Dietary intake and metabolic control of children aged six to ten with type 1 diabetes mellitus in KwaZulu-Natal

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Abstract

Objectives: The objective of this study was to assess the dietary intake and metabolic control of children with type 1 diabetes.

Design: A cross-sectional observational study was carried out.

Subjects: A total of 30 subjects whose ages ranged from six to ten years were included in the study.

Setting: The study was conducted at the Paediatric Diabetic Clinics at Grey's Hospital, Pietermaritzburg and Inkosi Albert Luthuli Central Hospital (IALCH), Durban, in KwaZulu-Natal.

Outcome measures: Dietary intake was assessed using a three-day dietary record. Metabolic control was assessed using glycosylated haemoglobin (HbA1c).

Results: The mean percentage contributions of macronutrients to total energy as determined by the three-day dietary records were as follows: carbohydrate – 52%; added sucrose – 2%; protein – 16%; fat – 32%. The mean intakes were similar to the recommendations of the International Society for Pediatric and Adolescent Diabetes (ISPAD) Consensus Guidelines (2002). Micronutrient intake was generally adequate. The mean latest glycosylated haemoglobin (HbA_{1c}) for the sample as at the time of the study was 9.7%. Five of the thirty subjects had HbA_{1c} values that were within the recommended levels for children with type 1 diabetes.

Conclusions: The macronutrient intake in this sample was found to be similar to the ISPAD Consensus Guidelines (2002) while micronutrient intake was adequate in most cases. Overall the sample had poor metabolic control.

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Introduction

In South Africa the leading causes of mortality in children under the age of five years are Human Immunodeficiency Virus (HIV)-associated conditions, perinatal conditions, pneumonia, diarrhoea and malnutrition. Approximately 20% of South African children suffer from a chronic condition which requires long-term management and care. The most prevalent of these chronic conditions among South African children are congenital heart disease, neurological disorders, HIV and asthma.[1] Type 1 diabetes is also a chronic disease in childhood but the prevalence in South African children is unknown.[2] What is known is that type 1 diabetes is currently the most common chronic disease in childhood after asthma and its prevalence is increasing by 3 to 5% per annum in many parts of the world.[3] Approximately 80 to 85% of all cases of diabetes in childhood are of type 1,[4] which involves autoimmune-mediated destruction of pancreatic beta cells and results in an absolute deficiency of insulin.[5]

Although diet has an important role to play in the overall management of type 1 diabetes, very little scientific literature about the dietary intake of children with type 1 diabetes and about how this compares to the dietary recommendations for children with diabetes has been published.[6] The most important goals in the management of diabetes are achieving metabolic control of blood glucose levels and the prevention of the long-term complications of diabetes.[7] Metabolic control in diabetics is used as a measure of how well the condition is being managed; achieving good metabolic control requires achieving a balance between food intake, insulin levels and energy expenditure.[8,9] Significant human observation studies carried out over the past 30 to 40 years have shown a direct link between high blood glucose levels and the development of diabetic complications.[10] Both the United Kingdom Prospective Diabetes Study (UKPDS) (1977 to 1991) and the Diabetes Control and Complications Trial (DCCT) (1983 to 1993) have shown that lowering blood glucose levels could slow or prevent the development of diabetic complications.[10,11] Given the lack of data on dietary intake and metabolic control in South African children with type 1 diabetes, the aim of this study was to assess dietary intake and metabolic control using HbA_{1c} in children with type 1 diabetes in KwaZulu-Natal.

Methodology

Study design and study population

A cross-sectional observational study was conducted on a total of 30 subjects aged six to ten years who were drawn from the paediatric diabetic clinics at Grey's Hospital and IALCH. At the time of data collection, approximately 200 children with type 1 and type 2 diabetes were being treated at the two sites; 35 of the 200 children had type 1 diabetes and were between the ages of six and ten years.

Criteria for inclusion in the study were the presence of type 1 diabetes; being between the ages of six and ten years; duration of diagnosis of three months or more; and the absence of mental retardation. Subjects who qualified for inclusion in the study were identified on the day of their attendance at the clinic. The caregivers and subjects were given a brief verbal explanation about the study while waiting for their consultation with the doctor. The caregivers of the 34 children who met the criteria for inclusion in the study were invited to participate. This resulted in a total of 30 children participating in the study. At the time of the study, 16 of the 30 subjects were on b.i.d. (twice daily) injections of a combination of short-acting and intermediate-acting insulin and 14 of the 30 subjects were on basal bolus (a combination of short-acting and long-acting insulin). For the basal bolus regimen, short-acting insulin was given at or just before each meal. Subjects followed a daily meal plan of three meals and three snacks in between.

Dietary intake

Dietary data were obtained from a three-day dietary record. Since no dietary reference method can provide a true measure of dietary intake, relative validation was done by comparing the 24-hour recall to Day 3 of the documented three-day dietary record. A comparison of nutrient intake between Day 3 of the three-day dietary record and the 24-hour recall of Day 3, using the Bland-Altman analysis, showed relatively good agreement, especially for iron, vitamin C, thiamin, niacin and riboflavin. The dietary record was collected on a Friday (Day 1), on the following Sunday (Day 2) and on Monday (Day 3). As the subjects were young and in some cases illiterate, the instructions for completing the dietary record were given to the caregivers. Caregivers from both clinics were asked to record their dietary intake on the same three days of the week so that it could be standardised amongst all subjects. Caregivers were also asked to record the use of any dietary supplements, and dietary intake away from home was obtained by asking the children to recall what they had eaten. A set of five measuring cups measuring volumes of 250 ml, 125 ml, 80 ml, 60 ml and 30 ml was provided and caregivers were also encouraged to use other household measures to record dietary intake. The caregivers were provided with an addressed, stamped envelope and the completed three-day dietary records were returned to the researchers via the postal service. The 24-hour recall was obtained from the caregivers by a registered dietician, by telephone. The Foodfinder database[12] was used to analyse the dietary intake. The Dietary Reference Intakes (DRIs) of the Institute of Medicine, Food and Nutrition Board, United States of America (USA) were used to determine the prevalence of inadequate intakes.[13–17]

Metabolic control

Glycosylated haemoglobin (HbA_{1c}) tests are normally carried out every three months at both clinics. The most recent HbA_{1c} value and previous HbA_{1c} values for the 12 months immediately prior to the date of data collection were recorded for all subjects. All HbA_{1c} blood samples were analysed at the IALCH Pathology Laboratory, using the VARIANT II Haemoglobin Testing System, which has been certified by the National Glycohaemoglobin Standardisation Programme (NGSP) as being similar to the DCCT reference method. Both HbA_{1c} values were compared to the normal ranges as used by the ISPAD (not > 7.6%) [9] and the American Diabetes Association (ADA) (not > 8%).[18]

Statistical analysis

The SPSS software program (version 13.0) was used to analyse data. The EAR cut-point method was used to estimate the prevalence of inadequate intakes by comparing the mean intake over three days with the EAR where an EAR was available, with the exception of energy, as the EAR cut-point method cannot be used to assess adequacy of energy intake.[19] To facilitate comparison with the USA-EAR/AI, the subjects were divided into two age groups, i.e. six to eight years of age and nine to ten years of age. No statistical analyses were carried out to find relationships between dietary intake and metabolic control as the dietary intake data obtained in this study can be regarded as level 1 and level 2 data and this does not allow for carrying out correlation or regression analysis.[20]

Ethics approval

Ethics approval (Ref. H263/05) was obtained from the Biomedical Research Ethics Committee of the Nelson R Mandela School of Medicine, University of KwaZulu-Natal. Written consent to participate in the study was obtained from the caregivers of the subjects.

Results

Sample

A total of 30 subjects were included in the study. Of the total sample, 27% (n = 8) were from the Grey's Hospital clinic and 73% (n = 22) were from the IALCH clinic. The mean age was 8.56 (± 1.45) years and the mean duration of diagnosis was 3.61 (± 2.25) years. Of the total sample, 43% (n = 13) were female and 57% (n = 17) were male. The sample comprised of Indians (47%, n = 14), Africans (33%, n = 10), Coloureds (10%, n = 3) and Whites (10%, n = 3).

Dietary intake

Table I shows the mean daily intakes of macronutrients from the three-day dietary record as a percentage of total energy compared to the ISPAD Consensus Guidelines (2002). Although a total of 30 subjects participated in the study, only 20 completed the three-day dietary records which were received via the postal service.

Table I: Mean daily intakes of macronutrients as a percentage of total energy compared to the ISPAD Consensus Guidelines (2002)

Macronutrient	Mean intake as a percentage of total energy ± SD	ISPAD Consensus Guideline (2002) (as a percentage of total energy)
Carbohydrate	52 ± 7	> 50%
Added sucrose	2 ± 2	Not > 10%
Protein	16 ± 3	Not > 15%
Fat	32 ± 7	Not > 35%

Overall, the macronutrient intake compared well to the ISPAD Consensus Guidelines (2002). The added sucrose intake was much lower than the maximum intake in the Guidelines (2% vs not > 10%).

Table II shows mean nutrient intakes from the three-day dietary record (average of three days) for children of six to eight years, compared to the USA-EAR/AI.

Protein intake was adequate in this age group, while the mean energy intake was lower than the EER. Micronutrient intakes were generally adequate. One of the nine children aged six to eight years had inadequate intakes for each of the following nutrients: magnesium,

Table II: Mean nutrient intakes from the three-day dietary record for children between six and eight years (n = 9) compared to the USA-EAR/AI

NUTRIENT	NUTRIENT INTAKE	EARs	AI	PERCENTAGE OF EARs	PREVALENCE OF INADEQUACY (%)
Energy (kJ)	6420 ± 1310	7316[a]		-	-
Total protein (g)	57 ± 15	13 to 24*		438 to 238**	0
Calcium (mg)	540 ± 210	-	800	-	-
Magnesium (mg)	218 ± 80	110		198	11
Phosphorus (mg)	935 ± 224	405		231	0
Iron (mg)	11.2 ± 3.6	4.1		273	0 0
Zinc (mg)	7.6 ± 3.1	4.0		190	0
Thiamin (mg)	1.1 ± 0.3	0.5		220	0
Riboflavin (mg)	1.4 ± 0.5	0.5		280	0
Niacin (mg)	17 ± 5	6		283	0
Vitamin B_6 (mg)	1.6 ± 0.3	0.5		320	0
Folate (µg)	255 ± 97	160		134	11
Vitamin B_{12} (µg)	2.4 ± 1.1	1.0		240	11
Vitamin C (mg)	64 ± 37	22		291	0
Vitamin A (µg)	525 ± 194	275		191	0
Vitamin D (µg)	3 ± 2	-	5	-	-
Vitamin E (mg)	9 ± 3	6		150	11

[a] Estimated energy requirement (EER) *Range calculated using EAR of 0.76g/kg/d
**Calculated using EAR range for protein

Table III: Mean nutrient intakes from the three-day dietary record for children between nine and ten years (n = 11), compared to the USA-EAR/AI

NUTRIENT	NUTRIENT INTAKE	EARs	AI	PERCENTAGE OF EARs	PREVALENCE OF INADEQUACY (%)
Energy (kJ)	8030 ± 1940	9572[b]		-	-
Total protein (g)	81 ± 30	19 to 33*	-	426 to 245**	0
Calcium (mg)	758 ± 306	-	1300	-	-
Magnesium (mg)	340 ± 125	200		170	18
Phosphorus (mg)	1330 ± 457	1055		126	27
Iron (mg)	14.5 ± 4.7	M: 5.9 F: 5.7		M: 256 F: 233	0 0
Zinc (mg)	13.1 ± 5.5	7		187	9
Thiamin (mg)	1.6 ± 0.6	0.7		229	9
Riboflavin (mg)	1.7 ± 0.6	0.8		213	9
Niacin (mg)	23 ± 12	9		256	0
Vitamin B_6 (mg)	3.1 ± 4.4	0.8		388	9
Folate (µg)	320 ± 88	250		128	27
Vitamin B_{12} (µg)	5.1 ± 3.4	1.5		340	9
Vitamin C (mg)	47 ± 27	39		121	45
Vitamin A (µg)	793 ± 523	M: 445 F: 420		M: 169 F: 206	0 0
Vitamin D (µg)	4 ± 2	-	5	-	-
Vitamin E (mg)	11 ± 5	9		122	27

M = Males F = Females
[b] Estimated energy requirement
*Range calculated using EAR of 0.76g/kg/d ** Calculated using EAR range for protein

folate, vitamin B12 and vitamin E. Mean nutrient intakes fell below the AI for both calcium (540 mg vs 800 mg) and vitamin D (3 µg vs 5 µg). The mean intakes of the following nutrients were higher than the tolerable upper intake levels (UL) in this age group: magnesium (218 mg vs 110 mg) and niacin (17 mg vs 15 mg). Mean energy intake in this group was lower than the EER.

Table III shows mean nutrient intakes from the three-day dietary record for children of nine to ten years, compared to the USA-EAR/AI.

Protein intake was adequate in this age group while the mean energy intake was lower than the EER. Five of the eleven children had inadequate intakes of vitamin C while three of the eleven children had inadequate intakes for each of the following nutrients: phosphorus, folate and vitamin E. Mean nutrient intakes fell below the AI for both calcium (758 mg vs 1300 mg) and vitamin D (4 µg vs 5 µg). Mean intakes of niacin were slightly higher than the UL (23 mg vs 20 mg) for this age group. Mean energy intake in this group was lower than the EER.

There was no significant difference between the latest HbA_{1c} and the insulin regimen or the mean HbA_{1c} over 12 months and the insulin regimen. The proportion of children with an HbA_{1c} < 8% was 17% (n = 5) for both the latest HbA_{1c} and the mean HbA_{1c} over 12 months (Table IV). When age was split at eight years, there was a significant difference between the age groups in terms of both the latest HbA_{1c} values (p = 0.005) and the mean HbA_{1c} over 12 months (p = 0.037). The children aged nine to ten years had higher HbA_{1c} values than the children of six to eight years of age (Table V).

Table IV: Subjects with HbA_{1c} values within the recommended levels for children with type 1 diabetes

	n (%)
Subjects with latest HbA_{1c} < 8.0 %*	5 (17)
Subjects with mean HbA_{1c} over 12 months < 8.0 %*	5 (17)

* Recommended range for HbA_{1c} from ISPAD Guidelines (HbA_{1c} not > 7.6%) and ADA Guidelines (not > 8%)

Table V: Relationship between age and metabolic control (HbA_{1c} %)

	Age	n	Mean (± SD)	p value*
Latest HbA_{1c} (%)	6 to 8 years of age	18	9.0 (± 1.7)	0.005
	9 to 10 years of age	12	10.8 (± 1.3)	
Mean HbA_{1c} over 12 months (%)	6 to 8 years of age	18	9.2 (± 1.6)	0.037
	9 to 10 years of age	12	10.3 (± 1.1)	

* Independent samples t-test, p < 0.05

Discussion

The results concerning dietary intake should be interpreted with caution due to the small number of subjects that provided information on dietary intake. The low number of completed three-day dietary records (n = 20) could be explained by the unreliability of the postal service in some areas of KwaZulu-Natal, as many of the caregivers who were contacted by telephone claimed that they had posted the records, but these were never received by the researchers. Although this study provided important baseline data on the intake of South African children with type 1 diabetes, some limitations occurred in the dietary intake component of the study. Besides the low number of completed three-day dietary records received, a further problem may have been due to the fact that the dietary intake of the subjects was recorded by the caregivers. It is possible that the caregivers

did not report the dietary intake accurately or honestly. Day 2 (Sunday) and Day 3 (Monday) of the three-day dietary record were consecutive because this proved to be convenient for record keeping by the caregivers. Ideally, the three days that make up the three-day dietary record should be non-consecutive to minimise the sequence or training effect that is usually seen when subjects complete the records on consecutive days.[20]

Although the mean energy intakes were lower than the EER in both age groups, the mean energy intakes compared well with the WHO/FAO Daily Energy Requirements which were calculated for each child on the basis of actual body weight (not reported here). Furthermore, the anthropometric results for the sample also suggested that the energy intake was not inadequate as only one child was found to be underweight and the majority of the children were at a healthy weight or at risk of overweight. The low energy intakes compared to the EER in both groups could also have been due to underreporting. Overall, the intake of macronutrients as a percentage of total energy was found to compare closely to the ISPAD Consensus Guidelines (2002). The mean contribution of carbohydrate to total energy from the three-day dietary record was 52%. This suggests that the subjects were consuming adequate amounts of carbohydrate. These findings were also in keeping with results from other, similar studies.[6,21-23] The added sucrose intake in this study could have been underreported as the children spent a significant time away from their caregivers. Although the fat intake in the study was recorded as below 35% of total energy, it remains important to monitor fat intake in children with type 1 diabetes as fat intake may be increased to account for the reduced energy resulting from a simple carbohydrate restriction.[24] Increased fat, specifically saturated fat intake, in children with type 1 diabetes may increase the risk of cardiovascular problems and may aggravate already increased lipid and lipoprotein levels.[25]

The results from this study showed that the dietary intake of the children was generally adequate, in contrast to the findings of the 1999 National Food Consumption Survey (NFCS).[26] It is possible that this study sample was drawn from a more affluent population with access to a wider variety of foods (data not reported here). Micronutrient intake may also have been improved due to the fortification of maize meal and bread in South Africa.[27] The mean intakes of calcium and vitamin D were below the AI in both age groups. This does not allow us to calculate the prevalence of inadequate intake for these nutrients,[19] but is of interest as low intakes of calcium and vitamin D have also been reported by other researchers investigating the dietary intake of children with type 1 diabetes.[6,21,23] The UL for magnesium is set in relation to non-food sources,[13] but it should be noted that it has been suggested that individuals with diabetes mellitus are distinctly susceptible to the adverse effects of excess niacin intake.[14]

The mean HbA_{1c} values reported in this study (9.7% and 9.6%, latest and mean over 12 months respectively) were higher than the HbA_{1c} values reported in other, similar studies conducted outside of South Africa.[23,28-30] Although it is desirable to aim for an HbA_{1c} of less than 8% in children, it can be difficult to achieve and must be weighed against the risk of hypoglycaemia. Less than 50% of the adolescents who received intensive treatment in the DCCT achieved a mean HbA_{1c} of less than 8%.[31] Findings of higher HbA_{1c} values in older children have also been reported in other studies.[28,32-34] The higher HbA_{1c} values in the older age group (nine to ten years) could be explained by possible hormonal changes taking place with pubertal development. A decrease in compliance with treatment routines, greater deviations from the diabetic diet, reduced parental supervision and increased self-care could also explain the higher HbA_{1c} values in the older age group.

Conclusion

The mean percentage contribution of macronutrients to total energy in the sample was found to be appropriate for children with type 1 diabetes, as it was close to the ISPAD Consensus Guidelines (2002). Overall, the micronutrient intake of the sample was adequate. The overall metabolic control was poor, as the mean latest HbA_{1c} for the sample was 9.7%. This study has provided useful and important baseline data in an area that has not been well researched in South Africa. Further studies using larger sample sizes should be carried out to confirm the findings of this study and to expand on research in this area.

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