

Application of Principal Component Analysis on Fat Intake Behavior

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Abstract Cohort studies in the past have shown that a high-fat diet is a major risk factor for excessive weight gain. The Malaysian Dietary Guidelines 2020 also recommend reducing the intake of foods high in fat and limiting the intake of saturated fat. Thus, this study was conducted to identify the fat intake behavior among staff at the Health Campus, Universiti Sains Malaysia. This is a cross-sectional study, in which respondents were recruited by convenience sampling. A questionnaire was used to assess the behavior of respondents regarding their fat intake practices. Principal component analysis (PCA) was applied to the questionnaire items to identify significant components. The results show that PCA has successfully identified six components of the fat intake behavior with eigenvalues greater than 1, which accounted for 62.9% of the variance. The components can be summarized as snacking on foods high in fat, consuming desserts associated with fat, using oil in the cooking method, consuming fatty portions in a meal, selecting healthier choices of food products, and consuming creamy foods. This study found that the mean values for all items ranged between 0.97 and 2.71, which falls under the category of negative fat intake behavior, reflecting high-fat consumption. The results suggest that more nutritional intervention is needed to increase awareness of healthy dietary practices among Malaysians.

Keywords Behavior, Fat, Principal Component Analysis, Questionnaire

1. Introduction

Obesity and the consequences associated with it have been the subject of concern for the past decade in both developed and developing countries. As long as the matter persists, the issues regarding the health risks, contributing factors, precautions, and intervention strategies associated with this subject will continue to be debated. Dietary intake is without a doubt one of the most important contributing factors to obesity [1]. As obesity is associated with an excessive amount of body fat, dietary fat intake would be an important criterion to assess when studying factors leading to obesity.

Dietary fats are essential to give energy to the body as well as to support cell function. However, the intake of fat in excess has been linked to the risk of chronic diseases such as cardiovascular disease and certain types of cancer. A high-fat diet induces oxidative stress which drives colonic mucosal inflammation, which is harmful for patients with inflammatory bowel illnesses [2]. A high-fat diet causes excess adiposity, particularly visceral adiposity and the induction of an inflammatory state [3]. Nevertheless, different fatty acids elicit different effects on health risks. Saturated fat intake was associated with higher cancer mortality based on a prospective cohort study [4]. In addition, high-fat diets and those high in saturated fat can exert negative effects on the gut microbiota and are linked to an unhealthy metabolic state [5]. As many various detrimental effects could arise from the consumption of dietary fat, any instruments that can effectively measure the intake of fat would help address the issues of obesity and

other chronic diseases.

Evaluation of dietary interventions is dependent on dietary intake measurements that are accurate and sensitive [6]. It is necessary to provide more trustworthy data to obtain reliable evidence for the diet-health relationship from nutritional cohort studies [7]. Food records, 24-hour diet recalls, and the food frequency questionnaire (FFQ) are some of the reliable dietary intake measurements that are widely used. However, in this study, a simpler questionnaire was applied to assess behavior related to fat intake. The questionnaire itself does not directly measure the quantity of fat consumed but focuses more on measuring behaviors that reflect the amount of fat intake in general. This is done by measuring the frequency of having fat-related products in a week, assessing the types of cooking methods practiced, and evaluating the selection of healthier-choice products. Despite the questionnaire's inability to measure nutritional intake directly, it may nevertheless be a useful tool for identifying relevant eating behaviors as it is quick to administer and analyze. Although all the items in the questionnaire measured behaviors related to the usage of fat, they are quite random and do not have a specific pattern. Thus, the direction of the data patterns was determined using principal component analysis (PCA), which highlighted similarities and differences between the data.

PCA is a widely used method to identify the direction of maximum variance in the data-set. It helps to simplify and understand the structure of the correlation or covariance matrix [8]. Moreover, PCA aids in visualizing data in lower-dimensional areas by reducing dimensionality, making it easier to understand complex datasets while still maintaining the details of the large data-set [9,10]. PCA has been successfully used previously in various nutrition contexts such as to identify dietary patterns [11-13] and evaluate the effect of a nutritional intervention program on patients [14]. In the present study, PCA was used to evaluate the fat intake behavior pattern of healthy Malaysian adults and study the correlation among the variables by grouping them into several components. It is hypothesized that PCA can be used to reduce the number of survey items and cluster them into meaningful patterns, from which the outcome can facilitate subsequent analyses. The research question would be to determine how many components contribute the greatest variance to the study.

2. Materials and Methods

2.1. Participants

This is a cross-sectional study in which 106 staff

members from the health campus of Universiti Sains Malaysia partook through convenience sampling. Prior to answering the questionnaire, each respondent provided informed consent to participate in the study. The research procedure was approved by the Human Ethical Research Committee, Universiti Sains Malaysia (USM/JEPeM/18070313).

2.2. Questionnaire

There were 16 items on the questionnaire that reflect the dietary fat behaviors of respondents in terms of eating, cooking, and food choice behaviors. The questionnaire was adapted from Dobson et al. [15] with modifications, such as combining similar items and adding Malaysian foods to suit the Malaysian eating culture. The respondents were asked to report their fat intake behavior, such as the frequency of fat products consumed, using the five-point Likert scale ranging from 1 (six or more times a week), 2 (three to five times a week), 3 (once or twice a week), and 4 (less than once a week) to 5 (never). Some of the questions required the respondents to report the amount or portion of fat consumed in a meal or the type of fat products consumed (full cream or reduced fat). In all items, the higher number indicates a lesser fat intake. The mean values for each item were calculated. For ease of reporting, mean values of 1.00-2.99, 3.00-3.99 and 4.00-5.00 indicate negative, neutral and positive fat intake behavior, respectively.

2.3. Data Analysis

All collected data was entered and analyzed using IBM Statistical Package for Social Science (SPSS) version 24.0. The internal consistency of measurement items was assessed using Cronbach's alpha. To test whether the data was appropriate for the factor analysis, the Kaiser-Meyer-Olkin and Bartlett's tests were employed. PCA was conducted on the 16 items using varimax rotation at an eigenvalue of 1.

3. Results and Discussion

Table 1 summarizes the demographic characteristics of the participants in this study. More than two-thirds (79.2%) of the respondents were female. The majority of the respondents were Malay (83%), followed by Chinese (12.3%), and Indian (4.7%). More than half of the respondents (60.4%) were between 19 and 29 years old. The next age range (30-39) came in second with 31.1%, and the remaining group of respondents (8.5%) was between 40 and 50 years old.

Table 1. Demographic characteristics of respondents

Variable	Frequency (N = 106)	Percent (%)
Gender		
Female	84	79.2
Male	22	20.8
Race		
Malay	88	83.5
Chinese	13	12.1
Indian	5	6.0
Age		
19-29	64	56.2
30-39	33	34.8
40-50	9	8.0
Level of Education		
High School	11	10.4
College / University	71	67.0
Post-degree	24	22.6
Level of Income		
<MYR 1000	18	17.0
MYR 1000 – 2000	24	22.6
MYR 2001 – 3000	14	13.2
MYR 3001 – 4000	16	15.1
MYR 4001 - 5000	16	15.1
>MYR 5000	18	17.0

Table 2 shows the mean value of the items in the questionnaire. The mean value ranges from 0.97 to 2.71. This indicates that respondents had negative dietary fat behaviors, which are associated with a high intake of fat for all the items measured. This means that respondents incorporate fat into cooking or meals between three and more than six times a week. It is quite surprising as the respondents were mostly well-educated, with 89.6% having attended college or university and acquired a postgraduate degree. The result of the present study does not support the findings of previous studies that a diet high in fat has been linked to lower education [16,17]. Instead, the present study is in line with a study by Cheah et al. [18], which assessed household expenditure on oil and fat products in Malaysia. According to the study, households with well-educated heads consumed more oil and fat products as compared to households with less educated heads. It is possible that the respondents' behavior toward fat consumption started early in life and was thus difficult

to change.

Table 2. Mean values of all items

	Items	Mean	SD
1	Type of milk consumed	2.16	1.43
2	Frequency of eating ice cream	1.21	0.99
3	Frequency of consuming cheese	0.97	0.99
4	Amount of fat on meat consumed	1.59	1.15
5	Amount of chicken skin consumed	1.07	0.63
6	Choice of cooking method for meat	2.71	1.54
7	Amount of butter or margarine spreads on bread	1.08	0.82
8	Frequency of eating sausage, burgers, nuggets, or any fried food coated with butter/breadcrumbs	1.59	0.81
9	Frequency of eating bread with butter or margarine	1.28	1.11
10	Frequency of eating gravy, cream sauce, cheese sauce, or coconut milk	1.91	0.96
11	Frequency of eating snacks such as chips and French fries	1.52	0.95
12	Frequency of consuming traditional cuisines that are fried with fat and oil	2.29	1.12
13	Frequency of eating fried rice/noodles	2.10	0.98
14	Frequency of eating bakery products such as cakes, pastries, and biscuits	1.90	0.96
15	Frequency of consuming chocolate, chocolate biscuits, or sweet snack bars	1.84	0.95
16	Frequency of adding butter, margarine or oil to vegetables, cooked rice/spaghetti/noodles	1.83	1.43

The overall Cronbach's alpha for all items was 0.687. The value of Cronbach's alpha between 0.60 and 0.80 is deemed acceptable [19]. The Kaiser-Meyer-Olkin score was 0.626, which was acceptable for a study with a sample size of 100-200 [20], and the Bartlett's test of sphericity value was significant ($P < 0.001$), indicating that the variables were intercorrelated and thus suitable to be used to conduct PCA analysis [21]. Table 3 shows that PCA derived six components, with the cumulative percentage of variance equal to 62.9%. The first component accounted for the most variance, which was 16.5%, while the second component contributed to 10.3% of the variance. The next subsequent components show a decreasing trend in the percentage of variance, with the last component contributing about 8.61%.

Table 3. Total variance explained for each component

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3.22	20.14	20.14	3.22	20.14	20.14	2.64	16.51	16.51
2	1.74	10.90	31.04	1.74	10.90	31.04	1.64	10.29	26.81
3	1.53	9.56	40.61	1.53	9.56	40.61	1.56	9.76	36.57
4	1.30	8.18	48.79	1.30	8.18	48.79	1.46	9.12	45.69
5	1.20	7.50	56.29	1.20	7.50	56.29	1.38	8.62	54.32
6	1.06	6.63	62.93	1.06	6.63	62.93	1.37	8.61	62.93
7	0.89	5.60	68.53						
8	0.86	5.43	73.96						
9	0.71	4.46	78.43						
10	0.70	4.41	82.84						
11	0.64	4.03	86.87						
12	0.55	3.44	90.31						
13	0.48	3.00	93.32						
14	0.44	2.76	96.08						
15	0.36	2.28	98.37						
16	0.26	1.62	100.00						

Table 4. Rotated component matrix

Items	1	2	3	4	5	6
1. Snacking foods high in fat						
Frequency of eating ice cream	0.47					
Frequency of consuming cheese	0.66					
Frequency of eating sausage, burgers, nuggets, or any fried food coated with butter/breadcrumbs	0.82					
Frequency of eating bread with butter or margarine	0.67					
Frequency of eating snacks such as chips and French fries	0.70					
2. Consuming desserts associated with fat						
Frequency of eating bakery products such as cakes, pastries, and biscuits		0.74				
Frequency of consuming chocolate, chocolate biscuits, or sweet snack bars		0.82				
3. Using oil in the cooking method						
Frequency of consuming traditional cuisines that are fried with fat and oil			0.73			
Frequency of eating fried rice/noodles			0.50			
Frequency of adding butter, margarine, or oil to vegetables, cooked rice/spaghetti/noodles			0.51			
4. Consuming fatty portion in a meal						
Amount of fat on meat consumed				0.56		
Amount of chicken skin consumed				0.76		
Amount of butter or margarine spreads on bread				0.58		
5. Selecting healthier choice of food products						
Type of milk consumed					0.73	
Choice of cooking method for meat					0.68	
6. Consuming creamy foods						
Frequency of eating gravy, cream sauce, cheese sauce, or coconut milk						0.79

Table 4 shows the rotated component loading with six principal components generated from the 16 items that measure the dietary fat behavior of the respondents. The principal components were named based on their shared traits. The first component consisted of five items, which included the frequency of having foods such as sausage, nuggets, burgers, chips, French fries, cheese, ice cream and bread spread with butter or margarine. Based on the food list, it was found that the foods either naturally contained high levels of fat or became high in fat due to the contribution of fat during the cooking process and were mostly consumed as snacks. Therefore, the general component deduced from the items was "snacking foods high in fat". According to Hatta et al. [22], ice cream and burgers were among the top three most frequently consumed fast foods among Malaysians. Another study reported that saturated fats were more prevalent in the Malaysian diet compared with healthier fats such as polyunsaturated (PUFA) and monounsaturated (MUFA) [23]. This indicates that the trend in dietary fat intake in Malaysia is quite worrisome.

The second component was composed of two items of the questionnaire, which were the frequency of having chocolate or chocolate products and that of bakery products such as cakes, pastries, and biscuits. The two items differ in terms of the ingredients used, in which chocolate products fall under the category of confectionary, which involves ingredients such as chocolate and sugar, while bakery products such as cakes, pastries, and biscuits refer to items that are made of flour and baked in an oven. Nevertheless, both items are generally regarded as desserts, which are often enjoyed as a sweet treat at the end of a meal and contain a significant amount of fat in their ingredients. Thus, the second component was referred to as "consuming deserts associated with fat".

The next component was composed of three items. The first was the frequency of consuming traditional cuisines that are fried with fats and oils. The second item was the frequency of adding butter, margarine, or oil to vegetables, cooked rice, spaghetti, or noodles. The last item under this component was the frequency of eating fried rice or noodles. The similarity of all of these items was contributed by the application of oil in the cooking method, which was mostly the frying method. Thus, to simplify the third component, it was simply called "using oil in the cooking method".

Unlike the previous components, the fourth one involved measuring the amount of fat consumed rather than reporting the frequency of fat consumption. The components consist of three items: the amount of chicken skin consumed, the amount of butter or margarine spread on bread, and the fat portion of the meat consumed. Since the amount of fat consumed is generally eaten during a meal, it seemed appropriate to name this component as "consuming fatty portion in a meal".

The type of milk consumed and the choice of cooking method usually applied to meat were the two items loaded

under the fifth component. These items specifically probed the respondents' behavior about whether they practiced healthy preferences in food choices, such as drinking low-fat milk or using low-fat cooking methods in their meat dishes. Thus, the suitable term to represent this component was "selecting healthier choices of food products". As indicated in Table 2, the items under this component received among the highest mean values (more than 2). The higher mean values indicated lower fat intake behavior, although it was still categorized as negative behavior. This result is supported by the study of Teng et al. [24], which found that only less than half (43%) of Malaysians were classified as "recommend" shoppers, defined as those who mainly purchased healthy foods as suggested by Malaysian Dietary Guidelines. This shows that more nutrition interventions must be implemented to increase awareness of healthy dietary practices among Malaysians.

The last component consisted of only one item, which was the frequency of consuming gravy, cream sauce, cheese sauce or coconut milk. As the foods mentioned in this item involve cream, the component was referred to as "consuming creamy foods". Hence, all of the original 16 items in the questionnaire were successfully reduced into six principal components that contain the maximum amount of information and explain 62.9% of the variation.

Nevertheless, the limitations of this research study should be acknowledged, particularly regarding the use of small sample size and the employment of a convenience sampling method in PCA analysis. With a limited number of observations, the results of PCA may lack robustness and may not fully capture the underlying structure of the data, potentially leading to less informative principal components. The small sample size, while chosen for logistical reasons, may not entirely represent the broader population, limiting the generalizability of the findings. Additionally, the convenience sampling method, which entails selecting participants based on accessibility and ease of recruitment, could introduce selection bias, potentially skewing the results. Therefore, caution is warranted when applying the study's conclusions to a larger and more diverse population.

4. Conclusions

The PCA analysis was performed to study the respondents' behavior associated with the intake of fat. Sixteen items in the questionnaire were successfully projected into six principal components, with 62.9% of the variance explained. The factors were named to give a meaningful interpretation that was relevant to the items they contained. The results of this study also indicate that the respondents had negative fat intake behaviors, which translated into having the most frequent behavior of adding fat to their cooking or incorporating generous amounts of fat into their meals. The elevated fat intake could contribute to an increase in body weight and consequently increase the

risk of obesity and becoming overweight. The findings indicate that greater nutritional intervention is required to raise Malaysians' understanding of good eating practices.

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Conflict of Interest

The authors declare no conflict of interest.

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