

A Study on the Relation Between Cognitive Abilities and Macronutrients Intake in Young Females

Dr. Shubhra Saraswat^{1*}, Dr. Madhvi Awasthi², Ankita Sharma³ and Richa⁴

¹Dayalbagh Educational Institute, Agra, India

²Manav Rachna International Institute of Research & Studies, Faridabad, India

³Manav Rachna International Institute of Research & Studies, Faridabad, India

⁴PDM University, Bahadurgarh, India

ABSTRACT **Background:** Cognitive function generally refers to mental abilities which comprises of obtaining knowledge, reasoning and manipulation of information. Nutrition has a crucial role in determining Cognition and Neurological function as it impacts the neurotransmitters, cell membranes and enzymes. **Aim:** This study aimed at determining the relation between Intake of Macronutrients and cognitive functioning among healthy, young females. **Methodology:** This Study was carried among 100 women aged 18-25 years in Gurugram. Cognitive abilities of the participants was determined using standardize questionnaire which was Cognitive ability Questionnaire (CAQ) and the dietary intake of the subjects was evaluated by a reliable and valid Food Frequency Questionnaire (FFQ). These questionnaires were administered Online and the samples were selected using Purposive Sampling Technique. **Results:** Significant differences were observed among different levels of Cognitive Function across BMI, Dietary Energy, Protein, Carbohydrates and fats . Participants of the first Quartile of cognitive abilities score (having a score 89-97 which was low) had a remarkably high Energy, Protein and Carbohydrates intake than those in other quartiles ($p < 0.05$). Energy, Carbohydrates and Fats were found to be statistically significant for the anticipation of cognitive functioning by using Multiple Linear Regression analysis. **Conclusion:** The outcomes of the study depict that cognitive functioning is associated with dietary macronutrients including Carbohydrate, Energy and Protein among women without any mental disability. **Keywords:** Cognition, Nutrients, Diet , Energy, BMI

Address for correspondence: Dr. Shubhra Saraswat, Assistant Professor, B.Voc (FPP), Dayalbagh Educational Institute, Agra, India. E-mail: Shubhrasaraswat.1@gmail.com

Submitted: 09-Dec-2021

Accepted: 26-Apr-2022

Published: 19-May-2022

INTRODUCTION

Cognitive function generally refers to different mental processes which comprises of problem solving, attention, thinking, decision making, remembering and learning¹. Nutrition is an essential factor in determining the cognitive functioning as it can determine the future cognitive impairment or dementia². Macronutrients including fat, carbohydrates and proteins are the chief sources of dietary energy, and a high-energy intake may elevate the possibility of cognitive disability. Diet and consumption of certain nutrients majorly influence the cognitive functions of individuals³.

Currently, it has been observed that healthy diet can constructively influence positive cognition as nutrition plays a crucial role in determining the cognitive functioning.

Neuroimaging has also demonstrated the beneficial changes in the brain that take place when a person consumes a healthy diet. There have been witnessed changes in brain volumes, Glucose uptake by the brain and also in the structure of the brain. A study demonstrated consumption of fish oil supplements (2.2 g/day) and its impact on the brain cells. It was observed that it not only provided structural changes like increase in white matter , grey matter volume but also increased 26% of cognitive performance in females between the age group 50-75 years and decreased loss of grey matter⁴.

Notably, there have been various studies which remarkably depict the importance of different Nutritional components

This is an open access journal, and articles are distributed under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike 4.0 License, which allows others to remix, tweak, and build upon the work non-commercially, as long as appropriate credit is given and the new creations are licensed under the identical terms.

Access this article online
Website: www.ijfans.org
DOI: 10.54876/ijfans_71-21

How to cite this article: Dr. Shubhra Saraswat, Dr. Madhvi Awasthi, Ankita Sharma and Richa. A Study on the Relation Between Cognitive Abilities and Macronutrients Intake in Young Females. Int J Food Nutr Sci 2022;11:1-7.

in declining cognitive performance and dementia. These components are PUFA (Polyunsaturated Fatty acids, antioxidants and various other B complex Vitamins⁵.

Diet and Cognitive Function

Diet is considered as an essential supporter of optimum cognitive abilities. Various nutrients from the diet not only provide energy but also act as a shield towards cognitive impairment and some of the neurological disorders which are majorly age related like Alzheimer's and Parkinson's disease. There are various nutrients that have an direct or indirect impact on the cognitive functioning and may also reduce cognitive decline. There have been noticed remarkable benefits (neuroprotection in neurological disorders) by consumption of the Mediterranean Diet (includes vegetables, olive oil (omega 3 source), fruits). The relationship between the nutrition and cognition is complex as a sole nutrient has no major impact on the brain cells whereas combination of various nutritional components, environmental factors and genes determine the impact on cognition. However, many studies have recently showcased the influence of nutrition on cognition, neurological function and disease and concluded that there lies a major impact of optimal energy status, intake of vegetables and fruits (act as an antioxidants), iron, copper, numerous vitamins and also PUFA on the cognitive performance⁶.

There are various factors which can have a negative effect on the central and peripheral immune cells and some circulatory factors which determine satiety by building inflammatory response. These factors generally include intake of high fat, poor nutrition in neonatal stage, overeating, obesity. These inflammatory molecules can further damage the brain immune cells and activate the microglia which further by the production of pro-inflammatory molecules can alter the brain structures which help in cognition by reducing their functions and leads to depression and dementia. Although, consumption of PUFA and polyphenols can alter the negative impacts by controlling immune cells (peripheral and central, both)⁷.

Role of Nutrients in Cognitive Functioning

The impact of specific nutrients on cognition is difficult to understand. However, there are few studies which have emphasised on the positive relation between certain nutrients like PUFA, Trace elements and Vitamins on cognition. Synergistic Interactions between specific nutrients are essential and may help in explaining the significance of an ideal balanced diet⁶. Cerebral functioning have been associated majorly with micronutrients⁸. The role of nutrients in cognitive ability are as follows:

Micronutrient's Role in Cognitive Functioning

The micronutrients which are correlated with cognitive ability comprise of all the water soluble vitamins, i.e., B-complex Vitamins and Vitamin C, and also some minerals. The interconnection between the brain, behaviour and diet is complex. Although, these micronutrients directly determine the cognitive function through their participation in the energy metabolism of glia cells and neurons, the production of neurotransmitters, receptor binding and the preservation of membrane ion pumps. Minimal deficiency of these micronutrients develop a number of general symptoms, many of which are linked to cognitive functioning⁹.

Macronutrient's Role in Cognitive Functioning

Macronutrients like fat, protein and carbohydrates are the major sources of dietary energy, and a high-energy consumption may increase the possibility of cognitive impairment¹⁰. Macronutrients are likely to change cognitive function by exerting effects on neural cell structure, neurotransmission, energy supply to the brain and metabolism³.

For neurological health, optimal nutrition is very crucial as it has a major impact on brain structure development and it's function.

Currently, it has been observed that healthy diet can constructively influence positive cognition as nutrition plays a crucial role in determining the cognitive functioning. Therefore, this study emphasized on the effect of the macronutrients on the cognitive functioning. In India, Several studies have been conducted and aimed to know the relationship between dietary patterns and cognitive ability but with different target groups. However, this study was conducted to know the relation between of Dietary intake (majorly macronutrients) and cognitive functioning and also the seven aspects of cognitive functioning i.e., memory, inhibitory control, planning, cognitive flexibility, selective attention, decision making, sustained attention, social cognition in healthy young women. This study emphasized on the impact of the macronutrients on various seven aspects of cognitive ability as discussed above which makes this study unique.

MATERIALS AND METHODS

Study Design

This cross-sectional study was conducted in Gurugram during January 2021. Purposive Sampling technique was used while selecting the sample. The sample was aged between 18-25 years and females without psychological disorders like Depression were selected. The subjects were selected purposively for study for the following reasons - Willingness to co-operate, Ease of Accessibility by the investigator and Availability of the target group.

Tools Used for Data Collection for Different Measurement Like

1. Cognitive Abilities

A Standard questionnaire (CAQ – cognitive abilities questionnaire) was administered to the participants. It is a valid tool which helps in measuring 7 aspects of cognitive performance i.e., cognitive flexibility, inhibitory control and selective attention, sustained attention, decision making, social cognition and memory, planning. This questionnaire consisted of 30 components defining each of the 7 parameters and rated on a five-point Likert scale (1-5) to provide a total score from 30-150 in which lower scores reflected better cognitive function for each parameter¹¹.

2. Anthropometric Measurements

Height and weight was taken by the administration of a self structured questionnaire. BMI was calculated accordingly.

3. Dietary Intake

A valid questionnaire i.e., Food Frequency Questionnaire consisting of 98 items was administered to the subjects in order to evaluate the dietary intake of the subjects¹². Nutrient

intake of each individual were calculated by the guidelines provide by National Institute of Nutrition, Hyderabad.

Data Collection

The standard questionnaires were administered to the subjects and shared via a link and the motive of the study was described to the subjects. The anonymity of the participants was taken care.

Statistical Analysis

For the Statistical Analysis, SPSS tool was used in which various tests were applied like ANOVA (One way analysis of Variance) in order to estimate the significant difference in the dietary intake and cognitive abilities score as 4 different quartiles were made for the Cognitive ability Scores. To assess the relation between the dietary components and cognitive ability tasks, Pearson Correlation was applied and to estimate the association between dietary intakes and quartiles of cognitive scores, Multiple Linear Regression was applied respectively.

RESULTS

The Mean±SD of Age, Height (m), Weight (kgs) and BMI

Table 1: Significant Difference Between the Dependent Variable (Cognitive Ability) and the Independent Variables (BMI, Dietary Energy, Protein, Carbohydrate and Fats)

ANOVA						
Dependent Variable		Type III Sum of Squares	df	Mean Square	F	Sig./p-value
BMI	CAQ	56726.2	4	14181.55	813.441	0
	Error	1673.67	96	17.43		
	Total	58399.86	100			
Energy (kcal)	CAQ	293510617.4	4	73377654.35	1891.456	0
	Error	3724250.61	96	38794.28		
	Total	297234868	100			
Protein (g)	CAQ	202806	4	50701.5	714.001	0
	Error	6817	96	71.01		
	Total	209623	100			
Carbs (g)	CAQ	8119738.59	4	2029934.65	1220.781	0
	Error	159630.41	96	1662.82		
	Total	8279369	100			
Fats (g)	CAQ	190238.21	4	47559.55	1262.019	0
	Error	3617.79	96	37.69		
	Total	193856	100			

Note: A significant difference was observed among different levels of cognitive function across BMI, Dietary Energy, Protein, Carbohydrates and Fat with F = 813.4, p = 0.00; F = 1891.456, p = 0.00; F = 714, p = 0.00; F = 1220, p = 0.00 and F = 1262, p = 0.00 respectively.

(Kg/m²) was 20.3±1.8 years, 1.61±.085 meters, 61.94±10.3 kgs and 23.7±4.26 kg/m² respectively.

Table 2 participants of the first Quartile of cognitive abilities score (having a score 89-97 which was low) had a significantly higher intake of Energy, Protein, Carbohydrates than those in other quartiles (p = <0.05).

Pearson Data revealed a negative correlation between BMI and Inhibitory Control and selective Attention (r = -0.23, p<0.05). Therefore, it signifies that the High BMI results in Low Inhibitory Control and selective Attention. Likewise, High Energy and Carbohydrate Intake is associated with Low Decision making ability and High Carbohydrate intake is associated with Low social Cognition and Cognitive Flexibility as a Negative Correlation was found between Energy intake, carbohydrate intake and Decision Making (r = -0.22, p<0.05; r = 0.22, p<0.05 respectively); Carbohydrate Intake and Social cognition were also found to be negatively correlated (r = 0.20, p<0.05) respectively.

DISCUSSIONS

The Findings of this Study revealed that Cognitive ability is

influenced by Dietary Intake and more importantly intake of Carbohydrates, Energy and Protein and the BMI also has an impact on the cognitive functioning. A similar study was conducted and the results showcased that the dietary energy, protein, calcium, carbohydrate, thiamine, zinc and Vitamin A are linked with cognitive functioning in Young Women¹³.

The findings of this study depicted that High Energy intake results in Low cognitive functioning and also it reduces the memory and overall cognitive functioning. However, energy intakes were not seen to affect other components of cognitive abilities like cognitive flexibility, inhibitory control and selective attention, sustained attention, decision making, social cognition and planning. Another Study depicted that Macronutrients like fat, protein and carbohydrates are the major sources of dietary energy, and a high-energy consumption may increase the possibility of cognitive impairment³.

Energy rich diets and a sedentary lifestyle result in susceptibility towards obesity and diabetes. There is a connection between these conditions and possibility of impaired cognitive function, dementia and depression which is age related^{14, 15}. Our Results showcased that the High BMI results in Low

Table 2: Dietary Intakes of the Subjects Across Cognitive Abilities Score's Quartiles

Variables	CAQ (Cognitive Ability Scores)				
	Q1 (N = 28)	Q2 (N = 27)	Q3 (N = 22)	Q4 (N = 23)	Total
BMI	25.58±4.56	22.77±3.36	23.16±3.80	23.41±4.83	23.79±4.27
Energy (kcal)	1796.75±142.14	1685.89±199.63	1716.95±232	1635.52±214.5	1712.18±202.98
Protein (g)	49.75±8.55	42.22±8.79	43.77±8.16	43.35±8.08	44.93±8.85
Carbs (g)	303.39±36.60	281.33±39.96	283.09±44.68	267.22±42.65	284.65±42.26
Fats (g)	42.11±6.53	43.52±5.67	45.50±6.91	43.70±5.35	43.60±6.16

Note: Data Representation: Mean±SD; Q1: Quartile 1 (CAQ score: 89-97); Q2: Quartile 2 (CAQ score: 98-100); Q3: Quartile 3 (CAQ score: 101-103) and Q4: Quartile 4 (CAQ score: 104-109). BMI: Body Mass Index.

Table 3: Pearson Correlation Coefficient Between Dietary Intake and Cognitive Abilities Task

Correlations					
Pearson Correlation					
	BMI	Energy (kcal)	Protein (g)	Carbs (g)	Fats (g)
Memory	-0.116	-0.138	-0.117	-0.187	0.12
Inhibitory control and selective attention	-.232*	-0.125	-.258**	-0.152	.259**
Decision making	-0.191	-.224*	-.271**	-.224*	0.059
Planning	-0.111	-0.089	-0.047	-0.067	-0.104
Sustain attention	-0.029	-0.015	0.04	-0.062	0.094
Social cognition	-0.185	-0.173	-0.01	-.202*	0.01
Cognitive flexibility	0.01	-0.166	-0.127	-.249*	0.193
Total cognitive ability	-.231*	-.271**	-.283**	-.313**	0.162

Note: **: Correlation is significant at the 0.01 level (2-tailed). *: Correlation is significant at the 0.05 level (2-tailed).

Inhibitory Control and selective Attention as well as cognitive functioning. However, BMI was not associated with other cognitive tasks like memory, sustained attention, decision making, social cognition, planning and cognitive flexibility. Another Study revealed the associations between BMI levels and progression of Dementia and concluded that High BMI was linked with decline in the cognitive abilities¹⁶.

A randomised-controlled experimental study showcased that obese and overweight participants with type 2 diabetes with both high and low carbohydrate diets and physical activity showcased same effects on the cognitive function. Therefore. Both diets including high carb or low carb can be incorporated as they show no negative influence on cognitive performance¹⁷. On the contrary, Our findings illustrated that High carbohydrate intake may have a negative impact on overall cognitive ability majorly in Decision making, cognitive flexibility and social cognition. Although, it is not associated with other aspects like inhibitory control and selective attention, planning, sustained attention and memory. Another Study stated that Alterations in the neurocognitive function can be seen across the lifespan if it is complemented by Persistent intake of refined carbohydrates. Refined carbohydrate consumption can also lead to damage to the Hippocampal accompanied by deformation of the prefrontal and mesolimbic reward pathways. Toxic Cognitive Ability might result from Early life exposure to refined carbohydrates⁹. Intake of Proteins have impact on the cognitive ability. However, the outcomes of the study depicted High protein intake may result in less cognitive ability. A Study depicted that there lies a Constructive correlation of Positive association of dietary protein intake mainly from the animal protein, eggs and meat and consumption of protein was observed whereas the intake of protein from milk and milk products were seen to showcase a negative impact on cognition among elderly¹⁸.

According to a study, Increased dietary fat intake have resulted in the overproduction of the inflammation as well as free fatty acids. These further go into the circulation and cause microglial proliferation especially in the hypothalamus. Oxidative stress is also linked to impaired cognitive performance as it leads to more production of the Reactive oxidative Species which leads to inflammation and cognitive deficit. Thus, the excessive consumption of High fat diet will gradually lead to the Central nervous system inflammation¹⁹. Although, the findings of the study depicted that fat was in a moderate range. Therefore, it had no major impact on cognitive functioning. But, if we observe the quality of fat according to a study, Consumption of high saturated and *trans* fat is related to considerably worsen the cognitive ability. Moreover, if substituted with MUFA, PUFA it possesses

positive impact on cognition²⁰. Another study was aimed to evaluate whether a low fat diet has an impact on cognitive performance or not in postmenopausal healthy women. The results showcased that the adoption of a low fat diet pattern was somewhat similar to that of a Dietary Approaches to Stop Hypertension diet as this dietary pattern included consumption of more fruits, vegetables, legumes and whole cereals and this dietary pattern therefore reduced the possibility of cognitive impairment in postmenopausal females²¹.

Overall, findings of this study depicted that High Dietary intake of Energy, Carbohydrate, Protein have a negative impact on the cognitive Ability. However, fats do not showcase any major impacts on Cognitive Ability which were similar to the Persian study¹³.

CONCLUSION

Nutrition is an essential factor in determining the cognitive functioning as it can determine the future cognitive impairment or dementia. Currently, specific nutrients are not considered essential to improve the cognitive performance but, the Mediterranean diet which is considered as a dietary pattern providing all the essential nutrients helps in improving the cognitive ability mainly due to the cumulative effect of different components which are present in Mediterranean diet types.

Diet is considered as an essential supporter of optimum cognitive abilities. Various nutrients from the diet not only provide energy but also act as a shield towards cognitive impairment and some of the neurological disorders which are majorly age related like Alzheimer's and Parkinson's disease. There are various nutrients that have an direct or indirect impact on the cognitive functioning and may also reduce cognitive decline. This Study showcased the impact of the Macronutrients on the cognitive ability whereas other studies have demonstrated the impact of micronutrients as well.

This study established that there is a negative impact of high energy, Carbohydrate, BMI and protein on the cognitive functioning whereas the cognitive ability task like decision making, memory, social cognition, cognitive flexibility, planning, selective attention, sustained attention and inhibitory control are not majorly impacted by the nutrients. Although, intake of high protein and low BMI resulted in better inhibitory control and selective attention; Low intake of energy and carbohydrates and low intake of protein resulted in better decision making; low intake of carbohydrate resulted in better cognitive flexibility. Alternatively, there was no Association found between memory, planning and sustained attention with BMI, Dietary energy, fats, carbohydrates and proteins.

In the summary, the outcomes of this study depicted the association of Energy, Carbohydrates and Protein with the cognitive functioning among healthy Young women (18-25 years). Although, it was not clear whether the quality of these macronutrients impact the cognitive ability or not. Therefore, further studies need to be conducted to explore the quality of diet as well as dietary interventions which may result in prevention of cognitive ability.

LIMITATIONS

Several limitations of this study are that it was conducted on a limited sample size and may not represent young women population at large. Secondly, the heavy reliance on the questionnaires which were administered online due to Covid'19 and also, this study focussed on the quantity of the dietary intake of Macronutrients rather than quality as few studies have demonstrated the importance of quality of certain nutrients like fat, carbohydrate and protein in relation with the cognitive functioning. This may further not identify the temporal linkage between the Diet and the cognitive performance.

REFERENCES

1. Fisher G., Chacon M., Chaffee D. (2019). "Theories of cognitive Aging and work" Chapter 2; Work across the lifespan Book. 17-45.
2. Scarmeas, N., Anastasiou, C. A., & Yannakoulia, M. (2018). Nutrition and prevention of cognitive impairment. *The Lancet. Neurology*, 17(11), 1006-1015.
3. Ding, B., Xiao, R., Ma, W., Zhao, L., Bi, Y., & Zhang, Y. (2018). The association between macronutrient intake and cognition in individuals aged under 65 in China: a cross-sectional study. *BMJ open*, 8(1).
4. Rodrigues B., Asamane E. A., Magalhães R., Sousa N., Thompson J. L., Santos N. C. (2020). The association of dietary patterns with cognition through the lens of neuroimaging-a Systematic review. *Ageing Res Rev*. Nov; 63: 101145. doi: 10.1016/j.arr.2020.101145. Epub 2020 Aug 17. PMID: 32818651.
5. Kesse-Guyot E., Andreeva V. A., Jeandel C., Ferry M., Hercberg S., Galan P. (2012). A healthy dietary pattern at midlife is associated with subsequent cognitive performance. *J Nutr*. May; 142(5): 909-15. doi: 10.3945/jn.111.156257. Epub 2012 Mar 28. PMID: 22457391.
6. Farooqui T. and Farooqui A. (2015). "Diet and Exercise in Cognitive Function and Neurological Diseases Book".
7. Spencer, S. J., Korosi, A., Layé, S., *et al.* (2017). Food for thought: how nutrition impacts cognition and emotion. *npjSci Food*. 1:7, 1-8.
8. Bourre J. M. (2006). Effects of nutrients (in food) on the structure and function of the nervous system: update on dietary requirements for brain. Part 1: micronutrients. *J Nutr Health Aging*. Sep-Oct; 10(5): 377-85. PMID: 17066209.
9. Huskisson E., Maggini S., Ruf M. (2007). The influence of micronutrients on cognitive function and performance. *J Int Med Res*. Jan-Feb; 35(1): 1-19.
10. Dye, L., Lamport, D., Boyle, N., Hoyland, A. "Macronutrients and cognitive performance". *Lifetime Nutritional Influences on Cognition, Behaviour and Psychiatric Illness*, 131-159.
11. Nejadi V. (2013). Cognitive Abilities Questionnaire: Development and Evaluation of Psychometric Properties. *Advances in Cognitive Sciences*; 15(2): 11-19.
12. Telles S., Abhishek B., Gupta R., Kumar A., Acharya B. (2016). Development of a Food Frequency Questionnaire to Assess Dietary Intake for the Residents of the Northern Region of India. *Indian Journal of Ancient Medicine and Yoga*. (9), 139-147.
13. Askari M., Abbaszadeh A., Saharkhiz M., Karbasi S., Talebpour A., Fashami A. A. A., Rezapour H., Hoseini Z.S., Mahmoudzadeh S., Ayadilord M., Ferns G. A., Bahrami A. (2020). A study of the association between cognitive abilities and dietary intake in young women. *Nutr Health*. Sep; 26(3): 263-270.
14. Keage, H. A., Gupta, S., Brayne, C. (2011). Alzheimer's Society Systematic Review Group. Risk for dementia and age at measurement. *International Journal of Geriatric Psychiatry*, 26, 329-330.
15. Fielding, R. A., Gunstad, J., Gustafson, D. R., Heymsfield, S. B., Kral, J. G., Launer, L. J., Penninger, J., Phillips, D. I., Scarmeas, N. (2013). The paradox of overnutrition in aging and cognition. *Annals of the New York Academy of Sciences*, 1287, 31-43.
16. Michaud T. L., Siahpush M., Farazi P. A., Kim J., Yu F., Su D., Murman D. L. (2018). The Association Between Body Mass Index, and Cognitive, Functional, and Behavioral Declines for Incident Dementia. *J Alzheimers Dis*; 66(4): 1507-1517. doi: 10.3233/JAD-180278. PMID: 30412484; PMCID: PMC6441968.
17. Tay, J., Zajac, I. T., Thompson, C. H., Luscombe-Marsh, N. D., Danthiir, V., Noakes, M., Buckley, J. D., Wittert, G. A., & Brinkworth, G. D. (2016). A randomised-controlled trial of the effects of very low-carbohydrate and high-carbohydrate diets on cognitive performance in patients with type 2 diabetes. *The British journal of nutrition*, 1-9. Advance online publication.

18. Li, Y., Li, S., Wang, W., Zhang D. (2020). Association between Dietary Protein Intake and Cognitive Function in Adults Aged 60 Years and Older. *J Nutr Health Aging*, 24, 223-229.
19. Tan, B. L., & Norhaizan, M. E. (2019). Effect of High-Fat Diets on Oxidative Stress, Cellular Inflammatory Response and Cognitive Function. *Nutrients*, 11(11), 2579.
20. Devore, E. E., Stampfer, M. J., Breteler, M. M., Rosner, B., Kang, J. H., Okereke, O., Hu, F. B., & Grodstein, F. (2009). Dietary fat intake and cognitive decline in women with type 2 diabetes. *Diabetes care*, 32(4), 635-640.
21. Chlebowski R., Rapp S., Aragaki A., Pan K., Neuhouser M., Snetselaar L., Manson J., Wactawski-Wende J., Johnson K., Hayden K., Baker L., Henderson V., Garcia L., Qi L., & Prentice R. (2020). Low-fat dietary pattern and global cognitive function: Exploratory analyses of the Women's Health Initiative (WHI) randomized Dietary Modification trial.