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ARTICLE

Exploring the prevalence of multiple forms of malnutrition in children 6–18 years living in the Eastern Cape, South Africa

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Background: The existence of multiple forms of malnutrition is a growing problem in developing countries. Children living in the Eastern Cape have a relatively high prevalence of cardiovascular disease (CVD) risk factors and food insecurity, suggesting the possibility of the several coexisting forms of malnutrition. Due to the negative long-term consequences of undernutrition, overnutrition and, to a greater extent, a combination of both, it is important for this issue to be identified early in children and addressed.
Aim: This study was undertaken to investigate the prevalence of the different forms of malnutrition in children living in the Eastern Cape province.
Methods: Secondary analysis of a cross-sectional sample of 237 school-aged children, aged 6–18 years, in the Eastern Cape province of South Africa was conducted. The variables included in the analysis were the demographic data, anthropometric data and biochemical data, specifically blood profiles related to micronutrient deficiencies and CVD risk factors. Fisher's exact test was used to compare the prevalence rates of several coexisting forms of malnutrition in the children. All data analysis was conducted in R version 4.0.3 and statistical significance was set at 0.05.
Results: In children with overweight/obesity, 13.6% had a micronutrient deficiency, while 37.71% of the children within the normal weight range had coexisting micronutrient deficiencies and CVD risk factors. The prevalence of folate deficiency was 73.0%, iron deficiency 6.3%, and hyperglycaemia was at 10.6%. Fisher's exact test was used to compare the prevalence rates between genders and no statistically significant differences were observed.
Conclusion: Further research is needed to understand the relatively high prevalence of CVD risk factors in these children within the normal weight range and to investigate how dietary intake contributes to the overall double burden of malnutrition in children.

Keywords: children, adolescents, overweight, cardiovascular risk factors, micronutrient deficiencies, double burden malnutrition

Introduction

A major challenge in developing countries is the coexistence of multiple forms of malnutrition such as undernutrition (micronutrient deficiencies, stunting, wasting, underweight), overweight, obesity and the rising prevalence of noncommunicable diseases (NCDs).[1] The State of Food Security and Nutrition in the World Report has listed several potential causes for the multiple burden of malnutrition, including food insecurity, stress, the body's adaptation to lack of food and poor diet quality.[1] In children, the consequences of this include a combination of the detrimental aspects of undernutrition, such as reduced cognitive development and academic performance,[2,3] combined with the negative health aspects associated with overnutrition such as the development of NCDs.[4,5] Overnutrition is associated with an increase in cardiovascular disease (CVD) risk factors, which include dyslipidaemia, an abnormal concentration of cholesterol and lipids in the bloodstream.[6] Other metabolic markers include hyperglycaemia and hypertension, deficiencies of folate, vitamin B6 and vitamin B12, and increased levels of inflammatory markers such as high-sensitivity C-reactive protein (hs-CRP), which has been linked to several NCDs and recommended for the assessment of CVD risk.[7,8] There are also economic implications related to increased frequency of hospitalisations, reduced earning potential and ultimately reduced quality of life.[9] Thus the coexistence of multiple forms of malnutrition presents a unique challenge for healthcare professionals and creates a need for appropriate and effective interventions and policies.[10]

According to the South African National Health and Nutrition Examination Survey (SANHANES), the average body mass index (BMI) of children aged 2–14 years in South Africa was 17.0 kg/m^2 for boys and 17.7 kg/m^2 for females and overweight and obesity were more prevalent for girls, while more boys were either underweight or normal weight.[11] The survey also revealed that in the Eastern Cape 80.9% of the children were normal weight or underweight, 12.4% were overweight and 6.7% were obese.[11] There are limited data available on the micronutrient status of children above the age of five and adolescents,[12] though an iron-deficiency prevalence of about 36% was observed in children and adolescents with hyperactivity.[13] Previous evidence suggests that South African children living in the Eastern Cape have a relatively high prevalence of low levels of high-density lipoprotein (HDL-C)-cholesterol, suggesting a high risk of developing cardiovascular disease (CVD).[14] These findings point to the possibility of the coexistence of multiple forms of malnutrition. The objective of this study was to assess the prevalence of the double burden of malnutrition in this population. Additionally, a secondary objective was to explore the presence of other coexisting forms of malnutrition.

Due to the negative long-term consequences of undernutrition, overnutrition and, to a greater extent, a combination of both, it is important for this issue to be identified early in children and addressed.

Methodology

Study design

This study was a secondary analysis of cross-sectional data collected in 237 children aged 6–18 years in a low-resource community in the Eastern Cape province.[14] The variables included in the analysis were the demographic data, anthropometric data such as BMI-for-age and height-for-age z-scores, and biological sample data, specifically blood profiles related to micronutrient deficiencies and CVD risk factors, such as dyslipidaemia. Dyslipidaemia is an abnormal level of cholesterol and other lipids in the bloodstream.[6]

Sampling

An adequately powered sample was collected in the original study based on 95% confidence level, a 6·25 confidence interval (CI) and the total number of public-school children ($n = 5\ 250$) in the Eastern Cape province, purposively selected based on their catering to Xhosa-speaking, low-income families. Ethical clearance was obtained from the Senate Research and Innovation Ethics Committee of the Vaal University of Technology (20130520-3). Parental informed consent and children's assent was obtained for each participant. Data were collected from 2014 to 2015. Data were de-identified and stored confidentially on researchers' computers.[14] For the purposes of the present analysis the school variable was ignored, and all children were treated as one group.

Study Data Collection Tools

Blood samples were obtained before 10h00, using a vacutainer needle in a fasted state, and breakfast was provided immediately afterwards. Household socioeconomic status (SES) was collected using a pre-tested sociodemographic questionnaire administered to the parent or primary caregiver. Height and weight were collected by a registered dietitian and a public health nutritionist.[14]

Measurements

Micronutrient deficiencies assessed in the analysis were:

- iron deficiency anaemia (IDA) (haemoglobin < 11.8 g/dl for children aged 6–11, < 12.6 g/dl for boys and < 11.9 g/dl for girls aged 12–15 years; < 13.6 g/dl for boys and < 12.0 g/dl for girls aged 16–19 years),[15]
- vitamin B12 deficiency (< 156 pmol/l),[16] and
- folate deficiency (< 5.9 nmol/dl).[17]

The selected CVD risk factors included in the analysis were:

- high serum total cholesterol (≥ 5.18 mmol/l),[6]
- low HDL-C levels (<1 .04 mmol/l),[6]
- high low-density lipoprotein-choesterol (LDL-C) levels (> 100 mg/dl),[6]
- high triglyceride (TG) levels (≥ 100 mg/dl for ages 0–9 years and ≥ 130 mg/dl for 10–19 years),[6]
- hyperglycaemia (> 6.1 mmol/l),[18] and
- systemic inflammation (high-sensitivity C-reactive protein (hs-CRP) ≥ 3 mg/dl).[7]

In addition to dyslipidaemia, systemic inflammation and hyperglycaemia were included as CVD risk factors. Systemic inflammation contributes to the development of CVD and is associated with obesity, low socioeconomic status and dietary intake.[19] There is also a general consensus that diabetes increases CVD risk, but the exact mechanism for the pathophysiological associations between diabetes and CVD risk is not yet fully understood.[19]

The WHO growth standards nutritional status classifications were:

- Thinness/wasting (BMI-for-age < −2 standard deviation (SD))
- Overweight (BMI-for-age > +1 SD)
- Obesity (BMI-for-age > +2 SD)
- Normal weight (BMI-for-age > −2 to <+1)
- Stunting (height-for-age < −2 SD).[20]

Statistical analyses

Descriptive statistics, such as means and SDs, were calculated for the continuous variables and frequency distributions for categorical data. Frequency tables and Fisher's exact test were used to compare the prevalence rates of the various forms of the double burden of malnutrition in the children. All data analysis was conducted in R version 4.0.3 (R Foundation for Statistical Computing, Vienna, Austria) and statistical significance was set at $p = 0.05$.

- The prevalence of nutritional status, micronutrient deficiencies (such as IDA, vitamin B12 and folate deficiencies) and CVD risk factors (such as hypertriglyceridemia, high serum cholesterol, low HDL-C, high LDL-C, systemic inflammation and hyperglycaemia) were assessed first. Results are displayed in Table 1.
- Next, the double burden of malnutrition was assessed based on coexisting undernutrition (micronutrient deficiencies, stunting, wasting, underweight) and overnutrition (overweight, obesity) in an individual. Only prevalence rates higher than 10% were reported.
- Other forms of malnutrition were then assessed based on the coexistence of micronutrient deficiencies and dyslipidaemia. Only prevalence rated higher than 10% was reported.

Boys and girls were analysed separately and compared, due to gender-based differences in the manifestation of malnutrition observed in some studies.[21] After establishing that there were no significant differences between gender groups, subsequent reporting focused on the whole group (boys and girls combined).

Results

The average ± SD age of the learners was 12.1 ± 3.8 years. There were 118 boys (49.8%) and 119 girls (50.2%). All (100%) of the learners were black, and most were from a single-headed household (62.7%). In terms of the caregivers, 19.3% had no formal education, 46.8% had primary education and 30.3% attended high school, while 3.8% had a tertiary level education. Table 1 summarises the prevalence of over- and undernutrition observed in the sample.

Table 1: Prevalence of under- and overnutrition variables in the study population

Factor	Definition	Total, *n* (%)	Boys, *n* (%)	Girls, *n* (%)	*p*-value
N = 237					
Iron-deficiency anaemia	Hb < 11.8 g/dl (6-11y) < 12.6 g/dl males and < 11.9 g/dl females (12–15 years), < 13.6 g/dl males and < 12.0 g/dl females (16–19 years)	15 (6.3%)	9 (3.8%)	6 (2.5%)	0.101
Vitamin B12 deficiency	Serum B12 < 156 pmol/l[16]	10 (4.2%)	7 (4.2%)	3 (1.3%)	0.216
Folate deficiency	Serum folate < 5.9 nmol/dl[17]	173 (73.0%)	86 (36.3%)	87 (36.7%)	1.000
Stunting[a]	Height for age < −2 SD[20]	11 (4.7%)	4 (1.7%)	7 (3.0%)	0.216
Thinness[a]	BMI-for-age < −2 SD[20]	7 (3.0%)	5 (2.1%)	2 (0.9%)	0.446
Overweight[a]	BMI-for-age > 1 SD[20]	33 (14.0%)	21(8.9%)	12 (5.1%)	0.708
Obesity[a]	BMI-for-age > 2 SD[20]	10 (4.2%)	5 (2.1%)	5 (2.1%)	1.000
High serum cholesterol	≥ 5.18 mmol/l[6]	7 (3.0%)	5 (2.1%)	2 (0.8%)	0.281
Low serum HDL-C levels	< 1.04 mmol/l[6]	99 (41.8%)	49 (20.7%)	50 (21.1%)	1.000
High serum LDL-C levels[b]	> 100 mg/dl[6]	21 (9.0%)	11 (4.7%)	10 (4.3%)	0.822
High serum TG	> 100 mg/dl[6]	47 (19.8%)	21 (8.9%)	26 (11.0%)	0.5161
Inflammation (hs-CRP)	≥ 3 mg/dl[22]	49 (20.7%)	23 (9.7%)	26 (11.0%)	0.749
High serum glucose	> 6.1 mmol/l[18]	25 (10.6%)	12 (5.1%)	13 (5.5%)	1.000

[a]Sample size *n* = 236, [b]Sample size *n* = 233.

The most prevalent form of undernutrition was folate deficiency (73.0%). In terms of overnutrition and CVD risk factors, 41.8% had low HDL-C levels, 20.7% systemic inflammation, 19.8% had high triglyceride levels and 14.0% were overweight. There was no statistically significant ($p > 0.05$) difference in the prevalence of various micronutrient deficiencies in boys and girls. There were also no statistically significant differences in the prevalence of various CVD risk factors between the genders. The prevalence of different coexisting forms of malnutrition was then assessed, and the results are summarised in Table 2.

The prevalence of children with coexisting CVD risk factors and micronutrient deficiencies was 48.3%. In children with overweight/obesity, a micronutrient deficiency was observed in 13.6% of the respondents. In normal-weight children, the coexistence of CVD risk factors and micronutrient deficiencies was relatively high in 37.7% of the children, while 53.0% had one or more CVD risk factor and 58.9% one or more micronutrient deficiencies.

Discussion

This study explored the prevalence of various forms of malnutrition in children in a low-income community in the Eastern Cape province of South Africa. The majority of the children (95.6%) lived below the national poverty line (R 647 per month).[23] The most prevalent form of undernutrition was folate deficiency, affecting almost three out of four children enrolled in the study. Folate is key for neurological and cognitive development, and also reproductive health.[24] There are currently no known studies that have assessed the folate status of children or adolescents in South Africa, except for one that assessed folate deficiency at one year and three years of age.[25] However, a review of studies conducted in other parts of Africa (Cameroon, Côte d'Ivoire, Democratic Republic of Congo, Ethiopia, Mali, Mozambique, Sierra Leone, Burkina Faso, Senegal, South Africa, Zambia) revealed a high prevalence of folate deficiency within school-aged children.[26] Folate plays a role in preventing CVDs through several different mechanisms and folate deficiency has been identified as a cardiovascular risk marker.[27] In this study, overweight and obesity affected 14.0% and 4.2% of the children, respectively. These findings were similar to those found in SANHANES, where 12.4% of the children in the Eastern Cape were overweight and 6.7% were obese.[11] The double burden of malnutrition, specifically the combination of overweight or obesity and one or more micronutrient deficiency, affected 13.6% of the children. Other forms of the double burden of malnutrition, such as overweight or obesity in combination with stunting, was very low in this population due to the low prevalence of stunting ($n = 11$, 4.7%). The double burden of malnutrition is a concern due to the burden that overweight or obesity, as well as micronutrient deficiencies, places on the health and well-being of an individual. When this condition manifests during childhood, it increases the risk of developing NCDs during childhood and in the future.[5,9]

Coexisting CVD risk and micronutrient deficiencies affected 37.7% of children within the normal weight range. CVD risk is usually associated with being overweight or obese.[28] The presence of concurrent micronutrient deficiencies and CVD risk factors in children within the normal weight range is concerning, because they are not normally the target of nutrition interventions. This finding appears to be unique to this population as no known studies have reported this phenomenon. Research studies have identified poor dietary intakes as a possible cause for the double burden of disease in children, as diets low in fruits and vegetables and high in sugar-sweetened beverages and other processed foods may contribute to both the micronutrient deficiencies and CVD risk factors.[1] In a previous study based on the same sample of children, dietary intakes confirmed low fruit and vegetable intakes and a large percentage of children consumed sugar-sweetened beverages.[14]

Nutritional deficits during the in-utero phase of children's development may also potentially hold insights into the current findings, since various studies suggest that these can lead to a

Table 2: Prevalence of the different forms of coexisting malnutrition

Double burden of malnutrition	Total, *n* (%)	Boys, *n* (%)	Girls, *n* (%)	
N = 236				
Overweight or obese with folate deficiency	31 (13.1%)	16 (6.8%)	15 (6.4%)	1.000
Overweight/obese with one or more micronutrient deficiencies	32 (13.6%)	16 (6.8%)	16 (6.8%)	1.000
Overweight/obese with one or more CVD risk factors	26 (11.0%)	16 (6.8%)	10 (4.2%)	0.299
Overweight/obese with one or more CVD risk factors and one or more micronutrient deficiencies	18 (7.6%)	10 (4.2%)	8 (3.4%)	0.807
More than one CVD risk factor and one or more micronutrient deficiencies	114 (48.3%)	57 (24.2%)	57 (24.2%)	1.000
Normal weight with one or more CVD risk factor and one or more micronutrient deficiencies	89 (37.7%)	43 (18.2%)	46 (19.5%)	0.788
Normal weight with one or more CVD risk factors	125 (53.0%)	59 (25.0%)	66 (28.0%)	0.434
Normal weight with one or more micronutrient deficiencies	139 (58.9%)	69 (29.2%)	70 (29.7%)	1.000

predisposition to health issues, such as cardiovascular disease and diabetes in later life.[29] Low socioeconomic status during childhood is also associated with increased CVD risk in childhood, adolescence and adulthood.[1] The high poverty rates observed in previous studies of this population[14] may indicate low ocioeconomic status and thus contribute to the CVD risk in children.

Strengths and limitations of the study

This study gave useful insights into the prevalence of various types of malnutrition within this population. Additional information related to HIV status or use of antiretroviral therapy regimens would have helped in understanding whether these factors contributed to the high folate deficiency. This might have also been useful in exploring the factors contributing to why over a third of normal-weight children have coexisting CVD risk and micronutrient deficiencies. Haemoglobin levels and serum folate were utilised as indicators of iron and folate status respectively. However, due to the limitations of both assays, ferritin and red blood cell folate concentrations could have been better measurements for this type of analysis.[30]

Conclusion

This study revealed the existence of multiple forms of malnutrition, not only in overweight or obese children, but also in normal-weight children in this low-income community. There was a high prevalence of folate deficiency and a high prevalence of coexisting CVD risk and micronutrient deficiencies even in normal-weight children. Although the findings cannot be generalised to other communities, it points to a challenge and adds another layer to the already complex nutrition situation in South Africa. It also highlights the importance of optimal nutrition during childhood to prevent the manifestation of different types of malnutrition in the population.

Recommendations

The findings of the current study highlight the need to assess the effect of diet on the double burden of malnutrition in the children from this community. More research is needed to investigate the role of dietary intake on the double burden of malnutrition observed in overweight and obese children, and those with normal weight. A retrospective study of these children can be conducted to investigate the potential developmental origins of the current findings, for example by investigating the associations between birth weight and current CVD risk status. Another possible area for future exploration is to investigate whether there is a genetic predisposition to CVD within this population and to explore the effect of HIV status or the use of antiretroviral therapy regimens. Other recommendations include screening for both micronutrient deficiency and CVD risk factors in children and adolescents. There is also the need for nutrition programmes and policies that target all children to improve their nutritional status with regard to weight status, micronutrient status and cardiometabolic health.

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