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Original article

Evaluation of validity of digital photograph based dietary intake in school children

Tugce Orkun Erkilic[1], *Gulden Pekcan*[2]

[1] Department of Nutrition and Dietetic, Faculty of Health Sciences, Bartin University, Bartin, Turkey
[2] Department of Nutrition and Dietetic, Faculty of Health Sciences, Hasan Kalyoncu University, Gaziantep, Turkey

Abstract. *Study Objectives:* Accurately assessing children's dietary intake is a challenging task. This study aimed to assess the dietary intake of school children using 24 hour records (RM) and digital photograph (DM) based dietary intake methods, to validate the use of a novel digital image-based food record and to assess the feasibility. *Methods:* This study was held in Mehmet Özcan Torunoğlu Elementary School in Ankara on 40 (50.0% boys) children. A questionnaire was applied, general characteristics, food consumption frequencies and physical activity levels of the children were assessed. Each week 5 children were recruited and 24-h record method (RM) was applied for 4 consecutive days with one day as a weekend day. For the same period by using a digital camera, the participants were instructed and demonstrated to take digital photos (DM) for all meals and snacks, before and after the consumption of foods. Anthropometric measurements (height, body weight, waist, and hip circumferences) of children were taken and body mass index (BMI), waist circumference/height ratios were calculated. *Results:* Mean (±SD) age of the boys and girls were 8.05±0.22 and 8.1±0.31 years, respectively. According to RM and DM, daily energy intakes of boys were 2226.9 ±613.13 and 1611±209.79 kcal ($p<0.05$) and girls were 1781.5±341.83 and 1404.7±258.04 kcal ($p<0.05$), respectively. Mean daily energy, protein, carbohydrate intakes and also the mean daily intakes of vitamins B1, B2, B6, folic acid, vitamin C, A, and E and minerals; calcium, magnesium, phosphorus, iron, and zinc were found higher in RM than DM ($p<0.05$). *Conclusions:* Dietary intakes of nutrients of children were found higher by RM than DM method, due to recording only food served on the plate but not considering the plate-waste. These results suggest that digital photographs are more feasible to use in dietary assessment in children and also to assist in RM. The use of technology is an important area of study in dietary assessment and may offer a means of addressing some of the challenges in dietary assessment in children as a practical, easy, and preferred method. For future research, DM should be evaluated in different age groups, such as in preschool children, adolescents, adults, elderly, and disabled people.

Keywords: Food Record Method, Digital Photography, Dietary Assessment, School Children

Introduction

To protect and improve health, nutritional status should be continuously monitored and evaluated especially in risk groups in the society (0-5 age group children, school age children, and youth, pregnant and lactating women, elderly people, workers) and patients (1). As adequate and balanced nutrition is crucial for survival (2). Nutrition of school children is important not only for providing physical development but also for protecting children from diseases (3). By the end of 2019, according to the Address Based Population Registration System results; the population of children constitutes 27.5% of the total population in Turkey (4). In Turkey, there are many studies aimed at determining the nutritional status of children of school age, but

classical food consumption methods were used in all of these studies. Because of the memory of children and adolescents is not as developed as adults, they may forget how much they eat if food is not served and recorded immediately (5-7).

In recent years, there has been an interest in developing valid methods for determining the food consumption of children (8). A variety of methods are available and are used for dietary intake studies. Recent advancements in technology in dietary assessment, specifically the use of digital imaging of food, is a promising method in nutrition and dietetics research and practice. Food photographs are widely used as instruments to estimate the amount of consumed foods. A study conducted on children aged 9-10 suggested that the use of a digital photography method to evaluate the food consumption of children in this age group had many advantages (9). The advantages of using electronic methods to collect dietary intake data are that entries can be completed faster than traditional methods (10), nutritional analysis can be performed in real time, and the researcher burden can be significantly reduced (11) especially as we practiced during the COVID-19 pandemic.

This study aimed to assess the dietary intake of school children using 24 hour records (RM) and digital photograph (DM) based dietary intake methods, to validate the use of a novel digital image-based food record and to assess the feasibility.

Material and Method

Participants

The sample of the study consisted of 40 (20 boys and 20 girls) volunteer children studying at Mehmet Özcan Torunoğlu Primary School. Ethical approval for the present study was obtained from the Scientific Research Evaluation Commission of Hacettepe University Faculty of Medicine with number 26-779.

Data collection and dietary intake

A questionnaire was applied for the determination of the general characteristics, food consumption frequency, and physical activity levels of the children. Anthropometric measurements (height, body weight, waist, and hip circumferences) of children were taken (12-13) and body mass index (BMI), waist circumference/height ratios (WHtR) were calculated (14) and evaluated. Each week 5 children were recruited and 24-h record method (RM) was applied for 4 consecutive days with one day as a weekend day. For the same period by using a digital camera, the participants were instructed and demonstrated to take digital photos (DM) for all meals and snacks, before and after the consumption of foods with the same photography technique shown as Figure 1.1 and Figure 1.2.

Some of the photographs taken before (Figure 2.1. - 4.1.) and after (Figure 2.2.- 4.2.) consumption of the foods by children are given respectively.

Statistical Analysis

The statistical evaluation of the data was performed using the Statistical Package for the Social Sciences (SPSS) 15.0 program. Descriptive statistics mean ($\bar{x}$) ± Standard Deviation (SD) was used for the evaluation of continuous variables, which were numeric variables with a normal distribution such as anthropometric measurements, food consumption, energy, and

Figure 1.1. Setting the distance

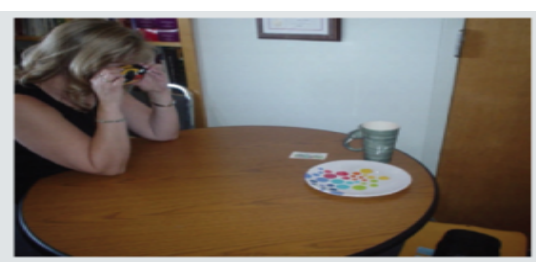

Figure 1.2. Photographing

Figure 2.1. Before consumption

Figure 2.2. After consumption

Figure 3.1. Before consumption

Figure 3.2. After consumption

Figure 4.1. Before consumption

Figure 4.2. After consumption

nutrient intake of the children by gender. Whether the data in the statistical analysis showed a normal distribution was reviewed with the Independent sample t-test. The Wilcoxon signed rank test and one sample Kolmogorov-Smirnov test was used for variables that did not show a normal distribution. Apart from these, Pearson correlation coefficients between continuous variables such as children's anthropometric measurements, and BMI were examined one by one and evaluated statistically (15). The significance level was taken as 0.05 and was considered statistically significant in the case of $p < 0.05$.

Results

Mean age and anthropometric measurements of children are listed in Table 1. The mean age of the boys and girls was 8.05±0.22 and 8.1±0.31 years, respectively. The body weight was 28.5±4.16 kg in boys and 29.1±5.83 kg in girls. Height was 133.0 ± 3.53 cm in boys and 131.9 ± 4.51 cm in girls. Waist circumference measurements of boys and girls were as follows respectively; 58.5±4.56 cm and 59.0±7.10 cm. The hip circumference was 68.6±4.47 cm for boys and 69.3±6.09 cm for girls. Body mass index (BMI; kg/m^2) was calculated as 16.9±2.68 kg/m^2 for boys and 15.8±2.24 kg/m^2 for girls. Waist hip ratio and waist height ratio was calculated as follows for boys and girls respectively; 0.9±0.04 and 0.4 ± 0.03 and 0.9±0.04 and 0.4 ± 0.05. The mid upper arm circumference was 20.0±1.78 cm for boys, and 20.4±2.44 cm for girls.

Nearly half of the boys (50.0%) and girls (45.0%) were in normal BMI classification according to WHO 2007 reference values (BMI: 15-85 percentiles) and in

the normal group for metabolic risk classification compared to WHtR (90.0% and 70.0%, respectively).

Correlations between children's anthropometric measurements are listed in Table 2. It was found that there was a positive and highly linear correlations between children's body weight and waist circumference (r = 0.909; p <0.05), hip circumference (r = 0.953; p <0.05), upper middle arm circumference (r = 0.839; p <0.05), waist circumference / height ratio (r = 0.816; p <0.05), and BMI (r = 0.934; p <0.05).

Daily energy and nutrients intake of children by gender according to food records (RM) and digital photography methods (DM) are given in Table 3. According to RM and DM, daily energy intakes of boys were 2226.9±613.13 and 1611±209.79 kcal (p<0.05) and girls were 1781.5±341.83 and 1404.7±258.04 kcal (p<0.05), respectively. Mean energy, protein, carbohydrate intakes, and also the mean daily intakes of vitamins B1, B2, B6, folic acid, vitamin C, A, E and minerals; calcium, iron, and zinc were found higher in RM than DM (p<0.05). Mean daily percentages of energy coming from carbohydrates were RM: 42.8±3.46% and DM: 40.1±4.17% for boys and RM: 45.9±5.39% and DM: 43.0±5.33% for girls, protein were RM: 15.8±1.94% and DM: 17.1±2.47% for boys and RM: 16.1±1.70% and DM: 17.4±2.46% for girls and fats were RM: 41.5±2.78% and DM: 42.9±3.60% for boys and RM: 38.2±4.75% and DM: 39.6±5.25% for girls, respectively.

The mean daily consumption of food groups by the genders according to food records and digital photography methods of children are listed in Table

Table 1. Anthropometric measurements of children and assessment of measurements according to standards and disease risk

Age and anthropometric measurements		**Boys (n=20)**		**Girls (n=20)**	
		$\bar{X}$**± SD**		$\bar{X}$**± SD**	
Age (years)		8.05±0.22		8.1±0.31	
Body weight (kg)		28.5±4.16		29.1±5.83	
Height (cm)		133.0 ± 3.53		131.9 ± 4.51	
Waist circumference (WC) (cm)		58.5±4.56		59.0±7.10	
Hip circumference (cm)		68.6±4.47		69.3±6.09	
BMI (kg/m^2)		16.9±2.68		15.8±2.24	
Waist/hip ratio		0.9±0.04		0.9±0.04	
Waist/height ratio (WHtR)		0.4 ± 0.03		0.4 ± 0.05	
Mid upper arm circumference (MUAC) (cm)		20.0±1.78		20.4±2.44	
BMI[a]	**Percentiles**	***n***	**%**	***n***	**%**
Underweight	< 3	3	15.0	3	15.0
Slightly underweight	3 - 15	1	5.0	2	10.0
Normal	15-85	10	50.0	9	45.0
Overweight	85-97	4	20.0	2	10.0
Obese	≥ 97	2	10.0	4	20.0
Disease risk from WHtR[b]					
Underweight	<0.4	2	10.0	3	15.0
Normal	0.4≤ - < 0.5	18	90.0	14	70.0
Overweight	0.5≤ - < 0.6	-	-	3	15.0
Obese	≥ 0.6	-	-	-	-

[a] *WHO Growth reference data*

[b] *Distribution according to Ashwell Chart*

Table 2. Correlations between children's anthropometric measurements (n=40)

Anthropometric measurements	Correlation Coefficient (r)					
	Height	**Weight**	**WC**	**HC**	**MUAC**	**WHtR**
Height	1					
Weight	0.463*	1				
WC	0.339**	0.909*	1			
HC	0.351**	0.953*	0.887*	1		
MUAC	0.263	0.839*	0.770*	0.794*	1	
WHtR	0.039	0.816*	0.953*	0.831*	0.730*	1
BMI	0.118	0.934*	0.881*	0.928*	0.829*	0.897*

** p<0.01 ** p<0.05*

Table 3. Daily energy and nutrients intake of children by the gender according to food records and digital photography methods

Energy and nutrients	Boys (n=20)					Girls (n=20)				
	RM		DM			RM		DM		
	$\bar{X}$	SD	$\bar{X}$	SD	t value	$\bar{X}$	SD	$\bar{X}$	SD	t value
Energy (kcal)	2226.9	613.13	1611.0	209.79	*4.51	1781.5	341.83	1404.7	258.04	*7.01
Protein (g)	83.4	17.09	67.4	11.77	*5.29	69.7	14.49	59.7	13.95	*6.66
Protein (%)	15.8	1.94	17.1	2.47	*-3.01	16.1	1.70	17.4	2.46	*-3.70
Fat (g)	103.5	28.06	77.5	11.90	*4.49	76.7	19.84	63.5	18.53	*6.19
Fat (%)	41.5	2.78	42.9	3.60	*-2.39	38.2	4.75	39.6	5.25	*-3.40
Carbohydrate (g)	234.5	77.45	157.3	27.96	*4.22	198.2	41.93	145.1	20.26	*6.70
Carbohydrate (%)	42.8	3.46	40.1	4.17	*2.96	45.9	5.39	43.0	5.33	*5.19
Vitamin B1 (mg)	0.9	0.29	0.7	0.21	*4.91	0.7	0.18	0.5	0.12	*5.87
Vitamin B2 (mg)	1.8	0.59	1.4	0.57	*6.04	1.5	0.33	1.1	0.29	*7.53
Vitamin B6 (mg)	1.5	0.50	1.1	0.24	*4.17	1.2	0.32	0.9	0.20	*6.59
Folic acid (mcg)	268.4	66.38	221.3	55.39	*5.35	216.1	59.69	178.1	49.14	*5.85
Vitamin A (mcg)	2238.7	2907.02	1949.6	2931.99	*f* *-3.36	1376.8	493.92	1218.2	503.37	*2.52
Vitamin C (mg)	127.6	58.05	82.5	43.68	*5.04	95.1	49.49	66.0	27.61	*3.61
Vitamin E (mg)	17.2	5.91	13.1	3.95	*5.02	12.1	3.91	10.3	3.46	*4.93
Calcium (mg)	1052.2	306.03	751.7	167.33	*5.16	912.1	246.25	670.9	226.18	*7.14
Iron (mg)	12.1	3.43	9.3	1.90	*4.07	9.7	2.03	8.0	1.60	*5.65
Zinc (mg)	11.4	2.14	9.5	1.56	*5.11	9.9	2.26	8.4	2.02	*6.07

** p<0.05 **p<0.001*

Table 4. The mean daily consumption of food groups by the genders according to food records and digital photography methods of children

Food groups (g/day)	Boys (n=20)					Girls (n=20)				
	RM		DM			RM		DM		
	$\bar{X}$	SD	$\bar{X}$	SD	t value	$\bar{X}$	SD	$\bar{X}$	SD	t value
Milk and dairy products										
Milk-yogurt	228.6	148.43	237.4	146.21	-1.74	276.0	94.13	267.0	97.63	0.89
Cheese	25.2	17.97	24.7	17.52	1.22	16.9	18.01	17.5	17.56	-0.57
Meats, eggs, and legumes										
Eggs	33.8	21.56	33.7	21.32	0.41	33.0	17.30	33.3	17.48	-0.27
Meats	45.1	23.75	48.7	23.35	**-1.86	44.1	18.18	44.1	22.06	0.0
Poultry	42.8	38.02	33.7	36.01	**1.92	26.0	23.87	25.6	23.82	0.24
Fish	5.6	13.57	3.8	11.70	1.00	1.9	5.97	1.9	5.97	Z: 0.0
Meat products	11.7	19.97	12.0	20.11	-1.19	11.9	13.69	11.8	13.76	0.20
Legumes	14.9	10.64	14.9	10.10	0.0	17.1	21.72	14.7	16.01	1.47
Bread and cereal										
Bread	50.3	32.45	53.2	32.44	-0.98	60.3	28.33	60.0	29.30	0.12
Cereal	78.9	48.84	78.4	49.97	0.14	61.5	45.10	49.4	33.78	*2.24
Vegetables and fruits										
Leafy greens	45.4	27.43	47.5	29.08	-1.59	33.6	32.76	31.4	30.68	0.47
Others	26.8	21.70	28.0	27.89	-0.63	23.9	13.77	22.0	12.21	**1.94
Potatoes	33.7	25.06	33.4	25.45	0.14	25.6	19.86	25.0	19.70	0.36
Fruits	69.9	40.09	61.8	39.07	1.53	55.9	55.23	46.1	53.06	**1.78
Fats and oils-sweets										
Fats	17.6	5.02	17.5	5.87	0.30	17.5	6.30	14.7	6.40	*4.26
Oils	10.1	6.73	9.9	6,66	0.48	7.9	4.29	7.7	4.17	1.16
Sweets	6.4	7.79	7.0	8.05	-1.35	5.0	4.81	3.6	4.48	**1.90
Water	194.5	188.05	224.5	194.10	*-2.37	136.2	92.71	154.0	87.90	-1.32

*$p<0.05$ **$p<0.001$

4. Mean daily poultry consumption amount of boys and the mean cereal, other vegetables, fruits, fats, and sweets consumption amount of girls were found lower by DM and the differences were found significant ($p<0.05$). Also, meat and water consumption of boys were found higher by DM ($p<0.05$).

Discussion

While recording the food consumption, it was determined that the plate residues of the children were not taken into account and the amount put in front of the child was recorded, not what the child consumed. In this study, it was considered that mean energy, protein, carbohydrate intakes and also the mean daily intakes of vitamins B1, B2, B6, folic acid, vitamin C, A, E, and minerals; calcium, iron, and zinc were found higher in RM than DM ($p<0.05$) was the reason of this.

In calculating the photographing method, the child's plate residues were also taken into account and the opportunity to reach correct results was provided. The stated reasons cause a difference between the

results obtained from the questionnaire and the photography method regarding the food consumption of children.

Although the photography method did not provide any advantage in terms of the accuracy of food consumption compared to other methods, it was found to be more useful and less troublesome for the participating children and their families (16). In a study, most of the participants' families shared that they reminded their parents to write down and take photos of the foods their children ate and that they helped their children complete the food registration (17). In this study, children and their parents indicated that they would prefer the digital photography method (85.0%), due to less time usage (92.5%) and for being an easier way to apply (90.0%).

In studies conducted on children, it was seen that the digital photography method was more appropriate because it did not give errors like other methods, reduced the burden on children's families, and increased the accuracy of the collected data (8). The food recording method based on digital photography has been determined as a method that can be preferred especially for reasons such as age, cognitive state, practicality in children and providing more accurate quantification in children. Assessment of food consumption by digital photography is a promising method that enables complete food consumption recording (8).

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Correspondence:
Gulden Pekcan
Department of Nutrition and Dietetic, Faculty of Health Sciences, Hasan Kalyoncu University, Gaziantep, Turkey
E-mail: gulden.pekcan@hku.edu.tr