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RESEARCH ARTICLE

Prevalence of risk factors for obesity, diabetes mellitus and hypertension in high school children and screening of high-risk children for glycosuria: A cross-sectional study in Dharwad District, India [version 1; peer review: 2 approved with reservations]

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Abstract

Background: India is currently undergoing a demographic and epidemiological transition leading to the occurrence of hypertension and type 2 diabetes, which were once considered as disease of the elderly among the adolescents.

Methods: A cross-sectional study was conducted in Dharwad district, Karnataka, including 1600 students between 11–17 years age group, across both private and government schools located in both rural and urban areas; information on socio-demographic variables, physical activity, dietary habits, substance abuse, and family history of hypertension, diabetes mellitus and level of stress among participants was collected. Anthropometric measurements were taken, blood pressure was measured, general physical examination was done to look for signs of insulin resistance. Urine was examined for the presence of glucose using urine glucose strips in overweight children with ≥ 2 risk factors (American Diabetes Association criteria for children).

Results: Prevalence of overweight/obesity was 4.6% and hypertension was 14.8%. Multivariate logistic regression done for variables found significant in univariate analysis on comparison of risk factors between overweight and normal children showed higher odds for family h/o diabetes (OR = 1.14, CI: 0.58–2.23), private school (OR = 1.5, CI: 0.75–2.96), high socio-economic status (OR = 2.0, CI: 0.95–4.30), hypertension (OR = 2.0, CI: 0.95–4.30) and acanthosis nigricans (OR = 219, CI: 71.49–672.42) among overweight and for variables found

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significant in univariate analysis on comparison of risk factors between hypertensives and normotensives showed higher odds for inadequate sleep (OR = 1.4, CI: 1.00–1.87), private school (OR = 1.32, CI: 0.96–1.81), high SES (OR = 1.43, CI: 0.95–2.14), psychological stress (OR = 1.97, CI: 1.42–2.73) and obesity (OR = 6.98, CI: 3.75–12.98).

Conclusions: Health education on healthy diet consumption and physical activity, BMI calculation and tracking of blood pressure should be integrated into school health programs.

Keywords

risk factors, adolescent, hypertension, diabetes mellitus, obesity, screening, glycosuria, schools

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Introduction

Diabetes mellitus (DM) prevalence is on a rise worldwide, predominantly in the middle- and low-income countries (Dunachie & Chamnan, 2019). India, in particular, is viewed as the capital of DM by the world. The prevalence of type 2 DM is increasing alarmingly amongst adults from 26 million in 1990 to 65 million in 2016 (Tandon *et al.*, 2018). This trend is going to continue considering that the country is currently undergoing a demographic and epidemiological transition, but surprisingly type 2 DM is appearing even among adolescents and children (Alberti *et al.*, 2004). A cause of major concern is the increasing incidence of childhood obesity, which significantly inflates the chances for development of type 2 DM (Sonya *et al.*, 2010). There is evidence of increasing prevalence of type 2 DM in the U. S, Libya, Australia, Canada, New-Zealand, Singapore, Japan, Taiwan, China and Bangladesh due to increasing obesity and decreased physical activity (Pinhas-Hamiel & Zeitler, 2005). There are reports of type 2 DM in Pima Indians due to westernized lifestyle (Pinhas-Hamiel & Zeitler, 2005). In India, very few studies, conducted mostly in urban areas, have shown occurrence of type 2 DM in children; Bhatia *et al.*, reported 12% (< 18 years) and Ranjani *et al.*, reported 3.7% of glucose intolerance in children (6–19 years) (Bhatia V; IAP National Task Force for Childhood Prevention of Adult Diseases, 2004; Ranjani *et al.*, 2013)

The American Diabetes Association recommendations for screening of type 2 DM in children is as follows: “Overweight (BMI 85th percentile for age and sex, weight for height 85th percentile, or weight 120% of ideal for height) plus any two of the following risk factors: family history of type 2 diabetes in first- or second-degree relative, race/ethnicity (American Indian, African-American, Hispanic, Asian/Pacific Islander), signs of insulin resistance or conditions associated with insulin resistance (acanthosis nigricans, hypertension, dyslipidaemia, PCOS). The test can be done at 10 years of age or at onset of puberty if puberty occurs at a younger age.” (Alberti *et al.*, 2004; Pinhas-Hamiel & Zeitler, 2005; Prasad, 2011).

The adolescents in the current generation have more access to the digital world which is further adding to a sedentary lifestyle and consumption of an unhealthy diet. Hypertension is a disorder which takes its origin in childhood; prevalence of hypertension in the young is rising, owing to the escalating rate of childhood obesity (Falkner, 2010).

Schools and other educational establishments render significant opportunities to prevent the behaviours and practices that predispose children to Non-Communicable Diseases (Alberti *et al.*, 2004; Prasad, 2011). Hence, the present study was undertaken to assess the prevalence of the risk factors for obesity, hypertension and type 2 DM among high-school children of India, and to screen high-risk children for overt DM.

Methods

Study setting

This study was undertaken in Dharwad district located in the western zone of the northern part of Karnataka state in India. It consisted of seven talukas (administrative units) when the study commenced.

Study design

A cross-sectional study was conducted from August 2015 to July 2017 among high-school children of 8th, 9th and 10th grade (11 to 17 years) in Dharwad district of Karnataka State in India. The district was divided into seven clusters (talukas) for sampling. Thirty-five schools (government, semi-government, private) distributed over seven clusters were selected by the probability proportionate to size sampling method i.e., the probability of selecting a unit was proportional to its size. The proportion of schools and the population proportion (students) selected in each taluka (cluster) was proportional to the total number of schools and the cumulative population in each taluka (cluster).

Sample size

Considering a prevalence rate (p) of 3.67% (Ranjani *et al.*, 2013) absolute error (L) of 1% and a dropout rate of 10%, the required sample size (n) was calculated to be 1505, however, 1600 students were recruited.

Sampling

In each of the 35 schools selected, one classroom belonging to either 8th, 9th or 10th grade was selected randomly. If the school administration denied permission for a particular grade to participate due to academic activities, the same was excluded from sampling.

Exclusion criteria

Children/parents who did not give assent/consent, those with a known history of type 1 DM, those absent on the date of visit and incompletely answered questionnaires were excluded.

Study tools

A pre-tested semi-structured questionnaire was administered to all participants to obtain data on socio-demographic variables, physical activity, dietary habits, substance abuse and family history of DM, hypertension and cardiovascular disease. The questionnaire was administered in English language for English medium schools and Kannada language for Kannada medium schools. Stress level in students was assessed using the Kessler Psychological Distress Scale (K10) (Kessler *et al.*, 2003). For both Kannada and English languages, testing for Chronbach's alpha validated the scale. The questionnaire used in the study is provided as extended data, please see the Data availability section (Shubhashri *et al.*, 2022b). A pilot study to test the questionnaire was conducted in one private and one public school before starting the main study.

Dietary habits: Frequency of intake of fruit, vegetables, junk food, non-veg, aerated drinks and beverages (tea, coffee) per week was assessed. It was categorized as none, 1–2, 3–5 and ≥ 6 servings per week. Dietary habit was classified as unhealthy if either of the following two criteria were met:

1. <3 –5 servings of vegetables AND <1 –2 servings of fruits per week
2. ≥ 3 servings of junk food OR ≥ 3 servings of aerated drinks per week.

Substance abuse: History of alcohol and tobacco consumption was requested.

Sleep: Children with <8 hours a day of sleep were considered sleep deprived.

Physical activity: Children with <7 hours of outdoor play or physical exercise per week were considered physically inactive (<https://www.who.int/news-room/fact-sheets/detail/physical-activity>).

Physical examination: anthropometric measurements

Weight, height, hip circumference and waist circumference were measured. Blood pressure (BP) was determined with the Omron BP apparatus (Model HEM 7112); an average of three readings were documented. A general examination was carried out to look for signs of insulin resistance and hyperandrogenism like acanthosis nigricans, skin tags, hirsutism, double chin, etc. All the anthropometric, BP measurements and physical examination were done by the first author in all the schools.

Screening for glycosuria

Urine was examined for the presence of glucose using urine glucose strips (USR 1G Urine reagent strips) in *overweight* children with at least two of the following risk factors: Asian ethnicity, family history of type 2 DM, maternal history of diabetes, signs of insulin resistance (acanthosis nigricans, hypertension, dyslipidemia, polycystic ovary syndrome, or small for gestational-age birth weight) (Alberti *et al.*, 2004; Pinhas-Hamiel & Zeitler, 2005).

Ethics

The institutional ethics committee of Karnataka Institute of Medical Sciences, Hubli, granted ethical approval, approval number: 916/2014-2015. Administrative clearance was obtained from Deputy Director of Public Instructions (DDPI), Dharwad District and the principals of schools. Assent was taken from the students and written informed consent was taken from their parents for participation in the study. The questionnaire was sent with the students to their homes and only those who obtained their parent's signature the next day were included.

Data analysis

Height percentiles and Body Mass Index were obtained and classified using WHO Anthroplus software 1.0.4. Diagnosis of hypertension was made in line with 'The fourth report on the diagnosis, evaluation, and treatment of high blood pressure in children and adolescents (2005)' by National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents. Data was entered into Microsoft Excel 2011 (RRID:SCR_016137) and statistical analysis was performed using SPSS version 25.0 (IBM SPSS Statistics, RRID:SCR_019096). The study data is provided as underlying data, please see the Data availability section (Shubhashri *et al.*, 2022a).

Results

A total of 1600 students participated in our study with equal distribution of males (49.2%) and females (50.8%), ranging in age from 11 to 17 years with a mean age of 14.11 ± 0.96 years. The majority belonged to a nuclear family (64.4%), attended government schools (59.88%) and 13.5% belonged to a higher socio-economic class (according to Modified B.G. Prasad socio economic status scale using the consumer price index for the month of September 2016). A detailed

description of socio-demographic characteristics of the participants is given in [Table 1](#). The mean weight, height and BMI of the study participants was 40.1 ± 8.7 kg, 153.7 ± 8.5 cm and 16.8 ± 2.9 kg/m² respectively and the mean waist and hip circumference were 69.9 ± 7.1 cm and 78.4 ± 7.4 cm respectively

The family history of gestational diabetes in the mother, DM and hypertension were 2.4%, 20.5% and 26.5% respectively. Of the participants, 12.2% were born through caesarean section, 26.4% had a history of low-birth weight and 26.6% were of birth order >2 ([Figure 1](#)).

Table 1. Socio-demographic characteristics of the study participants.

Variable	Value	Female (%) (n=812)	Male (%) (n=788)	Total (%) (n=1600)
Age group	11–12 years	36 (4.43)	26 (3.3)	62 (3.88)
	13–14 years	501 (61.7)	494 (62.69)	995 (62.19)
	15–17 Years	275 (33.87)	268 (34.01)	543 (33.94)
Religion	Hindu	693 (85.34)	635 (80.58)	1328 (83)
	Christian	104 (12.81)	133 (16.88)	237 (14.81)
	Muslim	3 (0.37)	8 (1.02)	11 (0.69)
	Others	12 (1.48)	12 (1.52)	24 (1.5)
Family type	Nuclear	525 (64.66)	505 (64.09)	1030 (64.38)
	Joint	287 (35.34)	283 (35.91)	570 (35.63)
Class studying	8th grade	189 (23.28)	181 (22.97)	370 (23.13)
	9th grade	359 (44.21)	416 (52.79)	775 (48.44)
	10th grade	264 (32.51)	191 (24.24)	455 (28.44)
SES*	Class I	29 (3.57)	27 (3.43)	56 (3.5)
	Class 2	84 (10.34)	76 (9.64)	160 (10)
	Class 3	169 (20.81)	143 (18.15)	312 (19.5)
	Class 4	212 (26.11)	233 (29.57)	445 (27.81)
	Class 5	318 (39.16)	309 (39.21)	627 (39.19)
School type	Government	504 (62.07)	454 (57.61)	958 (59.88)
	Private	308 (37.93)	334 (42.39)	642 (40.13)

*SES – Socio-economic status.

Figure 1. Percent prevalence of non-modifiable risk factors. *Family history of diabetes mellitus

Figure 2. Percent prevalence of modifiable risk factors.

It was observed that 1.4% of the study population smoked, 1.5% consumed alcohol, 18.8% were physically inactive, 64% were sleep deprived and 19.4% were in psychological stress. The prevalence of obesity including being overweight was 4.6% and hypertension was 14.8% (Figure 2).

The binary logistic regression analysis (Table 2) done to compare the prevalence of risk factors amongst obese/overweight and normal/underweight participants showed birth order more than 2 ($p = 0.039$), family history of diabetes ($p = 0.044$), school type ($p < 0.005$), psychological stress ($p < 0.005$) and high socioeconomic status ($p < 0.005$), to be statistically significant among obese/overweight. Also, acanthosis nigricans ($p < 0.005$) and hypertension ($p < 0.005$) showed statistically significant prevalence in the obese/overweight category. Multivariate logistic regression (Table 3) was done for variables found significant on univariate analysis. This showed higher odds ratio for family history of diabetes (OR = 1.14, CI: 0.58–2.23), private school (OR = 1.5, CI: 0.75–2.96), high socio-economic status (OR = 2.0, CI: 0.95–4.30), hypertension (OR = 2.0, CI: 0.95–4.30) and acanthosis nigricans (OR = 219, CI: 71.49–672.42).

Similarly, binary logistic regression analysis (Table 4) done for comparison of risk factors among hypertensives and normotensives depicted a statistically significant relationship with high socioeconomic status ($p < 0.005$), private school ($p < 0.005$), inadequate sleep ($p = 0.012$), psychological stress ($p < 0.005$), obesity and acanthosis nigricans ($p < 0.005$). Multivariate logistic regression (Table 5) was done for variables found significant on univariate analysis which showed higher odds ratio for inadequate sleep (OR = 1.4, CI: 1.00–1.87), private school (OR = 1.32, CI: 0.96–1.81), high SES (OR = 1.43, CI: 0.95–2.14), psychological stress (OR = 1.97, CI: 1.42–2.73) and obesity (OR = 6.98, CI: 3.75–12.98).

The mean (SD) Z score for BMI for age was -1.18 (1.18) with -0.96 (1.1) and -1.41 (1.22) respectively for females and males. The mean (SD) Z score for height for age was -0.93(0.92) with -0.87(0.83) and -0.99(0.99) for females and males respectively. Tables 6 and 7 show mean (SD) Z score and distribution of study participants according to the WHO (Kilombero District, n.d.) classification for BMI for age and height for age.

Screening for glycosuria

Of the participants, 4.6% ($n=74$) had overweight plus two risk factors. For them, urine was examined for the presence of glucose using urine glucose strips, however, overt DM was not detected in any of the study participants.

Discussion

The study was conducted in 35 schools across seven talukas of Dharwad district; 1600 high school students were recruited. Anthropometric measurements were taken, blood pressure was measured, and a general physical examination was done to look for signs of insulin resistance. Those who had overweight plus two risk factors were screened for glucosuria.

In the present study, 16.5% of students were severely thin, 22.4% were thin, 56.5% were normal, 4% were overweight and 0.6% were obese. The mean $\pm$ standard deviation of underweight, normal, overweight, obese students was $14.42 \pm 1.20 \text{ kg/m}^2$, $17.89 \pm 1.76 \text{ kg/m}^2$, $24.20 \pm 1.44 \text{ kg/m}^2$, $28.60 \pm 1.82 \text{ kg/m}^2$ respectively. There was significant difference in the mean of these BMI categories ($p = 0.0001$). Among males, 3.5% were overweight and 0.6% obese. Among females, 4.4% were overweight and 0.6% obese. A study by Laxmaiah *et al.*, in Hyderabad reported overweight and obesity

Table 2. Binary logistic regression - risk factors associated with obesity/overweight in study population.

Variable	Value	Obese/overweight (n=74)	Normal/underweight (n=1526)	Total (n=1600)	Chi-squared test	OR (95% CI)
Gender	Female	41 (55.4)	771 (50.5)	812 (50.8)	$\chi^2=0.67$ $p=0.412$	1.22 (0.76–1.95)
	Male	33 (44.6)	755 (49.5)	788 (49.3)		
Alcohol consumption	Yes	1 (1.4)	23 (1.5)	24 (1.5)	$\chi^2=0.012$ $p=0.914$	0.9 (0.12–6.76)
	No	73 (98.6)	1503 (98.5)	1576 (98.5)		
Smoking	Yes	1 (1.4)	21 (1.4)	22 (1.4)	$\chi^2=0$ $p=0.986$	0.98 (0.13–7.39)
	No	73 (98.6)	1505 (98.6)	1578 (98.6)		
Gestational diabetes in mother	Yes	2 (2.7)	37 (2.4)	39 (2.4)	$\chi^2=0.023$ $p=0.88$	1.12 (0.26–4.74)
	No	72 (97.3)	1489 (97.6)	1561 (97.6)		
Type of delivery	LSCS*	9 (12.2)	186 (12.2)	195 (12.2)	$\chi^2=0.001$ $p=0.995$	1 (0.49–2.04)
	Normal	65 (87.8)	1340 (87.8)	1405 (87.8)		
Sleep deprived	Yes	51 (68.9)	975 (63.9)	1026 (64.1)	$\chi^2=0.775$ $p=0.379$	0.8 (0.48–1.32)
	No	23 (31.1)	551 (36.1)	574 (35.9)		
Physically inactive	No	59 (79.7)	1240 (81.3)	1299 (81.2)	$\chi^2=0.108$ $p=0.743$	1.1 (0.62–1.97)
	Yes	15 (20.3)	286 (18.7)	301 (18.8)		
Unhealthy diet	Yes	66 (89.2)	1410 (92.4)	1476 (92.3)	$\chi^2=1.017$ $p=0.313$	0.68 (0.32–1.45)
	No	8 (10.8)	116 (7.6)	124 (7.8)		
Birth order	>2	12 (16.2)	413 (27.1)	425 (26.6)	$\chi^2=4.258$ $p=0.039$	0.52 (0.28–0.97)
	1&2	62 (83.8)	1113 (72.9)	1175 (73.4)		
Fam H/O of DM*	Yes	22 (29.7)	306 (20.1)	328 (20.5)	$\chi^2=4.056$ $p=0.044$	1.69 (1.01–2.83)
	No	52 (70.3)	1220 (79.9)	1272 (79.5)		
Psychologic stress	Present	21 (28.4)	289 (18.9)	310 (19.4)	$\chi^2=4.02$ $p=0.045$	1.7 (1.01–2.86)
	Absent	53 (71.6)	1237 (81.1)	1290 (80.6)		
School type	Private	48 (64.9)	594 (38.9)	642 (40.1)	$\chi^2=19.76$ $p<0.005$	2.9 (1.78–4.73)
	Govt	26 (35.1)	932 (61.1)	958 (59.9)		
Acanthosis nigricans	Yes	32 (43.2)	5 (0.3)	37 (2.3)	$\chi^2=575.40$ $p<0.005$	231.8 (86.0–624.5)
	No	42 (56.8)	1521 (99.7)	1563 (97.7)		
Hypertension	Present	41 (55.4)	196 (12.8)	237 (14.8)	$\chi^2=101.32$ $p<0.005$	8.43 (5.2–13.65)
	Absent	33 (44.6)	1330 (87.2)	1363 (85.2)		
SES*	High	23 (31.1)	193 (12.6)	216 (13.5)	$\chi^2=20.537$ $p<0.005$	3.11 (1.86–5.2)
	Low & Middle	51 (68.9)	1333 (87.4)	1384 (86.5)		

*Fam H/O of DM: Family history of diabetes mellitus; SES: Socio-economic status; LSCS: Lower section caesarean section.

Table 3. Multivariate logistic regression for obesity/overweight (with variables which are significant on univariate analysis).

Variable	P-value	AOR*	95% CI for AOR*	
			Lower	Upper
Birth order (>2)	0.233	0.615	0.276	1.368
Family h/o DM	0.716	1.136	0.572	2.258
Psychological stress	0.191	0.587	0.264	1.304
School type (Private)	0.251	1.494	0.753	2.966
Acanthosis nigricans	<0.005	219.259	71.495	672.418
Hypertension	<0.005	7.013	3.779	13.014
SES* (High)	0.066	2.027	0.954	4.305

*AOR: Adjusted odds ratio; CI: Confidence interval; SES: Socio-economic status.

prevalence of 5.1% and 1.0% respectively amongst boys and 6.6% and 1.6% amongst girls and in Siddiqui *et al.*, prevalence in boys was 6.81% and girls was 8.16% both of which are slightly higher than our study. However, prevalence in girls is higher than boys in both the studies, which is similar to our study (Laxmaiah *et al.*, 2007; Siddiqui & Bose, 2012). In our study, the prevalence of students being overweight, and obesity was 2.7% in government and 7.5% in private schools, whereas the study done by Jagadesan *et al.*, in urban Chennai showed 4% in government and 22.5% in private schools (Sonya, Ranjani, Priya, Ranjit & Mohan, 2014). The higher prevalence in their study might be because it was carried out in urban Chennai, which is a metropolitan city and rice is their staple food, and different scales were used to classify BMI. Our study was done in a non-metropolitan city including rural as well as urban areas, jowar is the staple diet of this population and WHO Anthroplus software 1.0.4 was used to classify BMI.

The prevalence of hypertension was 14.8% in this study, 8.8% had isolated systolic blood pressure, 3.2% had isolated diastolic blood pressure. The prevalence of hypertension was 14.21% and 15.39% in males and females respectively and there was no statistically significant difference between males and females ($p = 0.796$). There was a statistically significant relationship between increase in BMI with systolic ($p = 0.0001$) and diastolic blood pressure ($p = 0.0001$). In the study by Veena Kamath *et al.*, among the paediatric population of coastal India in the year 2010, the overall prevalence of hypertension was 2.2%, 2.1% and 2.4% in males and females respectively. The prevalence in our study is comparatively higher. It may be because of the geographical difference, age group 5–16 years in their study, increasing urbanization and lifestyle changes among adolescents and also because their evaluation of hypertension was based on the 1987 Task Force Report on High Blood Pressure in Children and Adolescents (National High Blood Pressure Education Program Working Group on Hypertension Control in Children and Adolescents, 1996). The prevalence was highest in the 14–16 years age group, whereas in our study it was the 13–14 years age group. There was no significant difference in prevalence between males and females in their study which is similar to ours. The systolic BP increased with increase in BMI but not with diastolic BP ($p = 0.041$ and $p = 0.131$ respectively), whereas in our study both systolic and diastolic BP increased with increase in BMI ($p = 0.0001$) (Kamath G. *et al.*, 2010). A study done by Jasmine Sundar *et al.*, among adolescents of Chennai city, reported the prevalence of hypertension as 21.5%. There was a statistically significant relationship between hypertension and gender, class, body mass index, family history of hypertension and waist hip ratio ($p < 0.001$). In our study, there was no significant difference with gender, physical activity, food habits but a significant relationship with grade, body mass index, socio-economic status and family history of mother with hypertension (Sundar, 2013). A similar study done by Amit Vasant Deshpande on hypertension in adolescents in Central India, which included 57.8% males and 42.2% females, showed the prevalence of pre-hypertension and hypertension as 15.9% and 13.9% respectively. Age wise distribution of hypertension among study subjects showed the prevalence of hypertension increases with age and there was no significant difference between gender, which is comparable to our study results (Deshpande, 2014).

A total of 4.6 % of students had an overweight plus 2 risk factors; they underwent a urine glucose strip test which showed a negative result in all students. This might be due to the fact that glucose is detected only when renal threshold for blood glucose exceeds 180 mg/dl (Na *et al.*, 2012). In the study done by Asha Bai *et al.*, consisting of 56.4% males and 43.6% females, the prevalence of glycosuria was 0.09% (Bai *et al.*, 1995). A study done by Bassey *et al.*, showed the prevalence of glycosuria at 0.7%; among males it was 1.2% and among females 0.2% (Na *et al.*, 2012). In the study done by Harish Ranjani *et al.*, the participants underwent an oral glucose tolerance test, and the prevalence of glucose intolerance was 3.7%, which included 0.3% with diabetes and 3.4% with prediabetes (Ranjani *et al.*, 2013).

Table 4. Binary logistic regression - risk factors associated with hypertension in study population.

Variable	Value	HTN* (n=237)	No HTN* (n=1363)	Total (N=1600)	Chi Square Test	OR (95% CI)*
Gender	Female	125 (52.74)	687 (50.4)	812 (50.75)	$\chi^2 = 0.442$	1.1 (0.83–1.45)
	Male	112 (47.26)	676 (49.6)	788 (49.25)	$p = 0.506$	
Alcohol consumption	Yes	2 (0.84)	22 (1.61)	24 (1.5)	$\chi^2 = 0.811$	0.52 (0.12–2.23)
	No	235 (99.16)	1341 (98.39)	1576 (98.5)	$p = 0.368$	
Smoking	Yes	2 (0.84)	20 (1.47)	22 (1.38)	$\chi^2 = 0.579$	0.57 (0.13–2.45)
	No	235 (99.16)	1343 (98.53)	1578 (98.63)	$p = 0.447$	
Gest diabetes in mother	Yes	5 (2.11)	34 (2.49)	39 (2.44)	$\chi^2 = 0.126$	0.84 (0.33–2.17)
	No	232 (97.89)	1329 (97.51)	1561 (97.56)	$p = 0.723$	
Delivery	LSCS	35 (14.77)	160 (11.74)	195 (12.19)	$\chi^2 = 1.731$	1.3 (0.88–1.93)
	Normal	202 (85.23)	1203 (88.26)	1405 (87.81)	$p = 0.188$	
Sleep deprived	No	68 (28.69)	506 (37.12)	574 (35.88)	$\chi^2 = 6.24$	0.68 (0.5–0.92)
	Yes	169 (71.31)	857 (62.88)	1026 (64.13)	$p = 0.012$	
Physically inactive	Yes	48 (20.25)	253 (18.56)	301 (18.81)	$\chi^2 = 0.378$	1.11 (0.79–1.57)
	No	189 (79.75)	1110 (81.44)	1299 (81.19)	$p = 0.539$	
Unhealthy diet	Yes	220 (92.83)	1256 (92.15)	1476 (92.25)	$\chi^2 = 0.13$	1.1 (0.65–1.87)
	No	17 (7.17)	107 (7.85)	124 (7.75)	$p = 0.719$	
Birth order	>2	56 (23.63)	369 (27.07)	425 (26.56)	$\chi^2 = 1.228$	0.83 (0.6–1.15)
	1&2	181 (76.37)	994 (72.93)	1175 (73.44)	$p = 0.268$	
Fam H/O of DM	Yes	58 (24.47)	270 (19.81)	328 (20.5)	$\chi^2 = 2.694$	1.31 (0.95–1.81)
	No	179 (75.53)	1093 (80.19)	1272 (79.5)	$p = 0.101$	
Psychologic stress	Present	72 (30.38)	238 (17.46)	310 (19.38)	$\chi^2 = 21.569$	2.06 (1.51–2.81)
	Absent	165 (69.62)	1125 (82.54)	1290 (80.63)	$p < 0.005$	
School type	Private	121 (51.06)	521 (38.23)	642 (40.13)	$\chi^2 = 13.834$	1.69 (1.28–2.23)
	Govt	116 (48.95)	842 (61.78)	958 (59.88)	$p < 0.005$	
Acanthosis nigricans	Yes	20 (8.44)	17 (1.25)	37 (2.31)	$\chi^2 = 46.222$	7.3 (3.76–14.15)
	No	217 (91.56)	1346 (98.75)	1563 (97.69)	$p < 0.005$	
Obesity	Present	41 (17.3)	33 (2.42)	74 (4.63)	$\chi^2 = 101.32$	8.43 (5.2–13.65)
	Absent	196 (82.7)	1330 (97.58)	1526 (95.38)	$p < 0.005$	
SES*	High	51 (21.52)	165 (12.11)	216 (13.5)	$\chi^2 = 15.32$	1.99 (1.4–2.82)
	Low & Middle	186 (78.48)	1198 (87.89)	1384 (86.5)	$p < 0.005$	

*HTN: Hypertension; OR: Odds ratio; CI: Confidence interval; SES: Socio-economic status.

Table 5. Multivariate logistic regression for hypertension (with variables which are significant on univariate analysis).

Variable	P-value	AOR*	95% CI for AOR*	
			Lower	Upper
Inadequate sleep	0.050	1.369	1.000	1.874
Psychological stress	<0.005	1.972	1.424	2.731
School Type (Private)	0.089	1.319	0.959	1.813
Acanthosis nigricans	0.853	1.088	0.447	2.647
Obesity	<0.005	6.980	3.755	12.976
SES (High)	0.087	1.426	0.949	2.143

*AOR: Adjusted odds ratio; OR: Odds ratio; CI: Confidence interval; SES: Socio-economic status.

Table 6. Mean (SD) Z scores for BMI for age and height for age.

Variable	WHO		
	Female	Male	Total
BMI for age z score*	-0.96 (1.1)	-1.41 (1.22)	-1.18 (1.18)
HFA z score*	-0.87 (0.83)	-0.99 (0.99)	-0.93 (0.92)

*SD: Standard deviation; BMI: Body mass index; HFA: Height for age.

Table 7. Distribution of study participants according to WHO Z scores.

Variable	SD* (Z scores)	WHO*		
		Female	Male	Total
		N (%)	N (%)	N (%)
BMI for age*	≤-3	85 (10.5)	192 (24.4)	277 (17.3)
	-2 to -2.99	164 (20.2)	193 (24.5)	357 (22.3)
	-1 to -1.99	240 (29.6)	185 (23.5)	425 (26.6)
	-0.99 to 0.99	282 (34.7)	185 (23.5)	467 (29.2)
	1 to 1.99	36 (4.4)	29 (3.7)	65 (4.1)
	2 to 2.99	5 (0.6)	4 (0.5)	9 (0.6)
	≥3	0 (0)	0 (0)	0 (0)
	Total	812 (100)	788 (100)	1600 (100)
Height for age	≤-3	30 (3.7)	57 (7.2)	87 (5.4)
	-2 to -2.99	140 (17.2)	181 (23)	321 (20.1)
	-1 to -1.99	339 (41.7)	272 (34.5)	611 (38.2)
	-0.99 to 0.99	299 (36.8)	263 (33.4)	562 (35.1)
	1 to 1.99	4 (0.5)	9 (1.1)	13 (0.8)
	2 to 2.99	0 (0)	4 (0.5)	4 (0.3)
	≥3	0 (0)	2 (0.3)	2 (0.1)
	Total	812 (100)	788 (100)	1600 (100)

*SD: Standard deviation; BMI: Body mass index; WHO: World Health Organization.

Conclusions and recommendations

The prevalence of obesity/overweight students was 4.6%, 18.8% were physically inactive, 19.4% were in psychological stress, 64% were sleep deprived and 92% consumed an unhealthy diet. We recommend that the Body Mass Index should be measured in schools on a regular basis. It is a simple cost-effective screening tool to look for malnutrition i.e., either obesity or under-nutrition. The effective implementation of nutrition programs in schools is highly recommended. Compulsory physical education (PE) and games classes should be a part of the curriculum in schools with a focus on female students especially in rural areas. Yoga classes were being conducted in some government schools included in the study; this could be extended to all government schools and even private schools. Health education on consumption of healthy and nutritious food should be given to the students by teachers as unhealthy diet consumption was noticed in a significant percentage of participants. The frequency of intake of vegetables and fruits should increase and that of bakery products, cool-drinks, junk and fast food and restaurant/street food should decrease. Of all the participants, 14.8% were hypertensive. The measurement of blood pressure in the routine school health check-ups is strongly recommended and tracking of blood pressure can be done in schools. A family history of DM and hypertension was found in 20.5% and 26.5% of students respectively, 2.4% had a mother with gestational diabetes, 12.2% had a history of caesarean delivery, 26.4% had low birth weight and 26.6% had high birth order (>2). The school health team can maintain a record of family history of DM and hypertension and using the guidelines for screening of type 2 DM used in our study (overweight plus two risk factors) screening tests can be performed.

Limitations

Blood glucose tests among the study group could not be done in the schools. Blood pressure measurement was recorded on the first examination day only and no follow-up was done.

Data availability

Underlying data

Figshare: Underlying data for 'Prevalence of risk factors for obesity, diabetes mellitus and hypertension in high school children and screening of high-risk children for glycosuria: A cross-sectional study in Dharwad District, India'. <https://doi.org/10.6084/m9.figshare.17942558> (Shubhashri *et al.*, 2022a).

This project contains the following underlying data:

- Data file: Adolescent Research Data.xlsx

Data are available under the terms of the [Creative Commons Zero "No rights reserved" data waiver \(CC0 1.0 Public domain dedication\)](#).

Extended data

Figshare: Extended data for 'Prevalence of risk factors for obesity, diabetes mellitus and hypertension in high school children and screening of high-risk children for glycosuria: A cross-sectional study in Dharwad District, India'. <https://doi.org/10.6084/m9.figshare.19127450> (Shubhashri *et al.*, 2022b).

This project contains the following extended data:

- Questionnaire: Adolescent research - Dharwad district.pdf

Data are available under the terms of the [Creative Commons Attribution 4.0 International license \(CC-BY-4.0\)](#).

Consent

Written informed consent for publication of the participants' details was obtained from the participants and the parents of the participants.

Acknowledgements

We thank the Deputy Director of Public Instructions, Dharwad District for giving permission to conducting the study and also informing the Block Education Officers of the seven talukas in the district regarding the conduct of the study. We thank all the principals, teachers and students of all the schools for their time, kind co-operation and support in the conduct of the study. We wish to acknowledge all the staff at the department of Community Medicine, Karnataka Institute of Medical Sciences, Hubli for all the support extended during the conduct of the study.

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Reviewer Report 19 April 2022

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Abhishek V. Raut

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Title

- Is high-school children a standard term for Class 8 to 10 students or secondary school children will be a more appropriate term? High school children is usually used for children in 11th and 12th standard. Else you may just specify the age range.
- Also risk factors for Obesity and Hypertension have been studied in detail, the same is not the case for DM, the title may be modified accordingly. Else include the results for the DM in the results.

Abstract:

- Introduction: punctuation and grammar needs to be improved to make it easier to comprehend. May include the objective in one line.
- Methods: kindly specify the study period and sampling technique used
- Results:
 - The results are not in sync with the title of the study, the title mentions prevalence of risk factors for obesity, HTN and DM, however, authors have mentioned the prevalence of obesity and HTN. The prevalence of risk factors should also be mentioned.
 - Prevalence should be reported with 95% CIs
 - Kindly include only the significant results in the abstract.
 - Short forms such as "h/o" may be avoided.
- Conclusions: The conclusions are not being drawn from the results of the study and are generic in nature. Conclusion should be restricted to what was studied and can be inferred from the results of the study.

Introduction:

- Some of the important literature seems missing particularly the findings from the STEPS survey conducted in India.
- Some of the references are old (2004, 2005) and may not be relevant to India. More Indian studies should be included and the research gap that the study tries to bridge should be specified explicitly.
- The objectives should be stated more clearly, you may choose to specify as primary and secondary objectives. Kindly refer to the comment regarding 'high school' and consider revising the same.

Methods:

- Sample size estimation need more justification. Sample size has been estimated based on the prevalence of glucose intolerance (Ranjani et al., 2013), however, the title and objective mentions about assessing the prevalence of the risk factors for obesity, hypertension and type 2 DM among high-school children of India, and to screen high-risk children for overt DM. Is the estimated sample size optimal for capturing the prevalence of risk factors for obesity, hypertension and type 2 DM? A post-hoc power analysis should be undertaken and be mentioned in the discussion section.
- Also design effect for multi-stage cluster sampling/probability proportionate to size sampling method should have been considered while estimating sample size and sample size adjusted accordingly. In a cross-sectional study with on follow-up involved, kindly explain the rationale for considering 10% drop out rate?
- Authors have mentioned as 'incompletely answered questionnaires' as one of the exclusion criteria. What was the proportion of such forms/participants and what were the reasons for the same? Could this have lead to bias should be discussed and explained.
- A study flow chart and response rates may help understanding the sampling procedure and the inclusion/exclusion numbers with reasons thereof in order to see how many of the initially sampled individuals actually participated.
- In substance abuse, what the authors mean by 'History of alcohol and tobacco consumption was requested' is not clear..... were these current users or past users or both, frequency and/or quantity of use?
- For Dietary habits, rationale for the mentioned criteria for unhealthy diet should be explained. If possible a reference be given.
- For physical activity, the criteria for considering physical inactivity mentioned and the reference cited for children and adolescents aged 5-17 years do not match with each other.
- What was the total number of potentially available schools in the clusters? Did the schools that were not selected differ from those that were selected? This should be discussed in the discussion.
- How were the students selected? Were all the children in the given class were considered or

was any-sub-sampling done? Should be explained clearly. How many students were selected from each school?

- Statistical analysis should be explained include variable selection and multivariable modelling. The details of the procedure followed for multivariable analysis and model assessment may be mentioned
- Under screening for glycosuria, the rationale for including Asian ethnicity as one of the risk factors should be explained, particularly, when all the students would probably meet this criteria.
- Under Ethics, the authors have mentioned that 'The questionnaire was sent with the students to their homes and only those who obtained their parent's signature the next day were included'. How many such forms were sent for which the students did not return with the signed consent form? This should also be explained in the flowchart mentioned above. Can the authors comment on the background characteristics of these non-consenting/responding participants, did they differ from those who responded, could this have led to a bias? The same should be discussed and explained in the discussion.
- All the variables captured may be explained in terms of exposure, outcome and confounding variables. E.g gestational diabetes is directly coming in results and not mentioned anywhere in the methods section.

Results:

- A table depicting the recruitment distribution over the clusters and types of schools; dropout rates, etc. should be given
- Prevalence should be specified with 95% CIs and may be sufficient to provide the results with a single decimal place.
- Figure 1: "birth order" needs more explanation. Could you also provide confidence intervals to the bars?
- Figure 2: Acanthosis nigricans needs more explanation, as it can be also a consequence of existing diabetes. Again, confidence intervals should be given.
- In the title and objectives, the authors write "risk factors for obesity, hypertension and type 2 DM" but the results only focus on analysis of risk factors for obesity and hypertension (not DM).
- Considering that this is a cross-sectional study, it is desirable to use Prevalence Odds Ratios (POR) instead of OR in bivariate analysis.
- In Table 5, the reference category for the variables should be specified.
- Also for logistic regression, the model fit data, VIF and r-square should be specified.
- Table 6 and 7: Considering that the authors have used Anthroplus software, it would be

better if the results are depicted using density curves/plots that are available through the software and will be easier for the reader to interpret.

- Results for the hip and waist circumference, have not been mentioned anywhere in the results, although it has been measured.

Discussion:

- This section needs improvement, the majority of the discussion is a repetition of the results. Findings of the study need to be discussed in the light of available evidence and the implications/way forward too, especially with the findings of STEPS surveillance findings.
- A critical discussion of BMI as a risk measures is missing
- It is recommend to start with the 2-3 most important findings and with the explanation what this study adds to the existing evidence. Also refer the points under different sections above wherein it has been suggested to explain and include the things in discussion.
- Strengths and limitations of the study should be mentioned
- The conclusions are not being drawn from the results of the study and are generic in nature. Conclusion should be restricted to what was studied and can be inferred from the results of the study. Authors should refrain from giving recommendations that have not been tested in their own study.

Is the work clearly and accurately presented and does it cite the current literature?

Partly

Is the study design appropriate and is the work technically sound?

Yes

Are sufficient details of methods and analysis provided to allow replication by others?

Partly

If applicable, is the statistical analysis and its interpretation appropriate?

Partly

Are all the source data underlying the results available to ensure full reproducibility?

Yes

Are the conclusions drawn adequately supported by the results?

Partly

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Implementation research, Non-communicable diseases, Early Childhood Development

I confirm that I have read this submission and believe that I have an appropriate level of

expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Reviewer Report 15 March 2022

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Dr. Andreas Deckert

Heidelberg Institute of Global Health, University of Heidelberg, Heidelberg, Germany

Abstract:

- Methods: please provide the time period when the study was conducted. You should also mention the sampling method.
- Results: the authors conducted a multivariable analysis, not a multivariate one (see <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3518362/>).
- Maybe only report the significant results in the abstract.
- It is completely sufficient to provide one decimal place instead of two or more for OR, percentages etc. (holds true for the whole article and the tables as well). Providing two creates an impression of a precision which is actually not given.
- "h/o" might not be comprehensible for everybody.
- The conclusions are very general and already known from many other studies. Isn't there anything more specific related to this study?

Introduction:

- Some of the literature seems to be out-dated, in particular with regards to diabetes. I miss the mentioning of diabetes and hypertension findings from the STEPS survey conducted in India.
- I would not call it "westernized lifestyle". For instance, to continue eating traditional rice dishes while living a sedentary lifestyle equally contributes to diabetes risk but is not really westernized...Maybe "modernized"?
- The objectives are not really clear. Which research gap is the study going to close? What differentiates it from the STEPS survey, for instance? The authors write that schools render significant opportunities to prevent behaviours. However, the authors do not assess the prevention measures of schools but just the prevalence of risk factors, hence, the link between these two sentences is missing. What is the hypothesis? Is it that prevalence of risk factors is still high although the schools provide prevention measures?

Methods:

- What was the total number of potentially available schools in the clusters? How were the students selected? Was it a full sample per school or a random sample? Actually, part of the "study design" better fits to "sampling" further down.
- Given that incomplete questionnaires were excluded from data analysis, a study flow chart

and response rates may help understanding the sampling procedure and the inclusion/exclusion numbers in order to see how many of the initially sampled individuals actually participated.

- Prevalence: sufficient to provide 1 decimal place.
- Dietary habits: How did the authors come up with the threshold for unhealthy diet? It looks a bit arbitrary.
- How was alcohol and tobacco history assessed (e.g. pack years)?
- The explanation of the statistical analysis (variable selection and multivariable modelling etc.) is missing.
- Did you apply any survey weights? (e.g. to account for the different school/cluster sizes).

Results:

- A table is lacking showing the recruitment distribution over the clusters and types of schools; drop out rates, etc.
- Table 1: you could provide a p-value to show potential differences between the sexes.
- In general: if an estimate is provided (such as prevalence), the confidence interval should also be provided.
- Figure 1: what does "birth order" mean here? Was it binary (I don't think so...)? You could also provide confidence intervals to the bars ("antennas").
- Figure 2: These are not all risk factors. Acanthosis nigricans can be also a consequence of an existing diabetes. Again, confidence intervals would be nice.
- In the introduction the authors write "risk factors for obesity, hypertension and type 2 DM" but the results only focus on analysis of risk factors for obesity and hypertension (not DM).
- Table 6 and 7: it would be easier for the reader to see some graphs here (boxplot, histogram).
- What happened to the hip and waist circumference?

Discussion:

- I recommend to start with the 2-3 most important findings and with the explanation what this study adds to the existing evidence.
- The beginning of the discussion is mainly repetition of the results.
- What about the inclusion of the STEPS survey in the discussion?
- A section on strengths and limitations of the study is missing (respectively, it is much too short (after "conclusion")). What about limitations of the study design? The sampling? Etc.
- A critical discussion of BMI as a risk measures is missing.

References

1. Hidalgo B, Goodman M: Multivariate or multivariable regression?. *Am J Public Health*. 2013; **103** (1): 39-40 [PubMed Abstract](#) | [Publisher Full Text](#)

Is the work clearly and accurately presented and does it cite the current literature?

Partly

Is the study design appropriate and is the work technically sound?

Partly

Are sufficient details of methods and analysis provided to allow replication by others?

Partly

If applicable, is the statistical analysis and its interpretation appropriate?

Partly

Are all the source data underlying the results available to ensure full reproducibility?

Partly

Are the conclusions drawn adequately supported by the results?

Partly

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: epidemiology, non-communicable disease (diabetes, hypertension, mental health), biostatistics

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

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