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Original article

Comparison of different food consumption methods to digital food photography method of elderly in nursing home

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Abstract. *Background:* Detection of food consumption by digital photography is a recently applied method in the world. The main purpose of the present study was to identify the most efficient method in determining the food consumption of the elderly in the nursing home by comparing different food consumption records to the digital photography method. *Methods:* A total of 52 (27 men, 25 women) elders, who did not have a neurological or psychiatric disturbance, were included in the study. The study was carried out in Ankara Seyranbağları Nursing Home Directorate for the Elderly Care and Rehabilitation Center. Nutritional status was screened using a questionnaire from the Mini-Nutritional Assessment, basic characteristics were determined and anthropometric measurements were assessed. Food consumption of elderly people was evaluated by daily food record, 24 hour retrospective food record, food frequency, and digital photography method, and the relevancy of these methods for the elderly were evaluated. *Results:* Most of the consumed food groups (milk, yoghurt, cheese, red meat, potatoes, fruit, oil, and sugar group for elderly men, eggs, red meat, fish, meat products, legume, bread, cereals, other vegetables and fat group for elderly women) were found to be highest according to food frequency, and then food records and lowest mean values were obtained by digital photography. At the end of the research, when the mean consumption of energy, protein, fat, and carbohydrate of elderly were ordered in descending order, it was seen that for all genders the order was same: the highest means had seen on food records than food frequency and the lowest means had seen on digital photography. Daily mean energy intake in the food record, digital photography and food frequency in respectively of men were 3172,86±484,42 kcal, 2189,60±470,69 kcal, and 2758,26±817,70 kcal and the women were 3312,20±359,41kcal, 2191,73±401,36 kcal and 2628,00±733,92 kcal. For both genders, the difference between the measuring methods of energy consumption was statistically significant (p=0,001). In both genders, the lowest intake of all other nutrients except sodium was determined by the digital photography method ($p<0.05$). *Conclusions:* As a result, the digital photography method can record the full food consumption of the elderly in the nursing home and it is also a promising method. Although there are various limitations in the digital photography method like the other methods used. Therefore, considering the advantages and disadvantages, it is thought that the limitations of the methods and possible errors can be avoided by using more than one method together in the determination of food consumption.

Keywords: food record methods, digital photography, food consumption, food frequency questionnaire, elderly.

Introduction

Aging is an inevitable process of change in the human body from birth to death. In this process, as time passes, irreversible structural and functional changes are defined as "aging" (1). As the aging process is inevitable, it is important to improve the life quality of the individuals and this makes regulating nutrition a necessity. Therefore, the elderly are one of the age groups at risk in society in terms of nutrition.

According to the research report with a worldwide scope of the Turkish Statistical Institute (TSI), the elderly population constitutes 8.8% of the world population in 2019. The population aged 65 and over constitutes 9.1% of the total population in Turkey. According to population projections, it is estimated that the rate of the elderly population will increase to 10.2 % in 2023, to 16.3% in 2040, and to 25.6% in 2080 (2).

Adequate and balanced nutrition, especially during the old age, is important in terms of protection, development, and improvement of health, delaying or preventing the occurrence of chronic diseases and extending the life span and improving life quality (3). Therefore, the detection of the nutritional status of the individuals of this age group at certain intervals and adopting measures to prevent poor nutritional status from affecting the life quality of the elderly is of great importance.

Nutritional status should be determined by dieticians as it is known that to determine the food consumption status of the elderly and to collect this information during the research is challenging (4-7). Daily food record and retrospective food recall (often 24 hours) are the methods commonly used to determine food consumption, nutritional history, and food frequency. If food consumption is recorded by the individuals participating in the study; erroneous data can be obtained due to cases such as individuals, who participate in the study, writing less or more of their food consumption, the probability of making mistakes in the portion sizes and transferring misinformation due to failure to record the food consumption on the same day (8-10). Research on the evaluation of food consumption record methods shows that recording food consumption by the participants causes a common problem and food consumption are underreported (11-14). In these studies, it is reported that participants underreported their energy intake in ratios 20% to 50% (14-17). While evaluating food consumption, the conversion of nutrients into the nutritional elements using relevant references and scales, the necessity of the nutritional expertise in calculating the usage ratios of the nutrients in the body and also impact of possible errors in the relevant references and scales on the results may cause difficulty in evaluating the actual food consumption and ± 10% error in the results (18).

The food frequency method is used to determine the nutritional status of the elderly as well as other methods. If this method is used in conjunction with a 24-hour food record, the results are closer to reality, which facilitates the identification of a possible link between the nutritional pattern and disease conditions of individuals (19-21).

Detection of food consumption by the digital photography method was first applied to 25 participants by Bird and Elwood (22). In this study, a high quality digital camera was given to the individuals, and all the food (food and drinks) in the plates before and after consumption was photographed. As a result of this study, Elwood and Bird (22) stated that the digital photography method was the most suitable method to be applied to the participants for determining food consumption. Another study on children (23); showed that food consumption by digital photography could be used in the evaluation of nutritional intake in children. Although the digital photography method does not provide any advantage in terms of the accuracy of food consumption compared to other methods, it is found to be more useful and less challenging for participants (23).

Preliminary studies in children confirm the digital photography method for evaluating food consumption (24). In the assessment of food consumption in adults, the digital photography method is recommended (25-26). Evaluation of food consumption using digital photography is reported as a promising method that allows for

complete food consumption recording (24-27). Compared to other methods, the digital photography method is accepted as a more reliable and validated method in the determination of food consumption in adults (26, 28). In a study conducted on eighteen participants, mobile technologies are reported to be useful and practical tools for determining and evaluating food consumption (29). As a result of many studies on the elderly, it is found that digital photography is a valid and useful method for measuring food consumption in institutions with the elderly population (28, 30-33).

The present study aimed to identify the most efficient method to be used for the elderly by determining the food consumption of the elderly in the nursing home daily food record, 24-hour retrospective food record, food frequency, and digital photography method, and comparing the results.

Materials and Methods

This study was carried out at Seyranbağları Nursing Home for Elderly Care and Rehabilitation Center affiliated to the T.R. Ministry of Family and Social Policies located in Ankara to compare different food consumption records to digital photography method for the elderly at the nursing home. A total of 52 nursing home residents including 27 men and 25 women aged 65 years and over, who did not have neurological or psychiatric disorders. Ethical approval for the present study was obtained from the Hacettepe University Ethics Committee with number 16969557-1280 and institutional permission was taken from the Ministry of Family and Social Policies.

Anthropometric measurements

The body weights of elderly individuals wearing minimal clothing without shoes were measured to the nearest 0.1 kg with a TANITA BC-532 model portable scale (21). Height of the elderly, waist circumference, hip circumference, mid-upper arm circumference anthropometric measurements were made with a rigid measuring tape with 0.1 cm sensitivity (19). Body Mass Index (BMI; kg/m²) was calculated for each subject. The results were evaluated according to the World Health Organization (WHO) classification (34).

Data collection and dietary intake

In the first interview, a questionnaire was applied to determine the general characteristics of individuals. The questionnaire was completed by the researcher by interviewing the participants themselves. Mini Nutritional Assessment (MNA) questionnaire was applied to each participant to evaluate the nutritional statuses of individuals. To determine the frequency of general food consumption habits of the elderly, the food frequency method was applied. Every week, food consumption records of an average of 5 participants for three consecutive days including one day on weekend, were taken. The records were kept by the elderly or the researcher by asking the elderly. In addition to daily food records, amounts of food and drinks were identified by photographing the plates for 3 days before each meal and after consumption with leftovers. Some of the photographs taken before (Figure 1.1.1.-Figure 1.6.1.) and after (Figure1.1.2.-Figure1.6.2.) consumption of the foods by the elderly are given respectively.

Statistical Analysis

The statistical evaluation of the data was performed using IBM SPSS 20.0 program. Whether the data in the statistical analysis showed a normal distribution was reviewed with the Kolmogorov-Smirnov test. 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 nutrient intake of the elderly by gender. Repeated measures ANOVA was used for repeated measurements for the comparison of mean energy, and nutrients obtained from daily food record, digital photography method, and food frequency that provide parametric assumptions, and Bonferroni was used for multiple comparisons. The Friedman test is used for variables that did

Figure 1.1.1. Before consumption

Figure 1.1.2. After consumption

Figure 1.2.1. Before consumption

Figure 1.2.2. After consumption

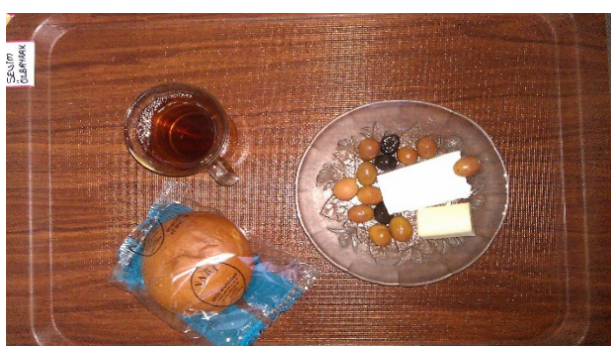

Figure 1.3.1. Before consumption

Figure 1.3.2. After consumption

Figure 1.4.1. Before consumption

Figure 1.4.2. After consumption

Figure 1.5.1. Before consumption

Figure 1.5.2. After consumption

Figure 1.6.1. Before consumption

Figure 1.6.2. After consumption

not provide parametric assumptions and multiple pairwise comparison test was used for multiple comparisons (35-36). The significance level was taken as 0.05 and was considered statistically significant in the case of $p < 0.05$.

Results

The socio-demographic characteristics of the participants are listed in Table 1. The mean age of the elderly was 76,8 ± 8,06 years and the proportion of men and women were 51.9% and 48.1%, respectively. 25,0% were primary school graduates while the elderly with the same ratio were university graduates. 78,8% of the elderly had at least one diagnosed disease. The most prevalent were hypertension (63,4%), cardiovascular diseases (46,3%), diabetes mellitus (29,3%) and rheumatic diseases (19,5%) (Table 1).

Anthropometric measurements of the elderly and assessment of measurements according to standards and disease risks are presented in Table 2. The body weight was 80,18±15,65 kg in men and 69,21±14,59 kg in women. Height was 169,48±6,81 cm in men and 149,96±6,46 cm in women. Waist circumference measurements of men and women were as follows respectively; 106,48±11,67 cm and 99,04±11,28 cm. The hip circumference was 107,59±7,51 cm for men and 110,00±9,79 cm for women. Body mass index (BMI; kg/m^2) was calculated as 27,83±4,57 kg/m^2 for men and 30,54±4,89kg/m^2 for women. Waist hip ratio and waist height ratio was calculated as follows for men and women respectively; 0,99±0,07 and 0,63±0,07 and 0,89±0,04 and 0,66±0,67. The upper mid arm circumference was 30,15±3, 73 cm for men, and 30,88±3,87 cm for women. Most of the men and women were overweight according to BMI (BMI: 25,0-29,9) (55,6% and

Table 1. Socio-demographic characteristics of the elderly (n=52)

Socio-demographic characteristics	n	%
Gender		
Men	27	51,9
Women	25	48,1
Age groups (years)		
<64	4	7,7
65-74	16	30,8
75-84	22	42,3
85+	10	19,2
Education status		
Illiterate	6	11,5
Literate (without formal education)	4	7,7
Primary school	13	25,0
Secondary school	5	9,6
High school	11	21,2
University	13	25,0
Disease status		
No disease	11	21,2
At least 1 diagnosed disease	41	78,8
Diagnosed disease		
Obesity	4	9,8
Cardiovascular	19	46,3
Diabetes mellitus	12	29,3
Hypertension	26	63,4
Gastrointestinal	4	9,8
Anemia	3	7,3
Rheumatic	8	19,5
Kidney	5	12,2
Osteoporosis	6	14,6
Others[a]	12	29,3

[a] *Liver-gall bladder disease (n=1), cancer (n=2), problems of eye (n=3), asthma (n=2), goiter (n=1), chronic obstructive pulmonary disease (COPD) (n=3)*

40,0%, respectively) and in the high risk group for metabolic diseases compared to waist circumference (70,4% and 84,0%respectively) and all elderly were in the risk group according to waist-height ratio. According to the waist-hip ratio, the majority of men (55.6%) were normal and all of the women are abdominal fat.

Nutrition, health status, and lifestyle characteristics of the elderly participants are shown in Table 3. It was found out that the elderly were fed on mean 2,96±0,19 main meals and 2,15±0,46 snacks. The mean number of medications used by the elderly was 2,30±2,13 for men and 3,64±2,33 for women. When the smoking status of the elderly was examined; 30,7 of the participants smoke and it was determined that the majority of the smokers were men (87,5%) (χ^2=11,718, p= 0,001). Daily cigarette consumption of the elderly

Table 2. Anthropometric measurements of the elderly and assessment of measurements according to standards and disease risk

Age and Anthropometric Measurements		**Men (n=27)**		**Women (n=25)**	
		$\bar{x}$ ± SD		$\bar{x}$ ± SD	
Age (years)		75,5±7,51		78,1±8,55	
Body weight (kg)		80,18±15,65		69,21±14,59	
Height (cm)		169,48±6,81		149,96±6,46	
Waist circumference (WC) (cm)		106,48±11,67		99,04±11,28	
Hip circumference (cm)		107,59±7,51		110,00±9,79	
BMI (kg/m^2)		27,83±4,57		30,54±4,89	
Waist/hip ratio		0,99±0,07		0,89±0,04	
Waist/height ratio (WHR)		0,63±0,07		0,66±0,67	
Mid upper arm circumference (MUAC) (cm)		30,15±3,73		30,88±3,87	
BMI[a]		*N*	*%*	*N*	*%*
Underweight	< 18.5	-	-	-	-
Normal	18.5-24.9	5	18,5	3	12,0
Overweight	25.0-29.9	15	55,6	10	40,0
Obese (I. Degree)	30.0-34.9	4	14,8	7	28,0
Obese (II. Degree)	35.0-39.9	3	11,1	4	16,0
Morbid Obese	≥ 40.0	-	-	1	4,0
Disease risk from WC[a]					
Normal	(M: <94 W: <80)	3	11,1	1	4,0
Risk	(94≤ M <102 80≤W <88)	5	18,5	3	12,0
High Risk	(M: ≥102 W: ≥ 88)	19	70,4	21	84,0
Waist/hip ratio[a]					
Normal	(M: <1.0 W: <0.8)	15	55,6	-	-
Abdominal obese	(M: ≥1.0 W: ≥0.80)	12	44,4	25	100,0
Disease risk from WHR[a]					
Normal	<0.5	-	-	-	-
Risk	≥0.5	27	100,0	25	100,0

[a] *N (%), M: Men, W: Women*

was 8,37±9,83 for men while the mean number is 1,00±3,54 for women. In general, when asked about their appetite, the majority of the elderly (92,6% in men and 72,0% in women) stated that their appetite was good. When chewing-dysphagia status was examined, 92,6% of elderly men and 80,0% of the elderly women did not experience any problem. The vast majority of the elderly participating in the study (all of the men and 92,0% of all women) were in normal nutritional status. The mean of MNA scores of the elderly was found to be 28,61±1,29 in men and 27,40±2,37 in women. No malnutrition was detected in any one of the elderly participants.

Mean daily consumption of food groups by genders according to food record, digital photography, and food frequency of elderly participants are given

Table 3. Nutrition, health status and lifestyle characteristics of the elderly (n=52)

Nutrition and Health Status	**Men (n=27)**		**Women (n=25)**	
Number of meals consumed (per day)	**$\bar{x}$ ± SD**		**$\bar{x}$ ± SD**	
Main meal	2,96±0,19		2,96±0,20	
Snack	2,07±0,27		2,24±0,60	
Medication use	2,30±2,13		3,64±2,33	
Smoking	8,37±9,83		1,00±3,54	
Appetite	*N*	%	*N*	%
Poor	-	-	1	4,0
Moderate	2	7,4	6	24,0
Good	25	92,6	18	72,0
Chewing/swallowing problems				
Never	25	92,6	20	80,0
Always	2	7,4	5	20,0
Mini-Nutritional Assessment score				
Normal (>23.5)	27	100.0	23	92.0
At risk (17-23.5)	-	-	2	8.0
Malnourished (<17)	-	-	-	-
$\bar{x}$ ± SD	28,61±1,29		27,40±2,37	

in Table 4. When the food consumption of the elderly was evaluated according to the applied methods, the mean of milk-yoghurt consumption of men and women is 272,41±88,56 g and 237,04±108,27 g in daily food record, 238,67±74,05 g and 219,48±103,60 g in the digital photography method and 354,81±187,94 g and 326,24±239,25 g in the food frequency according to the data obtained. When the data obtained from the food consumption status evaluation methods applied to the elderly were compared, these consumption differences between the mean milk-yoghurt consumption for both genders were found to be statistically significant ($p<0.05$).

The mean egg consumption of the elderly women with daily food record, digital photography and food frequency was 34,32±12,77 g, 20,24±12,32 g, and 23,16±13,67 g respectively. These differences for egg consumption means were statistically significant ($p=0,001$).

The mean red meat consumption of the elderly men and women was 73,11±15,41 g and 74,32±27,98 g by food record, 56,56±21,96 g and 41,20±21 by digital photography and 94,52±33,03 g and 55,56±34,03 g by food frequency, respectively. When the data obtained from the applied methods were compared, the differences between the red meat consumption means of the elderly were found to be statistically significant ($p<0.05$).

The mean consumption of poultry meat of elderly women was determined as 29,52±23,66 g, 13,36±14,90 g, and 41,28±30,93g respectively for food record, digital photography and food frequency methods while the mean consumption of legume was 38,24±17,72 g, 21,88±15,96 g, and 31,76±25,45 g respectively by the methods and the mean consumption of green-leaved vegetables was 21,76±14,63 g, 10,32±10,83 g and 22.,92±21,25 g (Table 4). It was found out that elderly

men consumed meat products on mean 16,04±29,73 g according to food record, 3,59±6,78 g according to digital photography and 9,93±14,28 g according to food frequency (Table 4). Mean poultry, legume, and green-leaved vegetable consumptions obtained by these methods used in the determination of food consumption of the elderly women and the differences between the consumption means of meat products were found statistically significant ($p<0.05$).

When the food consumption of the elderly was evaluated according to the methods applied, the mean bread consumption of the elderly men and women was recorded as 281,33±90,09 g and 187,20±117,35 g according to food record, 173,93±90,75 g and 115,12±96,50 g according to digital photography and 168,70±111,21g and 133,88±101,78 g according to food frequency while mean consumption of cereals by the same order was 214,96±59,57 g and 200,24±46,39 g by food record, 121,26±49,84g and 116,28±62,93 g by the digital photography and 152,70±58,69g and 194,24±107,19 g by the food frequency. When the data obtained from the methods applied to the elderly for consumption were compared, the differences between the mean consumption of bread and cereals for both gender were found to be statistically significant ($p<0.05$).

The mean potato, other vegetable and fruit consumptions of elderly men was respectively found as 30,70±12,48 g, 294,07±110,98 g, and 305,07±63,31 g according to the data obtained from food record, as 22,04±14,73 g, 190,33±79,58 g, and 288,41±101,31 g according to digital photography and as 78,89±44,25 g, 155,59±97,32 g, and 642,78±393,64 g according to food frequency (Table 4). When the mean potato, other vegetable and fruit consumptions of elderly women was examined, it was found as 38,00±18,88 g, 274,80±47,83 g, and 307,36±64,46 g according to food record, as 19,36±12,20 g, 147,68±66,68 g, and 216,08±86,53 g according to digital photography and as 92,36±83,06 g, 130,84±81,64 g, and 638,36±382,84 g according to food frequency (Table 4). When the data obtained from the food consumption determination methods applied to the elderly were compared, the differences between the mean consumptions of potato, other vegetables, and fruits for both genders were found statistically significant ($p<0.05$).

The mean fat consumption of elderly men and women was found as 66,67±5,26 g and 8,28±5,39 g according to food record, as 4,11±4,01 g and 5,72±4,28 g according to digital photography and as 4,56±5,27 g and 8,80±6,87 g according to food frequency. The mean consumption of liquid oil was by the same order 36,74±8,29 g and 36,08±9,92g according to food record, 25,78±8,12 g, and 21,76±8,75 g according to digital photography and 37,04±36,57 g and 24,32±16,79 g according to food frequency. According to the data obtained from the methods applied, elderly men consumed sugar of 23,59±14,91 g according to food record, 14,04±10,11 g in digital photography and of 37,00±23,34 g in food frequency method while elderly women consumed 15,72±9,53 g in food record, 13,08±8,05 g in digital photography and 39,00±23,38 g in food frequency. When the data obtained from these three methods used to determine the food consumption of the elderly were compared, the differences between fat, liquid oil, and sugar by these two genders were found to be statistically significant ($p<0.05$).

The differences between the mean consumption of cheese, eggs, poultry, fish, legumes, and green-leaved vegetables of elderly men and the mean consumption of cheese, fish, and meat products of elderly women were not statistically significant ($p>0.05$) when these were evaluated according to the methods applied. However, according to the data obtained when multiple comparison tests were applied to the mean consumption of the same food, the difference between the mean consumption of cheese, eggs, legumes and green-leaved vegetables of the elderly men found using digital photography and food record was found statistically significant ($p<0.05$).

Daily energy and nutrients intake by the genders according to food records, digital photography and food frequency of elderly participants are given in Table 5. The mean daily energy intake of elderly men was found as 3172,86±484,42 kcal, 2189,60±470,69 kcal, and 2758,26±817,70 kcal respectively according to food record, digital photography and food frequency while that of elderly women was 3312,20±359,41 kcal, 2191,73±401,36 kcal, and 2628,00±733,92 kcal. For both genders, the differences by the methods between the means of energy intakes were statistically significant ($p=0,001$). When the daily energy, protein, fat and

Table 4. The mean daily consumption of food groups by the genders according to food record, digital photography and food frequency of elderly participants (g/day)

Food Groups (g/day)	Men (n=27)				Women (n=25)			
	Food Record	Digital Photography	Food Frequency	F/χ2	Food Record	Digital Photography	Food Frequency	F/χ2
	x̄±SD	x̄±SD	x̄±SD		x̄±SD	x̄±SD	x̄±SD	
Milk and dairy products								
Milk-yogurt	272,41±88,56[a]	238,67±74,05[b]	354,81±187,94a	F=9,602	237,04±108,27[a]	219,48±103,60[b]	326,24±239,25[a,b]	F=5,113
Cheese	74,11±26,23[a]	61,15±28,12[b]	74,67±34,57a,b	F=2,732	77,68±17,90	89,08±39,00	89,04±45,89	F=1,576
Meats, eggs and legumes								
Eggs	27,33±17,53[a]	18,70±14,85[b]	25,67±25,23[a,b]	F=1,663	34,32±12,77[a]	20,24±12,32[b]	23,16±13,67[b]	F=9,952
Meats	73,11±15,41[b]	56,56±21,96[c]	94,52±33,03[a]	F=21,132	74,32±27,98[a]	41,20±21,47[b]	55,56±34,03[b]	χ2:21,840
Poultry	52,48±37,70[a]	47,22±34,14[a]	46,00±26,74[a]	F=0,546	29,52±23,66[a]	13,36±14,90[b]	41,28±30,93[a]	F=12,997
Fish	28,85±28,00	23,37±24,72	17,89±6,82	χ2:1,854	18,56±25,84	14,80±24,07	17,52±14,14	χ2:4,030
Meat products	16,04±29,73[a,b]	3,59±6,78[b]	9,93±14,28[a]	χ2:9,257	4,00±6,89	2,04±4,68	3,60±6,40	χ2:3,370
Legumes	38,07±16,41[a]	28,70±17,05[b]	37,44±27,68[a,b]	F=2,239	38,24±17,72[a]	21,88±15,96[b]	31,76±25,45[a,b]	F=4,566
Bread and cereal								
Bread	281,33±90,09[a]	173,93±90,75[b]	168,70±111,21[b]	F=18,647	187,20±117,35[a]	115,12±96,50[b]	133,88±101,78[a,b]	F=5,084
Cereal	214,96±59,57[a]	121,26±49,84[b]	152,70±58,69[b]	F=19,710	200,24±46,39[a]	116,28±62,93[b]	194,24±107,19[a]	F=9,210
Vegetables and fruits								
Leafy greens	30,19±11,58[a]	20,37±11,17[b]	22,33±22,77[a,b]	F=3,592	21,76±14,63[a]	10,32±10,83[b]	22,92±21,25[a]	χ2:15,816
Others	294,07±110,98[a]	190,33±79,58[b]	155,59±97,32[b]	F=20,365	274,80±47,83[a]	147,68±66,68[b]	130,84±81,64[b]	F=35,846
Potatoes	30,70±12,48[b]	22,04±14,73[c]	78,89±44,25[a]	F=36,647	38,00±18,88[b]	19,36±12,20[a]	92,36±83,06[c]	F=14,987
Fruits	305,07±63,31[a]	288,41±101,31[a]	642,78±393,64[b]	χ2:23,906	307,36±64,46[b]	216,08±86,53[c]	638,36±382,84[a]	F=25,110
Fats and oils-sweets								
Fats	6,67±5,26[a]	4,11±4,01[b]	4,56±5,27[a,b]	χ2: 9,276	8,28±5,39[a]	5,72±4,28[b]	8,80±6,87[a,b]	F=4,311
Oils	36,74±8,29[a]	25,78±8,12[b]	37,04±36,57[b]	χ2:20,250	36,08±9,92[a]	21,76±8,75[b]	24,32±16,79[b]	χ2:22,160
Sweets	23,59±14,91[a]	14,04±10,11[b]	37,00±23,34[a]	F=14,532	15,72±9,53[b]	13,08±8,05[c]	39,00±23,38[a]	F=29,794

Variance analysis and Friedman test are used for repeated measurements.

[a,b,c] *Values within row with different superscripts are significantly different (p<0.05).*

carbohydrate intake of the elderly was listed from highest to the lowest, the highest values were obtained from food record for both genders, which was followed by the means obtained from food frequency, and the lowest means are obtained from digital photography method.

When the differences between the methods were evaluated in terms of energy and these three nutrients, highest correlation coefficients were respectively fat (χ^2=28,222), energy (F=26,490), carbohydrates (F=25,046) and protein intake (F=18,143) for the elderly men while for elderly women; protein (F=32,747), energy (F=32,363), carbohydrate (F=31,427) and lowest fat (F=20,690) (p=0,001). Multiple comparison test results showed that means of energy and these 4 nutrient intakes were significantly different for all three methods.

Daily mean fiber consumption of elderly men was found as 39,02±5,34 g in food record, 34,05±12,34 g in food frequency and as 26,64±6,52 g in digital photography method. The difference between the means was statistically significant (F=22,517, p=0,001). Statistically significant difference was found out between the mean daily fiber consumption obtained from digital photography and food record and food frequency, respectively ($p_{DP\text{-}FR}$=0,001, $p_{DP\text{-}FF}$=0,002). Differences between the methods related to daily fiber consumption for elderly women were found statistically significant (F=17,472, p=0,001).

Since the results obtained from food frequency and digital photography method used to measure the daily mean polyunsaturated fat intake of the elderly men, the difference between these two methods was not significant (p>0.05). However, the differences between the means obtained by these two methods and the means obtained by the food record were statistically significant ($p_{DP\text{-}FR}$=0,001 and $p_{FR\text{-}FF}$=0,002) (Table 5). According to multiple comparison test results, the difference between the mean of digital photography and food frequency was not statistically significant (p=1,000) in elderly women (Table 5).

The differences between only the digital photography method and the other two methods for cholesterol intake of elderly men were found to be statistically significant ($p_{DP\text{-}FR}$=0,001 and $p_{DP\text{-}FF}$=0,001). The difference between the mean of the results obtained from three methods in elderly women was found to be significant (F=29,811, p=0,001).

The daily intake of vitamin A in elderly men was 1521.09±337.01 mcg, 958.21±287.76 mcg, and 1625,06±1334.17 mcg according to food record, digital photography, and food frequency. The main difference between the three methods were statistically significant (χ^2=27.630, p=0,001). Daily intake of vitamin E in elderly men was 31,18±5,22 mg according to food record, 21,46±5,44 mg according to digital photography and 24,88±10,65 mg according to food frequency while this value in elderly women was found 29,95±3,91 mg according to food record, 18,84±4,92 mg according to digital photography and 21,24±11,88 mg according to food frequency.

Daily mean of the Group B vitamins B1, B2 and B6 consumed by the elderly men were recorded as 1,28±0,20 mg, 2,13±0,34 mg and 1,99±0.36 mg according to food record; 0,95±0,25 mg, 1,65±0,37 mg and 1,47±0,36 mg according to digital photography and 1,20±0,39 mg, 2,20±0,69 mg and 1,83±0,55 mg according to food frequency. When the mean of intakes by the methods for Group B vitamins were compared, the differences between the means obtained by all three methods are found statistically significant (F_{B1}=12,067, F_{B2}=16,161, F_{B6}=14,441; p=0,001) (Table 5). When the means by the methods for the intake of Group B vitamins from the diet were compared similar to the elderly men, the differences obtained for the elderly women for three methods are found statistically significant (χ^2_{B1}=24.788, F_{B2}=9.840, F_{B6}=19.420; p <0.05) (Table 5).

Daily dietary intake of folic acid in both genders was found highest in food record, secondly in the food frequency, and thirdly in the digital photography method. In line with these results, the difference between the means of daily folic acid intakes of both genders was statistically significant (elderly men; F=22,899, elderly women; χ^2=22,640, p=0,000).

Daily vitamin C intake in elderly men was respectively 169,31±45,82 mg, 131,30±37,38 mg and 241,12±113,02 mg according to food record, digital photography and food frequency while these values were identified as 154,87±25,63 mg, 124,79±26,40 mg and 231,97±157,67 mg for elderly women (p<0.05).

The mean vitamin C intakes obtained by three methods was statistically significant and different in men and women ($p<0.05$).

Potassium and calcium intakes of the elderly were found highest in both genders in the food frequency, secondly in the food record, and thirdly in the digital photography method. Only for elderly men, the difference between the digital photography method and other methods for the potassium and calcium intakes was found statistically significant (p=0,001).

Daily magnesium intake of the elderly was respectively 450,92±94,50 mg and 470,90±101,06 mg for the elderly men and women according to food record, 408,63±143,31 mg and 414,77±193,59 mg according to food frequency and 333,83±91,59 mg and 300,26±81,12 mg according to digital photography with the lowest mean. There were statistically significant differences between the means in all three methods for magnesium intakes in men (F=14,313, p=0,001) and women (F=14,400, p=0,001) (Table 5).

When the mean daily phosphorus, iron, and zinc intakes of the elderly men and women were listed from highest to the lowest for three minerals, the highest intakes were obtained in food record, which was followed by food frequency, and the lowest mean was obtained from digital photography. When the differences between the methods were evaluated for these three nutrients, it was found statistically significant in both genders (p=0, 001).

Discussion

Food Consumption Statuses of the Elderly

Nowadays, technological developments and new techniques evolving in parallel are considered promising especially for large scale epidemiological studies to overcome logistics and financial constraints (37-38). It can be said that new techniques resulting from technological developments may contribute to studies to determine food consumptions because the limitations of traditional food consumption evaluation methods are well known (8, 39-40) and it is considered that new technological developments will allow for more accurate results by reducing the shortcomings of traditional food consumption evaluation methods (31). In a study, which was conducted earlier in Ankara on school children and identified and compared the food consumption of school children using food record and digital photography method, it was emphasized that digital photography was a valid method capable of complete food record (24). Despite this, there is no study measuring and comparing the food consumption of the elderly in our country from different methods. In this study, food consumption of the elderly was comparatively evaluated using food records, food frequency, and digital photography methods. When the differences between the methods in terms of daily consumption of nutrients in the food groups by the elderly were examined; in the evaluation of digital photography it was determined that the mean consumption of all foods other than poultry, fish, bread, and vegetables in men and the consumption of all foods except cheese in the women were the lowest (Table 4) because, in the food frequency and 24-hour food record methods, plate residues were usually evaluated by an observer at the moment but in the digital photography of the plate residues were recorded, which enabled other observers to control. In light of these findings, it was found out that the most realistic data was obtained from digital photography method as it prevented errors due to observer in the calculation of the mean food consumptions of the elderly and enabled post-control and digital photography method ensured complete recording of food consumptions and residues of the elderly at the nursing home. Therefore, as stated in the studies conducted in similar areas, it could be said that the digital photography method could be used in identifying the food consumption at the nursing homes (41-42). In addition, in comparison to the digital photography method to determine food consumption; nursing home staff in classical methods tends to exaggerate especially when conveying the food consumption of the elderly, which makes it mandatory to use field experts instead of nursing home staff. This can be seen as a disadvantage in the application of classical methods. In a study, it was observed that the data obtained by the expert researcher and the data obtained by the digital photography method gave almost the same results (43). In addition, the fact that consumption

Table 5. Daily energy and nutrients intake of elderly participants by the genders according to food records, digital photography and food frequency

Energy and nutrients	Men (n=27)				Women (n=25)			
	Food Record	Digital Photography	Food Frequency	F/χ2	Food Record	Digital Photography	Food Frequency	F/χ2
	x̄±SD	x̄±SD	x̄±SD		x̄±SD	x̄±SD	x̄±SD	
Energy (kkal)	3172,86±484,42[a]	2189,60±470,69[b]	2758,26±817,70[a]	F=26,490	3312,20±359,41[a]	2191,73±401,36[c]	2628,00±733,92[b]	F=32,363
Protein (g)	118,36±18,24[a]	89,21±20,37[b]	111,92±28,50[a]	F=18,143	117,76±12,32[a]	77,79±15,79[c]	97,31±29,38[b]	F=32,747
Protein (%)	15,22±0,80[b]	16,70±1,30[a]	17,04±2,72[b]	χ2:22,544	14,32±0,63	14,60±1,38	15,24±2,26	F=2,436
Fat (g)	134,91±25,65[a]	92,10±25,60[c]	116,02±50,17[b]	χ2:28,222	140,19±24,29[a]	96,16±25,69[b]	110,18±37,29[b]	F=20,690
Fat (%)	37,56±3,71	37,07±5,62	37,33±7,75	F=0,074	37,08±2,74	38,72±5,78	37,36±8,27	F=0,943
Carbohydrate (g)	364,50±55,06[a]	246,28±54,84[c]	305,71±107,47[b]	F=25,046	395,54±41,64[a]	250,88±54,11[b]	303,30±99,01[b]	F=31,427
Carbohydrate (%)	47,19±3,74	46,30±5,91	45,30±8,29	F=1,163	48,56±2,92	46,68±6,10	47,40±8,57	F=1,118
Fibre (g)	39,02±5,34[a]	26,64±6,52[b]	34,05±12,34[a]	F=22,517	40,21±3,80[a]	24,90±5,36[b]	34,49±15,90[a]	F=17,472
PUFA (g)	32,46±5,28[a]	23,39±60,01[b]	23,64±9,33[b]	χ2:24,074	38,38±13,28[a]	22,77±9,79[b]	21,81±11,65[b]	χ2:26,640
Dietary cholesterol (g)	387,69±117,28[a]	267,06±106,41[b]	379,55±151,40[a]	χ2:26,000	399,35±83,73[a]	255,59±79,78[c]	344,07±99,86[b]	F=29,811
Vitamin A (mcg)	1521,09±337,01[b]	958,21±287,76[a]	1625,06±1334,17[a]	χ2:27,630	2125,18±1133,08[a]	1292,79±762,80[b]	1330,65±576,43[b]	F= 9,802
Carotene (mg)	3,58±0,90[a]	2,36±0,80[b]	3,25±1,72a,[b]	F=7,982	3,16±0,90[a]	1,91±0,59[b]	3,97±2,99[a]	F=9,586
Vitamin E (mg)	31,18±5,22[a]	21,46±5,44[b]	24,88±10,65[b]	F=13,308	29,95±3,91[a]	18,84±4,92[b]	21,24±11,88[b]	F= 15,179
Tiamin (mg)	1,28±0,20[a]	0,95±0,25[b]	1,20±0,39[a]	F=12,067	1,80±0,94[a]	1,04±0,60[b]	1,15±0,45[b]	χ2:24,788
Riboflavin (mg)	2,13±0,34[a]	1,65±0,37[b]	2,20±0,69[a]	F=16,161	2,35±0,69[a]	1,70±0,56[b]	2,03±0,70[a,b]	F=9,840
Vitamin B6 (mg)	1,99±0,36[a]	1,47±0,36[b]	1,83±0,55[a]	F=14,441	1,85±0,25[a]	1,20±0,27[b]	1,79±0,70[a]	F=19,420
Folate (mcg)	453,68±68,03[a]	321,99±77,61[b]	398,95±126,47[a]	F=22,899	484,17±52,90[a]	329,47±58,30[b]	392,35±132,00[b]	χ2:22,640
Vitamin C (mg)	169,31±45,82[b]	131,30±37,38[c]	241,12±113,02[a]	F=22,757	154,87±25,63[a]	124,79±26,40[b]	231,97±157,67[a]	F=9,870
Sodium (mg)	7611,03±1612,48[a]	5933,74±1440,94[b]	4592,13±1511,61[c]	F=35,804	8827,38±3746,20[a]	6146,54±2457,60[b]	3541,46±1372,43[c]	χ2:46,080
Potassium (mg)	3450,17±572,57[a]	2608,18±544,07[b]	3778,74±1228,82[a]	F=19,376	3650,79±842,15[a]	2440,45±726,11[b]	3682,52±1536,09[a]	χ2:23,360
Calcium (mg)	1080,00±224,67[a]	856,06±202,56[b]	1200,50±404,62[a]	F=16,081	1180,24±307,95[a]	972,68±297,58[b]	1185,90±489,66[a,b]	F=4,364
Magnesium (mg)	450,92±94,50[a]	333,83±91,59[b]	408,63±143,31[a]	F=14,313	470,90±101,06[a]	300,26±81,12[b]	414,77±193,59[a]	F=14,400
Phosphorus	1937,17±353,07[a]	1448,95±343,90[b]	1696,17±480,93[a]	F=19,475	1874,23±205,90[a]	1322,67±246,20[c]	1596,48±524,73[b]	F=22,016
Iron (mg)	19,17±2,63[a]	13,49±2,97[c]	16,17±5,74[b]	F=19,033	19,75±2,45[a]	11,93±2,51[b]	14,71±6,10[b]	F=29,277
Zinc (mg)	17,46±3,12[a]	12,80±3,11[b]	16,19±4,55[a]	F=20,109	17,80±1,55[a]	11,66±2,18[b]	13,75±4,50[b]	F=32,692

Variance analysis and Friedman test are used for repeated measurements.

a,b,c Values within row with different superscripts are significantly different (p<0.05)

amounts obtained as a result of both methods were lower than the results conveyed by the nursing home staff points out that the digital photography method was more advantageous than other food consumption record methods (43). In another study by Pouyet et al. (28), it was stated that the digital photography method was valid and useful for detecting food consumption in nursing homes and was one of the most suitable methods for the elderly. With the digital photography method, consumption of meals given to the elderly and then the plate residues could be recorded completely. With this method, the error rate in the calculation of the number of nutrients consumed was considerably reduced. Nevertheless, when the digital photography method is applied, it is very important in terms of obtaining more accurate results that the photographs of the meals are taken by the researcher considering the errors likely to occur if the photographs are taken by the elderly themselves or nursing home staff formerly trained. Because, there is a possibility that the elderly may not able to use technological tools such as digital cameras and mobile phones, which are used for photographing. It is also possible to forget to photograph such nutrients as bread, drinks in main meals, or snacks. But since the digital photography method can be applied by nursing home staff with a short orientation, it also eliminates the necessity of direct observation by the expert researcher. Nevertheless, considering all these advantages and disadvantages, it is thought that the possible limitations of the methods and the errors that may arise may be prevented by using more than one method together.

Energy and Nutrient Intakes of the Elderly

The method frequently used to determine food consumption is to record 24 hours of food consumption in written form, either daily or retrospectively. However, at this point, the fact that human memory may fall insufficient in identifying the food consumption of the elderly and may cause errors or the individuals may not be willing to disclose the food or drink consumed is one of the important factors likely to have an adverse impact on the methods used. Consequently, it is thought that traditional nutritional recording methods, especially the individual's daily recordings, or the validity in individuals, who need to be recorded, may controversial and may cause prejudices affecting the evaluations (24, 44-45). Although the food record is a frequently preferred method in researches in this field, it causes incorrect results in large scale studies, which try to explain the relationship between chronic diseases and nutrition and prevent the definition of relations, as individual food consumption varies constantly (46). In a study investigating the validity of food record (47), food consumption of the individuals participating in the study was recorded by the camera that enabled direct observation and evaluation and a few days after the individuals were requested to note the food and drinks they consumed at lunch on that day. The amount of food consumption recorded by the questionnaire was compared to the amount of food consumption determined by camera recording and only 10 out of 32 individuals could correctly remember the amount of food they consumed (48).

Although the determination of the amount of food and nutrients consumed by the individuals was very important for scientific research in the clinical context, these measurements could be quite complex due to various factors (28). When the food consumption was determined in the elderly by traditional methods, it was not possible to get results from the elderly, who have memory loss, especially when asked about what they eat during the day (49). Moreover, the most important factor that comes to the fore in this kind of traditional methods is that the data obtained from the individuals verbally vary due to the differences in personal perception. Because, although the amount of food consumed does not change while evaluating the food consumption of individuals, due to perceptual differences, the concepts of little and much may vary (6). Therefore, the direct recording of the food consumed by direct observation and not asking the individuals is a more valid method for collecting accurate data (28). In recent years, digital cameras of mobile phones had been used for recording food consumption and it was reported that the collection of digital images

of food consumption in various studies had provided a strong approach and opportunity to increase the accuracy of food consumption evaluation (50-51).

In this study, daily mean energy and nutrient intake of the elderly was determined by food record, food frequency, and digital photography and the findings obtained by these methods were compared. Energy, protein, fat, and carbohydrate intake values of the elderly in both genders were found highest in food records, secondly in the food frequency and the values were the lowest in the digital photography method. Multiple comparison test results showed that energy and these 4 nutrient means were significantly different for all three methods (Table 5). The reason for the order of the means obtained by these methods was that all the nutrients in the food record were recorded as consumed while the food frequency included certain food groups and the fact that plate residues were not included in the calculation in the digital photography method.

In a study conducted on the elderly (52), it was found out that the ratio of those, who were under daily energy intake requirement, was 4.9% at nursing homes and the elderly consumed calcium, vitamin B1, magnesium, fiber, zinc, and carbohydrates that were the main source of energy and other nutrients in varying and lesser amounts recommended for them. However, as a result of the evaluation made in this study, no energy elements and nutrients were found to be consumed insufficiently in all three methods (<67.0%). It was thought that this was because the diet follow-up and the menu planning of the elderly in the nursing home were made by the dietitian.

Comparison of Food Consumption Record Methods

New techniques such as a computer, internet, telecommunication and imaging resulting from technological advances have been effective on methods of assessing nutritional status and increased the number of studies conducted to compare and improve existing methods (53-56). In this context, as an opportunity offered by technological advances, digital photography offers a new alternative to the methods used in the field of food consumption records. A leading method among traditional methods used for food consumption record, obtaining food consumption records using a questionnaire (24), food consumption record by direct observation (57) and the weighing method, which was considered as the golden standard, were used in many studies conducted in the nursing homes (58-60). Detection of nutritional status by these methods took a very long time, and as more than one food was involved, the determination of food consumption became even more complicated (61-65). However, in the determination of food consumption of the elderly; "digital photography method", which is the method of calculating the plate by visual estimation according to the photographs taken before and after the meal, becomes more prominent compared to the accuracy rates of the other methods. According to the results of the questionnaire conducted on the methods used for the determination of food consumption in the elderly within the scope of this study, it was found out that the digital photography was the least time-consuming (92,3%) and feasible (92,3%) method. The reason for this was that the food consumption record taken by the digital photography method during the study was photographed by the researcher independently from the elderly. In other methods, asking the consumption to the elderly increased the time spent on research by the elderly and this might make the elderly bored. In the digital photography method, the amount of food consumed could be recorded with minimum personnel support and reduced amount of error and evaluations with high accuracy ratios can be made (66-67). In addition, the digital photography method allowed the data to be collected and archived in a computer environment and to be determined directly with long-term monitoring of food consumption. It had also contributed to this study in the sense that it was possible to visually differentiate and quantify the different dishes and amounts in the plate by looking at the photographs (28). As a result of this study, it was known that the main factor that affected the interpretation of the data obtained by the digital photography method was that the photographs should be taken from a certain distance and angle with a digital camera with high resolution to prevent low quality photographs.

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