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ORIGINAL ARTICLE

Impact of National Egyptian school feeding program on growth, development, and school achievement of school children

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Abstract

Background School feeding program (SFP) increases access to education and to better health. This study aims to evaluate the effects of SFP on physical growth, cognitive development, psychosocial behavior, and learning achievement of school children.

Methods A quasi-experimental study was conducted. The intervention group included 903 pupils in the fifth grade receiving the school meal, while the control group included 886 pupils, matched for age and sex, without meal. The meal consisted of a pie made of flour fortified with vitamins A, B6, B12, C, thiamin, riboflavin, niacin, folate, calcium, iron, zinc, and phosphorus. Socioeconomic position, nutritional status, and dietary behavior were evaluated. Neuropsychological tests were done. Psychosocial behavior was rated and educational achievement was recorded. Post hoc and independent sample *t* tests were used to detect the association of the studied parameters with the intake of school snack.

Results Children who took the meal had better scores on visual memory, auditory vigilance tests (9.71 ± 2.80 vs. 7.45 ± 3.25; 25.02 ± 3.36 vs. 10.82 ± 8.92, respectively, $P < 0.001$), the afternoon attention and working memory test (8.20 ± 2.21vs. 7.75 ± 3.05) ($P < 0.001$), but less score of externalizing behavior ($P < 0.001$) than the control group. No significant changes of children's nutritional status were detected between the two groups. School meal was the main predictor of visual memory and auditory vigilance ($P < 0.001$), and was the strongest predictor of academic achievements when combined with family size and meals' frequency ($P < 0.001$).

Conclusion School meal improves academic achievements of school children.

Keywords Cognition · Growth · Performance · School feeding

Introduction

In Egypt, malnutrition among children is a major public health concern affecting all aspects of children's lives [1, 2]. More than 30% of Egyptian school children are affected by malnutrition disorders, whether stunting, underweight, or overweight [3–5]. A positive impact on children's academic achievement, behavior, and productivity is observed for improving children's nutrition [6].

Schools that provide meals help to reduce hunger for millions of children around the globe and contribute to better student behavior and attentiveness [7]. School feeding programs (SFPs) are linked directly to Sustainable Development Goals (SDG) 2 (zero hunger), and indirectly to SDG 1 (no poverty) [8]. SFP in Egypt covers 13.5 million children of all ages with total government finances of 957 million Egyptian pounds [9, 10].

This study aimed to: (1) investigate to what extent did the SFP have significant positive impact due to cumulative interventions over the long term on the following: cognitive development, psychosocial problems, and nutritional status, as detected by anthropometry and educational outcomes; (2)

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investigate which of the studied parameters was more likely to be affected as a result of the *SFP* (cognitive development, psychosocial problems, nutritional status, or learning achievement); (3) among sociodemographic factors and eating habits, which factors reinforced the effect of the meal on the studied parameters.

The research results and its implications are valuable because of their local and global relevance to promoting health of school children, especially in low- and middle-income countries.

Methods

Intervention type

The fifth-grade primary school children received Egyptian school meal in the form of fortified snack (sweet pie) along five years.

Composition of the Egyptian school meal

The pie constituents were as follows: total proteins (8.08 g/100 g), animal protein (25% of the total protein), total fats (10.20 g/100 g), energy (395.73 cal/100 g), sugar (15% g), iron (4.18 mg/100 g), and humidity (13.05%). The pie flour was fortified with vitamins A, B6, B12 and C, thiamin, riboflavin, niacin, folate, calcium, iron, zinc, and phosphorus. Although this flour provided only 16.9% of recommended daily allowance (RDA) for energy, 4.3% of RDA for vitamin C, and 5.5% of RDA for calcium; yet, it provided 35.8% of RDA for iron and 41.7% of RDA for folate and about 26.81% of RDA for protein. The pie also contained either minced dry dates or jam (30% of the pie) to be more tasty and nutritious. The meal was wrapped in an attractive packing containing a brief educational message to raise the nutritional awareness of the children.

Proximate analysis of pie

The pie was analyzed in the National Nutrition Institute of Egypt for moisture, protein, ash, fat, and crude fiber according to the methods of Analysis of the Association of Official Analytical Chemists, (AOAC), 2005 [11]. Total calories were obtained calculated by the formula of James, 1995 [12]. Total calories = Fat × 9 + Protein × 4 + Total carbohydrate × 4.

Nutritional evaluation of pie

RDA provided from 100 g of pie was calculated as percent of the Estimated Average Requirements [13]. The pie was provided once daily, early before classes in the school day to alleviate hunger. Teachers were responsible for ensuring that pies were eaten by the children. For schools with no feeding program, children were left on their own choices either to have snacks or breakfast. All measurements and tests were taken at the same hour.

Study area

Sixty randomly surveyed schools distributed along 16 districts within three randomly selected governorates of Egypt, with average three rural schools/ district were studied. Public schools in rural areas that are matched for geographical characteristics were randomly selected. The sampled children were matched for age and sex.

Study participants

This study included 1789 pupils for both intervention and control groups (903 from schools which took the meal along five years and 886 from schools which never took the meal). Subjects were chosen in the form of clusters (30 clusters/ each type of school); each cluster consisted of 30 students. The inclusion criteria included apparently healthy prepubescent fifth-grade students. The exclusion criteria included students proved to have any mental disorder, chronic disease, feeding problem, and visual or auditory impairment.

Study design

The study was quasi-experimental with random selection and posttest-only control looking into the cumulative effect of SFP on school children along the five years of intervention.

Sample size

It is reported that 50% of fifth-grade children had cognitive and physical growth problems. After five years of having school meals, the expected decrease in prevalence of the expected problems would be 10%. With expected difference of 0.10, accepted power of 80%, level of significance of 95%, 10% for non-responders, and design effect of 3, 900 children from each group (1800 for both intervention and control groups) are required to ensure the reliability of the study [14]. There was a drop out of 1.78% among the control group which is less than the expected 10% lost considered during the sample size calculation.

Methods for data collection

Five well-structured questionnaires were administered to each student. A pilot study was done on 10% of the children for testing the questionnaires.

Anthropometric measures for assessing the nutritional status

It was carried out through measurements of weight and height. All measurements were made according to techniques described in the Anthropometric Standardization Reference Manual [15]. Anthropometric measurements were taken during morning hours on empty stomach before having breakfast or school meal, within minimum 8 h after micturition and defecation and after the morning exercises of spine stretching. All scores were calculated based on the WHO growth standards with the help of Anthro-Program of PC [16].

Dietary pattern assessment

Students provided data on their diet to evaluate dietary habits and behavior of children (skipping breakfast, number of daily meals, eating the served school meal, and source of other meals consumed during the school day).

Cognitive performance assessment

Cognitive performance was assessed by a battery of four psychological tests that covered verbal and non-verbal intelligence, memory, learning, problem solving, and attention. The children were individually tested by trained researchers. These tests were applied in Egyptian nutrition studies [17–19]:

The Digit Span Test (Forward and Backward). It is a subtest of the Revised Wechsler Intelligence Scale for children [20]. The cut-off scaled score of ≤ 5 has typically been associated with 90% specificity [21]. Methodologically, digit span tasks have been proven to be both reliable and valid measures of working memory capacity [22]. The reliability scores of digit span forward and backward tests are 0.891 and 0.598, respectively [23]. The Arabic version of the Revised Wechsler Intelligence Scale for children was used [24].

Coding test is also a subtest of the Revised Wechsler Intelligence Scale for children. It assesses visual-motor coordination, visual encoding, and speed of information processing [25].

The auditory vigilance test measures the attention ability modelled after the suggestions of Polite, 1984 [26].

The figural memory test is a measure of free recall of visual objects. It was designed after suggestions of Polite, 1984 [26]. The free recall score is the number of items recalled correctly (Full score is 20). This test has a reliability of 0.74 from 4 to 17 years.

Behavioral assessment was measured using the Pediatric Symptom Checklist-17 (PSC-17), which was a psychosocial screen designed to facilitate the recognition of emotional and behavioral problems filled out by the teachers. It was scored into three broad mental health problems: Internalizing; Attention, and Externalizing subscales [27, 28].

Data analysis

Data were analyzed using Statistical Package for Social Sciences (SPSS) version 21.0 software. Quantitative data were presented as means ± standard deviations (SD) and qualitative data by percent. Post hoc test, Chi-square, and the independent sample *t* test were used to study the association of the studied parameters including the four cognitive tests with the intake of school snack and to analyze differences between the intervention and control group. Probability values (*P*) of less than 0.05 were regarded as statistically significant. Multiple linear regression analysis was done to assess the contribution of each independent variable in explaining the academic achievement, visual memory, auditory attention, short-term memory, working memory, and speed of information processing [29].

Results

Egypt's ministry of education used a "poverty map" to determine which schools had the priority to receive school meals in each governorate. The majority of the intervention group children belonged to families with high percentage of low educated parents and low-income father's job (Table 1). The order of the child as the third or more was higher in the intervention group than that in the control group.

Children who took the meal had significantly higher score ($P < 0.001$) in recall of figural memory test and lower score in classification than the control group (Table 2). Moreover, children who had a school meal expressed more right responses to auditory stimuli and less wrong responses than the control group with highly significant difference ($P < 0.001$). In addition, children with SFP intervention got higher scores in digit span test at the end of school day, but had lower scores in morning digit span and coding tests than their peers.

Neither the mean scores of the intervention group nor that of the control group reached the standard cut-offs of psychosocial problems, externalizing behavior, internalizing behavior, or inattention problems. However, it was observed that the intervention group got significantly ($P < 0.001$) higher scores than their peers in the total psychosocial problems and all subscales except the externalizing subscale. Academic achievement was found to be higher in children who had taken the school meal than that in those who did not. This was more clear in math exam scores ($P < 0.001$) rather than in Arabic language scores.

Table 1 Comparing sociodemographic characteristics between the intervention and control groups

Socioeconomic parameters	Students had not taken school meal (control group) ($n=884$, %)	Students had taken school meal (intervention group) ($n=902$, %)	P value
Father education			
No education (illiterate), read and write only	346 (39.1)	542 (60.1)	<0.001
Primary/preparatory/secondary	71 (8)	74 (8.2)	
High school, university, or diploma	467 (52.9)	286 (31.7)	
Mother education			
No education (illiterate), read and write only	337 (38)	633 (70.2)	<0.001
Primary/preparatory/secondary	54 (6.1)	41 (4.5)	
High school, university, or diploma	493 (55.9)	228 (25.2)	
Father employment			
Unemployed	10 (1.1)	26 (2.9)	<0.001
Labor worker	370 (41.8)	556 (61.7)	
Administrative/ professional work	504 (57.1)	302 (35.4)	
Mother employment			
Unemployed/housewives	567 (64)	777 (86)	<0.001
Labor worker	24 (2.7)	32 (3.5)	
Administrative/professional work	293 (33.3)	93 (10.4)	
Child order			
First or second child	561 (63.3)	485 (53.7)	<0.001
Third or more	323 (36.7)	417 (46.3)	
Family size			
Mean family size, mean ± SD	5 ± 1	5 ± 1	>0.05
Sex			
Male	476 (53.7)	458 (50.7)	> 0.05
Female	410 (46.3)	445 (49.3)	

$P<0.05$ is significant, $P>0.05$ is insignificant, $P<0.001$ is highly significant according to the results of Post hoc test and Chi-square test

Out of the indicators of the nutritional status of the school children (weight for age, height for age and body mass index), there was more overweight children in the control group than the intervention group with high significant difference ($P<0.001$).

Mother's education reinforced the meal effect on visual memory (free recall) ($P=0.012$,), speed of information processing ($P=0.023$), and morning working memory ($P=0.001$) (Table 3). The strongest predictor of working memory in the afternoon and academic achievement was the school meal ($P<0.001$ in both), followed by mother's education ($P=0.002$ and 0.022, respectively).

Discussion

Undernutrition results in impairing healthy development and affecting life-long productivity [30]. It is recommended that nutritional education programs should be directed very early to new mothers about the importance of exclusive breastfeeding to reduce undernutrition problems later during childhood [31].

Poor nutritional status of Egyptian school children was associated with behavioral problems and retarded educational accomplishment [32, 33]. Moreover, Egyptian studies recommend that any intervention for improving cognitive functions should start very early in life.[34, 35], and hence the role of SFPs is helping to satisfy the nutritional demands of these children.

The current research studied the effect of SFP on education outcomes including learning achievement, cognitive, psycho-emotional behaviors, and on growth. The study showed that school meal had a positive effect on the cognitive abilities of school children including memory recall, auditory response, and afternoon digit span. Our approach for providing the pie meal as breakfast meal had a positive effect on task behavior at school mainly for math exam scores rather than the Arabic language scores. Similar findings were found in other studies that children who consumed their breakfast and midday meal were more able to concentrate, and be alert with high grades especially in

Table 2 Comparing cognitive abilities and psychosocial problems between the intervention and control groups

Cognitive parameter	Students had not taken school meal (control group) ($n=884$, mean ± SD)	Students had taken school meal (intervention group) ($n=902$, mean ± SD)	*P* value
Cognitive abilities			
Figural memory (short-term visual memory)			
Recall	7.45 ± 3.25	9.71 ± 2.80	< 0.001
Classification	8.48 ± 3.08	5.66 ± 2.03	< 0.001
Auditory vigilance (A) right responses	10.82 ± 8.92	25.02 ± 3.36	< 0.001
Auditory vigilance (B) right responses	5.07 ± 6.02	14.01 ± 2.09	< 0.001
Digit span (working memory)			
Morning	8.57 ± 1.66	8.38 ± 1.692	0.02
Afternoon	7.75 ± 3.05	8.20 ± 2.21	< 0.001
P value of paired t test between two means (morning and evening)	< 0.001	> 0.05	
Coding (information processing)	28.79 ± 9.82	26.80 ± 9.92	< 0.001
Psychosocial problems			
Total score of PSC-17	4.92 ± 5.31	9.09 ± 5.85	< 0.001
Score of internalizing behavior	1.18 ± 1.94	2.66 ± 2.11	< 0.001
Score of externalizing behavior	3.30 ± 2.67	2.96 ± 2.54	< 0.001
Score of inattention	2.53 ± 2.32	3.49 ± 2.18	< 0.001

PSC-17 pediatric symptom checklist-17, *SD* standard deviation. $P<0.05$ is significant, $P>0.05$ is insignificant, $P<001$ is highly significant according to the results of independent sample *t* test

math [36–39]. The studies attributed this phenomenon to the fact that the school meal alleviated hunger which in turn improved children's concentration and attention [37]. In the current study, school meal flour provides 16.9% of RDA for energy and 26.81% of RDA for protein. Providing the pie meal early in the school day helped in alleviating hunger before classes, and in improving attention, concentration, and achievement of our children. Also, having meal or breakfast affected cognitive performance of children indirectly, through improvement of mood, alertness, and motivation which was in accordance with the results of other studies [39–42]. Psychoemotional development is also encouraged to start early during antenatal and postnatal care [43]. In the current study, children receiving school meal showed a higher level of psychosocial problems, inattention and internalizing behavior but not externalizing behavior. This finding may be due to the presence of other contributing factors such as low socioeconomic status of the family, order of the child and deficient parental education. This finding was consistent with the results of the other Egyptian study [43].

The current study showed that physical growth of children was not affected by taking the school meal as shown by anthropometric measurements of weight and height. Although this seems to be strange and opposite to what is expected, yet it can be explained by the fact that school meal needs a long time to show measurable impact on nutritional indicators. In addition, other factors affecting the physical status of the studied children also existed, such as parents' education, number of siblings, child order, and better nutrition at home. The significant presence of more overweight children in the control group than the intervention one ($P<0.001$) could be attributed to the fact that these children were deprived of the highly nutritive school meal which might be replaced with alternatives that easily leaded to obesity. This emphasized the role of school meal in combating obesity. Similar findings were reported in an Indian study [44]. On the contrary, other studies found a higher WAZ and HAZ of children under SFP [45–48]. It is recommended to develop nutrition guidelines and standards to ensure that school meals and other available foods are in line with targeted children's needs and context [49].

Our results indicated that the school meal was the strongest predictor of higher scores of visual memory and auditory attention test. Meanwhile, the role of mother's education was one of the main predictors of the improved information processing speed and morning working memory. These results are in agreement with that of several Egyptian studies [31, 43, 50]. This means that cognitive performance of school children could be predicted by nutritional factors in combination with improved enabling environment (small family size, high income, and mother education).

This study was a longitudinal study that facilitated the investigation of the short-term and long-term effects of school meal on cognitive function in school children. We recruited a convenient representative sample of children on which results provided comprehensive parameters, reliable

Table 3 The weight of school meal, dietary behavior, and socioeconomic variables in explaining variation in cognitive parameters

Dependent variables	Independent variables	Unstandardized coefficients	Standardized coefficients		*P* value
		B	Beta	CI, lower limit and upper limit of coefficient	
Visual memory (free recall)					
$R^2 = 0.126$	Constant	6.995		(2.980–4.737)	< 0.001
SE = 3.016	School meal	2.329	0.362	(2.061–2.650)	< 0.001
F ratio = 85.362	Mother education	0.387	0.059	(0.077–0.676)	0.012
P < 0.001	Taking breakfast	0.386	0.054	(0.072–0.694)	0.015
Visual memory (categorization)					
$R^2 = 0.239$	Constant	8.506		(9.670–11.042)	< 0.001
SE = 2.584	School meal	2.820	0.476	(3.013–2.519)	< 0.001
F ratio = 189.679	Sex	− 0.301	− 0.051	(0.063–0.546)	0.014
P < 0.001	Family income	0.254	0.043	(0.037–0.532)	0.044
Auditory vigilance					
$R^2 = 0.547$	Constant	8.588		(− 8.879 to 3.979)	< 0.001
SE = 6.584	School meal	14.323	0.733	(13.542–14.783)	< 0.001
F ratio = 538.024	Frequency of meals	1.429	0.047	(0.496–2.477)	0.004
P < 0.001	Sex	0.751	0.038	(− 1.392 to 0.142)	0.017
	Taking breakfast	0.843	0.039	(0.128–1.550)	0.019
Speed of information processing					
$R^2 = 0.041$	Constant	28.116		(17.482–23.863)	< 0.001
SE = 9.729	Sex	− 2.515	− 0.127	(1.610–3.419)	< 0.001
F ratio = 15.187	Mother education	1.206	0.060	(0.221–2.297)	0.023
P < 0.001	School meal	1.493	0.075	(2.286–0.369)	0.002
	Child order of birth	1.316	0.065	(1.390–2.255)	0.006
	Family income	1.025	0.052	(1.067–2.032)	0.041
Working memory (in morning)					
$R^2 = 0.027$	Constant	8.035		(6.166–7.368)	< 0.001
SE = 1.659	Family income	0.331	0.098	(0.165–0.497)	< 0.001
F ratio = 12.403	Mother education	0.275	0.080	(0.106–0.444)	0.001
P < 0.001	Frequency of meals	0.302	0.058	(0.061–0.542)	0.014
	Sex	− 0.180	− 0.054	(0.025–0.335)	0.023
Working memory (in afternoon)					
$R^2 = 0.024$	Constant	7.462		(4.638–6.200)	< 0.001
SE = 2.639	School meal	0.669	0.125	(0.394–0.913)	< 0.001
F ratio = 11.009	Mother education	0.448	0.082	(0.162–0.718)	0.002
P < 0.001	Family income	0.352	0.066	(0.082–0.614)	0.010
	Sex	− 0.306	− 0.057	(0.060–0.550)	0.014
Academic achievement					
$R^2 = 0.175$	Constant	44.644		(− 2.543 to 13.838)	< 0.001
SE = 19.486	School meal	18.468	0.431	(16.279–20.226)	< 0.001
F ratio = 62.868	Size of family	4.827	0.113	(2.873–6.680)	< 0.001
P < 0.001	Frequency of meals	7.250	0.109	(4.214–9.871)	< 0.001
	Family income	2.995	0.070	(1.431–1.473)	0.003
	Gender	− 3.012	− 0.070	(1.065–4.714)	0.001
	Mother education	2.424	0.056	(0.451–3.095)	0.022

$P < 0.05$ is significant, $P > 0.05$ is insignificant, $P < 0.001$ is highly significant according to the results of multiple linear regression analysis

markers, and indicators for the Egyptian SFP using reliable tools.

Although, many Egyptian models highlighted the strength of empowering families through education as one of the best approaches for achieving a healthy lifestyle for different health settings [51–55]. Yet, due to the difficulty of families' accessibility, our approach for SFP interventions was limited to school facilities without the engagement of educating mothers about healthy eating and improving family understanding of the need and value of having breakfast to improve child health. There were no baseline data to apply pretest–posttest control design. Using teacher report in PSC-17 can sometimes lead to measurement bias.

In conclusion, SFP had a positive impact on cognitive function of children in terms of memory and attention and school achievement, which was prominent for math results. No positive outcomes were found for behavioral and nutritional parameters.

Author contributions AMM designed the study and the approach, and reviewed the manuscript. MMS wrote the manuscript. AMM, LAE, and EMS reviewed and revised the manuscript. EMS, HAH, AH, and ZMM shared in data collection. HAH and AH did the statistical analyses. NH supervised the data collection process. AMM, MMS, LAE, and EMS interpreted the data. AMM and MMS shared in putting the final format. All authors provided input into the manuscript and approved the final manuscript.

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Compliance with ethical standards

Ethical approval The study was approved by the Medical Research Ethics Committee of the National Research Centre with the ethical approval number of 19068. Permission to conduct the research was obtained from the Ministry of Education. Competing interest for all authors "No financial or non-financial benefits have been received or will be received from any party related directly or indirectly to the subject of this article.

Conflict of interest We declare no competing interests.

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