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Protective Effects of Vegetarian Diet on Aggressiveness in School Going Children

Research Article

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Abstract

Background: Nutrition quality and dietary patterns affect health, cognition, emotions and behavior. Aggressive and anti-social behaviors by adolescents and youth have been increasing world-wide. Measurements of correlations between vegetarian and omnivorous dietary patterns and aggressiveness in children are of interest for developing cost-effective strategies to reduce anti-social behaviors.

Objectives: To assess the effects of Indian dietary patterns on aggressiveness in school-going children.

Methodology: Cross-sectional study with students studying in III –V classes in private co-educational schools in New Delhi. Demographic characteristics of the study sample, including the socio-economic status were recorded after obtaining informed consent of parents. Aggressiveness and dietary patterns were determined from self-report questionnaires. Data were analyzed statistically using Chi-Square test. Relationships between dietary patterns and aggressiveness were compared between genders, socio-economic status by effect-sizes (Cohen's d).

Results: Average scores of overall-aggressiveness as well as reactive- and pro-active aggressiveness were observed to be lower in lacto-vegetarians as compared to omnivores both in boys and girls. The effect sizes of the lacto-vegetarian dietary pattern were, small (-0.12 to -0.20) and statistically insignificant. Interestingly, the protective effects of lacto-vegetarian diet were less in lower socio-economic status and in females.

Discussion: Small intake of eggs and meat (once or twice / week) by the omnivore children and consumption of junk-foods may explain the small effectsizes. Diversity of gut-micro-biota resulting from the presence of fibers, anti-oxidants and poly-phenols in the vegetarian diets could underlie the physiological mechanisms.

Conclusions: Limited but consistent data in the present study, support the hypothesis that lacto-vegetarian Indian diets can reduce aggressiveness, violence and anti-social behaviors. Implications of vegetarian and vegan foods for academic performance, social wellness and environmental protection warrant comprehensive studies on large samples in diverse geographical and cultural environments.

Keywords: Aggressiveness; Anti-Social Behavior; Dietary patterns; Eggs; Lacto-Vegetarian; Meat; Omnivore; Junk food

Introduction

Adequate nutrition is vital for survival, good health and behavior. The importance of dietary contents and dietary patterns for human health and welfare has been recognized since ancient times [1,2].

In the present world scenario, eating habits are changing fast due to the development of food industry and intensive marketing by food companies. Several empirical and observational studies have reported that diets involving consumption of meat and / or junkfoods are associated with maladaptive behaviors negatively affecting mood, emotions and cognition [3,4]. Increase in easy availability and consumption of pre-processed and preserved foods (fast or junk food) has also been linked with many anti-social behaviors and psychosomatic chronic diseases like obesity, diabetes, cardiovascular problems and cancer [5,6]. Such unhealthy eating habits as part of modern life-styles are emerging issues of public health all over the world.

Plant based vegetarian diets, in contrast, act to reduce the risk of

aggressive behavior [7,8,9,10]. Because of the potential health benefits of plant-based diets, researches to investigate effects of various vegan and vegetarian dietary patterns have been growing in recent years [7]. Most of such studies aim to investigate physical health. Previous studies regarding the behavioral effects of nutrition have primarily focused on adults. Only a few studies deal with the effects of dietary patterns on mental health associated behavioral issues, such as aggressiveness, conduct disorders and criminal behaviors, especially in children and adolescents. Children, due to their developing organs, neuro-muscular and cognitive systems in particular, are likely to be more vulnerable to chemical agents absorbed within the body. The skills, cognition and behavioral patterns acquired during childhood are likely to have lasting effects influencing adult life. Additionally, behavioral effects are relatively easier to observe in children and adolescents. Systematic and comprehensive research on relationships between dietary patterns and mental health issues in children would be, therefore, very relevant for public health and wellbeing [11].

Aggressiveness is the tendency to physically or psychologically hurt other living beings or their environment. Displayed in many forms, aggressiveness can be reactive as an impulsive reaction to some provocation or proactive, well planned, motivated and aimed to attain a goal [12]. In the past few decades, aggressiveness of both kinds has been observed to increase in all sections of the society worldwide [13]. Children with persistent high aggressiveness are at higher risk of developing anti-social behaviors and conduct disorders leading to violent crimes in later life. The issues could be serious in children with low IQ [14]. In India, crime and violent activities have been reported to increase day by day, especially by juveniles' population [15-17]. Therefore, there is an urgent need to develop strategies prevent these serious issues in a cost effective and easy to implement manner [18, 19].

To develop effective preventive strategies, it is important to identify individuals at risk and the risk modifying factors. Within this framework, a previous cross-sectional epidemiological study was carried out on children from low socio-economic status families attending government primary schools in urban environment of an Indian metropolitan city. It was observed that vegetarian diets and co-educational environment are important risk-reducing (protective) factors [8]. The purpose of the present study is to examine the correlations between dietary patterns and aggressiveness in children and adolescents belonging to middle socio-economic families and attending co-educational private primary schools.

Material and Methods

Ethical Clearance, Study Sample and Setting

Clearance from Ethical Committee of JVBI and permission from School authorities was obtained to conduct the study on primary school students. Informed consent in the prescribed form was obtained from the parents/guardians of the participants before starting the study. The data were collected during the academic session 2018–2019.

The sample consisted of 399 healthy school children (247 males: 152 females) from 3rd to 5th standards of three private primary schools located at Chattarpur, Mehrauli and its neighboring areas in

New Delhi. Children suffering from any serious physical or mental disabilities and who did not attend the self-report sessions regularly or correctly were excluded.

Methodology

Methods were similar to our previous study. ^[8] The sociodemographic variables such as age, gender, type of diet were recorded on prescribed forms. The instrument used in the present study to quantitatively assess levels of aggressiveness was a simplified Hindi version, based on a self-report questionnaire [8]. The questions pertained to 16 items related to reactive (8 items) and proactive (8 items) aggressive tendencies. Students in the class were asked to truthfully answer each question on a 4-point scale questionnaire, the overall aggressiveness score (OA-score) is measured between 16 (minimum) - 64 (maximum). The modified Hindi version of the selfreport aggressiveness scale was tested for validity and reliability as described earlier [8].

Children with OA-scores 16 to 32 were broadly categorized as low; those with OA scores 33 to 48 as moderately aggressive and children with OA-scores 49 to 64 as highly aggressive.

The self-report questionnaire (SRQ) for Diet-Quality (DIFQ) consisted of 24 item based on a 4 point scale (1-4). The food items were divided into three broad categories viz. (i) *Satvik*: basic Indian vegetarian food consumed at home such as Daal, Roti, Rice and cooked Vegetables, (2) *Rajsik*: deep fried and high salt and spice based diet and non-vegetarian dishes containing eggs, meat, chicken, fish etc. and *Tamsik*: fast food based diet (junk food) containing processed food, packed snacks, carbonated soft drinks and street foods like Chaumin, Momos or French fries etc. The SRQ included 8 questions for each category, validated and tested for reliability.

Statistical analysis

Data collected on printed datasheets were double entered into Microsoft Excel Sheet and validated. A clean database was generated and copied into IBM SPSS Version 25.0 for further analysis. Frequency distributions of OA-scores in the study population were analyzed and associations with different socio-demographic variables were examined for statistical significance using Chi Square test, $P \le 0.05$ (Confidence level 95%) was considered significant. To determine the strength of the relationship between diet and aggressiveness, effect-size [Cohen's d (w) = (M₂ – M₁)/SD _{Pooled}] were calculated.

Results

Socio-Demographic Characteristics of the Study Sample

Excluding subjects who did not attend the self-report sessions regularly, the sample comprised of 399 subjects of middle socioeconomic status (MSES) families of skilled or semi-skilled income earners. Majority of parents were literate or studied up to graduate level. The average family income varied between Rs. 25,000 and 50,000 per month (Table 1).

Aggressiveness Profile and Prevalence

Figure 1 shows the distributions of the over-all aggressiveness scores (OA-Score) measured using the self-report questionnaire.



Table 1: Socio-demographic Characteristics of the population.

Characteristics	Participants (N, %)		
Total Subjects	399 (100%)		
Age (years) 7-10, (MEAN = 09.06 ± 0.87) 11-13, (MEAN = 11.39 ± 0.63)	348 (87.2 %) 51 (12.8 %)		
Gender Male (Age range:7 Yr-13 Yr., Mean Age: 9.46±1.18) Female (Age range: 7 Yr-13 Yr., Mean Age:9.19±1.07)	247 (61.9 %) 152 (38.1 %)		
Religion Hindu Muslim	382 (95.7 %) 17 (04.3 %)		
Dietary Pattern Omnivore Vegetarian	240 (60.2 %) 159 (39.8%)		
Family Type Nuclear Joint	241 (60.4 %) 158 (39.6 %)		
Mother s Status House wife Working	339 (85.0%) 60 (15.0%)		
School Environment Co-education (Pvt. School at Chhatterpur in Urban Delhi)	NLS 98 (24.6 %) SBM 91 (22.8 %) SNP 210 (52.6 %)		

The distribution of OA-Score of sample population follows normal distribution. The average OA-score of the sample is 34.72 (SD \pm 9.41). The observed heterogeneity in the OA-scores is not unexpected since a number of biological (gender, age, genetic predisposition), socio-cultural (religion, dietary patterns), socio-economic and socio-environmental (home, school, community) factors are known to significantly influence child's behavior. From the distribution of the OA-Scores, 3 sub-groups of children have been distinguished. Low-aggressive children (OA-Score 16 -32) comprised 42.6%; moderately aggressive (OA-Score: 33 -48) were 49.4% and highly aggressive (OA-Score: 49 - 64) were 8%.

Dietary Patterns

Information was obtained from SRQ about the type of diet provided to children at home (Table 2). Students were not provided mid-day meals in the private schools.

Data in Table 2 indicate that the major qualitative difference between the omnivore and lacto-vegetarian dietary pattern concerns the inclusion or exclusion of eggs and meat (chicken, fish) products.

Students eat their basic diet which is generally *Satvic* (lacto-vegetarian), thrice in a day as breakfast, lunch and dinner. Rice, Roti, Daal and Sabzi (cooked vegetables) are used as the staple diet. Other foods like cheese, meat, egg are taken mostly one or two times in a week or occasionally for a change or variation in daily diet routine. Notably, however, the frequency of junk foods is relatively high- 3 to 5 times in a week.

All participants were aware about the healthy food choices. Most of the students take milk and curd or yogurt at least once in a day. They also take sprouts (Chana and Mung daal) at least once in a week as a healthy choice. Schools also encourage students to eat seasonal fruits like Banana, Mango, Oranges and Apple etc.

Curd, Cheese, Pickles and fresh sauces (general ingredients used are Coriander, Mint and Ginger, Garlic, Tomato, Onion and Chili, Pepper etc.) are frequently used options in the diets of both vegetarian and omnivore groups of the participants. Home food is mostly cooked in Deshi Ghee (clarified butter) or Mustard oil. Participants did not take alcohol containing drinks and were free from smoking habits.

Average Aggressiveness Scores of OMN and LVEG Children

It is observed that omnivores display higher levels of aggressiveness as compared to lacto-vegetarians (Figure- 2 & 3). in agreement with previous reports. [8] Interestingly, the observed influence of dietary

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Table 2: Dietary patterns and diet quality of Children Attending Private Primary schools in New Delhi (Gross Estimation).

Food Group	Manual Missa Mutainta	Intake Frequency in a week		
(Components)	macro- and micro-Nutrients	Omnivores (OMN)	Lacto-Vegetarians (LVEG)	
Cereal Grains (Wheat, Rice)	 Bran: fiber omega-3 fatty acids, vitamins and dietary minerals Endosperm: mainly starch (3) Germ: vitamin E, folate, thiamine, phosphorus, magnesium 	7 Times	7 Times	
Pluses, Beans, Gram	Proteins, Fibers, low Glycemic index diet, low fat, Folate, Iron,	7 Times	nes 7 Times	
Vegetables and Fruits (cooked, Raw)	Vitamins, Minerals, Dietary Fibers, Antioxidants	7 Times	7 Times	
Dairy (Milk, Curd, Cheese)	Calcium, Protein-complex and pro-biotic advantages	7 Times	7 Times	
Spices (Currys, Pickels, Murabba, Fresh Sauces; Chilli, Pepper)	Micronutrients, Vitamin C, Ash, Fiber, Satiety	7 Times	7 Times	
Fats (Oils, Ghee)	Omegas, vitamins, energy and Satiety	7 Times	7 Times	
Fast Food (Noodles, Momos, Fried Namkeen, Chips) Soft- Carbonated Drinks, Sweets etc	High Sodium, MSG, Calories, Trans fats,	3 to 5 times	2-4 Times	
Eggs	Proteins, Cholesterol	1 - 2 times		
Meat (Chicken)	Proteins, fats	1 - 2 times	Nil	
Fish (Mostly not eat)	Proteins, fats 1 - 2 times			

 Table 3: Protective effects of vegetarian dietary pattern on aggressiveness of Co-Ed Primary school children.

SES	Variables	N (%)	Effect Size	X ² (DF)	p-value
Middle SES ¹ N = 399 Mean age:	Male (Total) Male -OMN Male –VEG	247 (61.9) 156 (63.2) 091 (36.8)	- 0.20	0.06 (2)	0.96
9.36 ±1.15 Age range : 7 Yr-13 Yr.	Female (Total) Female-OMN Female-VEG	152 (38.1) 083 (54.6) 069 (45.4)	- 0.16	0.03 (2)	0.98
Low SES ² N = 745 Mean age 9.02± 1.26	Male (Total) Male -OMN Male -VEG	342 (45.9) 155 (45.3) 187 (54.7)	- 0.18	0.29 (2)	0.86
Age range 6 Yr-14 Yr.	Female (Total) Female-OMN Female-VEG	403 (54.1) 174 (43.2) 229 (56.8)	- 0.12	0.03 (2)	0.98

i) Middle SES, Pvt. Schools of Urban Delhi.

. ii) Low SES, MCD Schools of Urban Delhi (Data taken from Jain et. al 2018) ^{*} p ≤ 0.01 is consider statically significant

patterns on aggressiveness is also less in girls (Figures 2 & 3). Notably, the calculated effect-sizes are, however, small especially in the female group. The average OA-scores are lower in girls than in boys (Table 3, Figures 2 & 3).

Discussion

Important Findings

The present study provides epidemiological evidence in support of a protective role of vegetarian diet against aggressiveness. Key findings, underlying possible biological mechanisms and implications are briefly mentioned below.

Aggressiveness Profile and Dietary Pattern-Effects of LVEG Compared to OMN Dietary Patterns on AG

The present data indicate that the intake of Indian LVEG diet by school going boys and girls display lower aggressiveness in comparison to subjects whose diet also includes meat and eggs (Figures 2 & 3). This trend is in agreement with earlier reports and is observed not only in the average OA-scores but also in subgroups of RA and PA [8]. LVEG diet is healthier and beneficial due to gut friendly nature and high contents of fibers and antioxidants [20-22]. The major dietquality difference between the LVEG and OMN diets is the intake of chicken and eggs (Table 2). Results suggest that non-vegetarians are likely to be at greater risk of developing into aggressive, violent and anti-social personalities.

Protective Effects of LVEG Diet are Small and Statistically Insignificant: The effect-sizes for LVEG protective risk-factor for aggressiveness (calculated Cohen's d) in the present study are small and statistically insignificant (Table 3). This may be due to several factors: (A) small intake of eggs and meat (only one or two times in a week) by children in the OMN group (Table 2); (B) OMN children also take the LVEG diet which forms the basic staple diet of the Indian children; (C) Consumption of processed and preserved foods (junk food) containing ingredients rich in salt, sugar and high trans fats and addictive agents, such as MSG. Based on these considerations, larger protective effect sizes of vegetarian or vegan diets would be expected in populations consuming eggs, meat and processed foods on daily basis.

Females are Less Aggressive and Less Susceptible to Dietary Patterns: The average OA-scores of females are lower than Males in both the OMN and LVEG groups (Figures 2 & 3). This is in agreement with most of published reports.

Interestingly, our data indicate that the LVEG protective effectsizes are also lower in females (Table 3), which suggest that males are likely to be more susceptible or sensitive for diet quality and aggressiveness.

The gender differences can be explained by the known differences in chromosomes between females and males (XX vs XY) and associated body structures, gene expressions, neuro-endocrine status, basal metabolic rates (BMR) and immune responses. Additionally, dietary preferences may also be a factor in the gender-dependent

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effects. In this study percentage of female vegetarians was 45.4% as compared to male vegetarians 36.8%. The higher prevalence of vegetarianism in female population as compared to male population supports the theory of evolutionary development and differences in physiological and psychological requirements of the sexes.

Consumption of Dairy products

The data clearly show that the LVEG and OMN take dairy products specially Milk and curd regularly in same frequency (Table 2). Regular consumption of dairy products are beneficial and consider as health protective supplement food but in detailed analysis of the chemistry of milk indicates that some chemical compound especially BMC-7 delayed psychomotor development and have possible negative effects on neuro-psycho function of the consumer [23-25]. This warrants further studies.

Consumption of Spices

Present data indicate that the frequency of eating spices is likely to be somewhat less in LVEG group (Table 2). A variety of spices, particularly turmeric, cumin, coriander, chilies, clove, cinnamon and pepper are popular and important constituents of Indian diet. Spices have been used in India since ancient times for improving flavor, color and medicinal value [26]. Recent studies have reported that some spicy foods are associated with aggressive behavior and can trigger aggression. Regular consumption of chili, peppers or similar spices may raise the level of hormones in men and make them adventurous or hyperactive [27, 28]. This warrants further studies.

Addiction to Junk Foods

Junk Foods (JF) mostly consist of processed, ready to eat food items called fast foods. Fast food items are, energy dense, rich in high sugar, salt and trans-fatty acids. Fast food items such as potatochips, coca-cola, instant noodles etc. are usually contaminated with preservative chemicals, coloring and addictive agents such as MSG, which are added to increase shelf-life and to make them attractive and tasty. Despite the well documented harmful effects, the consumption of JF by children, adolescents and youth has increased rapidly due to intensive promotion by the food industry in last few decades [29,30]. Data in Table 2 indicate that many children in OMN as well as LVEG groups eat junk food quite frequently, in agreement with other published surveys in India [31, 32].

Aggressiveness Scores are higher in MSES Children

Notably, the present data indicate that children from middle socio-economic status (MSES) families attending private schools show slightly higher levels of aggressiveness as compared to LSES children going to public schools (Figures 3-4) [19]. For example, in MSES children the average OA-score of omnivore boys is observed to be 36.89 against 34.96 in vegetarian boys. In contrast, in the previous work with LSES children, average OA-score was lower being 35.05) in OMN boys and 33.75 in LVEG (Figure 4). These results are not in agreement with some published reports, where it has been shown that children from LSES display higher aggressiveness as a consequence of adverse conditions they have to face [33]. Greater quantities of junk foods, consumed by MSES children may be one of the factors underlying this trend [34]. Further studies on larger sample sizes are needed to clarify this controversy.

Physiological Mechanisms Underlying Beneficial Influence of LVEG Diet

Researches to identify the processes responsible for the effects of dietary patterns on health and behavior are gaining importance because of implications for developing Nutritional Medicine and environmental protection.

Several epidemiological studies have provided evidence that vegetarian diets are generally associated with lower risks of chronic psychosomatic disorders. The protective effects of the vegetarian diets could be due to complex interplay of several biological processes such as differences in BMR, BMI, hormone levels, amino-acids mainly Tryptophan and Tyrosine, fatty-acid as omega-3 and type of carbohydrates micronutrients [35]. Based on recent literature, some of the important processes are outlined in the following:

Lower Energy Intake, BMI and BMR in Vegetarians

Energy intake has been shown to be directly related to Body Mass Index (BMI) and energy intake of males is greater than females [36]. The present study indicates that males showed higher AG scores compared to females suggesting that energy intake options can directly affect AG quantitatively and qualitatively. Vegetarian foods are known to be less energy dense (kcal g⁻¹) as compared to meat containing and processed foods. Vegetarian diets associate significantly with lower BMR and BMI of the consumer due to its contents of low calories, proteins and zinc which further affect the hypothalamus- pituitary- thyroid- axis (HPTA) leading to changes in metabolism, mood and immunity. Similar changes also underlie aggressiveness [37,38,39,40].

Gut Micro-Biome Profile Differences induced by LVEG and OMN Diets

There is a bidirectional relationship between gut micro-biome and brain development and function (GI-Brain Axis). Profile of human gut micro-biome is profoundly influenced by multiple factors including the type of daily food intake, emotional states and social interactions, inflammation and immunity [41,42]. These are mediated by mechanisms like production of neurotransmitters (such as dopamine, serotonin, nor-epinephrine, acetylcholine and GABA, Gut-brain axis (GBA) between the CNS and enteric nervous system, by synthesis of nutrients such as vitamins (B-complex group and short chain fatty acids) and immunity modulation [41,43,44,37].

It is noteworthy that the diversity of micro-biome is dependent on the quantity and quality of animal products or fibers (pre-biotics) consumed and is higher in vegetarians and vegans compared to omnivores. Non-vegetarian and Junk foods [45,46], which are consumed by the majority of population living with modern life style, significantly decreases the diversity of gut-micro-biota. These factors warrant further investigations in children in relation with aggressiveness and delinquent behaviors.

Oxidative Stress and Role of Anti-oxidants in Protection against Brain Damage

The protective effects of the vegetarian diets could be due to higher amounts of anti-oxidants such as ascorbic acids (vitamin C),

flavonoids and polyphenols in plant-based diets [47,48]. Oxidative stress in vegetarians has been found to be lower as compared to omnivores [35]. Digestive and metabolic activities of meat based diet, on the other hand, elevate the oxidative stress in the body [49]. Several studies have reported that higher levels of free radicals in human body are related to brain cell damage, defective brain development, neuro- degeneration and cognitive impairments [50-52]. Intake of anti-oxidant rich diet especially vitamin C, green or yellow vegetables could, therefore, protect against childhood hyperactivity, conduct and emotional problems [24,54]. These facts support our data indicating lower levels of aggressiveness in vegetarians.

Brain Development and Stress Coping Capacity

Stress, in particular psychological stress, is a predictor of aggressiveness [19]. Empirical studies suggest that vegans and vegetarians can cope with mental stress in better ways and have less mood disorders as compared to non-vegetarians [9,10]. Interestingly, psychological stress and mood disorders show positive correlations with inflammation in brain cells. Presence of flavonoids and polyphenols in the diet can reduce the gene expression of pro-inflammatory markers and increase the blood circulation in the brain [55]. Low calorie short-chain poly-unsaturated fats (PUFA) in plant based fats are also associated with proper development of the nervous system and cognitive faculties. Detailed studies of these relationships, particularly in children with high aggressiveness, would be interesting.

Limitations and Strengths of the Present Study

The study design, sample, and methodology used suffer from several limitations: (1) it is a cross-sectional observational study with a sample confined to primary school-going children from private schools in a particular locality of New Delhi. (2) Aggressiveness is assessed only from self-report questionnaires without any further confirmation by biological markers. (3) The dietary patterns have been categorized in a general way as omnivorous and lacto- vegetarian without precisely measuring the diet quality. (4) Contribution of Consumption of JF, a confounding factor, has not been assessed separately. (5) Family and community environments not considered and (6) the protective effect sizes of LVEG diet are modest and statistically insignificant, restricting the generalizations of the results.

Important strengths of the study are: (1) Sample size of about 400 children from a relatively similar socio-economic status families (2) Reliable estimates of aggressiveness profiles and identification of low, moderate and highly aggressive subpopulations of children from 3 private primary schools have shown similar trends (3) Effects of dietary patterns on aggressiveness compared in boys and girls from two different SES. (4) Important physiological processes underlying the protective effects of Indian LVEG diet identified on the basis of available information from literature. (5) Data provided new insight on the associations between aggressiveness, socio-economic status and diet of children.

Conclusions and Implications of the Present Study

Despite the limitations, the epidemiological data presented in this study draw attention to (i) exclusion of meat and eggs from the diets and inclusion of contents which are rich in fiber, antioxidants and pre/pro biotic foods as in Lacto-vegetarian Indian diet, is an important risk-reducing (protective) factor against developing high aggressiveness and antisocial behaviors, especially in boys.

Considering the social implications of the study for youth - violence, mental health, cognitive impairments and psychosomatic diseases, it is suggested that: (i) Large-scale investigations in populations with different geographical and cultural background should be undertaken. (ii) Since predictors of aggressiveness are similar for cognition abilities, it is suggested that relationships between diet, aggressiveness, intelligence and academic performance of school going children should form an important topic in future studies.

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Conflicts of Interest

There are no conflicts of interest.

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