Journal of Science and Technology, Vol. 40, No. 1 (2022), pp 38 - 50

RESEARCH PAPER

ASSOCIATIONS BETWEEN DIETARY PATTERNS, NUTRITIONAL STATUS AND COGNITIVE PERFORMANCE OF FINAL YEAR UNDERGRADUATE STUDENTS IN THE DEPARTMENT OF FOOD SCIENCE AND TECHNOLOGY, COLLEGE OF SCIENCE, KNUST

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ABSTRACT

This study explored the relationship between dietary patterns, nutritional status and cognitive performance of final year undergraduate students in the Food Science and Technology department of KNUST. A cross sectional study was conducted among the final year undergraduate students of the Food Science and Technology Department, KNUST, Kumasi. A total of 30 participants were conveniently sampled for the study; however, only 21 were able to complete the study due to the Covid-19 pandemic and the resulting closure of schools. Five distinct dietary patterns were obtained using 99 food components identified through the food frequency questionnaire. These mainly comprised of starch-based foods, soups and stews with little fruits and vegetables consumption. A good proportion of participants (42.9%) had normal BMI. The prevalence of underweight, overweight and obesity was 14.3%, 28.6% and 14.3% respectively. Participants with normal cognitive performance were slightly higher (52.4%) than those with mild cognitive impairment (47.6%) according to the Montreal Cognitive Assessment test. The results showed no significant correlation between dietary patterns and nutritional status. Adherence to dietary pattern 4 characterized by low consumption of iron-enhancing fruits, sea foods, soups and stews, high consumption of starch-based foods, no iron-enhancing vegetables and snack consumption was associated with cognitive decline. Fruits and vegetables consumption was generally low, necessitating nutrition education and campaigns to encourage healthy eating. Furthermore, it will be necessary to apply policies to regulate the quality of food sold at on-campus cafeterias and canteens since students eat from these places while on campus.

Keywords: Dietary pattern, nutritional status, cognitive performance

INTRODUCTION

Understanding the dietary patterns of a population is key to the determination of their nutritional status (Apprey et al., 2019). Dietary patterns can be defined as the quantity, variety or combination of various foods and drinks and the frequency with which they are consumed. They are a representation of individual preferences affected by environmental, socio-economic, genetic and cultural determinants (Corrêa et al., 2017). These patterns are developed over time and have significant influence on an individual's health (Schulze et al., 2018). Unhealthy dietary habits are becoming frequent due to the ongoing nutrition transition being experienced by various developing countries (Salameh et al., 2014). Unhealthy dietary habits are well established risk factors for non-communicable diseases and the youth are reported to be most vulnerable to unhealthy habits (Omage and Omuemu, 2018).

Nutritional status is the physiological state of an individual, dictated by nutrient intake and the body's ability to use those nutrients. It is influenced by food intake, cultural, age, sex, physical activity, disease of the person as well as socio-economic status (Upadhyay and Tripathi, 2017). Dietary patterns are directly related to nutritional status (Apprey et al., 2019). Dietary patterns have been associated with disease indices among college students (Blondin et al., 2016) which is an indication of the effect of dietary pattern on health.

Good nutrition has been well documented as essential for optimal brain growth and cognitive performance (Annan et al., 2019). One out of three university students skips breakfast which is not compensated for in the rest of the meals consumed in the day (Sámano et al., 2019). Cognitive performance include learning, language, memory, problem solving abilities, perception and reading and these are influenced by multiple factors including nutrition (Gómez-Pinilla, 2008). The triple burden of malnutrition is prevalent in many developing countries and Ghana is no exception. The population of Ghana is mainly comprised of the youth; thus, anything that poses a risk to their health is a threat to the country's health profile.

MATERIALS AND METHODS

Design and Sample

This was a cross sectional study. The sample comprised 30 final year undergraduate students of the department of food science and technology. The participants were aged between 20 and 25. Due to incomplete data, only 21 participants (9 males, 12 females) were included in the analysis. The study was approved by the head of department and ethical clearance sought from the Committee on Human Research, Publications and Ethics of Kwame Nkrumah University of Science and Technology, School of Medical Sciences and Komfo Anokye Teaching Hospital, Kumasi, Ghana (CHRPE/AP/075/20). All participants signed an informed consent before proceeding to partake in the study. All final year undergraduate students in the department were eligible for the study. However, only those who agreed to participate were included. Female students who were pregnant or in their menstrual period and students on medication or acutely ill were exempted from the study.

Data Collection

Data were collected between February and March 2020. Data on socio-demographic variables and dietary habits were collected using a semi-structured questionnaire and food frequency questionnaire (FFQ) respectively.

Anthropometric Indices

All anthropometric indices were carried out following standardize protocols. The heights of the participants were measured using a stand-alone stadiometer (model: HM200P Charter, USA). The students were asked to stand straight on the stadiometer with their heads, buttocks and heels touching the pole of the stadiometer. The top of their heads was also made to touch the movable board. Readings were taken at the eye level to ensure the correct measurement and were taken to the nearest 0.1cm. These measurements were taken and the average recorded.

A body composition monitor (model: HBF 400; Omron, China) was used to determine the weights of the subjects. Participants were asked to remove their heavy outer garments and shoes. They were asked to stand in the center of the platform such that weight was evenly distributed to both feet. The weight was measured twice and average was taken to the nearest 0.1kg. BMI levels of subjects were then categorized as (<18.5kg/m²) underweight, (18.5-24.9kg/m²) normal, (25-29.9kg/m²) overweight and (>30kg/m²) obese according to WHO, (2008) criteria. The body composition monitor and stadiometer were placed on a flat and smooth surface to ensure accuracy in measurements.

Cognition Performance Assessment

The Montreal Cognitive Assessment Test which measures short term memory, visuospatial abilities, executive functions, language, attention, concentration, memory making and orientation to time and place was conducted to assess cognitive performance of participants. The test was administered to participants in a calm and serene environment with minimal distraction under proper supervision. The test procedures were explained to them and the test taken.

Statistical Analysis

All data collected were analyzed using the Statistical Package for Social Sciences (SPSS) version 22 software (IBM Corp., 2013). All categorical variables including sociodemographic data, BMI status and cognitive test scores were presented as absolutes and relative frequencies. Dietary pattern from the food frequency questionnaire was obtained using principal component analysis (PCA). All PCA analysis were performed in accordance with study by Apprey et. al (Apprey et al., 2019). Briefly, the patterns were selected based on screen plot as well as the factor loading coefficient of ±0.3 for the dietary component form the PCA output. Bivariate analysis was used to determine the relationship between dietary pattern and nutritional status and that between dietary pattern and cognition.

RESULTS

Nutritional Status of Participants

Using the WHO classification for BMI, 14.3% of the participants were underweight, 28.6% overweight, 14.3% obese and 42.9% normal. A majority of them had normal visceral fat (85.7%). Only 4.8% of the students had very high visceral fat and 9.5% with high visceral fat according to Omron classification (model: HBF 400; Omron Full Body Sensor Body Composition Monitor and Scale).

In terms of percent body fat (%BF), 33.3% were normal, 9.5% were high, while 14.3% and 42.9% had low and very high %BF respectively.

Table 1: Nutritional status by BMI and Body fat categorization of the participants

Variable	Categories	n (%)	P-Value
BMI	Underweight	3 (14.3)	0.194
	Normal	9 (42.9)	
	Overweight	6 (28.6)	
	Obese	3 (14.3)	
Body fat	Low	3 (14.3)	0.101
	Normal	7 (33.3)	
	High	2 (9.5)	
	Very high	9 (42.9)	
Visceral fat	Normal	18 (85.7)	< 0.0001
	High	2 (9.5)	
	Very High	1 (4.8)	
Total		21 (100)	

Cognitive Performance of Participants

The mean test score was 26.05 ± 1.88, which was within the normal cognitive performance range. Based on the test scores, participants were categorized as having Normal cognitive performance (NCP) and Mild Cognitive impairment (MCI) using the Montreal Cognitive Assessment (MoCA) Test. There was only a slight but non-significant difference between participants with normal cognitive performance (52.4%) and those with mild cognitive impairment (47.6%), (p = 0.827).

Table 2: Cognitive Performance Categories of Participants Based the MoCA Test Results

	Minimum	Maximum	Mean SD
Cognitive score	23	29	26.05 ± 1.88
Cognitive performance category	NCP	MCI	
	n (%)	**n (%)**	**Total** **P-Value**
	11 (52.4)	10 (47.6)	21 (100) 0.827

Dietary Pattern of Participants

Figure 1.0 depicts the identified dietary patterns generated from 99 food components. Dietary pattern one was called starched based, soups and stews, sea foods, snacks and animal proteins. This comprised of high factor loading matrices of meat pie (0.903), palm soup (0.893), meat bread (0.88), corn porridge (0.806) and sardines/mackerels (0.797). Dietary pattern 2 was associated with high factor loading matrices of sandwich (0.832), pizza (0.773), sharwarma (0.732), pork (0.685) and chips (0.646) and was called snacks, starch based, animal proteins and other food group pattern. The third dietary pattern was called starch based, soups and stews, iron enhancing fruits pattern and was characterized by high load matrices of mango (0.889), oats (0.659), millet (0.649), shrimps (0.686) and bread (0.536).

Dietary pattern 4 was associated with high factor matrices of pineapple (0.784), ayoyo (0.743), okro soup (0.598), millet (0.566) and bush meat (0.531) and was called starch based, soups and stews, non-heme iron rich foods pattern. The fifth pattern called starch based, iron-enhancing fruits, soups and stews and non-heme iron-rich food pattern was comprised of high factor loading matrices of soya bean (0.604) and leafy dark vegetables (0.516). The full table containing the food components and their various matrices can be found in the appendices.

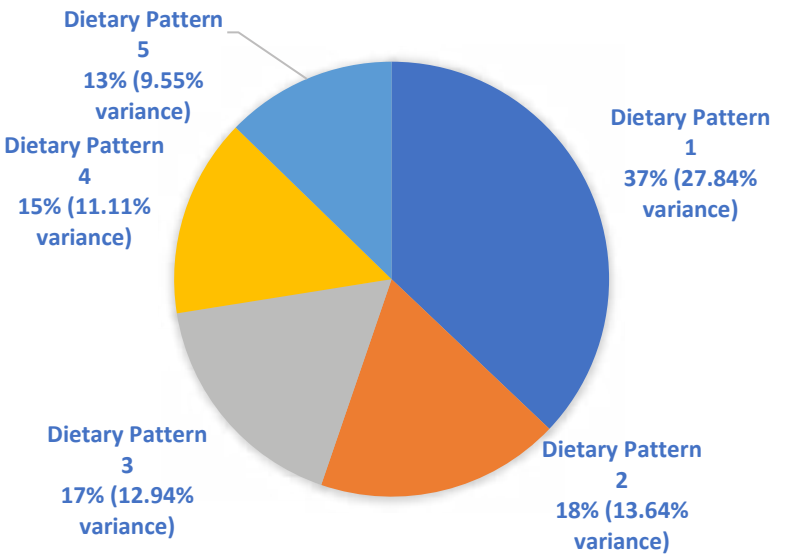

Figure 1.0: A pie chart depicting the identified dietary patterns

Table 3: Dietary Pattern of Study Participants

	Dietary Pattern 1	Dietary Pattern 2	Dietary Pattern 3	Dietary Pattern 4	Dietary Pattern 5
% variance	**27.84**	**13.64**	**12.94**	**11.11**	**9.55**
Food Groups N= 99	**Starch Based, Soups and Stews, Sea Foods, Snacks, Animal Proteins**	**Snacks, Starch Based, Animal Proteins, Other Food Group**	**Starch Based, Soups and Stews, Iron Enhancing Foods**	**Starch Based, Soups and Stews, Non-Heme Iron Rich Foods**	**Starch Based, Iron-Enhancing Fruits, Soups and Stews, Non-Heme Iron-Rich Foods**
Iron-Enhancing Fruits					
Watermelon		**0.533**	0.451		0.313
Banana	0.493	-0.357	-0.467		
Citrus	**0.517**				0.465
Mango			**0.889**		
Pineapple			-0.314	**0.784**	
Pawpaw	**0.535**	**0.57**	0.343		
Apple	**0.599**	-0.328		-0.541	0.32
Pear	0.495		-0.612		0.386
Iron-Enhancing Vegetables					
Tomatoes	0.348				
Garden Eggs	**0.748**	-0.304	-0.456		0.31
Carrot	**0.6**				
Non-Heme Iron-Rich Foods					
Kwansosaa (Abedru)		-0.768	-0.464		
Lettuce	**0.666**			-0.525	
Kontomire	**0.666**			-0.576	
Okra	**0.767**			0.386	
Cabbage	**0.651**				0.445

Table 3 Continued

Leafy Dark Vegetables			-0.301	0.366	**0.516**
Ayoyo	0.472			**0.743**	
Snacks					
Rock Buns		**0.638**	-0.427		-0.43
Spring Rolls	**0.684**		-0.61		
Samosa		**0.554**	-0.601		
Meat Pie	**0.903**				
Meat Bread	**0.88**	-0.378			
Chips	-0.354	**0.646**	0.368		-0.31
Scones			-0.383		
Roasted Nuts		**0.542**	-0.522		
Sandwich	0.324	**0.832**			
Sobolo	**0.554**		0.353		-0.454
Fresh Yogurt	**0.56**	0.498		-0.31	0.31
Starch Based					
Oats			**0.659**	0.332	
Wheat	0.464	-0.308	0.493	0.309	0.493
Millet		-0.402	**0.649**	**0.566**	
Hausa Koko	**0.6**	-0.453		0.319	
Rice Water	**0.709**	-0.587			
Kenkey	**0.586**	-0.316			
Corn Porridge	**0.806**				0.338
Brown Rice			-0.721		
Polished Rice	0.431			0.312	
Roasted Corn		0.317		-0.47	0.368
Banku	**0.786**			-0.315	-0.323
Sugar		-0.358			
Tuo Zaafi	**0.558**	-0.373			0.475
Kokonte	-0.061	0.422	0.458		
Fufu	**0.545**				
Gari	**0.655**	-0.371			-0.469

Bread		**0.581**	**0.536**		0.316
Plantain	**0.646**		0.481		
Potato	**0.721**	0.476			
Cocoyam	**0.566**			0.336	0.498
Yam	**0.508**				-0.668
Cassava	0.336	0.463	0.57	-0.379	
Animal Protein					
Beef	**0.707**			0.372	-0.463
Cow, Goat, Lamb	**0.617**				-0.523
Chicken	0.417	0.393			
Pork		**0.685**			
Corned Beef	**0.73**	0.342		0.382	
Bush Meat			-0.584	**0.531**	
Offal	0.37	0.347		-0.439	-0.628
Sausage	**0.663**		-0.322	-0.305	
Sea Foods					
Salmon	**0.685**		0.474		
Herrings		0.341			-0.531
Tuna	**0.546**				-0.544
Cassava Fish	**0.752**	-0.354		-0.385	
Oyster	0.453	-0.583	-0.503		
Shrimps	**0.519**		**0.686**		0.314
Anchovies	0.455		-0.522	0.421	
Sardines/ Mackerels	**0.797**				-0.545
Plant Protein					
Beans	**0.657**	-0.435	0.402		-0.396
Soya Bean	**0.535**	0.412		0.319	**0.604**
Garden Peas	0.352			0.481	
Soups and Stews					
Tomatoes Stew	0.41		0.48	0.428	
Cabbage Stew	**0.591**				0.666

Table 3 Continued

Kontomire Stew	**0.666**			-0.576	
Garden Eggs Stew	**0.748**	-0.304	-0.456		0.31
Bean Stew	**0.692**		0.426	-0.444	
Egg Stew	**0.635**			-0.377	-0.387
Okro Stew	0.498		0.319	0.355	-0.541
Light Soup	0.415	-0.538			
Groundnut Soup				-0.789	
Palm Soup	**0.893**				
Okro Soup			0.432	**0.598**	
Others		**0.585**			
Ice Cream	**0.607**		-0.471	-0.379	
Sharwarma	0.414	**0.732**			
Pizza		**0.773**		0.394	
Ketchup				-0.415	
Soy Sauce	**0.782**	**0.533**			
Mayonnaise	**0.646**			**0.527**	
Salad Cream	**0.681**		-0.405	0.322	
Alcohol		0.418			
Beverages	**0.541**	**0.559**		-0.409	0.345

Absolute values of correlation co-efficient < 0.3 not shown, absolute values of correlation co-efficient ≥ 0.5 in bold.

Association between dietary pattern, nutritional status and cognitive performance of participants

There was no significant correlation between the various dietary patterns and nutritional status. Only dietary pattern four was negatively correlated with MoCA. This means that, these two are inversely related; hence, as consumption of dietary pattern four goes up, cognitive performance declines.

Table 4: Relationship between dietary pattern, nutritional status and cognitive performance of participants

		Dietary Pattern_1	Dietary Pattern_2	Dietary Pattern_3	Dietary Pattern_4	Dietary Pattern_5
BMI	Correlation	-0.213	-0.1	-0.251	0.363	0.116
	p-value	0.555	0.783	0.484	0.303	0.749
Body fat	Correlation	-0.096	0.173	0.049	0.172	0.244
	p-value	0.791	0.633	0.893	0.635	0.497
Visceral fat	Correlation	-0.357	-0.317	-0.444	0.279	0.057
	sig. (2-tailed)	0.311	0.372	0.198	0.435	0.875
MoCA	Pearson correlation	0.055	0.036	-0.067	**-.665***	0.265
	sig. (2-tailed)	0.88	0.922	0.853	0.036	0.459
	N	10	10	10	10	10

** correlation is significant at the 0.05 level (2-tailed).*

DISCUSSION

This study looked at the relationship between dietary pattern, nutritional status and cognitive performance of final year undergraduate students from the Department of Food Science and Technology, KNUST, Ghana. About 42.9% of them had a normal BMI. The relationship between dietary patterns and obesity among undergraduate students have been established in other studies (Omage and Omuemu, 2018, Blondin et al., 2016, Salameh et al., 2014). The prevalence of obesity, overweight and underweight were 14.3%, 28.6% and 14.3% respectively. The observed prevalence of malnutrition in this study were slightly higher compared to Nigerian undergraduate students who recorded 9.5% underweight, 14.0% overweight and 6.0% obese. Obesity has been well established as a risk factor for non-communicable diseases (Agyapong et al., 2020, Apprey et al., 2019). This also shows that malnutrition is not only a problem among children under 5 or the aged but the entire population of the country. It has been reported that, diet quality decreases with increasing age (Blondin et al., 2016). This may be due to the various transitions that people go through viz: moving away from home, making independent decision and fending for one's self. Adolescents/college students have been found to patronize energy dense foods and skip breakfast and these could account for the observed prevalence.

The mean score of the participants for the Montreal Cognitive Assessment (MoCA) was 26.05 ± 1.88 which falls within the normal cognitive performance range. It is surprising that there was an almost equal ratio of

normal (11) to mild cognitive impaired (10) participants. Cognitive performances include learning, language, memory, problem solving abilities, perception and reading (Gómez-Pinilla, 2008). This implies that, any impairment affects learning and academic performance. Mild Cognitive Impairment (MCI) is characterized by a minor decline in mental abilities such as slowed speed of processing information, difficulties in organizing thoughts and poor memory and concentration (Allott et al., 2016). The high levels of impairment among the students can be accounted for partly by stress and depression associated with the maintenance of educational achievements, social and intimate relationships (Dubuc et al., 2017). Levels of physical activity, eating habits, lifestyle factors, body composition and sociodemographic factors are well established as influencing factors of academic performance (Dubuc et al., 2017). These can account for the recorded MCI.

Carbohydrate-rich foods were the most consumed foods across all the dietary patterns. All the identified patterns contained varied food groups with pattern 1 having the most. Participants who consumed dietary pattern 1 were likely to include food from all the food groups in their diet. Dietary patterns 3 and 4 were the least varied; however, participants adhering to dietary pattern 3 were more likely to consume iron-enhancing fruits and vegetables than those adhering to dietary pattern 4. Comparing dietary patterns 2 and 5, participants adhering to dietary pattern 2 were more likely to consume snacks, alcohol, fast foods (pizza, sharwama), animal protein and less likely to consume soups and stews, iron-enhancing fruits and vegetables and non-heme iron-rich foods than those adhering to dietary pattern 5. Variety is key to a quality diet because consuming foods from different food groups increases the likelihood of meeting dietary recommendations (Brunt et al., 2008). It ought to be mentioned that, consuming the same foods for a long time may be a risk for nutrient deficiency and obesity (Brunt et al., 2008). The consumption of fruits and vegetables was not at its best in the identified dietary patterns. This is consistent with existing literature which report lack of fruit and vegetables consumption among college and university students (Brunt et al., 2008, Gómez-Pinilla, 2008, Blondin et al., 2016, Antonopoulou et al., 2020). Hence, more education is needed to encourage participants to include fruits and vegetables which are replete of minerals in their diets. The identified dietary patterns can be improved since dietary intake is a modifiable lifestyle behaviour (Blondin et al., 2016).

There were no significant correlations between the identified dietary patterns and percentage body, visceral fats and BMI of participants. This may be due to the small sample size of this study; a larger sample size is therefore needed before a conclusion can be drawn. Furthermore, the dietary patterns comprised mainly of staple Ghanaian foods which provide some vitamins and minerals in addition to enough calories, rather than refined foods which are packed with sugar and fat and associated with high BMI and percentage body fat (Antonopoulou et al., 2020, Blondin et al., 2016, Apprey et al., 2019). Findings from the study suggests that, adherence to dietary pattern 4 is associated with declining cognitive performance. Dietary pattern 4 is characterized by low consumption of iron-enhancing fruits, sea foods, soups and stews, high consumption of starch-based foods, no iron-enhancing vegetable and snack consumption. Fish intake has been found to improve cognition; thus, the lack of sea food consumption can account for this observation (Antonopoulou et al., 2020). Sea foods are rich sources of iodine which is necessary for optimal brain development and function (Amarra et al., 2007). Nutrients such as protein, iron, fatty acids and vitamins are all needed in adequacy for optimum cognitive performance (Rogers, 2001, Taras, 2005,

Nyaradi et al., 2014). It is no surprise that the dietary pattern lacking in food sources of these nutrients is associated with cognitive decline. This finding is consistent with existing evidence which suggest that quality dietary pattern is associated with both physical and mental health (Apprey et al., 2019, Antonopoulou et al., 2020, Nyaradi et al., 2014). There is the need for nutritional education and interventions for undergraduate students since the role of dietary habits in both physical and mental health has been established. It will be necessary to apply policies to regulate the quality of food sold at the on-campus cafeterias and canteens since students eat from there.

CONCLUSION

This study has provided insight into the dietary patterns, nutritional status and cognitive performance of some selected final year students at KNUST, Ghana. The findings suggest that the double burden of malnutrition exists among these students. There was also low consumption of fruits and vegetables; thus, there is the need for nutrition intervention among university students who are only a few years away from adulthood to ameliorate the incidence of non-communicable diseases later in life.

ACKNOWLEDGMENTS

Students from the Department of Food Science and Technology, KNUST and all who contributed to the success of this study.

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