of the respondents did not engage in physical activity. This is in contrast with the study carried out among Nigerian secondary school adolescents which reported that majority engaged in physical activities[15]. Physical inactivity can increase the risk of being overweight which is a risk factor of many cardiovascular diseases. Observational studies have consistently demonstrated a protective effect of physical activity in preventing hypertension and controlling blood pressure[16].

Obesity and overweight prevalence were higher in female than in male according to BMI-for-age, waist hip ratio and subscapular skinfold thickness but there was a little variation in tricep skinfolds where there were more overweight females than males but more obese males than females. In contrast, another study reported higher prevalence of overweight/obesity in boys than in girls according to BMI, waist circumference, triceps skinfold thickness and subscapular skinfold thickness[17]. The high prevalence of overweight and obesity in the present study could be attributed to the high rate of physical inactivity observed among the respondents.

The prevalence of hypertension and pre-hypertension in the present study was 16.9% and 18.2%, respectively, which was higher than what was reported in earlier studies among adolescents in Enugu State[18,15]. The variation in the prevalence of hypertension among adolescents in these studies could be attributed to changes in lifestyle choices and environmental factors, such as dietary habits, physical activity, and exposure to stressors, which contribute to hypertension over time.

Overweight/obesity appeared to be the risk factor driving the prevalence of hypertension and pre-hypertension upwards within this population. However, hypertension and pre-hypertension are emerging non-communicable public health challenge among adolescents. More females than males were hypertensive (19.9% vs. 12.7%) while more males than females were pre-hypertensive (19.0% vs. 17.7%). This is in contrast to a previous study which reported a higher rate of prehypertension among females (20.1%) than males (14.3%)18. This pattern could be as a result of higher rates of obesity witnessed among females than their male counterpart. Significant differences ($p < 0.05$) were observed in the respondents' blood pressure based on their age groups; 22.4% of respondents aged 14-16 years had hypertension, whereas those aged 10-13 years and 17-19 years had prevalence rates of 18.7% and 6.6%, respectively. Previous studies have reported similar findings, indicating a more rapid increase in blood pressure during mid-adolescence[18,19]. The observed surge in high blood pressure during mid-adolescence can be linked to the rapid hormonal changes and physiological alterations associated with pubertal maturation. This phase marks a period of heightened hormonal fluctuations, exerting a more pronounced influence on blood pressure regulation compared to earlier or later stages of adolescence. These hormonal shifts impact vascular function and play a key role in the observed elevation of blood pressure levels. In addition, the accelerated physical growth, characterized by rapid changes in body size and composition during mid-adolescence, contributes significantly to the blood pressure elevation. The substantial increase in muscle mass and potential alterations in fat distribution impose more demands on the cardiovascular system, potentially impacting blood pressure regulation.

The findings demonstrated a moderately positive correlation between the respondents' BMI-for-age and blood pressure ($r = 0.519$, $p < 0.01$). This observation aligns with previous reports, which showed that BMI had a significant positive correlation with systolic and diastolic hypertension ($r = 0.46$, $p < 0.001$, and $r = 0.33$, $p < 0.001$, respectively)[15].

The correlation between BMI and blood pressure has been attributed to various interacting complex systems observed in obese children. These include over activity of the renin angiotensin and sympathetic nervous systems, insulin resistance, and abnormalities in vascular structure and function. No significant correlation ($r = 0.052$, $p = 0.269$) was observed between the waist-hip ratio of the respondents and blood pressure and this contrasts with a study carried out in 2016 where a significant correlation was observed between waist-hip ratio and diastolic blood pressure ($r = 0.08$, $p = 0.002$)[15].

Conclusion

The study revealed that a greater proportion of the respondents were in their mid-adolescence stage with high prevalence of hypertension, particularly among females compared to males. The prevalence of obesity and overweight was also higher among females. The study showed a positive correlation between blood pressure and anthropometric indices, including BMI, triceps skinfold thickness, and sub-scapular skinfold thickness, but not with the waist-hip ratio. There is urgent need for targeted interventions aimed at improving dietary diversity and encouraging healthier lifestyle behaviours among adolescents in the study area.

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