

A Study to Assess and Evaluate the Impact of Various Food Habits and Physical Activity Habits on The Development of Overweight and Obesity in Rural School-Aged Adolescents

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Abstract:

Aim: The aim of this study was to estimate and compare the effects of different dietary habits and habits related to physical activity in the development of overweight and obesity among rural school going adolescents.

Methods: The prospective cross-sectional study which was carried in Department of Community Medicine, Bhagwan Mahavir Institute of Medical Sciences, (BMIMS), Pawapuri, Nalanda, Bihar, India. A prospective follow-up study was conducted among adolescents (14–18 years) studying at secondary and higher-secondary level (Classes IX to XII) in four selected school. The participants, who were permanent residents of the rural areas, were surveyed at the beginning, and a follow-up assessment was done after 6 months. Thus, two repeated measures were taken on each individual participant. A total of 100 participants (38 male and 62 female respondents) were ultimately included in this study.

Results: In the cumulative (overall) model, intake of fast showed highest risk (3.15, 95% CI: 1.97–4.86) in favor of development of overweight. The risk estimate for fast food intake causing overweight was also the highest among the girls (4.60, 95% CI: 1.81–10.75). Those who had a regular intake of soft drinks were at 2.42 (95% CI: 1.52–3.88) times risk of getting overweight. In the GEE model for boys, older age did not have any statistically significant effect. However, similar to the cumulative model fruit and vegetables ingestion, soft drinks, and fast food, intake did have a statistically significant relationship. Among the boys, the maximum risk was observed with eating less vegetable (4.75, 95% CI: 1.95–11.80). In case of the girls, risk of older girls becoming overweight was 5.12 (95% CI: 1.82–14.69). While none of the variables related to physical activity were significant statistically in any of the models, inadequate daily work was observed to have statistically significant risk of 2.59 (95% CI: 1.22–5.67). Eating less vegetable was not statistically significant among girls. However, intake of soft drinks had a risk (4.50, 95% CI: 1.94–10.60) comparable to that of fast-food intake. Overall unhealthy dietary habit was found to contribute a risk of 8.73 (95% CI: 5.49–13.91), which was higher compared to risk contributed by inadequate physical activity (6.69, 95% CI: 3.83–10.94). Both these risks increase in boys and girls separately.

Conclusions: Strong evidence was generated of dietary practices being more rigidly related to overweight among the adolescents. Healthy dietary practices coupled with physical activity should be promoted to mitigate the risk of obesity.

Keywords: Adolescents, Diet, Nutrition, Obesity, Overweight, Physical Activity, Risk Factors, Rural.

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Introduction

The word ‘adolescence’ is derived from the Latin verb ‘adolescere’, which means “grow to maturity.” Adolescence is a grey area in the spectrum of life falling between childhood and adulthood. It is an age of transition when an individual experiences rapid growth and development, both physical and

psychological and changes from being a child to an adult.[1] WHO defines adolescents as persons in the age group of 10 to 19 years.[2] In India, there are an estimated 190 million adolescents comprising over one-fifth of the entire population.[3] Adolescence is also a period when development of the reproductive

system, sexual maturation, formation of identity, and gender roles set in, and issues relating to identity, gender roles, and related problems arise.[4] A study conducted by Kotecha et al. regarding identification and ranking of problems among urban adolescents could identify problems broadly into the category of health and nutrition, academic, physical growth, and development.[5] The development of healthy eating habits is important as the rapid physical growth in adolescence is associated with increased nutritional needs. Various studies on diet and nutrition intake of adolescents and young adults in the developed world have shown that their diets are often high in fats and refined carbohydrate.[6] Adolescence is also a period of increased vulnerability to obesity. Lack of physical activity and outdoor sports, along with the consumption of fatrich 'junk' foods, is the major cause of obesity among the affluent population.[7] Consumption of diet high in sugar, saturated fat, salt, and calorie content in children can lead to early development of obesity, hypertension, dyslipidaemia, and impaired glucose tolerance.[8] Some dietary patterns appear quite common among adolescents, to mention a few: snacking, usually on energy-dense foods; meal skipping, particularly breakfast, or irregular meals; wide use of fast food; and low consumption of fruits and vegetables.[9-11] Adolescents also tend to suffer from a variety of eating disorders i.e., anorexia nervosa, bulimia nervosa as well as depression, anxiety and psychological stress.[12] In developing countries including India, adolescents' health and nutrition is largely under-researched and has been ignored due to the silent nature of nutritional problems, undocumented evidence of life threatening epidemics, less assertive attitude of adolescents, muted political interest and financial constraints. Lack of data on adolescents' nutritional status, dietary practices and physical activities also make it difficult to draw the attention of Government officials, program managers and policy makers to formulate and develop appropriate adolescent specific strategies for addressing their nutritional and socio-psychological needs. The association between age-specific nutrition and long-term health effects has always been of interest, the current study was designed to compare the nutritional status, dietary practices and physical activities of school going adolescent boys and girls.

Material and Methods

The prospective cross-sectional study which was carried in the Department of Community Medicine, Bhagwan Mahavir Institute of Medical Sciences, (BMIMS), Pawapuri, Nalanda, Bihar, India from March 2025 to September 2025

A prospective follow-up study was conducted among adolescents (14–18 years) studying at secondary and higher-secondary level (Classes IX to XII) in four selected school. The participants, who

were permanent residents of the rural areas, were surveyed at the beginning, and a follow-up assessment was done after 6 months. Thus, two repeated measures were taken on each individual participant. A total of 100 participants (38 male and 62 female respondents) were ultimately included in this study.

Study variables and data collection: A predesigned pretested questionnaire was prepared reviewing the GSHS instrument [13] and the WHO- STEPS instrument [14] and comprised of a section on physical activity and another section on dietary habits. There was a question regarding family history as well. Socio-demographic information of the participants was collected during the initial visit. The questionnaire was translated to Bengali and was then back translated to English by two different experts. Validity of the questionnaire was checked by statistical tests, the discussion of which is beyond the scope of the current article (Cronbach's alpha [15] was estimated to be 0.82, ensuring good statistical reliability.[16] This instrument was administered among students of a selected section during a single period all at once. Each of them, already allotted an identification number against their roll numbers and name, were then subjected to measurements of height and weight by standardized stadiometer (IndoSurgical[®] Height Measuring Scale) and bathroom type weighing machine (MCP[®] Analog Mechanical Weighing Scale), respectively, following standard protocol. Body mass index (BMI) was calculated as weight (in kilograms)/ height (in meters). The WHO adolescent BMI percentile chart was used to classify the nutritional status of the children.[17] A follow-up visit was done after 6 months to the selected schools, and the same process was repeated on those who were already allotted the identification number from the previous visit.

Study variables and statistical analysis: Gender of the participants was the only time-invariant predictor of nutritional status. Age of the students, dietary habits, and practices related to physical activity were considered time-dependent predictors directly influencing the occurrence of overweight or obesity. Family history of any NCDs or its risk factors (including obesity) was taken as a time-invariant predictor. Those who did not respond to the question were counted to have no family history for the sake of simplicity of analysis. Among dietary habits, episodes of going hungry (i.e., having no food), infrequently eating vegetables or fruits, frequent intake of soft drinks and fast foods were the variables used. Infrequent walking to commute to school, major duration of sitting activities, and infrequent other daily physical work were indicative of physical activity status of the participants. All these variables were measured in terms of a 5-point Likert-type scale. To arrive at a single variable

describing the dietary factors, a principal component analysis was done on the related variables, and single factor with eigen value >1 was taken and then dichotomized into healthy or unhealthy habits. Physical activity variables were also reduced similarly to a single indicative factor.

The variables, both time-varying and time-invariant, were analyzed with the help of population average model or more commonly known as marginal population model – Generalized Estimating Equations (GEEs)[18,19] to find the effect of the predictors with change in time. Robust standard errors were used to achieve an unbiased model fit, especially with respect to outliers. Effect size (epidemiological risk) was estimated in terms of the risk ratio obtained, and the 95% confidence intervals (95% CIs) were reported. P value was considered significant at <0.05 . The interaction in-between was considered, and the model was compared to GEE model without the interaction terms. Although both the models showed overall fit ($P \chi^2 < 0.001$), model with interaction did not differ from the main model significantly. Next, another model was created with the composite dietary habit and physical activity variables to estimate how much an unhealthy habit overall contributes to the morbidity. In this model, interactions with age and gender were included with the previously mentioned variables. In this case, however, the model with interactions differed significantly from that without interactions. A gender-dependent analysis on these factors was also performed. A statistical invariance of the baseline background information of the students excluded from the analysis was established to maintain sampling integrity and representativeness.

Results

The mean age of the participants was 16.2 (± 1.66) years (range: 14–18 years). Most of the respondents (56%) were aged 16 years or below. Among the participants, majority were female (62%), Hindu (80%), and belonging from a nuclear family background (78%). Majority of the participants (56%) were studying in the secondary level (Classes IX and X). Rest of the adolescents were studying at higher secondary level. While 15% of the respondents belonged to Class I of BG Prasad socioeconomic status classification (December, 2016 modification) [20] 33% were from Class IV.

Among those who responded regarding their father's education, majority of the fathers were educated up to higher secondary level (29%). On the contrary, the majority of the mothers had received primary level of education (46%), while 22% were educated up to higher secondary level. While majority students reported that their fathers were involved in farming as occupation (50%), majority of their mothers were homemakers (72%).

The normal nutritional status was observed among 87% of the participants initially; but after 6 months, the proportion was 79%. There was a stark rise in proportion of overweight from 1% to 8% with obesity rising to 2% from previously 1%. Interestingly, the other spectrum of adolescent malnutrition – thinness also increased in prevalence from 13% to 15%, though not as sharp as that of overweight. While girls show an improvement in thinness status over time, boys reported a higher burden of thinness as well. These observed differences were found to be statistically significant as well ($P < 0.001$).

Trend of diet and physical activity related risk factors: Table 1 compares the distribution of the risk factors related to dietary habits, physical activity, and family history of NCDs and risk factors between the two observation points. Among the dietary habits, the students reported that 11% went hungry most of the times, 51% were eating fruits less than once a day, and 26% were eating vegetables less than once a day. Regarding frequent intake of soft drinks and fast foods, the prevalence was 47% and 55%, respectively, at the time of initiation. However, on follow-up visit, all the prevalence were seen to be higher except frequent intake of junk foods, which fell down to 51%. Infrequent intake of vegetables was prevalent among 31% of the participants on follow-up. Now, this difference was statistically significant. While the prevalence of unhealthy dietary habits overall was noted to be 71% at the baseline, there was a marginal decrease to 69%. However, this difference also was not significant statistically. Risk factors pertaining to physical activity among adolescents, for example, usually not walking or cycling to school increased to 34% on follow-up compared to 31% at the baseline. However, there was a marginal decrease in prevalence of sitting activities from 16% at the baseline to 15%. Similarly, for inadequate other daily physical work, the prevalence decreased from 26% to 25%. However, the overall prevalence of inadequate physical activity increased to 52% from the baseline value of 49%. However, none of these differences were statistically significant. After completion of follow-up, 11% of the students were found to have reported the presence of family history.

It is important to note that while there is a statistical difference in the outcome variable (overweight and obesity) over time, such differences are mostly not there for the risk factors of interest. Although effect of the predictors on the outcome cannot be simply written off basing on only this disparity, it can be well understood that the cause of disparity is most likely hidden in the effect of the risk factors over time (i.e., the time interaction)

Predictors of overweight and obesity: Table 2 shows the GEE models done for different dietary

risk factors and risk factors of physical inactivity. Female gender and older age group (i.e., >16 years of age) were at higher risk of developing overweight and obesity. In the cumulative (overall) model, intake of fast showed highest risk (3.15, 95% CI: 1.97–4.86) in favour of development of overweight. The risk estimate for fast food intake causing overweight was also the highest among the girls (4.60, 95% CI: 1.81–10.75). Less fruits and vegetables consumptions were statistically linked with overweight and obesity. Those who had a regular intake of soft drinks were at 2.42 (95% CI: 1.52–3.88) times risk of getting overweight. In the GEE model for boys, older age did not have any statistically significant effect. However, similar to the cumulative model fruit and vegetables ingestion, soft drinks, and fast food, intake did have a statistically significant relationship. Among the boys, the maximum risk was observed with eating less vegetable (4.75, 95% CI: 1.95–11.80). In case of the girls, risk of older girls becoming overweight was 5.12 (95% CI: 1.82–14.69). While none of the variables related to physical activity were significant statistically in any of the models, inadequate daily work was observed to have statistically significant risk of 2.59 (95% CI: 1.22–5.67). Eating less

vegetable was not statistically significant among girls. However, intake of soft drinks had a risk (4.50, 95% CI: 1.94–10.60) comparable to that of fast-food intake.

Table 3 summarizes the effects of overall dietary habit and physical activity adjusting for gender age group of the respondents. The two-way interaction terms are incorporated to identify the significant interactions between the modifiable and nonmodifiable risk factors. Overall unhealthy dietary habit was found to contribute a risk of 8.73 (95% CI: 5.49–13.91), which was higher compared to risk contributed by inadequate physical activity (6.69, 95% CI: 3.83–10.94). Both these risks increase in boys and girls separately. The unhealthy dietary practices lead to 14.91 times (95% CI: 8.68–25.66) cumulative risk among the girls, which is higher compared to that in boys. On the other hand, inadequate physical activity among the boys leads to a very high cumulative risk of developing obesity. Along with the main effects, the interactions also appeared significant statistically in the mentioned models. However, this statistical significance implies the interrelationship of the modifiable and nonmodifiable risk factors.

Table 1: Comparison of dietary practices, physical activity, and family history of the respondents at baseline and at follow-up after 6 months (n=100)

Risk factors	Baseline, n (%)	After 6 months, n (%)	P
Most of the times going hungry at home	11 (11)	15(15)	0.517
Eating fruits less than once a day	51 (51)	53 (53)	0.331
Eating vegetables less than once a day	26 (26)	31(31)	0.042
Intake of soft drinks more than thrice a week	47 (47)	50 (50)	0.873
Intake of fast food more than thrice a week	55 (55)	100 (50)	0.084
Unhealthy dietary habits	71 (71)	69 (69)	0.433
Usually not walking or cycling to-and-from school	31(31)	34(34)	0.341
≥4 h of sitting activity	16 (16)	15 (15)	0.790
Inadequate other daily physical work (including outdoor sports)	26(26)	25 (25)	0.503
Inadequate physical activity (overall)	49(49)	52 (52)	0.698

Table 2: Factors affecting development of overweight and obesity

Factors affecting development of overweight and obesity	Overall (n=100)		Female (n=62)		Male (n=40)	
	Risk ratio (95% CI)	P	Risk ratio (95% CI)	P	Risk ratio (95% CI)	P
Sex: Female	2.22 (1.52-3.77)	0.001	-	-	-	-
Age group: Older (>16 years)	2.78 (1.68-4.65)	<0.001	1.63 (0.91-3.09)	0.067	5.12 (1.82-14.69)	0.002
Family history	1.88 (0.68-4.66)	0.246	1.99 (0.48-8.43)	0.343	1.83 (0.51-7.52)	0.431
Usually not walking or cycling to-and-from school	1.67 (0.95-2.72)	0.067	1.92 (0.82-4.33)	0.130	1.77 (0.98-3.83)	0.067
≥4 h of sitting activity	1.36 (0.65-2.61)	0.301	1.44 (0.59-3.47)	0.375	1.14 (0.33-3.33)	0.754
Inadequate other daily physical work (including outdoor sports)	1.82 (0.95-3.55)	0.068	2.39 (0.86-6.41)	0.083	2.59 (1.22-5.66)	0.033

Most of the times going hungry at home	1.42 (0.72-2.89)	0.321	1.35 (0.55-3.36)	0.714	2.51 (0.78-8.21)	0.121
Eating fruits less than once a day	2.42 (1.62-3.77)	<0.001	3.54 (1.97-6.28)	<0.001	3.16 (1.70-5.27)	<0.001
Eating vegetables less than once a day	1.97 (1.19-3.54)	0.022	4.74 (1.94-11.79)	0.001	1.28 (0.53-3.04)	0.364
Intake of soft drinks more than thrice a week	2.42 (1.52-3.88)	0.001	2.37 (1.31-4.11)	0.002	4.51 (1.95-10.61)	0.001
Intake of fast food more than thrice a week	3.15 (1.97-4.86)	<0.001	3.13 (1.74-5.44)	<0.001	4.60 (1.81-10.75)	<0.001
CI: Confidence interval						

Table 3: effects of overall dietary habit and physical activity adjusting for gender age group of the respondents

Factors affecting development of overweight	Overall (n=100)		Female (n=62)		Male (n=38)	
	Risk ratio (95% CI)	P	Risk ratio (95% CI)	P	Risk ratio (95% CI)	P
overweight and obesity						
Main effects						
Sex: Female	7.57 (3.83-14.25)	<0.001	-	-	-	-
Age group: Older (>16-years)	9.66 (4.64-18.51)	<0.001	10.67 (5.64-21.47)	<0.001	20.45 (5.88-72.22)	<0.001
Overall physical activity: Inadequate	6.69 (3.83-10.94)	<0.001	13.86 (6.68-28.57)	<0.001	8.59 (4.83-15.23)	<0.001
Overall dietary habit: Unhealthy	8.73 (5.49-13.91)	<0.001	10.78 (5.79-19.41)	<0.001	14.91 (8.67-25.66)	<0.001
Interactions						
Inadequate physical activity and unhealthy diet	0.39 (0.16-0.81)	0.014	0.22 (0.05-0.72)	0.015	0.13 (0.04-0.37)	<0.001
Female and inadequate physical activity	0.33 (0.15-0.89)	0.012	-	-	-	-
Female and unhealthy dietary habits	0.38 (0.16-0.72)	0.015	-	-	-	-
Older age and Inadequate physical activity	0.26 (0.11-0.64)	0.002	0.11 (0.03-0.43)	0.001	0.79 (0.16-5.17)	0.703
Older age and unhealthy dietary habits	0.23 (0.08-0.63)	0.002	0.22 (0.06-0.69)	0.011	0.14 (0.03-0.55)	0.007

Discussion

In consonance with the findings of the other researchers, [21-26] prevalence of obesity and overweight was observed to be on a rising note in the current study as well with a sharp rise of around 9% among the participants. Since overweight and obesity are itself time-varying dynamic condition, the difference observed is actually a net increase (newly developing overweight – those returning below overweight BMI category); therefore, this can be regarded as a “net incidence,” which is in fact a proxy marker for incidence of the morbidity under discussion. In a comparative study in West Bengal, Ghosh [22] found the prevalence of overweight and obesity to be higher in urban area. However, the proportions depicted in that study in the rural areas were very much comparable to the baseline findings of the current study. Craig et al. [27] found that in rural South Africa, the effect of female sex on development of obesity was very high. The findings

were supported by the current study through the obtained risk estimates, which were indeed high. This was also the case in several of the India studies [21,25,26,28] and also consistent with NFHS-4 report. [29] Several authors studying the risk factors of obesity have concluded with behavioural modification, diet, and physical activity being their part, [23,24,26,30] but were not able delineate the effect size or the relative risk of these behavioural factors. In the current study, by virtue of its longitudinal design, the risk estimates for different modifiable factors adjusting for the non-modifiable factors were obtained.

There is strong evidence of dietary practices being more rigidly related to overweight among the adolescent. Although inconsistent conceptually, the variables of physical activity did not show statistical significance individually in the primary model. However, the significance of cumulative effect was derived from the interaction model. It was observed

that age itself was a more important predictor of overweight and obesity among females than males. Among the dietary factors studied, fast food intake followed by soft drinks intake was the most vital risk factors identified. These are even more important in case of females. The cause may be that the girls tend to eat and drink these items more compared to boys in the rural area. However, less vegetable intake was more detrimental in case of boys, as observed in the study. The likely explanation for this lies within the fact of less consumption of vegetables by boys as compared to girls, with boys receiving more calorie and protein intensive diet. Goyal et al. [26] showed that the lifestyle factors have an enormous effect on overweight and obesity, which are similar across different socioeconomic groups. However, the invariance of effect across different groups was not studied currently; rather the cumulative or crude measure of effect was noted.

It is well understood that the risk factors of the NCDs itself form a spectrum with intricate interrelation. The current study attempted to capture the effect of two selected factors contributing to obesity adjusting for some non-modifiable factors. One of the drawbacks in the study however remains with the use of questionnaires, as conscious falsification by the respondents would always create a skewed result. Because sections of a class were selected, the study could have encountered selection bias at the initial phase. The current study despite being school-based, an individual-level longitudinal study was conducted thus overcoming the probable source of ecological fallacy. An interventional design with a higher power (larger sample size) will help to get a more precise result in future. The recommendations that emerged from the study were that healthy dietary practices and physical activity should be promoted to mitigate the risk of obesity. Increasing awareness among the girls regarding the ill-effects of junk foods and soft drink is also needed. Since in the rural areas, still farming remains the dominant profession, adolescents should be encouraged to consume more fruits and vegetables; this, however, is more required for the male child. The teachers and the parents should be educated and motivated about behavioural change trainings of the adolescents. With the increase in overweight and obesity in such epidemic proportions, the regular school-based health checkups are a generic requirement.

Conclusion

Strong evidence was generated of dietary practices being more rigidly related to overweight among the adolescents. Healthy dietary practices coupled with physical activity should be promoted to mitigate the risk of obesity.

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