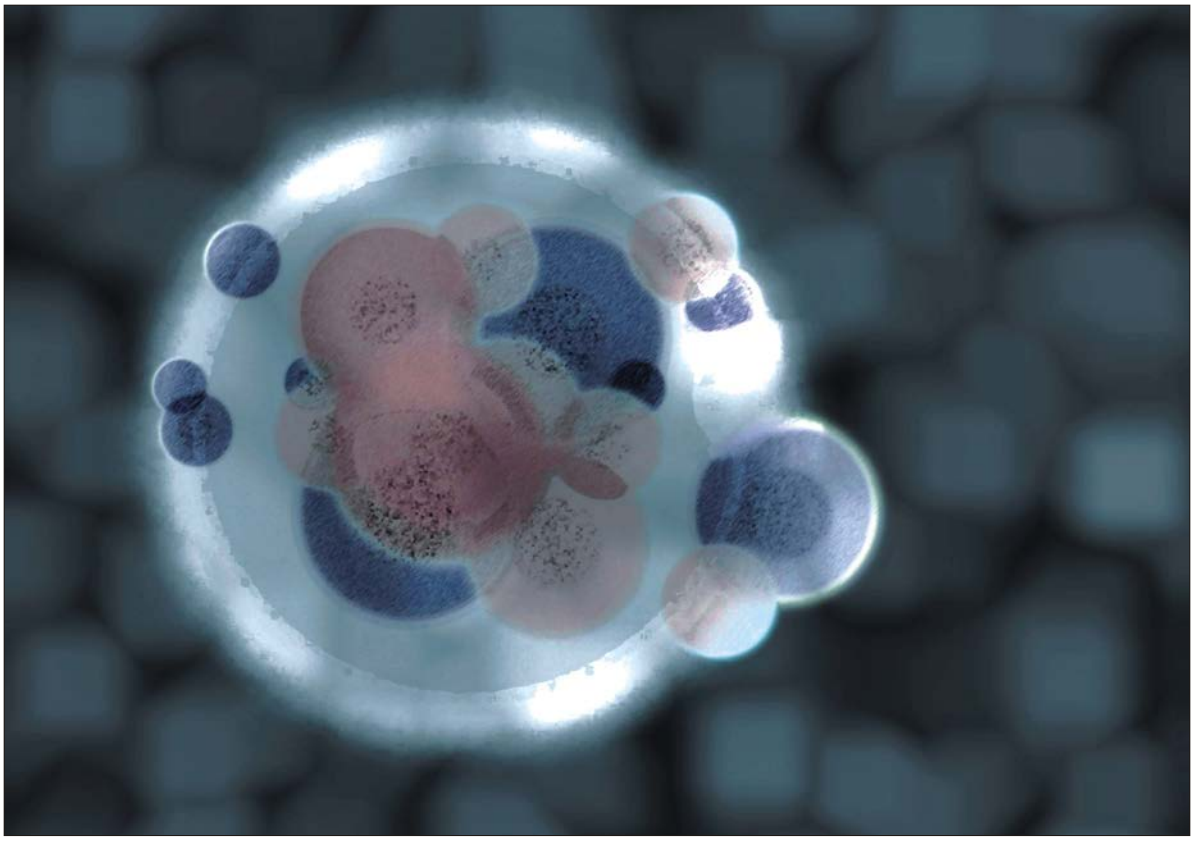

Journal of Biological Sciences

ISSN 1727-3048

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Journal of Biological Sciences 8 (7): 1246-1250, 2008
ISSN 1727-3048

Effects of Nutritional Deficiency on Visual Acuity

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Abstract: This research reports the findings of the study carried out to determine the effects of dietary intake on visual acuity in high school children in and around Mthatha district of Eastern Cape province, South Africa. One hundred and forty three students, aged 14-20 years were randomly selected from one of the schools in Mthatha. Snellen's eye chart and a food frequency questionnaire were used to collect the information. About 16% of the subjects had poor vision. Statistical analysis showed a clear association between the scores of protein and vegetables intake with visual acuity. Diet poor in proteins, fruits and vegetables led to poor visual acuity in the subjects. Carbohydrate diet had no influence on visual acuity.

Key words: Visual acuity, food frequency questionnaire, Snellen's eye chart, vitamin a deficiency

INTRODUCTION

Vision is the primary means of integration between individuals and external environment. It has been estimated that 75-90 % of all learning in the class room comes to the students either wholly or partially via the visual pathway (Negrel *et al*., 2000).

Visual problems have negative effects on learning and social interaction, thus affecting the natural development of academic and social abilities. Uncorrected refractive error is recognized as the principal cause of visual impairment in school aged children.

In the beginning of 1998, a series of visual acuity study in children were carried out in several geographic areas: a rural district in Eastern Nepal (Pokharel *et al*., 2000), the semirural Shunyi district near Beijing, China (Zhao *et al*., 2000), the urban La Florida area of Santiago, Chile (Maul *et al*., 2000), a rural area near Hyderabad in Southern India (Dandona *et al*., 1999), an urban area of New Delhi, India (Murthy *et al*., 2002), a semi-rural/urban area of Durban, South Africa (Naidoo *et al*., 2003) and most recently in Guangzhou, China (He *et al*., 2004). These population based surveys of school aged children document the wide variation in visual impairment across different areas of the world. Of the approximately 1.4 million children with blindness in the world, about 75% live in high poverty areas in Asia and Africa. The major cause of blindness is refractive errors.

Throughout Africa, the main meal of the day is lunch, which usually consists of a mixture of vegetables, legumes and sometimes meat (Lentz and Carola., 1999). However, though different meats are considered staples in many areas, many Africans are not able to eat meat often, due to economic constraints. Beef, goat and sheep (mutton) are quite expensive in Africa, so these foods are reserved for special days. However, fish is abundant in coastal regions and in many lakes. The combination of various foods is called stew or soup depending on the region. This mixture is then served over a porridge or mash made from rice or corn. Regional differences are reflected in variations on this basic meal, primarily in the contents of the stew. In urban areas, however, the diet of (black) Africans is increasingly dependent on meat as well as on empty calories from prepackaged foods. The result is an unbalanced diet.

The purpose of this study was to investigate the visual acuity in relation to dietary intake in high school children. Findings from this study will help to make appropriate recommendations to identify and to treat the visual impairment in an early stage so that it will not affect the academic and social development of the students.

MATERIALS AND METHODS

Subject selection: This is a cross sectional study with systemic sampling done in 2006. A random selection of 10 classes out of 25 totaling 400 students, from one of the schools in Mthatha was requested to participate in the study. The principal of the school was contacted and informed consent obtained after a detailed explanation of the purpose, content and benefit of the study. Each volunteer was interviewed and the procedures as well as

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the benefits of doing the study were explained to each subject. Each subject was required to acknowledge in principle that they fully understood the reasons for the study and what was required of them. Furthermore they were required to sign a consent form, which gave permission to use them as subjects.

Methods

Snellen test for visual acuity: US criteria was adopted for measuring the visual acuity. The subjects in this study were considered to have visual impairment, if their best visual acuity was below 20/30. Visual acuity was measured in a quiet room of 10×8 m size, using a properly illuminated Snellen chart at 6 m to discriminate different letters:

- Each eye was tested separately and was allowed to repeat the procedure three times
- A child, who wore eye glasses were examined with their glasses appropriately placed
- Letters in the charts are of a size that can be seen by the normal eye at a distance of 6 m (20 feet) from the chart
- Letters appear in rows and are arranged so as the normal eye can see them at distances 9, 12, 15 m (30, 40, 50 feet) and so forth
- A person who could identify the letters of the size 6 at 6 m (20 at 20 feet) was said to have 6/6 (20/20) vision
- The result from the best of the two eyes was used to determine visual acuity

The numerator expressed the distance between the observer and the letters while the denominator expresses the distance at which they could be distinguished by the normal eye.

Food frequency questionnaire: The food frequency questionnaire included three basic food groups: protein rich; carbohydrate rich; and vegetables and fruits. The protein group comprised of animal products such as eggs, dairy products, organ meats and fish. Carbohydrate group comprised of cereals, bread and other commonly used food and a variety of fruits and vegetables containing beta carotene, which the body converts into vitamin A were included in the questionnaire. Subjects were asked to complete the questionnaire.

Different ratings were given to these food stuffs based on the frequency of consumption like 2-3 times daily, daily, 2-3 times a week, once a week, once a month and never in the order 5 to 0. For each food group, the individual food item scores were added to derive the aggregate food scores for the group. The aggregate food scores for carbohydrates, proteins and fruits and vegetables were 40, 30 and 45, respectively. Subject's questionnaires were treated with confidentialities and the subjects were informed as such.

Anthropometric measurements: A single measurement of height was taken while the subject was standing with heels together against the stadiometer with the body held in a maximally erect (stretched) position. Hands were placed on hips directed posteriorly and anteriorly, respectively. The head was held in the Frankfurt plane, the eyes and nose were directed straight forward and a maximum inspiration was taken. The subject was instructed to put hands on hips, look straight ahead and take a deep breath. The measurement was taken at the end of the inspiration.

Weight was measured while the subject was standing on the bathroom scale, minimally clothed (shorts, light weight shirt), feet comfortably spread with the weight evenly distributed on both feet and the hands-on hip position. Two readings were obtained. The subject was instructed to step off the scale between readings and the scale was zeroed between trials.

A single measurement of abdominal girth was measured at the level of the umbilicus at the end of expiration with the subject supine and breathing quietly. The hip girth was measured at the level of maximum protrusion of the gluteal muscles while the participant stood erect and the weight distributed equally over both feet.

A Lange Calliper (Cambridge Scientific Industries) calibrated to give a constant pressure (deleted) throughout the full range was used throughout the study. The skinfold thickness was read to the nearest 0.5 mm. The skinfold thickness was measured over the biceps (BCP), triceps (TRCP), subscapular (SSCP) and the suprailiac (SPIL) areas of the non-dominant side of the body.

Statistical analysis: All statistical analysis were done with the (STATISTICA), a commercially available statistical analysis software. The subjects were divided into those with normal vision and those with poor vision. Anthropometric measurements and dietary intake between the two groups was compared using the Mann-Whitney test. Correlation between dietary intake and visual acuity for each eye was done using the Spearman Rank Correlation test.

RESULTS

Visual acuity was measured in 143 out of a possible 400 subjects (38% response rate). Of these, eighty one were females and sixty two were males. 22 (16%) subjects showed poor vision. Table 1 shows that the mean height

Table 1: Summary of the participants in the study

Sex	Age (years)	Height (m)	Weight (kg)	BMI
Males	18±2	1.73±0.07	65±13	21.9±4.53
Females	17±1	1.59±0.06	60±12	23.7±4.75

Table 2: Food frequency questionnaire: Intake of carbohydrates

Variables	Mean	Minimum	Maximum	SD
Bread	4.14	0	5	0.70
Cereals	3.21	0	5	1.24
Rice	3.11	0	5	0.82
Umnqusho	2.06	0	4	1.02
Umvubo	1.33	0	4	0.95
Imbila	0.95	0	4	1.07
Umqa	0.57	0	3	0.73
Isigwampa	0.36	0	2	0.59

Table 3: Food frequency questionnaire: Intake of proteins

Variable	Mean	Minimum	Maximum	SD
Chicken	3.19	0	5	0.90
Milk	2.92	0	5	1.64
Egg	2.85	0	5	0.91
Beef	2.16	0	4	0.99
Fish	1.52	0	4	0.93
Pork	1.13	0	4	0.99

Table 4: Food frequency questionnaire: Intake of fruits and vegetables

Variable	Mean	Minimum	Maximum	SD
Carrot	2.78	0	5	1.15
Pumpkin	2.62	0	5	1.19
Spinach	2.47	0	5	1.17
Cabbage	2.37	0	5	1.28
Orange	2.16	0	5	1.14
Broccoli	1.57	0	4	1.39
Apricot	1.03	0	4	1.07
Papaya	0.46	0	4	0.84
Itolofia	0.17	0	4	0.50

Table 5: Visual acuity in school children studied

	Normal acuity	Poor acuity	Total
Male	68	13	81
Female	53	9	62
Total	121	22	143

and weight of males was slightly higher than the females although the Body Mass Index (BMI) was higher in females. From the food frequency questionnaire analysis it was revealed that the major reason for their poor vision was unbalanced food habits.

The most frequently used carbohydrate rich food among the school aged children were bread, cereals and rice and the traditional foods like imbila, umvubo, umqa and isigwampa were less frequently used (Table 2).

From Table 3, it is assumed that the most popular protein rich foods include chicken, egg and milk but pork and fish were less frequently used.

Among the fruits and vegetables orange, carrot, pumpkin, spinach and cabbage were frequently used. The mean score of the fruits and vegetables were lower than that of carbohydrates and proteins (Table 4).

Of the 121 children studied, 16% of the males and 14.5% of the females showed poor visual acuity (Table 5).

Table 6: Association between poor visual acuity and type of food intake

	Visual acuity		
Variables	Normal	Poor	p-value
Carbohydrates	15.53±3.03	16.78±3.04	0.070
Proteins	13.98±3.20	12.26±3.19	0.019
Fruits and vegetables	16.53±4.78	11.26±2.32	0.00001

Table 7: Anthropometric measurements of the students with good and poor visual acuity

Variables	Good acuity	poor acuity	p-value
Height	1.65±0.097	1.65±0.09	0.07558
Weight	60.76±10.95	68.45±18.23	0.07
BMI	22.53±3.99	25.24±7.30	0.012
Waist	70.91±9.51	76.23±14.1	0.027
Hip	94.35±10.4	99.00±15.24	0.09
Biceps	6.47±3.27	9.36±5.36	0.00084
Triceps	13.69±7.10	18.95±10.26	0.0035
subscapular	14.45±7.48	20.41±11.61	0.0021
Suprailiac	14.54±7.12	19.55±11.14	0.006
Total	215.00±40.39	243.68±61.66	0.0058

Table 6 depicts higher mean scores of carbohydrate ($p<0.07$)and lower scores of protein, fruits and vegetables for subjects with poor visual acuity. Subjects with normal visual acuity showed lower mean scores of carbohydrates and higher scores of , proteins ($p<0.019$) and significantly lower mean scores of fruits and vegetables ($p<0.00001$). This showed that carbohydrate had no effect on visual acuity but more Significantly the importance of fruits and vegetables in the diet.

In addition to the association between the food intake and poor visual acuity, the association between anthropometric parameters and visual acuity was studied. The data was subjected to Mann-Whitney test. Those with high BMI and more adipose tissue showed poor visual acuity. Skinfold thickness measurement showed an obvious relationship between excess adiposity and poor visual acuity, as shown by excess biceps, triceps, subscapular and suprailiac measurements. However, less significant association between waist and hip measurements (Table 7).

DISCUSSION

Although the present study is in line with many of the earlier reports, this report is the first of its kind in the region of Eastern Cape in South Africa which is previously disadvantaged in many respects. In addition some of the food consumed is unique to this region and this may explain some of the unique findings in the present study. The frequently consumed carbohydrate rich food among the school children are bread, cereals and rice. Most of the subjects didn't even know about the traditional foods like imbila, umvubo, umqa and isigwampa, which are prepared with grain products, leafy

vegetables and milk, thus rich in carbohydrates, proteins and vegetables. The mean scores of the fruits and vegetables are comparatively lower than that of carbohydrates and proteins. These habits lowered the intake of proteins and vitamins in their diet. High carbohydrate intake may take care of the energy needs but less likely the vitamin needs. Many children who experience academic difficulty may have a treatable visual impairment. Vision problems can interfere with the ability to perform in the class room or can impair the ability to read with comfort and efficiency. 16% of the subjects in this study showed poor vision and their diet was poor in protein, fruits and vegetables and also they showed a high score for carbohydrates. They are probably obese people with higher BMI and more adipose tissue than the students with good visual acuity. This showed that carbohydrate had no effect on visual acuity and stresses the association between obesity and poor visual acuity. This is a novel finding since exclusion of traditional food in fact led to vitamin deficient diet which led to poor visual acuity and replacement of traditional food with bread has in fact led to poor visual acuity although energy needs are catered for. Even the anthropometric data is quite revealing since the waist and hip measurement did not have any impact on visual acuity although overall BMI scores were reflective of obesity. Refractive error could be the major reason for poor vision. This study did not check the refractive error of the students, but it only focused on the effects of nutrition on visual acuity. It could have produced better result, if it could check the refractive error of the subjects.

There are few data available on the prevalence and type of refractive errors in children in developing countries, myopia (5.6%) was the most common refractive error among school children. In the Indian study 5.1% of the children in school had a visual acuity of less than 20/40 in the better eye, while 12.5% had a visual acuity of less than 20/30 or worse in either eye (Kalikivayi *et al*., 1997). Recent studies in Nepal, covering 40,000 children over a period of two years revealed high incidence of xerophthalmia (Pokharel *et al*., 2000). Vitamin A deficiency has long been recognized in much of South and Southeast Asia by the common presentation of clinical cases of xerophthalmia (Quek *et al*., 2004; Lin *et al*., 2001). Subsequent studies in Africa, where it had been less well recognized, indicated that a large proportion of pediatric blindness was due to acute deterioration in vitamin A status during measles and similar childhood infections (Naidoo *et al*., 2003). Parental education coupled with enhanced school-based screening may be needed to help identify children with visual impairment.

CONCLUSION AND RECOMMENDATIONS

Lack of proteins, high carbohydrate diet and negligible fruit and vegetable intake seem to be one of the causes of poor visual acuity in school children. Periodic eye screening programmes can identify previously undetected eye disorders in the school age population. It is suggested that screening programmes for school age children coupled with immediate referral and follow up procedures are worth while. Low visual acuity can be treated easily and such the detrimental impact of visual impairment on a child's education and development could be prevented. It is also important to educate the parents and the youth about the importance of following a balanced diet. A school based vision screening at least in the rural communities of South Africa is recommended. It will improve the children's academic life and quality of life in general.

ACKNOWLEDGMENTS

The authors acknowledge the technical help given by Ms. Mapele in the study and thank Mr. Vattakkunnel, Principal, Khanyisa High School , Mthatha for providing the necessary assistance to carry out this project. Many thanks for the students and their parents for their tremendous cooperation in carrying out this project.

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