IOSR Journal of Biotechnology and Biochemistry (IOSR-JBB)
ISSN: 2455-264X, Volume 8, Issue 1 (Jan. – Feb. 2022), PP 05-11
www.iosrjournals.org

Evaluation of Lipid Levels in Multiple Sclerosis Patients from Gaza Strip

Aya Nbhan[1], Mazen Alzaharna[2], Shawqi Muhaisen[3], Kamal Elkahlout[4]
[1]*Department of Biology, Faculty of Science, Islamic University of Gaza, P.O. Box 108, Gaza Strip, Palestine*
[2]*Department of Medical Laboratory Sciences, Islamic University of Gaza, P.O. Box 108, Gaza Strip, Palestine*
[3]*Neuroscience Department, Alshifa Medical complex, Gaza, Gaza Strip, Palestine*
[4]*Department of Biotechnology, Islamic University of Gaza, P.O. Box 108, Gaza Strip, Palestine*

Abstract:
Objective: *To assess lipid levels and their relationship to disease severity and degree of relapse, according to the Clinical Rating Scale (EDSS) for patients with multiple sclerosis in the Gaza Strip.*
Materials and Methods*: The research involved 31 MS patients who were separated into two categories. The first group consisted of 20 patients in the remission condition and the second group consisted of 11 patients in the relapsed state and 31 apparently healthy individuals as a control group. A questionnaire was used to collect the data used in the statistical analysis. Blood samples were collected from the participants and analyzed for as triglycerides (TG), cholesterol (CH), Low-density lipoprotein (LDL), and High-density lipoprotein (HDL) was calculated using Friedewald formula. An ethical approval was granted from Helisinki Committee at Gaza. All data were analyzed using the computerized statistical program SPSS.*
Results*: The mean levels of TG, CH, and LDL in MS patients were higher and statistically significant than in the control group, while the average HDL level in MS patients was lower and statistically significant compared to the control group. It is noted that there is no clear statistically significant difference between the two groups of MS. The results also show that the correlation between EDSS and CH, HDL and LDL were positive and strong. The correlation was statistically significant (P = 0.017, 0.003 ,0.014 respectively) in the relapse group.*
Conclusion: *Patients with MS have higher levels of TG, CH, & LDL, and lower levels of HDL compared to the control group. There is a correlation between the lipid levels and disability in patients with MS.*
Key Word*: Relapsing-remitting multiple sclerosis, cholesterol, triglycerides, Low density lipoprotein, High density lipoprotein, Expanded Disability Status Scale, Gaza Strip.*

Date of Submission: 04-01-2022 Date of Acceptance: 15-01-2022

I. Introduction

Multiple sclerosis is complex neuropathology multifactorial. It has been shown that the immune system attacks myelin, leading to inflammatory demyelination and axonal damage, although its etiology remains unclear **(1)**. Globally, the number of people with MS is 2–2.5 million (approximately 30 per 100,000). The prevalence varies greatly, where high prevalence levels are seen in North America and Europe (> 100/100,000 inhabitants) compared to low prevalence levels in Eastern Asia and sub -Saharan Africa (2/100,000 inhabitants). It affects females more than males (2:1), the number of deaths by this disease is about 19,000 deaths per year **(2)**. Although there is no any formal statistics for MS patients in Gaza strip, the information obtained from the Palestinian Ministry of Health clinics show that the number of MS patients receiving treatment in Gaza Strip is 132 patients. Most of these patients are females and are diagnosed as RRMS. Epidemiologic studies about the distribution of MS in a range of populations could help interpret new environmental and racial signs about this disease and develop an understanding of the respective roles of endogenous and exogenous causes of MS.

MS can be divided into four groups based on the course of the disease: relapsing-remitting MS (RRMS), secondary-progressive MS (SPMS), primary-progressive MS (PPMS) and progressive-relapsing MS (PRMS). According to the National Multiple Sclerosis Society, a relapse is defined as "an exacerbation that results in new symptoms or worsening of old symptoms" **(3)**. For an event to be considered a true relapse, the exacerbation must last for a minimum of 24 hours and must be separated by a minimum of 30 days from previous exacerbations. RRMS is the most prevalent type of MS, accounting for approximately 85% of all diagnoses. Younger patients are more likely than older patients to get this form of MS **(4)**. It is characterized by spontaneous relapses or worsening of neurological function, followed by remission or recovery periods in which symptoms completely improve or resolve. There is no disease progression between relapses **(3)**.

MS signs and symptoms are unpredictable and differ greatly from person to person and over the course of the disease depending on the location of affected nerve fibers. People with MS tend to have their first symptoms between the ages of 20 and 40. Some people signs develop and get worse steadily over time, while for others they come and go, periods **(5)**. MS is typically diagnosed based on the presenting signs and symptoms, in combination with supporting medical imaging and laboratory testing. The degree of disease progression can be classified according to several measures of clinical disability, based on historical findings and physical examination. The most widely accepted is the Kurtzke 10-point Extended Disability Scale (EDSS), which was originally developed in 1955 as the Disability Scale and has been revised over the years **(6)**.

The Brain is the most lipid-rich organ in the body, myelin sheath is rich in lipids, forming about 80% of dry weight of the intact myelin, and it contains about 700 different lipid species, specifically sphingolipids, and glycerophospholipids **(1)**. Different lipid species play numerous roles in the CNS **(7)**. The body's lipid metabolism may have direct and indirect effects on MS impairment and disease development because they are important for inflammatory responses to be controlled and for CNS remyelination and repair. Lipid homeostasis disturbance may also affect myelin integrity and modulate neurodegeneration **(1)**. Dyslipidemia, a known player in atherosclerosis and in the vasculitis underlying cardiovascular disease, has been suggested to play a role in MS. In recent years it was shown that dyslipidemia play a role in patients with MS where they have a higher incidence of high CH and lipoprotein levels Function **(8)**.

So, the study of lipids at disease onset could be an important tool to better understand the biological processes occurring at the beginning of the disease or even to help in the diagnosis. Accordingly, several studies have tended to limit the development of disability in disease cases through a diet and a number of drugs such as (fingolimod and dimethyl fumarate and simvastatin), which can modify the metabolic imbalance in fats **(9).**

II. Material and Methods

The study is a case control one. The target population of this study comprises adult males and females who have MS for a different period of time and at different ages and apparently healthy persons. The sample size consisted of 31 patients that were previously diagnosed with RRMS, 11 during relapse and 20 stable MS patients, and 31 apparently healthy persons.

Inclusion criteria includes MS patients diagnosed with RRMS from all hospitals and clinics in the Gaza Strip who fulfilled the clinical definite criteria for MS. While patients with any other diseases that are similar to MS, or affect lipid levels and those with chronic diseases were excluded.

The necessary ethical approval to conduct the study was obtained from the Helsinki committee- Gaza. Facilitation letter was also obtained from the Palestinian ministry of health to conduct the study. Participants in the study were informed about the nature and objective of the study and an informed consent form was signed by them.

A meeting interview was conducted for filling the questionnaire by the doctor. The questionnaire consisted of three sections. The first section involves demographic information about the condition, such as age, gender, body mass, date of injury and number of relapses. The second section includes the gradations of the disability scale for each body function separately, EDSS, and the third section was designed for the specialist to determine the final degree of disability for the case. All the necessary tests and questions were performed and asked by the doctor himself.

5 ml of venous blood was drawn after fasting overnight for 12-14 hours from all participants. The blood in plain vacutainer tubes was obtained. The blood was left for a while to allow the blood to clot. Then the serum was separated after centrifugation of the blood sample at 4000 rpm for 10 minutes, collected in two plastic tubes, then stored at -20°C until the time of analysis. The biochemical analysis that were performed involved the determination of CH, TG, HDL, LDL & glucose. For all biochemical tests, the normal and abnormal controls were used.

The Statistical Package of Social Science (SPSS version 25) program was used for data entry and analysis. Frequency tables were used to show baseline characteristics by number (n) and percentage (%) in categorical data. Normal distributed quantitative data were described by mean & standard deviation (SD). Moreover, cross-tabulation for main findings and other statistical tests such as the Chi-square test to compare categorical variables, and t-test or One-way ANOVA test to compare means of numeric variables were used as required to analyze data. The level $P < 0.05$ was considered as the cutoff value or significance.

III. Results

General characteristics of the study population

The general characteristics of the study population are presented in Table 1. The percentage of males and females was 32.3% & 67.7% in both controls and cases respectively, the difference is not statistically significant (P = 1). The number of controls and cases between the age 20-40 years was 67.7%, and between 40-60 years was 32.3%, the difference was not statistically significant (P = 1).

Table (1): General characteristics of the study population.

Characteristics	Controls (n=31)	Cases (n=31)	Statistical test χ^2	P-value
Sex				
Males	10 (32.3)	10 (32.3)	0.000	1.000
Females	21 (67.7)	21 (67.7)		
Age (years)				
20-40	21 (67.7)	21 (67.7)	0.000	1.000
40-65	10 (32.3)	10 (32.3)		

The number of cases in the relapse state was 11 (35.5%) and the number in the stable state was 20 (64.5%). The number of male patients in the relapse and stable groups was 18.2 & 40.0% respectively (Table 2), while the number of female patients was 81.8 & 60.0% respectively, the difference was not statistically significant (P = 0.214). On the other hand, the number of patients in the relapse and stable groups with age 20-40 years was 63.6 & 70.0% and those with age 40-60 years was 36.4 & 30.0% respectively (Table 2), the difference was not statistically significant (P = 0.717). The average duration of disease in stable and relapse groups was (7.45±6.58 & 5.45±4.29 years) respectively, the difference was not statistically significant (P = 0.312). The average number of relapses in the relapse and stable groups was 14.55±21.75 & 3.02±2.12 times, the difference was statistically significant (P = 0.024).

Table (2): The relation between relapse and socio-demographic data among cases.

		Total (n=31)	Cases		Statistical test		P-value
			Relapse (n=11)	Stable (n=20)	t	χ^2	
Sex	n (%)						
Male		10 (32.3)	2 (18.2)	8 (40.0)		1.546	0.214
Female		21 (67.7)	9 (81.8)	12 (60.0)			
Age (years)							
20-40		21 (67.7)	7 (63.6)	14 (70.0)		0.132	0.717
40-65		10 (32.3)	4 (36.4)	6 (30.0)			
Duration of MS (years)	Mean±SD (Min-Max)	6.2±5.2 (0-17)	7.5±6.6 (1-17)	5.5±4.3 (0-15)	1.029		0.312

n: number of the subjects; **SD:** standard deviation; **t:** student t-test; χ^2**:** chi-square test, * indicates a statistically significant at P<0.05.

Clinical data of the cases

Kurtzke Expanded Disability Status Scale (EDSS) among cases

The average of score among cases according to Kurtzke Expanded Disability Status Scale (EDSS) was (4.79±1.05) with a minimum (3.2%) for score 1.5, 3.5, 7.0 and maximum (25.8%) for score 5 (Table 3).

Distribution of the clinical rating scale among cases

The clinical classification scale between cases is described in Table (4). The average of visual (optic) function defect among cases was (1.35±0.75) and the majority were to the scores 1&2 at 41.9%, while the Pyramidal functions defect among cases was (2.32±1.11) and the majority for score 2 at 48.4%. Sensory functions defect among cases was (2.0±1.03), whereas Bowel and bladder functions defect among cases was (1.77±0.8) ,Cerebellar functions defect among cases was (2.03±1.11), Brainstem functions defect among cases was (1.58±1.03),with a majority for score 2 at (35.5% ,41.9%,38.7%,38.7%) respectively. On the other hand, Cerebral functions defect among cases was (1.74±1.12) with a majority for score 1 at35.5%. The results show that most cases suffer from more than one function defect.

Table (3): Kurtzke Expanded Disability Status Scale (EDSS) among cases.

Kurtzke Expanded Disability Status Scale (EDSS)	Frequency (n=31)	Percent (%)
1.5	1	3.2
3.0	2	6.5
3.5	1	3.2
4.0	2	6.5
4.5	7	22.6
5.0	8	25.8
5.5	6	19.4
6.0	3	9.7
7.0	1	3.2

n: number of the subject; **SD:** standard deviation

Table (~~Error! No text of specified style in document.~~4): Different functions score among cases.

	Function	Functions score	Frequency (n=31)	Percent (%)	Mean±SD
1	**Visual (optic)**	0	4	12.9	1.35±0.75
		1	13	41.9	
		2	13	41.9	
		3	1	3.2	
2	**Pyramidal**	0	2	6.5	2.32±1.11
		1	3	9.7	
		2	15	48.4	
		3	5	16.1	
		4	6	19.4	
3	**Sensory**	0	1	3.2	2.0±1.03
		1	10	32.3	
		2	11	35.5	
		3	6	19.4	
		4	3	9.7	
4	**Bowel and bladder**	0	1	3.2	1.77±0.8
		1	11	35.5	
		2	13	41.9	
		3	6	19.4	
5	**Cerebellar**	0	5	16.1	2.03±1.11
		1	2	6.5	
		2	12	38.7	
6	**Cerebral**	0	4	12.9	1.74±1.12
		1	11	35.5	
		2	6	19.4	
		3	9	29.0	
		4	1	3.2	
7	**Brainstem**	0	5	16.1	1.58±1.03
		1	9	29.0	
		2	12	38.7	
		3	4	12.9	
		4	1	3.2	

n: number of the subject; **SD:** standard deviation

Fasting blood glucose and Serum lipid profile levels among the study participants

The average serum concentration of fasting blood glucose (FBG) among the relapse and stable groups was (73.3±7.3 & 77.6±14.5 mg/dl), the difference was not statistically significant (P = 0.195). In contrast, the average serum concentration of FBG among the controls was (68.48±7.87 mg/dl), the difference between controls and the stable group was statistically significant (P = 0.003) (Table 5).

Table (5): FBG and lipid profile among the study population.

Test	Controls (n=31)	Cases		Test		
		Relapse (n=11)	Stable (n=20)	F	P-value	Post Hoc
FBG (mg/dl)						0.195 [a]
Mean±SD	68.5±7.9	73.3±7.3	77.6±14.5	4.73	0.012	0.003* [b]
(Min-Max)	(53-84)	(64-89)	(57-124)			0.272 [c]
TG (mg/dl)						0.017*[a]
Mean±SD	92.3±23.9	117.8±27.6	126.8±37.5	9.04	<0.001	0.000* [b]
(Min-Max)	(41-138)	(67-170)	(63-239)			0.421 [c]
CH (mg/dl)						0.150* [a]
Mean±SD	141.3±29.7	162.4±38.2	172.9±55.7	3.77	0.029	0.010* [b]
(Min-Max)	(81-190)	(111-234)	(123-371)			0.500 [c]
HDL (mg/dl)						0.004* [a]
Mean±SD	48±7.4	39.3±8.8	43.9±9.2	4.85	0.011	0.086 [b]
(Min-Max)	(38-63)	(31-62)	(30-71)			0.146 [c]
LDL (mg/dl)						0.047* [a]
Mean±SD	75±28.7	101.1±30.2	107.6±49.1	5.37	0.007	0.003* [b]
(Min-Max)	(20-121)	(53-151)	(47-252)			0.641 [c]

CH: Cholesterol; **F:** Analysis of variance (ANOVA) test; **FBG:** fasting blood glucose**; HDL:** high-density lipoprotein; **LDL:** low-density lipoprotein; **n:** number of the subjects**; SD:** standard deviation; **TG:** Triglycerides; [a] Controls *vs.* Relapse; [b] Controls *vs.* Stable; [c] Relapse *vs.* Stable; *P-value significant at P≤0.05.

Serum Triglycerides Level

As shown in (Table 5), the average serum TG level in relapse and stable groups was (117.8±27.6 & 126.8±37.5 mg/dl), the difference was not statistically significant (P = 0.421). In contrast, the average serum TG

in controls was (92.29±23.9 mg/dl). The difference between controls and both the relapse & the stable groups was statistically significant (P = 0.017 & P < 0.001) respectively.

Serum total cholesterol Level

The average serum total CH level among relapse & stable groups was (162.4±38.2 & 172.9±55.7 mg/dl), the difference was not statistically significant (P = 0.50). In contrast, average serum total CH in controls was (141.29±29.7 mg/dl). The difference between controls and the stable group was statistically significant (P = 0.010) as shown in (Table 5).

Serum HDL cholesterol Level

The average serum HDL level in relapse & stable groups were (39.3±8.8 & 43.9±9.2 mg/dl), the difference was not statistically significant (P = 0.146). In contrast, the average HDL in controls was (48±7.4 mg/dl), (Table 5). The difference between controls and the relapse group was statistically significant (P = 0.004).

Serum LDL cholesterol Level

The average serum LDL level in relapse & stable groups were (101.1±30.2 & 107.6±49.1 mg/dl), the difference was not statistically significant (P = 0.641). In contrast, the average of LDL in controls was (74.97±28.7 mg/dl), (Table 5). The difference between controls and both the relapse & the stable groups was statistically significant (P = 0.047 & P < 0.003) respectively.

Correlation between ESSD and studied parameters among cases

Table (6) shows the correlation between EDSS and the different studied chemical parameters. The results show that the correlation between EDSS and CH, HDL and LDL were positive and strong. The correlation was also statistically significant (P = 0.017, 0.003 ,0.014) in the relapse group. On the other hand, the correlation between EDSS and CH, HDL, FBG, TG & LDL was not statistically significant in the stable group (P > 0.05).

Table (4.11): Correlation between ESSD and studied parameters among cases.

Variables	Kurtzke (EDSS)			
	Relapse (n=11)		Stable (n=20)	
	r	P-value	r	P-value
FBG (mg/dl)	-0.309	0.355	0.164	0.491
TG (mg/dl)	-0.058	0.866	0.065	0.785
CH (mg/dl)	0.697	**0.017***	0.128	0.590
HDL (mg/dl)	0.802	**0.003***	0.096	0.686
LDL (mg/dl)	0.711	**0.014***	0.112	0.637

CH: Cholesterol; **FBG:** fasting blood glucose**; HDL:** high-density lipoprotein; **LDL:** low-density lipoprotein; **n:** number of the subjects**; r:** Pearson correlation; **TG:** Triglycerides; *P-value significant at P≤0.05.

IV. Discussion

MS is a complex global health problem. It is one of the most common diseases of the central nervous system. Early diagnosis improves the patients' management. To be able to diagnose the disease and distinguish it from various diseases of the nervous system, several biomarkers have been used. The current study is the first to assess lipid levels and their role as a vital marker to detect disease and its rate of progression among MS patients in Gaza.

The ages of the target population who participated in this study ranged from 20-60 years, with no statistically significant difference. On the other hand, there were no significant differences between the stable and Relapse groups in the disease period. The study indicated that the ratio of females to males in the two disease groups was 2:1.

The data presented here indicate that most of the participants scored five on the Extended Disability Scale, and some others scored 4. On the other hand, the most common complications reported among MS patients were in Visual, Pyramidal, Sensory functions, Bowel and bladder, cerebellum, and brainstem functions. Our results indicate that there were no statistically significant differences between the relapse group and the stable group regarding the complications reported when a patient was diagnosed with MS, as one or more of these complications appeared. Moreover, the duration of relapse between the relapse group and the stable group was not statistically significant (P = 0.312). These results are consistent with those of Meyer-Moock et al. who stated that there are a number of tools that describe the severity and progression of MS and are increasingly being used as endpoints to assess the effectiveness of treatment interventions (10).

The results of the present study show a higher level of FBG in the relapse group and stable group compared to controls which were statistically significant (P = 0.012). The results agree with those of Wens et al. who showed that the levels of FBG was higher in the MS group compared to the control group and the difference was statistically significant (11). In another study, Maric et al. results implicate the presence of higher prevalence of insulin resistance in MS patients compared to healthy individuals (12). Our results also agree with those of Soliman et al. who reported a higher FBG and insulin levels in MS patients compared to controls (13).

Our results show that the average level of TG in the stable and relapse groups was higher compared to the controls. The difference was statistically significant (P < 0.001). Moreover, it was found that levels of total CH and LDL were significantly higher in patients from both groups compared to the control group. In contrast, there was no statistical significance difference between the relapse group and the stable group in TG, CH or LDL. The results of the present study agree with those of Akbay et al. (14), Soliman et al. (13) and Marica et al. (12). Our results also agree with those of Rádiková et al. regarding the CH and LDL levels but disagree regarding the results of TG which was lower in the MS group compared to the control group (15).

In contrast, there was a significant decrease in HDL in the stable and relapse groups compared with the control group (P = 0.011). The results are consistent with those of Soliman et al. who showed that HDL levels are significantly lower in MS group compared to the control group (13). Akbay et al. also reported that HDL levels were lower in the MS group compared to the control group but the difference was not statistically significant (14). On the other hand, Marica et al. reported no difference in HDL levels between the MS group compared and the control group (12). In contrast, the results of Rádiková et al. show that the levels of HDL in MS group is higher compared to the control group (15).

The results also showed that the correlation between EDSS and CH, HDL & LDL was statistically significant (P = 0.017, 0.003, 0.014) in the relapse group. The results are consistent with those of Weinstock-Guttman et al. who found that worsening disability is associated with higher levels of TG, CH and LDL (16). The results also agree with those of Tettey et al. who found that an adverse lipid profile was associated with high levels of MS disability and disease progression (17).

V. Conclusion

Patients with MS have higher levels of TG, CH, & LDL, and lower levels of HDL compared to the control group. There is a correlation between the lipid levels and disability in patients with MS. Physicians should be aware of the associations between lipids and disability in MS. Therefore, continuous monitoring of lipid levels and early intervention including treatment and lifestyle changes may be beneficial for MS patients and may improve their neurological condition.

Acknowledgments

The authors would like to acknowledge the considerable help and support of the late Dr. Alaa Alkhusondar that made this work possible. The authors would like also to thank the healthcare workers and the staff at Naser Medical Complex and Alshifa Medical complex for their help and support.

References

[1]. Nogueras L, Gonzalo H, Jové M, Sol J, Gil-Sanchez A, Hervás J, et al. Lipid profile of cerebrospinal fluid in multiple sclerosis patients: a potential tool for diagnosis. Scientific reports. 2019;9(1):1-9.
[2]. Wallin MT, Culpepper WJ, Nichols E, Bhutta ZA, Gebrehiwot TT, Hay SI, et al. Global, regional, and national burden of multiple sclerosis 1990–2016: a systematic analysis for the Global Burden of Disease Study 2016. The Lancet Neurology. 2019;18(3):269-85.
[3]. Tillery EE, Clements JN, Howard Z. What's new in multiple sclerosis? Mental Health Clinician. 2017;7(5):213-20.
[4]. Goldenberg MM. Multiple sclerosis review. Pharmacy and Therapeutics. 2012;37(3):175.
[5]. Ukueberuwa DM, Arnett PA. Evaluating the role of coping style as a moderator of fatigue and risk for future cognitive impairment in multiple sclerosis. Journal of the International Neuropsychological Society. 2014;20(7):751-5.
[6]. Çinar BP, Yorgun YG. What we learned from the history of multiple sclerosis measurement: expanded disability status scale. Archives of Neuropsychiatry. 2018;55(Suppl 1):S69.
[7]. Saher G, Quintes S, Nave K-A. Cholesterol: a novel regulatory role in myelin formation. The Neuroscientist. 2011;17(1):79-93.
[8]. Blumenfeld Kan S, Staun-Ram E, Golan D, Miller A. HDL-cholesterol elevation associated with fingolimod and dimethyl fumarate therapies in multiple sclerosis. Multiple Sclerosis Journal–Experimental, Translational and Clinical. 2019;5(4):2055217319882720.
[9]. Bjelobaba I, Savic D, Lavrnja I. Multiple sclerosis and neuroinflammation: the overview of current and prospective therapies. Current pharmaceutical design. 2017;23(5):693-730.
[10]. Meyer-Moock S, Feng Y-S, Maeurer M, Dippel F-W, Kohlmann T. Systematic literature review and validity evaluation of the Expanded Disability Status Scale (EDSS) and the Multiple Sclerosis Functional Composite (MSFC) in patients with multiple sclerosis. BMC neurology. 2014;14(1):58.
[11]. Wens I, Dalgas U, Deckx N, Cools N, Eijnde B. Does multiple sclerosis affect glucose tolerance? Multiple Sclerosis Journal. 2014;20(9):1273-6.
[12]. Maric G, Lalic K, Pekmezovic T, Tamas O, Rajkovic N, Rasulic I, et al. Could the performance of oral glucose tolerance test contribute to the brain health-focused care in multiple sclerosis? Multiple Sclerosis and Related Disorders. 2020;46:102536.

[13]. Soliman RH, Farhan HM, Hegazy M, Oraby MI, Kamel SH, Hassan A. Impact of insulin resistance and metabolic syndrome on disability in patients with multiple sclerosis. The Egyptian Journal of Neurology, Psychiatry and Neurosurgery. 2020;56(1):1-6.
[14]. Akbay GD, Karakullukçu E, Mutlu AA, Besler HT. Determination of Lipid Profile and Anthropometric Measurements of Multiple Sclerosis Patients: A Controlled Descriptive Study. 2019.
[15]. Rádiková Ž, Penesová A, Vlček M, Havranová A, Siváková M, Šiarnik P, et al. Lipoprotein profiling in early multiple sclerosis patients: effect of chronic inflammation? Lipids Health Dis. 2020;19(1):1-10.
[16]. Weinstock-Guttman B, Zivadinov R, Mahfooz N, Carl E, Drake A, Schneider J, et al. Serum lipid profiles are associated with disability and MRI outcomes in multiple sclerosis. J Neuroinflammation. 2011;8(1):1-7.
[17]. Tettey P, Simpson Jr S, Taylor B, Blizzard L, Ponsonby A-L, Dwyer T, et al. An adverse lipid profile is associated with disability and progression in disability, in people with MS. Multiple Sclerosis Journal. 2014;20(13):1737-44.

Aya Nbhan, et. al. "Evaluation of Lipid Levels in Multiple Sclerosis Patients from Gaza Strip." *IOSR Journal of Biotechnology and Biochemistry (IOSR-JBB), 8*(1), (2022): pp. 05-11.