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Original Article

Generalizability and Consistency of Derived Dietary Patterns across Gender and Residence Subgroups among University Students in Saudi Arabia

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ABSTRACT Numerous studies have reported dietary patterns among university students. However, specific research on the generalizability and consistency of dietary patterns across student subgroups is limited. The study aimed to empirically explore dietary patterns and to assess the generalizability and consistency of these patterns across gender and residence subgroups of university students. Between 2023 and 2024, a cross-sectional study was conducted among undergraduate students at the College of Nursing and Health Sciences, Jazan University, Saudi Arabia. The dietary intake of 650 students (350 boys and 300 girls) was collected using a food frequency questionnaire. Both exploratory and confirmatory factor analysis were used to explore the dietary patterns. The congruence coefficient was used to assess the generalizability and consistency of the factors between subgroups of gender and residence. Four optimal dietary patterns were identified: a western food pattern, consisting of salty snacks/chips, fried foods, cakes/biscuits/sweets, soda drinks, pastries/pizzas, and drinks/juices; a traditional food pattern, consisting of breakfast cereals/seeds, meat/chicken, rice/pasta/potatoes, traditional foods, milk/milk products, and eggs; a protein food pattern, consisting of processed meat and fish/seafood; and a prudent food pattern, consisting of fruits, nuts, vegetables, and legumes. The empirically derived dietary patterns were generalizable and consistent across subgroups of gender and residence. Further research with a longitudinal setting is required to assess the relationships between dietary habits and chronic diseases.

Keywords: Diet, Factor Analysis, Western Foods, Traditional Foods, Prudent Foods, Protein Foods, Congruence Coefficient.

INTRODUCTION

For young people, university education is a time of transition from the safety of parental supervision to self-dependence c. Because of the unfamiliar surroundings at university, first-year students may display changes in their personalities, perspectives, and behaviors [2]. Over the last four decades, the economic boom of the Kingdom of Saudi Arabia has resulted in people moving toward westernized food choices, which are heavy in sugar, salt, and fat, leading to a high obesity rate [3]. The diets of university students have also evolved due to social circumstances, fast food, and technology [4]. Dietary habits established during students' university years often persist into adulthood, making this period critical for promoting healthy eating behaviors. Multiple studies conducted over the past two decades have shown that university students frequently adopt unhealthy eating habits [5-9]. Research from Saudi Arabia has proven that fast food influences unhealthy dietary habits [10,11]. According to a study [12], students in the United Arab Emirates consume more meat and dairy products and fewer fruits and vegetables than recommended. Evaluating dietary variations among university students can be difficult and may entail looking at foods, nutrients, or eating habits [13]. Studies have employed two broad approaches to determining dietary patterns. First, food variables can be categorized according to the combination of nutrients and the nature of the foods [14]. Second, data reduction techniques can derive dietary patterns using empirical statistical modeling of dietary data, enabling analyses that can generate hypotheses. Factor analysis is a popular posterior approach to determining dietary patterns and enables establishing the actual consumption of foods by the population [15,16]. The dietary patterns obtained by factor analysis are useful for assessing the associations between diet and chronic disease [17,18]. Overall, research has shown that dietary

patterns are reproducible. Homogeneous dietary patterns have been observed within a wide range of population groups [18]. Studies have proven that residence and race are significantly related to nutrient consumption in the United States among White and Black men [19,20]. A cross-sectional study by Alsayegh et al. (2023) assessed the dietary behaviors of university undergraduate students in Saudi Arabia. The study reported four dietary patterns among undergraduate university students: western food, traditional food, prudent food, and protein food patterns [21]. Despite numerous general studies on diet and health using factor analysis to explore dietary risks, there is a lack of comprehensive studies on dietary information across gender and residence subgroups in the Kingdom of Saudi Arabia. Our study aimed to apply rigorous statistical approaches, both exploratory and confirmatory analysis, to empirically explore dietary patterns among university students and assess whether these dietary patterns are generalizable and consistent across student subgroups.

MATERIALS AND METHODS

Study design: The cross-sectional study was conducted between 2022 and 2023 at the College of Nursing and Health Sciences, Jazan University, Saudi Arabia. A pretested food frequency questionnaire [22], with additional questions on sociodemographic characteristics, gender, and residence, was distributed among university student groups. A pilot study was conducted among 50 students to help identify and reduce errors in the questionnaire. The final version of the questionnaire was developed in both Arabic and English. Both male and female students at Jazan University were included except pregnant students. An information program was conducted to explain the importance of the study and to motivate students to participate in the study. Ethical approval: The study addressed the ethical issues according to the Declaration of Helsinki and the National Committee of Bioethics, Saudi Arabia. Consent was obtained from the students, and they were assured that their data would remain confidential. Ethical clearance for this study was granted by the Standing Committee for Scientific Research of Jazan University (REC-44/06/471). Dietary data: In total, 103 common Saudi food items, for which the intake frequencies were included, in the questionnaire. Eight choices were given to the students to indicate their food intake frequency: more than 6 times daily, 5 to 6 times daily, 2 to 4 times daily, once daily, 5 to 6 times weekly, 2 to 4 times weekly, once weekly, and 1 to 3 times monthly. Sample size: A sample size of 648 was found to be sufficient for the Jazan University students, based on a 5% margin of error, a 1% significance level, and a 50% response distribution [21]:

$n = N*X / (X + N-1)$

where $X = Z^2 * P * (1-P) / MOE^2$, N is the size of the population, P is the participant response rate, Z is the table value of 2.58 at 1% level of significance, and margin of error is at 5%. Statistical analysis: Exploratory factor analysis (EFA) was employed to explore the dietary patterns using principal component analysis (PCA). A total of 103 food items were categorized into 18 food groups based on the nature and nutrient combinations of the foods (Supplementary Table 1) [21]. Food frequencies were converted into weekly frequencies [14]. To examine the generalizability and consistency of the identified dietary patterns, the whole sample was separated according to gender (male and female) and residence (urban and rural). The random split sample method was used to split the samples, as in earlier research [23]. EFA was employed across samples to obtain two- to four-factor solutions for improved interpretability of the results. Scree plots were created to examine the variance explained. An eigenvalue of greater than 1.1 was chosen based on the scree plots for better interpretability of the obtained factors. The aim of the study was to assess whether the factors can be derived from the whole sample or whether they should be derived separately from population subgroups. PCA was conducted on the stratified samples of gender (male and female) and residence (urban and rural) separately. The coefficient of congruence was calculated to assess the similarity between a stratified pair of sample factor solutions regarding gender (male and female) and residence (urban and rural). The congruence coefficient was categorized as “excellent” when it was >0.8, “good” when it was between 0.65 and 0.8, “acceptable” when it was between 0.5 and 0.65, and “poor” when it was <0.5 [16]. The optimal number of factors was obtained from the best congruence across gender and residency. Confirmatory factor analysis (CFA) was also employed on the stratified samples (gender and residence) as well as the entire sample to validate the PCA findings. The root mean square error of approximation (RMSEA) and the comparative fit index (CFI) were calculated both for all food groups and for the reduced food groups. Lastly, EFA was repeated for the optimal number of factors and factor loading for the individual food items. A ‘P’ value of less than 0.05 was considered significant. R software (version 4.3.1) for Windows and the ggplot2 package were used for analysis and plots.

RESULTS

In total, 650 students (350 boys and 300 girls), from whom the dietary intakes were obtained through a questionnaire, were included in the study. The scree plot at an eigenvalue of 1.1 and the PCA suggest that the four-factor solution was the optimal solution for the university students’ dietary data. Further, subsequent EFA for each stratified sample of gender (male and female) and residence (urban and rural) revealed excellent congruence for the four-factor solution (Table 1). After the food groups with a low factor loading were deleted from the CFA, the RMSEA was slightly increased, but it did not exceed the threshold of 0.05, while the CFI was greater than 0.90. Furthermore, the

RMSEA and CFI confirmed that for each stratified sample of gender (male and female) and residence (urban and rural), the four-factor solution was excellent. Thus, all the indicators suggested that the four-factor solution was excellent and that further removing dietary groups would not significantly enhance the model fit (Figure 1).

Table-1: Congruence Coefficient for Four-Factors across Gender and Residence

	Factor Number	Factor Number	Congruence Coefficient
Gender	Male	Female	
	1	1	0.98
	1	2	0.68
	1	3	0.62
	1	4	0.63
	2	2	0.99
	2	3	0.67
	2	4	0.53
	3	3	0.98
	3	4	0.58
	4	4	0.99
Residence	Urban	Rural	
	1	1	0.99
	1	2	0.62
	1	3	0.68
	1	4	0.63
	2	2	0.99
	2	3	0.66
	2	4	0.51
	3	3	0.97
	3	4	0.53
	4	4	0.98

CFA confirmed that the four-factor solution was excellent, with an RMSEA of less than 0.05 and a CFI of 0.91. All 18 food groups had a good correlation, ranging from 0.47 to 0.71, with the respective dietary patterns. No collinearity was found, and the model fit was excellent (Figure 2).

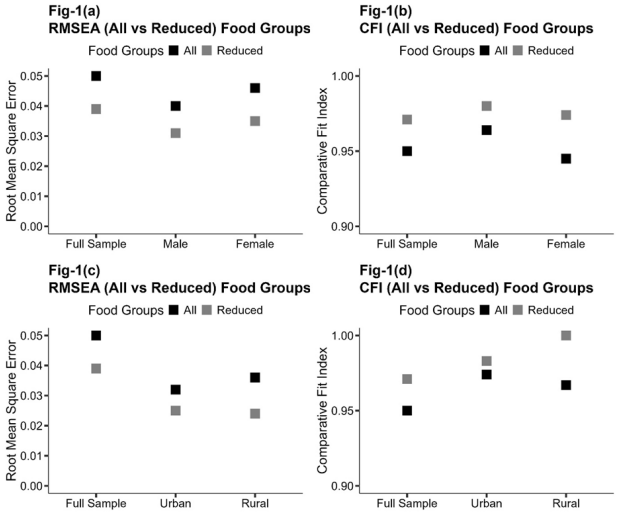

Figure 1: Four Factor Solution between Stratified Groups of Gender and Residence

PCA with varimax rotation and a fixed four-factor solution was employed on the 18 food groups of students' dietary data. This revealed that the western food pattern consisted of salty snacks/chips, fried foods, cakes/biscuits/sweets, soda drinks, pastries/pizzas, and drinks/juices; the traditional food pattern consisted of breakfast cereals/seeds, meat/chicken, rice/pasta/potatoes, traditional foods, milk/milk products, and eggs; the protein food pattern consisted of processed meat and fish/seafood; and the prudent food pattern consisted of fruits, nuts, vegetables, and legumes. The four major patterns of western, traditional, protein, and prudent foods explained 20%, 18%, 13%, and 9% of the total variance, respectively, and as a whole, the model explained 60% of the total variance (Table 2).

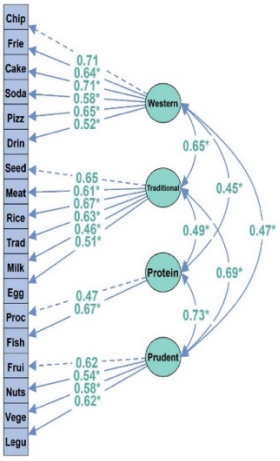

Figure 2: Confirmatory Factor Analysis of Dietary Patterns
Legu-legumes, Vege-vegetables, Frui-fruits, Fish-fish/sea foods, Proc-processed meat, Milk-milk/milk products, Trad-traditional foods, Rice-rice/pasta/potatoes, Meat-meats/chicken, Seed-breakfast/seeds, Drin-drinks/juices, Pizz-pastries/pizza, Soda-soda drinks, Cake-cake/biscuits/sweets, Frie-fried foods and chip-salty snacks/chips.*Highly significant (P<0.01)

Table 2: Dietary Patterns among University Students (Factor Loadings>0.5)

Food group	Western foods	Traditional foods	Protein foods	Prudent foods
Salty snacks/chips	0.75			
Fried foods	0.74			
Cake/biscuits/sweets	0.73			
Soda drinks	0.72			
Pastries/pizza	0.64			
Drinks/juices	0.60			
Breakfast/seeds		0.74		
Meats/chicken		0.71		
Rice/pasta/potatoes		0.67		
Traditional foods		0.60		
Milk/milk products		0.59		
Egg		0.53		
Processed meat			0.78	
Fish/sea foods			0.68	
Fruits				0.73
Nuts				0.72
Vegetables				0.53
Legumes				0.50
Proportion Variance	0.20	0.18	0.13	0.09

Cumulative Variance	0.20	0.38	0.50	0.59

DISCUSSION

The present study revealed four dietary patterns among university students using both EFA and CFA after assessment of the reproducibility of the factors between the gender (male and female) and residence (urban and rural) subgroups of students. The analytically obtained dietary patterns were varied and explainable and confirmed the patterns of dietary intake among university students. The four derived dietary patterns were also consistent across the gender (male and female) and residence (urban and rural) subgroups of university students. Furthermore, the RMSEA and CFI confirmed that the four-factor solution was excellent for each stratified subsample of gender (male and female) and residence (urban and rural). A population-based REGARDS study aiming to find the reasons for ethnic and racial differences in stroke incidence stated that the empirically derived factors using factor analysis showed reproducibility and strong congruence across race, gender, and residence [16]. Additionally, a systematic review study from Japan assessing the generalizability of empirically derived dietary patterns using PCA stated that some of the major dietary patterns are relatively reproducible across subpopulations within a country, whereas others are not. This highlights the importance of carefully interpreting PCA-derived dietary patterns [24]. A cross-sectional study from Malaysia investigating the consistency and generalizability of empirically derived dietary patterns among members of a multiethnic working population reported that there was no subgroup-specific dietary pattern and that the empirically derived dietary patterns using a pooled sample were consistent and generalizable across the subgroups of gender, ethnicity, and residences status [25]. EFA is a widely used statistical approach to empirically derive dietary patterns among individuals. The main goal of our study was to derive dietary patterns among Jazan University students through EFA. Four dietary patterns—that is, western foods, traditional foods, prudent foods, and protein foods—were explored. Earlier research has reported that the number of dietary patterns can range from three to seven [26-30]. In fact, all these dietary factors accounted for around 54.89% of the total variance in food frequencies, with the sweet and starch food patterns accounting for most of the variance (20.68%). Similar results were obtained in the current study, showing that the western food pattern accounted for 20.020% of the total variance [27-29]. The western food pattern, consisting of salty snacks/chips, fried foods, cakes/biscuits/sweets, soda drinks, pastries/pizzas, and drinks/juices, demonstrates a significant relation to the intake of energy foods. This pattern is packed with food items with added sugars and starchy foods of refined grains, thus containing food items with a high energy intake [31]. Many other studies have derived westernized food patterns, although the composition of the food items can vary among studies. A cross-sectional survey of Mexican households in 2018 reported that the intake of foods typical of the Mexican food culture reflects a local western dietary pattern composed of pulses, oils or fats, sugar, sweets, industrialized drinks, foods made from corn/maize, wheat, rice, oats or bran, coffee, tea, and eggs [32,33]. High caloric intake coupled with an inadequate intake of fruits and vegetables is found to contribute to higher rates of diabetes and obesity [33]. The present study found that the traditional food pattern is characterized by traditional Saudi dishes, such as harees, masoob, and gerish, as well as breakfast cereals/seeds, meat/chicken, rice/pasta/potatoes, traditional foods, milk/milk products, and eggs (Table 1). Research on the diet and health of the Saudi population is scarce [34-36]. Studies have reported that the traditional Saudi diet consists of white rice, wheat bread, dates, and Arabic coffee [35,37]. This diet is high in fat and simple carbohydrates, causing the body mass index (BMI) to increase. In contrast, compared with a western diet, traditional diets are usually lower in fat and higher in complex carbohydrates. However, it does not seem to cause people of normal weight to gain weight, suggesting that limiting carbohydrate intake may not be universally effective in reducing obesity and cardiovascular risk [38,39]. The expected effect of high carbohydrate intake is probably offset by the fact that traditional foods have less total energy and possess more dietary fiber than non-traditional foods, which improves insulin resistance and protects from many chronic diseases [40,41]. The protein food pattern is composed of a high intake of processed meat and fish/seafood. This pattern could be associated with central obesity and hypertension [42]. The prudent food pattern includes fruits, nuts, vegetables, and legumes. Another label for this food pattern is the health food pattern [43-45].

LIMITATIONS

The study population was restricted to university students, who share certain key characteristics (e.g., age and education) that may have a different distribution in the general population, which could have had an influence on the patterns detected. Thus, the number of patterns obtained by factor analysis and their labeling might not be applicable to other settings.

CONCLUSIONS

The four empirically derived dietary patterns of western, traditional, protein, and prudent food patterns are generalizable and consistent across subgroups of gender and residence. Further research with a longitudinal setting is required to assess the relationships between dietary habits and chronic diseases.

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CONFLICTS OF INTEREST

Authors declare that they have no conflicts of interest.

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