Nutrient Intake Adequacy among Older Adults in Rural Communities of Obafemi Owode Local Government Area, Ogun State

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ABSTRACT
Background: *The process of aging is associated with various physiological changes thus making the older adults vulnerable to malnutrition.*
Objective: *This study aims to assess the Nutrient intake adequacy of the older adults in rural communities of Obafemi Owode Local Government Area, Ogun State.*
Methods: *This study which was cross-sectional in design was carried out among 372 respondents. Bio-data of the respondents was collected using a well-structured interviewer's administered questionnaire. Anthropometric measurements were taken using appropriate instruments. Dietary intake was assessed using a single day multi-pass-24-hour recall questionnaire and a single day weighed-food intake was taken for 30 respondents. Adapted Total Dietary Assessment software was used to convert food intake into nutrient intake. SPSS version 20 was used to process all data.*
Result: *About half (54.3%) of the respondents were overweight and 38.7% of the respondents were obese. There was a significant association between Body Mass Index (BMI) and Waist Circumference (P=0.001), BMI and age (P=0.001), BMI and working situation (P=0.001).This study found out that 62.6% and 55.6%of the respondents had inadequate intake of energy and carbohydrate. Also, 74.5%, 53.8%, 86.3% and 74.2% of the respondents had inadequate intake of potassium, magnesium, calcium and Vitamin C respectively. There was no significant difference between the actual nutrient intake from the 24-hour recall and the weighed food intake of the respondents except for protein (P=0.001).*
Conclusion: *Most of the respondents had inadequate intake of energy, carbohydrate and some micro-nutrients which can predispose to malnutrition.*

Keywords: Older adults, Nutritional Status, Nutrient adequacy, Nutrient intake

Introduction

Aging is a developmental process beginning at conception and ending with death [1]. The process of aging is associated with various physiological changes and needs, which makes the older adults vulnerable to malnutrition [2].
Although it has been reported that life expectancy is increasing, these extra years are not always spent in good health because the risk of most common chronic diseases increases with age [3].

Nutrition plays a significant role among other factors that modulate aging [4] and the process of aging is associated with various physiological changes and needs, which makes the older adults vulnerable to malnutrition [4, 5]. The older adults are at a higher risk of malnutrition due to poor food selection, insufficient dietary intake and mal-absorption [4].

For the rapidly growing older adult population, the achievement and maintenance of good nutritional status are critical to health, functioning, and quality of life as embodied in the National Goals of Healthy People and these outcomes are of high public health priority [2].

Choosing a nutrient-dense diet is one of the many challenges faced by the older adults [4]. It is well established that it is important to assess nutrient intake and adequacy in the diet of the older adults in order to appropriately address their health and nutritional needs[6].

Conversely, inadequate dietary intake, with associated imbalances of needed nutrients and energy from food, can increase the vulnerability of the older adults to adverse health outcomes and these include diminished immune response, longer hospital stays and increased likelihood of hospital readmission, impairment in physical and cognitive function, premature institutionalization, and mortality [7].

Nutritional inadequacy represents a potential health threat to the entire older adult population and it has been reported that the risk of poor nutrition is greater among some subgroups of community-living older adults [8]. These include women, minorities, those with limited income and education. Previous studies showed an increased interest in the nutritional status of the older adults, but few researchers targeted the increasing rural older adults' population [9].

The main objective of this study is to assess the adequacy of nutrient intakes and nutritional status of the older adults in rural communities of Obafemi Owode Local Government Area Ogun State.

Methodology

Study Design and Location: The study was descriptive and cross-sectional in design and conducted in ten communities which includes; Mowe, Abaren, Ofada, Loburo, Owode, Siun, Ogunrun, Pakuro, Olojo and Adesan in Obafemi Owode Local Government Area (LGA)

Sample size: Three hundred and seventy-two (372) respondents were randomly selected which comprised of both male and female older adults. The inclusion criteria are older adult persons aged fifty (50) years older who are permanent resident of Obafemi OwodeLGA in Ogun State.

Data Collection: Personal characteristics of the respondents was collected using a well-structured interviewer's administered questionnaire

Anthropometric Measurements: Weight was taken using a digital bathroom weighing scale to the nearest 0.1kg and height was taken using a heightometer to the nearest 0.1cm. Body Mass Index (BMI) was calculated by dividing weight (kg) by the square of the height (m^2) and was used to define underweight (BMI < 18.5kg/m^2), normal weight (BMI = 18.5 to 24.99), overweight (BMI = 25 to 29.99), obesity (BMI = 30 to 40), [10].Waist circumference was also measured using a flexible non-stretchable measuring tape to the nearest 0.1cm at the midpoint between the lower rib border and the iliac crest at the end of expiration while participants were standing upright. Respondents were classified based on the WHO guidelines where a Waist Circumference (WC) >102cm in males and WC >88cm in females is considered a risk factor for abdominal obesity [10].

Dietary Assessment: A single day multi-pass 24-hour dietary recall questionnaire was used to assess dietary intake of the respondents. Single day weighed food intake was also measured using an electronic weighing scale for all food item consumed for a sub-sample of thirty (30) respondents.

Nutrient Adequacy Ratio

According to Schaetzel, Nutrient adequacy ratio (NAR) of energy and each of the selected nutrients were computed and categorized as low intake (intake <60% of RDA), adequate intake (60% - 80% of RDA) and excess intake (80% - 100% of RDA)[11, 12].

NAR = (Nutrient intake ÷ Recommended intake) × 100

Statistical Analysis: Adapted Total Dietary Assessment (TDA) software was used to convert food intake of the respondents to nutrient intake. Statistical Package for Social Science (SPSS) version 20 was used for descriptive statistics (frequencies, mean and percentages) and inferential statistics (Chi square and correlation).

RESULTS

Table 1 shows that 39% of the respondents were between the ages 51-59years and less than one-quarter (19.4%) of the respondents were above 70years. Majority of the respondents (61%) are Christians, 36% were Muslim and 2.7% were traditional worshipers. The main language spoken in the area is Yoruba because the study was carried out in a Yoruba speaking area. More

than two-third (83%) of the respondent are married, 5% are divorced and about 12% are widowed. Seventy-tree percent (73%) of the respondent live with their spouse while about 8% of the respondents live alone.

Table 2 shows the anthropometric characteristics of the respondents. About half of the respondent (54.3%) were overweight 38.7% were obese and only 7% of the respondents had normal body weight. The body mass index of the male and female respondent was not significantly different from each other. About half (52.8%) of the respondent had excess abdominal fat and it was significantly higher among the female respondents. A significant relationship was also observed between abdominal obesity and BMI (P= 0.001)

Table 1: Personal Characteristics of respondents

Parameters	Frequency	Valid Percentage	Cumulative percentage
Gender			
Male	194	52.4	52.4
Female	178	47.6	100.0
Total	372	100.0	
Age			
51-59	144	38.7	38.7
60-69	156	41.9	80.6
70 and above	72	19.4	100.0
Total	372	100	
Religion			
Christianity	227	61.0	61.0
Islam	135	36.3	97.3
Traditional	10	2.7	100.0
Total	372	100.0	
Marital Status			
Married	308	82.8	82.8
Divorced	18	4.8	87.6
Widowed	46	12.4	100.0
Total	372	100.0	
Living Status			
Alone	28	7.5	7.5
With children	72	19.4	26.9
Spouse	272	73.1	100.0
Total	372	100.0	
Tribe			
Yoruba	304	81.7	81.7
Hausa	19	5.1	86.8
Igbo	49	13.2	100.0
Total	372	100.0	

Table 2: Anthropometric Characteristics of the Respondents

Parameter	Male N(%)	Female N(%)	Total N(%)	P-value
BMI				
Normal weight	9(4.6)	17(9.6)	26(7)	**0.286**
Overweight	107(55.2)	95(53.4)	202(54.3)	
Obese	78(40.2)	66(37.0)	144(38.7)	
Total	194(52.2)	178(47.8)	372(100)	
WC				
[1]Not at risk	148(76.3)	27 (15.3)	175(47.3)	***0.001**
[2]At risk	46 (23.7)	149(84.7)	195(52.7)	
Total	194(51.6)	176(47.4)	370(100.0)	

	Normal N (%)	Overweight N (%)	Obese N (%)	Total N (%)	
WC					
Not at risk	19(70.4)	116(58)	40(28.0)	175(47.3)	
At risk	8(29.6)	84(42)	103(72.0)	195(52.7)	
Total	27(100)	200(100)	143(100)	370(100)	***0.001**

1-Not at risk of abdominal obesity
2-At risk of abdominal obesity

Table 3 shows the relationship between body mass index and personal characteristics of the respondents. The result shows that there was a significant association between the age of the respondents and their BMI (P= 0.001). Obesity was significantly higher among respondents 51-69 years. Also, a significant association was observed between the working status and BMI of the respondents. Despite the fewer number of respondents not working, a higher percentage of them had a normal BMI compare to those respondents working.

Table 4 shows the median intake of the nutrients consumed by the respondents. The median actual energy intake of the respondent was1610.7kcal and median weighed intake was 1655.9, median actual protein intake was 74.3, median weighed protein intake was 63.5 with a statistical significance (P=0.05) while the median actual carbohydrate intake was 198.4 and median weighed carbohydrate intake was 212.3. The need for comparison between the actual intake and weighed intake is to validate the result of the Recall ability of the respondents.

The nutrient intake adequacy of the respondents is shown in table 5. The result shows that less than half (31.7%) of the respondents had adequate energy intake, 30.6% of the respondents had excess energy intake and 37.4 % had inadequate intake. About 38.4% of the respondents had inadequate intake of fat, 20.2% had adequate intake and 40.9% had excess intake of fat. Twenty- six percent of the respondents had adequate intake of carbohydrate, 54.8% had inadequate intake and 18.8% had excess intake of carbohydrate. About 86% of the respondent had inadequate intake of Calcium, 5% have adequate calcium intake and 9% had excess calcium intake

Comparing the dietary intake as reported by the respondent and the weighed dietary intake, there was no significant difference between the reported intake using the 24-hr recall questionnaire and the weighed intake.

Discussion

The result of this study shows that none of the respondents was underweight. A study

Table 3: Association between BMI and Personal Characteristics of the Respondents

Parameter	Normal weight N (%)	Overweight N (%)	Obese N (%)	Total N (%)	R	R^2	P-value
Age							
51-59	11 (7.6)	75 (52.1)	58 (40.3)	144 (38.7)	-0.11	0.0121	*0.001
60-69	8 (5.1)	75 (48.1)	73 (46.8)	156 (41.9)			
70 and above	7 (9.7)	52 (72.2)	13 (18.1)	72 (19.4)			
Total	26 (7.0)	202 (54.3)	144 (38.7)	372 (100.0)			
Educational status							
Informal	11 (8.2)	74 (55.2)	49 (36.6)	134 (36.0)	0.090	0.0081	0.5
Secondary	9 (7.8)	66 (56.9)	41 (35.3)	116 (31.2)			
Degree Holder	5 (5.2)	52 (53.6)	40 (41.2)	97 (26.1)			
Higher Degree	1 (4.0)	10 (40.0)	14 (56.0)	25 (6.7)			
Total	26 (7)	202 (54.3)	144 (38.7)	372 (100.0)			
Working situation							
Still working	18 (5.7)	166 (52.2)	134 (42.1)	318 (85.5)	-0.193	0.037	*0.001
Not working	8 (14.8)	36 (66.7)	10 (18.5)	54 (14.5)			
Total	26 (7.0)	202 (54.3)	144 (38.7)	372 (100.0)			
Cooking ability							
Self	16 (8.5)	103 (54.8)	69 (36.7)	188 (50.5)	0.060	0.0036	0.4
Assisted	10 (5.4)	99 (53.8)	75 (40.8)	184 (49.5)			
Total	26 (7.0)	202 (54.3)	144 (38.7)	372 (100.0)			
Gender							
Male	9 (4.6)	107 (55.2)	78 (40.2)	194 (52.2)	-0.046	0.0021	0.3
Female	17 (9.5)	95 (53.4)	66 (37.1)	178 (47.8)			
Total	26 (7.0)	202 (54.3)	144 (38.7)	372 (100.0)			

conducted in Brazil showed a similar finding where no prevalence of underweight was observed among the older adult respondents [13]. It has been reported that the prevalence of malnutrition among the older adults is not because malnutrition is an inevitable side effect of ageing but because changes associated with ageing can promote malnutrition [14]. Malnutrition could manifest as either under nutrition or over nutrition (overweight and obesity) [15] and it is a serious health problem among the older adults as it reduces morbidity and mortality [16].

The high prevalence of overweight and obesity observed among this group is of serious public health significance. In Osun state, Nigeria, the prevalence of overweight and obesity that was reported seems not to be too different from that observed in this study [17]. Increase in the prevalence of overweight and obesity among the

Table 4: Dietary Intake and Relationship between Actual Intake and Weighed Intake of Selected Nutrients

Dietary intake (Macro - nutrients)	N	Median	LQ-UQ	R	R2	P-value
Energy (Kcal)						
Actual intake	372	1610.7	1274.4-2033.4	0.2	0.04	0.28
Weighed intake	30	1655.9	1119.7-2130.3			
Protein (g)						
Actual intake	372	74.3	51.5-97.8	0.4	0.16	*0.05
Weighed intake	30	63.5	34.0-86.5			
Carbohydrate (g)						
Actual intake	372	198.4	150.7-259.2	0.1	0.01	0.60
Weighed intake	30	212.3	137.3-301.7			
Fat (g)						
Actual intake	372	55.9	37.2-87.1	0.2	0.04	0.29
Weighed intake	30	46.1	27.4-90.1			
Vitamin A						
Actual intake	371	3468.1	851.8-6881.8	0.01	0.0001	0.98
Weighed intake	30	4391.9	2902.2-8616.5			
Vitamin C						
Actual intake	352	12.9	5.5-64.1	-0.1	0.01	0.51
Weighed intake	30	10.4	3.1-75.7			
Calcium						
Actual intake	372	249.3	157.1-524.2	0.02	0.0004	0.93
Weighed intake	30	237.5	126.0-438.1			
Phosphorus						
Actual intake	371	1068.8	657.4-1451.3	0.2	0.04	0.21
Weighed intake	30	930.2	472.6-1428.5			
Sodium						
Actual intake	372	930.2	472.6-1428.5	0.2	0.04	0.23
Weighed intake	30	1068.8	657.4-1451.3			
Potassium						
Actual intake	372	1525.6	1104.2-2113.2	-0.02	0.0004	0.94
Weighed intake	30	1627.7	517.2-2136.9			
Zinc						
Actual intake	372	11.4	8.1-18.1	0.06	0.0036	0.76
Weighed intake	30	11.9	6.4-15.3			
Iron						
Actual intake	372	15	10.9-28.1	0.05	0.0025	0.80
Weighed intake	30	18.1	9.5-28.1			
Magnesium						
Actual intake	372	209	159.8-288.9	0.1	0.01	0.61
Weighed intake	30	182	128.9-401.4			

P-value >0.05 is not significant

*statistically significant

Table 5:Nutrient adequacy categorization of selected nutrient consumed by respondents

Nutrients	Inadequate N (%)	Adequate N (%)	Excess N (%)	Total N (%)
Energy	233(62.6)	0(0)	139(37.4)	372(100)
Protein	65(17.5)	57(15.3)	250(67)	372(100)
Carbohydrate	207(55.6)	95(25.5)	70(18.8)	372(100)
Fat	144(38.7)	73(19.6)	155(41.7)	372(100)
Vitamin A	65(17.5)	15(4)	292(78.5)	372(100)
Vitamin C	276(74.2)	8(2.2)	88(23.7)	372(100)
Calcium	321(86.3)	32(8.6)	19(5.1)	372(100)
Phosphorus	55(14.8)	23(6.2)	294(79)	372(100)
Sodium	168(45.2)	35(9.4)	169(45.4)	372(100)
Potassium	277(74.5)	66(17.7)	29(7.8)	372(100)
Zinc	94(25.3)	82(22)	196(52.7)	372(100)
Iron	23(6.2)	12(3.2)	337(90.6)	372(100)
Magnesium	200(53.8)	87(23.4)	85(22.8)	372(100)

older adults has recently been reported and it has been reported to be associated with increased mortality, functional decline and a risk factor for cardiovascular diseases [18]. Studies have shown that overweight and obesity could be caused by combination of different factors ranging from the socio-demographic, age, occupation, educational level and gender [19]. The body mass index of the male older adults was not significantly different from the female. In contrast to the result of a study in Kamrup District, India where there is a significant difference between the male and female respondents [20, 21].

Waist circumference is an anthropometric index for measuring the amount and distribution of body fat [22]. Excess abdominal fat is a risk factor for different health problems [23]. It is important to know that excess abdominal fat in an individual can be a risk factor for cardiovascular diseases and several other metabolic diseases [24]. More than half (52.8%) of the respondents had abdominal obesity which was significantly higher among the female older adults (P=0.001). Studies have shown that the prevalence of obesity and increased WC is higher in female than male [25]. This could be because women have greater tendency of accumulating fat than men and women have less lean muscle when compared to men [26].

There was a significant association between BMI and WC (P=0.001). Nuttall, (2015) reported that two individuals having the same BMI may have different proportion of body fat distribution [27]. A person having normal BMI can exceed the safe range of abdominal fat [28]. Also, some individuals may be overweight not because of fat distribution but because of muscle mass [29]. Older adult may experience decline in lean muscle mass because of aging, their BMI may decrease or remain the same but fat redistribution may increase body fat [30]. It is important to validate BMI of the older adults with WC determination of overweight and obesity.

Although ageing brings about a number of chronic diseases, studies have shown that they are not inevitable consequences and making healthy lifestyle choices, such as diet can prevent these occurrences [31]. Excess energy intake observed among this group could be one of the factors contributing to overweight and obesity among the respondent [32]. Also,many studies have associated high intake of energy, fat and carbohydrate with obesity and overweight and lower energy intake with body decomposition and underweight [33].

It has been reported that a diet high in fat stimulate voluntary energy intake due to their high energy density [34]. Fat, carbohydrate and protein contribute to the total energy. Nearly half (41.4%) of the respondents had excess intake of fat which could be a contributing factor to the high prevalence of overweight and obesity among the respondent. It has been reported that individuals who consume diets high in fat particularly saturated fat are at risk of diabetes

and heart disease [35]. High-fat diet which leads to excessive energy intake has been linked to the increased rate of obesity in the United States [36].
Inadequate intake of protein in older adult populations can predispose to loss of muscle mass and malnutrition [37]. The result of this study shows that 16.4% of the older adults had inadequate protein intake.
The importance of calcium on the health of the older adults especially the women cannot be overemphasized. Calcium has been shown to have beneficial effects on bone mass at all ages [38] and high intake of calcium rich food can lead to a higher bone mass density than people with low intake whereas inadequate intake of dietary calcium can predispose to osteoporosis and fracture [39, 40]. Only 13.7% of the respondent in this study had adequate intake of calcium.
Low intake of phosphorus in the older adults can lead to an increased risk of fracture [40]. In this study more than two-third of the respondent had excess intake, about 6% of the respondent had adequate intake of phosphorus.
As the levels of phosphorus in the body decreases, the bones lose mass and become very weak, brittle and much easier to break [41]. Osteoporosis is a dangerous complication of phosphorus deficiency because most people do not have symptoms until they actually break a bone. An inadequate intake of zinc is of concern as this nutrient is important in the immune function [42]. Aging also affects the functioning of the immune system, contributing to increased morbidity and mortality [43] and about one-quarter of this group of older adults had inadequate zinc intake. It has also been reported that dietary zinc deficiency has an association with memory impairment but the mechanism underlying this effect remain unclear[44].
It can be concluded from this study that the prevalence of overweight and obesity is high among the respondents and it can be a risk factor for non-communicable diseases. There is a significant relationship between the BMI of the respondents and WC with the female having a higher risk of abdominal obesity. There is need to promote nutrition education among the older adults especially their eating habit, and promotion of health for the general population in order to have a healthy aging since the present nutritional status of an individual is a reflection of past nutrition history.

Conflict of Interest

The Authors declares that there is no conflict of interest.

References

[1]Lytle, M., Foley, P., & Cotter, E. (2015). Career and Retirement Theories: Relevance for Older Workers Across Cultures. *Journal of Career development, Volume 42* (Issue 3), pages 185-198.

[2] Leslie, W., & Hankey, C. (2015). Aging Nutritional Status and Health. *Healthcare (Basel,¡Switzerland), Volume 3* (Issue 3), pages 648-658.

[3] Jaul, E., & Barron, J. (2017). Age-Related Diseases and Clinical and Public Health Implications for the 85 Years Old and Over Population. *Frontiers in Public Health, volume 5* (Issue 335).

[4] Shlisky, J., Bloom, D., Beaudreault, A., Tucker, K., Keller, H., Freund-Levi, Y., et al. (2017). Nutritional Considerations for Healthy Aging and Reductions in Age-Related Chronic Disease. *Advances in Nutrition (Bethseda, Md.), Volume 8* (Issue 1), 17-26.

[5] Marco, M., & Eugenio, M. (Eds.). (2016). *Molecular Basis of Nutrition and Aging: A Volume in the Molecular Nutrition Series*. Academic Press.

[6] Granic, A., Mendonca, N., Hill, T., Jagger, C., Stevenson, E., Mathers, J., et al. (2018). Nutrition in the Very Old. *Nutrients, 10* (3), 269.

[7] Troesch, B., Biesalski, H., Bos, R., Buskens, E., Calder, P., Saris, W., et al. (2015). Increased Intake of Foods with High Nutrient Density Can Help to Break the Intergenerational Cycle of Malnutrition and Obesity. *Nutrients, 7* (7), 6016-6037.

[8] ter Borg, S., Verlaan, S., Hemsworth, J., Mijnarends, D., Schols, J., Luiking, Y., et al. (2015). Micronutrient intakes and potential inadquacies of community-dwelling older adults: a systematic review. *The British Journal of Nutrition, 113* (8), 1195-1206.

[9] Jung, S., Bishop, A., Kim, M., Hermann, J., Kim, G., & Lawrence, J. (2017). Nutritional Status of Rural Older Adults is Linked to Physical and Emotional Health. *Journal of the Academy of Nutrition and Dietetics, 117* (6), 851-858.

[10] WHO. (2018). *Obesity and Overweight*. Geneva: World Health Organization.

[11] Schaetzel, T. (2012). *Dietary Diversity and Nutritional Outcome: Agriculture and Nutritional Global Learning and Evidence Exchange (N-GLEE)*. USAID and SPRING.

[12] Oladoyinbo, C., Ugwunna, U., & Ekerette, N. (2017). *Dietary Diversity and Nutrient Intake Adequacy Among Women in Iwo Local*

Government Area, Osun State, Nigeria. African Journal of Food, Agriculture, Nutrition and Development, 17 (4), 12641-12656.
[13] Gomes, D.C.K., Sichieri, R., Junior, E.V. et al. *Trends in obesity prevalence among Brazilian adults from 2002 to 2013 by educational level.* BMC Public Health 19, 965 (2019). https://doi.org/10.1186/s12889-019-7289-9
[14] Fávaro-Moreira, N.C., Krausch-Hofmann, S., Matthys, C., Vereecken, C., Vanhauwaert, E., Declercq, A., Bekkering, G. E., & Duyck, J. (2016). *Risk Factors for Malnutrition in Older Adults: A Systematic Review of the Literature Based on Longitudinal Data. Advances in nutrition (Bethesda, Md.), 7*(3), 507–522. https://doi.org/10.3945/an.115.011254
[15] Ngaruiya, C., Hayward, A., Post, L., &Mowafi, H. (2017). *Obesity as a form of malnutrition: over-nutrition on the Uganda "malnutrition" agenda. The Pan African medical journal, 28, 49.* https://doi.org/10.11604/pamj.2017.28.49.11176
[16] Jaul, E., & Barron, J. (2017). *Age-Related Diseases and Clinical and Public Health Implications for the 85 Years Old and Over Population. Frontiers in public health*, 5, 335. https://doi.org/10.3389/fpubh.2017.00335
[17] Adebayo, R.A., Balogun, M.O., Adedoyin, R.A., Obashoro-John, O.A.,Bisiriyu, L.A., & Abiodun, O.O. (2014). *Prevalence and pattern of overweight and obesity in three rural communities in southwest Nigeria. Diabetes, metabolic syndrome and obesity: targets and therapy*, 7, 153–158. https://doi.org/10.2147/DMSO.S55221
[18] Kyrou, I., Randeva, H.S., Tsigos, C. et al. *Clinical Problems Caused by Obesity.* [Updated 2018 Jan 11]. In: Feingold KR, Anawalt B, Boyce A, et al., editors. Endotext [Internet]. South Dartmouth (MA): MDText.com, Inc.; 2000-. Available from: https://www.ncbi.nlm.nih.gov/books/NBK278973/
[19] Adetunji, A.E., Adeniran,K.A., Olomu, S.C., Odike, A.I., Ewah-Odiase,R.O., Omoike, I.U. et al. (2019) *Socio-demographic factors associated with overweight and obesity among primary school children in semi-urban areas of mid-western Nigeria*. PLoS ONE 14(4): e0214570. doi:10.1371/journalpone0214570
[20] Agar-Walla, R.A., Saikia, A.M., and Baruah, A. (2015). *Assessment of the nutritional status of the older adults and its correlates. J Family Community Med*. 22 (1): 39–43.
[21] You, H., Li, X. L., Jing, K. Z., Li, Z. G., Cao, H. M., Wang, J., Bai, L., Gu, J. H., Fan, X., & Gu, H. (2018). *Association between body mass index and health-related quality of life among Chinese older adults-evidence from a community-based study. BMC public health*, 18(1), 1174. https://doi.org/10.1186/s12889-018-6086-1
[22] Belarmino, G., Torrinhas, R. S., Sala, P., Horie, L. M., Damiani, L., Lopes, N. C., Heymsfield, S. B., &Waitzberg, D. L. (2018). *A new anthropometric index for body fat estimation in patients with severe obesity. BMC obesity*, 5, 25. https://doi.org/10.1186/s40608-018-0202-8
[23] Maffetone, P. B., Rivera-Dominguez, I., & Laursen, P. B. (2017). *Overfat Adults and Children in Developed Countries: The Public Health Importance of Ident*ifying Excess Body Fat. Frontiers in public health, 5, 190. https://doi.org/10.3389/fpubh.2017.00190
[24] Paley, C. A., & Johnson, M. I. (2018). *Abdominal obesity and metabolic syndrome: exercise as medicine? BMC sports science, medicine & rehabilitation*, 10, 7. https://doi.org/10.1186/s13102-018-0097-1
[25] Hu, L., Huang, X., You, C., Li, J., Hong, K., Li, P., Wu, Y., Wu, Q., Wang, Z., Gao, R., Bao, H., & Cheng, X. (2017). Prevalence of overweight, obesity, abdominal obesity and obesity-related risk factors in southern China. PLoS one, 12(9), e0183934. https://doi.org/10.1371/journal.pone.0183934
[26] He, X., Li, Z., Tang, X., Zhang, L., Wang, L., He, Y., Jin, T., & Yuan, D. (2018). *Age- and sex-related differences in body composition in healthy subjects aged 18 to 82 years. Medicine,* 97(25), e11152. https://doi.org/10.1097/MD.0000000000011152
[27] Nuttall, F. Q. (2015). Body Mass Index: Obesity, BMI, and Health: A Critical Review. Nutrition today, 50(3), 117–128. https://doi.org/10.1097/NT.0000000000000092
[28] Kyrou, I.,Randeva,H.S, Tsigos, C, et al. *Clinical Problems Caused by Obesity.* [Updated 2018 Jan 11]. In: Feingold KR, Anawalt B, Boyce A, et al., editors. Endotext [Internet]. South Dartmouth (MA): MDText.com, Inc.; 2000-. Available from: https://www.ncbi.nlm.nih.gov/books/NBK278973
[29] Goossens, G. H. (2017). *The Metabolic Phenotype in Obesity: Fat Mass, Body Fat Distribution, and Adipose Tissue Function. Obesity*

facts, 10(3), 207–215. https://doi.org/10.1159/000471488
[30] Boutari, C., &Mantzoros, C. S. (2017). *Decreasing Lean Body Mass with Age: Challenges and Opportunities for Novel Therapies. Endocrinology and metabolism (Seoul, Korea),* 32(4), 422–425. https://doi.org/10.3803/EnM.2017.32.4.422
[31] Bodai, B. I., Nakata, T. E., Wong, W. T., Clark, D. R., Lawenda, S., Tsou, C., Liu, R., Shiue, L., Cooper, N., Rehbein, M., Ha, B. P., Mckeirnan, A., Misquitta, R., Vij, P., Klonecke, A., Mejia, C. S., Dionysian, E., Hashmi, S., Greger, M., Stoll, S., … Campbell, T. M. (2018). Lifestyle Medicine: A Brief Review of Its Dramatic Impact on Health and Survival. The Permanente journal, 22, 17–025. https://doi.org/10.7812/TPP/17-025
[32] Romieu, I., Dossus, L., Barquera, S., Blottière, H. M., Franks, P. W., Gunter, M., Hwalla, N., Hursting, S. D., Leitzmann, M., Margetts, B., Nishida, C., Potischman, N., Seidell, J., Stepien, M., Wang, Y., Westerterp, K., Winichagoon, P., Wiseman, M., Willett, W. C., &IARC working group on Energy Balance and Obesity (2017). Energy balance and obesity: what are the main drivers? Cancer causes & control: CCC, 28(3), 247–258. https://doi.org/10.1007/s10552-017-0869-z
[33] Al-Kutbe, R., Payne, A., de Looy, A. et al. A comparison of nutritional intake and daily physical activity of girls aged 8-11 years old in Makkah, Saudi Arabia according to weight status. BMC Public Health 17, 592 (2017). https://doi.org/10.1186/s12889-017-4506-2
[34] Rolls B. J. (2017). Dietary energy density: Applying behavioural science to weight management. Nutrition bulletin, 42(3), 246–253. https://doi.org/10.1111/nbu.12280
[35] Gray A, Threlkeld RJ. Nutritional Recommendations for Individuals with Diabetes. [Updated 2019 Oct 13]. In: Feingold KR, Anawalt B, Boyce A, et al., editors. Endotext [Internet]. South Dartmouth (MA): MDText.com, Inc.; 2000-. Available from: https://www.ncbi.nlm.nih.gov/books/NBK279012/
[36] Romieu, I., Dossus, L., Barquera, S., Blottière, H. M., Franks, P. W., Gunter, M., Hwalla, N., Hursting, S. D., Leitzmann, M., Margetts, B., Nishida, C., Potischman, N., Seidell, J., Stepien, M., Wang, Y., Westerterp, K., Winichagoon, P., Wiseman, M., Willett, W. C., &IARC working group on Energy Balance and Obesity (2017). Energy balance and obesity: what are the main drivers? Cancer causes &control: CCC, 28(3), 247–258. https://doi.org/10.1007/s10552-017-0869-z
[37] Deer, R. R., & Volpi, E. (2018). *Protein Requirements in Critically Ill Older Adults. Nutrients*, 10(3), 378. https://doi.org/10.3390/nu10030378
[38] Cormick, G., &Belizán, J. M. (2019). *Calcium Intake and Health. Nutrients,* 11(7), 1606. https://doi.org/10.3390/nu11071606
[39] Institute of Medicine (US) Committee to Review Dietary Reference Intakes for Vitamin D and Calcium; Ross AC, Taylor CL, Yaktine AL, et al., editors. Dietary Reference Intakes for Calcium and Vitamin D. Washington (DC): National Academies Press (US); 2011. 2, Overview of Calcium. Available from: https://www.ncbi.nlm.nih.gov/books/NBK56060/
[41] Vorland, C. J., Stremke, E. R., Moorthi, R. N., & Hill Gallant, K. M. (2017). *Effects of Excessive Dietary Phosphorus Intake on Bone Health. Current osteoporosis reports*, 15(5), 473–482. https://doi.org/10.1007/s11914-017-0398-4
[42] Wu, D., Lewis, E. D., Pae, M., &Meydani, S. N. (2019). *Nutritional Modulation of Immune Function: Analysis of Evidence, Mechanisms, and Clinical Relevance. Frontiers in immunology,* 9, 3160. https://doi.org/10.3389/fimmu.2018.03160
[43] El Chakhtoura, N. G., Bonomo, R. A., & Jump, R. (2017). *Influence of Aging and Environment on Presentation of Infection in Older Adults. Infectious disease clinics of North America,* 31(4), 593–608. https://doi.org/10.1016/j.idc.2017.07.017
[44] David, D.M., & Raymond, D. (2011). *Unravelling The Role of Zinc in Memory. PNAS*(Proceedings of the national Academy of science of the United States of America), 108 (8), 3103-3104. Retrieved from https://doi.org/10.1073/pnas.1100323108