An-Najah National University

Faculty of Graduate Studies

Relationship of Omega-3 Status with Diabetes Mellitus Type 2 Control Measurements in Nablus City

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Dedication

I would like to offer gratitude and appreciation to my special supervisors, Dr. Mariam Al-Tal and Dr. Nihal Natour, for providing their support and guidance along the way. I am also grateful to my parents, my husband, and my friends, who helped me to go through really hard times. I would like to show them my gratitude because they were so patient and understanding and their encouragement made it possible to achieve my goal.

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الإقرار

أنا الموقع أدناه مقدم الرسالة التي تحمل العنوان:

The Relationship of Omega-3 Status with Diabetes Mellitus Type 2 Control Measurements in Nablus City

العلاقة بين حالة أوميجا 3 وقياسات التحكم لمريض السكري النوع الثاني في مدينة نابلس

أقر بأن ما اشتملت عليه هذه الرسالة إنما هي نتاج جهدي الخاص، باستثناء ما تمت الإشارة إليه حيثما ورد، وأن هذه الرسالة ككل، أو أي جزء منها لم يقدم لنيل أية درجة أو لقب علمي أو بحثي لدى أية مؤسسة تعليمية أو بحثية أخرى.

Declaration

The work provided in this thesis, unless otherwise referenced, is the researcher's own work and has not been submitted elsewhere for any other degree or qualification.

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Date: 17/9/2020	**التاريخ: 2020/9/17**

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List of Abbreviations

AA	Arachedonic Acid
ALA	Alpha-Linolenic Acid
BMI	Body Mass Index
CAFÉ	Compositional Analyses from Frequency Estimates program
CHD	Coronary Heart Disease
CVD	Cardiovascular Disease
DHA	Docosahexaenoic Acid
DMT2	Diabetic Mellitus Type Two
EFSA	European Food Safety Authority
EPA	Eicosapentaenoic Acid
FAO	Food and Agriculture Organization
FAs	Fatty Acids
FFQ	Food Frequency Questionnaire
GBD	Global Burden of Disease
GC	Gas Chromatography
HbA1c	Glycated Hemoglobin
IDF	International Diabetes Federation
IRB	Institutional Review Board
LA	Linoleic Acid
MENA	Middle East and North Africa
PMoH	Palestinian Ministry of Health
PUFAs	PolyUnsaturated Fatty Acids
RBCs	Red Blood Cells
SD	Standard Deviation
USDA	United States Department of Agriculture
WHO	World Health Organization

Study Terms

DMT2

Diabetes Mellitus Type 2 (adult-onset diabetes) is a form of diabetes that is characterized by high blood sugar, insulin resistance, and relative lack of insulin. Common symptoms include increased thirst, frequent urination, and unexplained weight loss.

Omega 3 Index

Omega-3 index is the sum of EPA and DHA in the blood (plasma or RBC). It is expressed as the percentage of the total FAs present the blood.

Omega 3

Omega-3 fatty acids (FAs) belong to the group of polyunsaturated fatty acids (PUFAs).

Gas Chromatography

Gas chromatography (GC) is used nowadays to analyze different types of FAs.

Relationship of Omega-3 Status with Diabetes Mellitus Type 2 Control Measurements in Nablus City

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Abstract

Various studies suggest that the dietary intake of omega-3 fatty acids (FAs) has the potential to prevent serious medical conditions, including diabetes mellitus type 2 (DMT2). Even though DMT2 is one of the major chronic diseases in Palestine, omega-3 index has not been evaluated among healthy or Palestinian adults diagnosed with DMT2 on a population level.

Aim of the Study: The study aimed at evaluating the omega-3 status in the selected group of Palestinian adults diagnosed with DMT2.

Methodology: A quantitative cross-sectional study was conducted on 105 DMT2 Palestinian patients in Nabulus City. Total consumption of dietary omega-3 FAs over the last three months was assessed using a Food Frequency Questionnaire (FFQ). Controlling measurements including glycated hemoglobin (HbA1c), blood glucose level and blood triglycerides level were analyzed after obtaining blood samples from each patient and omega-3 FAs were analyzed using gas chromatography (GC).

Results: The study revealed that omega-3 index was extremely low with a mean of 0.26 ± 2.15, while omega-3 FAs mean intake was 1.04 ± 0.90 g/day which was within the “Acceptable Macronutrient Distribution Range” (AMDR) values. In addition, there was a positive but not significant ($P \geq$

0.05) relationship (r= 0.047) between omega-3 FAs intake and omega-3 index. On the other hand, there were negative but not significant ($P \geq 0.05$) relationships between omega-3 index and HbA1c (r= -0.021), omega-3 index and blood glucose level (r= -0.14) and between omega-3 index and blood triglycerides level (r= -0.11).

Conclusion: The study concluded that a linear relationship existed between omega-3 index and omega-3 FAs intake. That is, the higher the intake, the higher is omega-3 index. It also concluded that the sufficient intake of omega-3 FAs had a lowering effect on blood glucose level, HbA1c and blood triglyceride level.

Recommendations: It is recommended for stakeholders to assess omega-3 index among DMT2 patients in the RBC rather than plasma, and to apply the study including patients with DMT2 from all cities of Palestine.

Keywords

Omega-3 Intake, Omega-3 Index, DMT2, Gas Chromatography, Controlling Measurements.

Chapter 1

1.1 Background

Worldwide, DMT2 is an epidemic as the number of patients is growing and expected to increase greatly in the following years **(Shaw *et al*., 2010).** Several long-term vascular complications may be caused by this condition such as chronic kidney disease, stroke, peripheral vascular disease, heart disease and death. In addition, extra weight and obesity are likely to appear as a result of these complications **(Colosia *et al*., 2013).**

The worldwide existing prevalence of DMT2 is about 425 million people (International Diabetic Federation Diabetes, 2018). In 2019, the new reported DMT2 cases in PMoH Primary Health Care diabetic clinics in the West Bank were 5,671 cases (573 in Nablus alone) with an incidence rate of 210.4 per 100,000 populations, distributed to 2,505 cases among males with an incidence rate of 182.7 per 100,000 populations and 3,166 among females with an incidence rate of 239.1 per 100,000 populations **(Palestinian Ministry of Health, 2019).**

Omega-3 FAs belong to the poly-unsaturated fatty acids (PUFAs) group and possess several health benefits. For instance, they play a major role in preventing coronary heart disease (CHD), Crohn disease, prostate and colon cancer, autoimmune diseases such as nephropathy and lupus, rheumatoid arthritis and mild hypertension (Connor, 2000).

The most important omega-3 FAs are EPA, DHA, and Alpha-Linolenic Acid (ALA). Fish is the richest source of EPA and DHA, whereas some plant-derived foods such as flaxseeds, walnuts, canola and their oils are the richest sources of ALA **(Bradberry and Hilleman, 2013).** However, due to the inefficient conversion of ALA to EPA and DHA, its extremely important to supply the human body with these two essential FAs from external sources (dietary intake of certain foods). Fatty fish such as salmon, albacore tuna, sardines, herring and mackerel are the richest sources of EPA and DHA. Other foods include eggs and meat **(Weylandt *et al*., 2015).**

Omega-3 index is the sum of EPA and DHA in RBCs membrane and is expressed as a percentage of the total FAs present in RBCs (Harris, 2007). It is usually used in nutritional studies to indicate the medium and long-term intake of Omega-3 FAs **(Abu and Oluwatowoju, 2009).** This index is considered a risk factor of death from CHD **(Harris, 2007)**.Harris (2007) proposed the cut-off points of omega-3 index (figure 1), and defined low, intermediate and high risk levels of omega-3 index (> 8%, 4%–8% and < 4% respectively).

Importantly, in regions where omega-3 FAs are frequently consumed, omega-3 index is high. It is estimated that the average omega-3 index is 4-5% in USA, whereas in Japan, it is much higher (9-10%). As a result, cardio vascular diseases (CVD) are less common, which leads to a longer lifespan. Whereas, very low levels of omega-3 index (≤ 4%) was reported in the Middle East, Central and South America, Africa and Southeast Asia **(Stark *et al*., 2016).**

Omega-3 index is influenced by several factors such as gender, physical activity, age, Body Mass Index (BMI), diabetes and drinking alcohol (Von Schacky, 2010). The EPA and DHA intake significantly affects omega-3 index, where each 4g of the ingested EPA and DHA per month cause an increase of 0.24% in omega-3 index value **(Von Schacky, 2010).**

1.2 Metabolism of Omega-3 PUFAs.

Omega-3 and omega-6 PUFAs are essential to the human body, and undergo several metabolic pathways through which are converted into longer chain FAs by the elongation of the hydrocarbon chains (up to 20-22 carbon atoms) and by the desaturation (addition of extra double bonds) **(Simopoulos, 1991).**

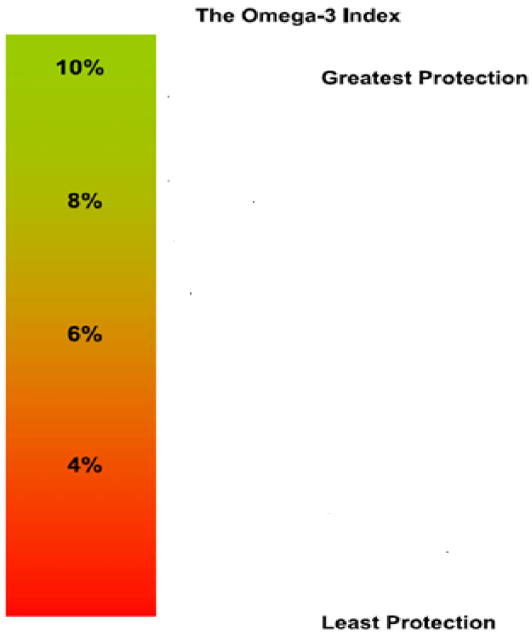

Figure 1: Cut-off points for omega-3 index.
Source: Harris and Von Schacky (2004).

ALA and linoleic acid (LA) are the parents of omega-3 and omega-6 FAs families, respectively. ALA is elongated into EPA and DHA whereas LA is converted into arachidonic acid (AA). Both families compete for the same enzyme that is responsible for their desaturation and chain elongation **(Nabavi *et al*., 2015).**

For example, Δ-6-desaturase enzyme, which converts ALA to EPA and DHA, prefers ALA over LA. However, the conversion of ALA has two limitations. The increased intake of omega-6 PUFAs increases the level of metabolism of LA, and consequently, the enzymatic action is shifted toward the metabolism of omega-6 PUFAs pathway **(Budowski, 1988).** The shift will inhibit the conversion of ALA to EPA and DHA, which represents the first limitation. The other limitation is that the conversion of ALA to EPA and DHA is inefficient **(Gerster, 1998)**. In addition, elongation and desaturation of ALA and LA are disturbed with the intake of Trans FAs **(Hague and Christoffersen, 1984; Hagve and Christoffersen, 1986).**

1.3 Dietary Sources of Omega-3 FAs and their Recommended Intake

The most common dietary sources of ALA and the required amount to meet adequate intakes are demonstrated in Table 1.1 **(Gebauer *et al*., 2006)**. Whereas, Table 1.2 summarizes EPA and DHA content in some types of fish **(Buzby and Hyman, 2012).** On the other hand, AA is found in dairy, eggs and in the phospholipids of grain-fed animals **(Nabavi *et al*., 2015).**

Table 1.1: Dietary sources of ALA andthe required Amount to meet adequate intakes.

Source of ALA	ALA	Amount needed by women to meet recommendation (1.1 g ALA/day)	Amount needed by men to meet recommendation (1.6 g ALA/day)
	g/tbsp.	tbsp.	tbsp.
Pumpkin seeds	0.051	21.6	31.4
Walnuts, black	0.156	7.05	10.3
Soybean oil	1.231	0.89	1.3
Rapeseed oil	1.302	0.84	1.2
Walnut oil	1.414	0.78	1.1
Flaxseeds	2.350	0.47	0.68
Walnuts,	2.574	0.43	0.62
Flaxseed oil	7.249	0.15	0.22

Source: Gebauer*et al*. (2006).
Note: Tbsp: table spoon.

Table 1.2: EPA and DHA content in some types of fish.

Fish	EPA + DHA	Amount needed to get 500 mg EPA + DHA/day	Amount needed to get 500 mg EPA + DHA/day
	Mg/Serving	Serving	Servings/Week
Shrimp	267	1.9	13.3
Tuna, canned	733	0.68	4.8
Salmon	1825	0.27	1.9

Source: Buzby and Hyman (2012).
Note: 1 serving = 85 g (3 oz.) cooked portions.

According to Food and Agriculture Organization (FAO) and World Health Organization (WHO), the AMDR value of omega-3 PUFAs (including ALA and long-chain omega-3 FAs) is estimated as 0.5-2% from total energy intake. In addition, the AMDR of EPA+ DHA is estimated as 0.25-2 g/day **(Joint FAO/WHO, 2008).**

European Food Safety Authority (EFSA) has reported that the excess intake of omega-3 FAs leads to abnormal bleeding, increased lipid peroxidation, impaired immune functions and impaired glucose and lipid metabolism **(EFSA, 2012).**

1.4 Analysis of Omega-3 FAs

GC is frequently used to analyze different types of FAs. This technique is sensitive, robust and accurate **(Abu and Oluwatowoju, 2009).** Samples of FAs should undergo derivatization in order to become more volatile and, therefore, eluted at specific temperatures. The derivatization insures that FAs will not be decomposed at higher temperatures. One of the most common derivatization methods is methylation, by which free FAs are released from lipids through the hydrolysis of ester bonds. In this case, free FAs are converted to FA methyl esters (FAMEs) by the trans-methylation method. FAMEs are used to refer to the FAs composition. Therefore, GC is used to determine the concentration of free FAs in the sample (Burdge *et al*., 2000). Analysis of FAs requires three major steps: 1) extracting the lipid phase from tissues or cells, 2) the methylation step and 3) injecting the sample in question into the injection port of the GC **(Mesood *et al*., 2005; Kuriki *et al*., 2006; Ratnayake and Galli, 2009).**

1.5 Insulin Resistance and Omega-3 FAs.

Insulin sensitivity is influenced by many factors such as adiposity, age, genotype and perinatal factors. In addition, physical activity and diet, which are considered modifiable lifestyle factors, affect insulin activity **(Kim *et al*., 2007).** Although increasing the physical activity and weight loss may improve insulin sensitivity, this goal is difficult to achieve for a large population. It was found that small dietary modifications such as increased intake of fish or the dietary supplementation may enhance insulin sensitivity, thus reducing the risk of DMT2, the metabolic syndrome and CVD **(Albert *et al*., 2014).** It was reported that insulin resistance is inversely associated with omega-3 index due to its anti-inflammatory effect. In addition, it could be used as a reflective biomarker for pro-inflammatory diseases **(Thomas and Garg, 2016).**

1.6 Study Justification and Problem Statement

DMT2 is one of the major chronic diseases in the West Bank **(Mosleh *et al*., 2016).** The benefits of omega-3 FAs and their positive effects on inflammation, which is strongly linked to DMT2, are obvious **(Ellulu *et al*., 2016)**. Therefore, it is important to raise the awareness about omega-3 FAs at a population level. Unfortunately, the measurement of omega-3 index is unavailable in the West Bank (including Nablus) due to the high cost of operation. Therefore, it is important to determine the relationship between omega-3 index, omega-3 FAs intake and DMT2.

Therefore, this study and its results focus on the importance of omega-3 index and omega-3 FAs intake among Palestine adults diagnosed with DMT2. The results of the current study will draw more attention to the importance of omega-3 FAs to health, the risks associated with low omega-

3 levels and its consequences. The study will also help diabetics and physicians to identify and maintain correct omega-3 levels.

Furthermore, this study will provide some strategies to bring awareness and instruct the majority of people living in Palestine about the benefits of omega-3 index and intake from dietary sources or as supplements. Due to the related prevalence of DM in Palestine, we concluded that it is important to study the impact of omega-3 on diabetics and their health.

1.7 Objectives of the Study

1. To evaluate omega-3 index in selected groups of Palestinian adults diagnosed with DMT2.
2. To evaluate the dietary intake of omega-3 FAs in selected groups of Palestinian adults diagnosed with DMT2.
3. To evaluate the relationship between omega-3 index and controlling measurements (blood glucose level, HbA1c, and triglyceride) in selected groups of Palestinian adults diagnosed with DMT2.
4. To examine the correlation between the dietary intake of omega-3 FAs and omega-3 index in selected groups of Palestinian adults diagnosed with DMT2.

1.8 Research Questions

1. What is the level of omega-3 index in the selected groups of Palestinian adults with DMT2?

2. Is there any relationship between omega-3 index and the controlling measurements (blood glucose level, HbA1c, and triglyceride)?
3. What is the average of omega-3 FAs intakeamong the selected groups of Palestinian adults with DMT2?
4. Is there a correlation between the dietary intake of omega-3 FAs and omega-3 index in the selected groups of Palestinian adults with DMT2?

CHAPTER 2

Literature Review

2.1 Relationship between Omega-3 FAs and DMT2

A study conducted by Orang *et al*. (2020) aimed to investigate the effect of omega-3 FAs on inflammatory markers and insulin resistance indices in DMT2 patients in a randomized-double blind clinical trial. Patients with DMT2 were randomly allocated to omega-3 group and placebo group. Omega-3 group used 2 g/ day omega-3 for 12 weeks. Anthropometrics, dietary intake, fasting blood glucose, and HbA1c and serum insulin were assessed before and after the study. 44 participants (aged 49 and 47 for omega-3 group (n = 22) and placebo group (n = 22) group, respectively) finished the study. At the baseline, dietary intake and blood samples analysis did not show any significant differences between groups. Anthropometrics parameters were not statistically different. The results showed β cells function significantly increased in omega-3 group but had no effect on other glycemic and insulin resistance parameters (FBG, HbA1c, HOMA-IR, serum insulin, insulin sensitivity). The study also showed that consuming daily 2 g of omega-3 for 3 months in DMT2 patients significantly increased β cells function, but had no effect on other glycemic and insulin resistance and other inflammatory markers.

Jamilian *et al*. (2017) carried out a meta-analysis based on prospective cohorts to evaluate the effect of omega-3 FAs on the risk of

DMT2. Pooled diabetic risk was calculated using a fixed or random effects model. The dose–response relationship was assessed by meta-regression analysis. Results showed that consumption of single omega-3 FA was associated with an increased risk of DMT2; whereas the relative risk for mixed omega-3 FAs was statistically insignificant. The dose–response curve presented an inverted U-shape of diabetes risk corresponding to the dose of omega-3 consumption. Sub analysis showed that omega-3 was inversely associated with DMT2 risk. The study findings suggested that dosage and composition of omega-3, ethnicity, trial duration, and age could influence the effect of omega-3 on DMT2 progression.

In China, Yao *et al*. (2015) conducted a study to investigate the association between the composition of PUFAs in various tissues and DMT2 among Chinese Han people. A case–control study was employed and included 421 healthy adults and 331 DMT2 patients. Results showed that the ratio of AA/LA, which reflects Δ6 desaturase activity, was significantly increased in DMT2 patients. Furthermore, the ratio of EPA/ALA, which reflects Δ5 desaturase activity, was markedly decreased in DMT2 patients. Importantly, among four single nucleotide polymorphisms in the FADS1-FADS2 gene cluster, only minor allele (T) of rs174616 was associated with decreased risk of DMT2 in both codominant and dominant models after adjustment for age, gender and BMI. Furthermore, the ratio of AA/LA in both controls and DMT2 was reduced in T carriers while an increased proportion of LA was seen in DMT2 patients compared with control patients. The study concluded that their data suggest that in northern Han Chinese people, the minor allele (T) of rs174616 in the FADS1-FADS2 gene cluster is associated with a decreased conversion rate of LA to AA, which may contribute to decreased reduced risk of developing DMT2.

A study was performed by Brostow *et al*. (2011) in a Chinese population in Singapore to examine the association between the risk of DMT2 and total omega-3 FAs, omega-6 FAs, marine EPA and DHA, non-marine omega-3 FAs (ALA) and omega-6: omega-3 ratio. The study was performed at the Singapore Chinese Health. The study sample consisted of a 43176 Chinese men and women (free from chronic diseases) within an age group of 45-74 years-old. Whereas the association between the risk of developing DMT2 and FAs intake was examined using cox regression models. Results of the study revealed that DMT2 was inversely associated with the increased intake of total omega-3 FAs. In contrast, the risk of DMT2 was strongly associated with the intake of non-marine omega-3 FAs. In addition, the incidence of DMT2 was not associated with omega-6/omega-3 FAs ratio. However, DMT2 risk was not associated with marine omega-3 FAs (EPA and DHA) **(Brostow *et al*., 2011).** Their study concluded that among Chinese Singaporeans, the decreased risk of DMT2 was associated with the ingestion of ALA (nan-marine source of omega-3 FAs) **(Brostow *et al*., 2011).**

The association between the risk of DMT2 and long chain omega-3 FAs and consumption of fish and shellfish was examined among middle-aged Chinese population in a prospective population-based cohort study performed by Villegas *et al*. (2011). The study consisted of a sample of non-diabetic 64,193 women and 51,963 men who were free from cancer and CVD at baseline. Data including the physical activity, anthropometric measurements and dietary intake was collected. The association between risk of DMT2 and long-chain omega-3 FAs and consumption of fish and shellfish was evaluated using Cox regression model. Results indicated that an inversely proportional relationship was found between DMT2 among women and long-chain omega-3 FAs, fish and shellfish consumption **(Villegas *et al*., 2011).**

Ramel *et al*. (2008) conducted a study to investigate the effects of seafood consumption on insulin resistance in overweight participants during energy restriction. In an 8-week dietary intervention, 324 participants (20–40 years, BMI 27.5–32.5 kg/m^2, from Iceland, Spain and Ireland) were randomized to one of four energy-restricted diets of identical macronutrient composition but different long chainomega-3 PUFA content: control ($n = 80$; no seafood; single-blinded); lean fish ($n = 80$; 150 g cod, three times/week); fatty fish ($n = 84$; 150 g salmon, three times/week); (4) fish oil ($n = 80$; daily DHA/EPA capsules, no other seafood; single-blinded). Fasting glucose, insulin, adiponectin, plasma triacylglycerol and FAs in RBCs membrane were measured at baseline and endpoint.

Results indicated that of the participants, 278 (86%) completed the intervention. Fish oil intake was a significant predictor of fasting insulin and insulin resistance after 8 weeks, and this finding remained significant even after including weight loss, triacylglycerol reduction, increased long chain omega-3 PUFA in membranes or adiponectin changes as covariates in the statistical analysis. Weight loss was also a significant predictor of improvements. Ramel *et al*. (2008) concluded that long chain omega-3 PUFA consumption during energy reduction exerts positive effects on insulin resistance in young overweight individuals, independently from changes in body weight, triacylglycerol, RBC membrane or adiponectin.

Kaushik *et al*. (2009) conducted a cohort study among 195,204 US adults from both genders. The study consisted of 152,700 women and 42,504 men who were free from chronic diseases at baseline from 14-18 years. A validated food-frequency questionnaire was used to assess the intake of long-chain omega-3 FAs and fish at baseline and was updated every 4 years. During these years, 9380 new cases of DMT2 were investigated. And while keeping all other dietary intake and life style factors constant, it was documented that incidence of DMT2 was positively associated with the intake of long-chain omega-3 FAs. The study concluded that there was no evidence that the risk of DMT2 is reduced by the higher intake of fish and long-chain omega-3 FAs. In contrast, the incidence of the disease was moderately increased by the higher intake of these FAs. The study recommended that further investigations should be made to understand the relationship found between DMT2 and long-chain omega-3 FAs, given that these FAs are beneficial when it comes to reduce the risk of cardiovascular diseases **(Kaushik *et al*., 2009).**

2.2 Relationship between Omega-3 Index and DMT2

In Finland, Takkunen *et al*. (2016) examined the longitudinal associations of serum FA composition with DMT2, insulin secretion and insulin sensitivity over several years. A prospective cohort study derived from the randomized Finnish Diabetes Prevention Study was conducted. Total serum FA composition was measured using GC in 407 overweight, middle-aged people with impaired glucose tolerance at baseline (1993–1998) and annually during the intervention period (1994–2000). The baseline proportions of EPA and DHA were associated with lower incidence of DMT2 during a median follow-up of 11 years. These long-chain omega-3 FAs were associated with higher insulin sensitivity in subsequent years. Whereas, saturated, monounsaturated, transFAs and ALA, LA, were inconsistently associated with DMT2 or related traits. The study concluded that serum long-chain omega-3 FAs predicted lower DMT2 incidence in people at a high risk of diabetes attending to an intervention study; a putative mechanism behind these associations was higher insulin sensitivity.

A study of Albert *et al*. (2014) was made to assess the association between insulin sensitivity and other metabolic outcomes and omega-3 index. The study sample consisted of 47 overweight males at the age of 46.5 ± 5.1 years-old. The assessment was made two times (16 weeks apart). Matsuda method (from oral glucose tolerance test) was used to assess the insulin sensitivity. It was concluded that increased insulin sensitivity and favorable metabolic profile was associated with higher omega-3 index among overweigh men **(Albert *et al*., 2014).**

Virtanen*et al*. (2014) investigated the associations between serum omega-3 PUFAs including EPA, docosapentaenoic acid (DPA), DHA, ALA, and risk of incident DMT2 in middle-aged and older Finnish men. A total of 2,212 men from the prospective, population-based Kuopio Ischemic Heart Disease Risk Factor study, aged 42–60 years and free of DMT2 at baseline in 1984–1989, were investigated. Serum PUFA was used as biomarkers for exposure. Dietary intakes were assessed with 4-day food recording. DMT2 was assessed by self-administered questionnaires and fasting and 2-h oral glucose tolerance test blood glucose measurement at reexamination rounds 4, 11, and 20 years after the baseline and by record linkage to hospital discharge registry and reimbursement register on diabetes medicate on expenses. Results of their study revealed that during the average follow-up of 19.3 years, 422 men developed DMT2.

Men in the highest versus the lowest serum EPA + DPA + DHA quartile had 33%lower multivariate-adjusted risk for DMT2.No statistically significant associations were observed with serum or dietary ALA, dietary fish or EPA + DHA. The study concluded that serum long-chain omega-3 PUFA concentration, an objective biomarker for fish intake, was associated with long-term lower risk of DMT2 **(Virtanen*et al*., 2014).**

Djoussé *et al*. (2011) performed a study to evaluate the incidence of DMT2 and omega-3 FAs in plasma. The study sample consisted of 3088 old women and men with an average age of 75 years-old, and it was performed at the Cardiovascular Health Study from the year 1992 to 2007. In order to measure the plasma omega-3 FAs, GC was used whereas DMT2 was ascertained by testing serum glucose and hypoglycemic agents. Multivariable-adjusted relative risks were estimated by using Cox proportional hazards models **(Djoussé *et al*., 2011).** Results of the study found out that new cases of DMT2 occurred during the median follow-up of 10.6 years. Several factors were controlled by a multivariable model such as race, sex, body mass index, physical activity, alcohol intake, smoking, clinic site, LA, and LDL cholesterol. It was found that relative risks for DMT2 were 1.0 for reference, 0.96, 1.03, and 0.64 across consecutive quartiles of phospholipid EPA and DHA. Whereas the corresponding relative risks for ALA in phospholipid were 1.0 for reference, 0.93, 0.99 and 0.57. The study concluded that the incidence of DMT2 was not associated with ALA and long-chain omega-3 FAs (by using objective biomarkers). However, lower risk of DMT2 was found in people with the highest concentrations of ALA and long-chain omega-3 FAs **(Djoussé *et al*., 2011).**

A study by Krachler *et al*. (2008) was conducted in order to investigate the relationship between the development of DMT2 and FAs present in RBCs membrane. The study used a nested case-referent design and included 159 participants who were non-diabetics at baseline and after 5.5 years were diagnosed with DMT2. The study also included 291 control sample (sex and age-matched). The results of the study revealed that increased risk of DMT2 as associated with higher proportions of dihomogamma-linolenic, palmitoleic and adrenic acids. Whereas reduced risk of DMT2 was associated with higher proportions of other FAs such as heptadecanoic, pentadecanoic. In addition, DMT2 incidence was inversely associated with clupanodonic and LA **(Krachler *et al*., 2008).**

Chapter 3

Methodology

3.1 Introduction

This chapter describes the methods and techniques used in the study, including study design, description of the sample of the study, the formulation of the study tool and validity and reliability measures. In addition, the chapter includes a description of the procedures used in implementing the study and statistical data analysis.

3.2 Study Design

The current study is a quantitative cross-sectional study

3.3 Study Site and Sitting.

The participants were chosen from Almakhfya Clinic in Nablus city among DMT2 patients, since it is a specialized clinic that receives DMT2 patients, in which all the examinations and blood analysis related to the disease are conducted, and where the patient is followed up, disclosed and given all treatment according to WHO recommendations.

3.4 Population and Sample Size

3.4.1 Population

The newly reported DMT2 cases visiting the PMoH Primary Health Care diabetic clinics in the West Bank in 2019 reached 5,671 (573 in

Nablus alone). Reaching a total number of 248008 DMT2 cases in the West Bank **(Palestinian Ministry of Health, 2019).**

3.4.2 Sample Size and Sampling Technique

Using the Robert Mason equation below, the sample size of the participants totaled (105) and the convenient sampling method was used to select them.

$$n = \frac{N}{\left[\left(S^2 \times (N-1)\right) \div pq\right] + 1} \qquad \textbf{(1)}$$

n: Sample size

N: Population size =573

S: Standard error 0.05/ 1.96

P: Percentage of picking a choice expressed as decimal=0.5

q=(1-P):0.5

3.4.3 Inclusion Criteria

Participants in the current study are DMT2 patients from Almakhfya clinic in Nablus city from both genders and are more than 30 years old.

3.4.4 Exclusion Criteria for Study Group

- Excluding Alzheimer's patient
- Excluding pre-DMT2 patients.

3.5 Data Collection Tool

3.5.1 Study Questionnaire

A structured questionnaire (Appendix 1) was used to collect the data through interviewing the participants. The questionnaire included the following sections.

3.5.1.1 Part One

3.5.1.1.1 Socio-Demographic Data

Sex, residency location, marital status, educational level, monthly income, occupational status.

3.5.1.1.2 Information Regarding the Medical History.

A record of information about a person's health, including information about illnesses (current and past), surgeries, medicines taken and health habits, such as diet and exercise.

3.5.1.1.3 Anthropometric Measurements

a. Weight.

An electronic scale was used to measure body weight in kilograms with precision of ± 0.1 g. Participants were weighed wearing light clothes without shoes, standing in the center of the scale platform, hands resting at sides, looking straight ahead.

b. Height.

A stadiometer was used to measure participants' height. They were asked to stand straight (head was pointing straight forward) without shoes.

c. BMI

Results obtained from height and weight measurements were used to calculate BMI as follows:

BMI= weight (Kg) / height (m^2)…………………………………….**(2).**

d. Waist Circumference.

Waist circumference in cm was taken with the help of putting a measuring tape around a person's waist for both genders.

3.5.1.1.4 Dietary Assessment.

The FFQ (Appendix 7), modified from Shen *et al*. (2019), was used to assess the omega-3 FAs intake, participants were instructed to describe accurately with details the food portion size during the interview. The participants' responses to FFQ were converted by recoding the answers into numeric values. The recoding was conducted as follows: three points were given for "more than 3 times" answers; two points were given for "1-3 times" answers; one point was given for "0 times". Additionally, for yes or no questions, the answers "yes" were converted into two points and "no" into one point. Data from FFQ was converted manually into average daily intake data using the fact sheet for omega-3 FAs provided from United States Department of Agriculture **(USDA, 2020).**

3.5.1.2 Part Two

3.5.1.2.1 Biochemical Tests

To determine blood glucose level, HbA1c and blood triglyceride levels, blood samples were collected over the period of two months (from $24^{th}$of September, 2019 till the 5^{th} of November, 2019) during the clinic's day hours. In collaboration with the laboratory administration and after participants' approval, blood samples were collected at a medical laboratory with the help of nurses working at Almakhfya Clinic in Nablus city. Blood was drawn from fasting participants. Biochemical tests were done soon after blood collection with the help of nurses at Almakhfya Clinic.

3.5.2 Validity and Reliability

After a translator translated the data collection tool into Arabic, content validity was used. Finally, the tool was reviewed by experts, the ten copies of the questionnaire were distributed to the doctors from An-Najah National University for their opinion and to ensure the reliability of the questions and the ease of understanding among the participants and to ensure the relevance of the questionnaire to subject under study.

3.5.3 Pilot Study.

A pilot study was conducted on (5%) of the sample size and was included in the sample size. It was conducted to determine the clarity of the questionnaire and to estimate the time necessary for the data collection. The reliability scale (Alpha Cronbach) was computed, with a result of 0.83. This value indicates that the instrument is acceptably valid.

3.6 Field work and procedure

125 blood samples (5.0 ml each) were collected from each participant in EDTA tubes, centrifuged at 4000 rpm at room temperature for 10 minutes to separate cells from the plasma and stored at -60 °C until analysis.

1. Half of the samples were stored at AlMakhfya clinic’s laboratory for further biochemical tests (analyzed by nurses and recorded in

participant's medical files) such as HbA1c, blood triglycerides level and blood glucose level.

2. The rest of samples were stored in the laboratory of the Department of Public Health at the An-Najah National University to determine the amount of EPA and DHA in plasma.
3. Omega-3 index was determined using GC system in the Galil society
4. Medical records for each participant was used to obtain all information needed for the research (including medications).

3.6.1. Determination of Omega-3 Index

3.7.1.1. Analysis of Omega-3 FAs

Omega-3 FAs were determined by the method described by Köhler *et al*. (2010). Blood samples were allowed to melt at room temperature, and three hundred microliters were taken from each blood sample and saponified by mixing with 1ml of KOH in methanol for 15 minutes in a boiling water bath (100 ºC). Afterwards, plasma FAs were trans-methylated by adding 1 ml of boron trifluoride (BF3) solution in methanol (14%) in a boiling water bath for 10 minutes. FAMEs, which resulted from the methylation step, were extracted with 500 microliters of isooctane.

Afterwards, 1.00 microliter was taken from the isooctane layer (upper layer) and injected into the injection port of the gas-liquid chromatography. At this point, FAs composition was analyzed by the GC system at the Galilee Society (the Arab National Society for Health Research and Services).

3.6.1.2 Determination of Omega-3 Index.

The FAMEs were determined by comparison of retention time with standards of cis-4,7,10,13,16,19-DHA and cis-5,8,11,14,17-EPA.Omega-3 index was calculated as follows: Omega-3 index= DHA%+ EPA%

3.6.1.3 Chemicals and Biochemical Reagents that used to analyze omega 3 index

NaOH (Batch no. LC24350) and methanol (Batch no. LC 16800) were purchased from LabChem, USA. Boron trifluoride (BF3) (Batch no. 109637), isooctane (Batch no. 2087591), cis-4,7,10,13,16,19-Docosahexaenoic acid (Batch no. 6217-54-5) and EPA Method 8260 Standards Kit (Batch no. 48261) were purchased from Sigma-Aldrich, St. Louis, MO, USA.

Agent 1: KOH

Agent 2: BF3 in MeOH (14%)

Agent 3: isooctane

Agent 4: cis-4,7,10,13,16,19-Docosahexaenoic acid (98%)

Agent 5: cis-5,8,11,14,17-Eicosapentanoic acid analytical standard

3.6.1.2 Equipment

Water bath, centrifuge, GC, glass vails (100 cc) \COD vails, GC vails, EDTA tubes.

3.7 Statistical Methods and Data Analysis

After completing data collection, the researcher digitally recorded the data and conducted statistical analysis using the Statistical Package for Social Science (SPSS25).

The following statistical measures were calculated:

1. Frequencies and percentages.
2. Means and standard deviations.
3. Pearson's correlation was used to assess the correlation between omega-3 FAs intake and omega-3 index, omega-3 FAs intake and controlling measurements and between omega-3 index and controlling measurements. Data was considered significant at $P < 0.05$.

Independent variables: omega-3 index, omega-3 FAs intake, blood glucose level, HbA1c, triglyceride, age.

The dependent variable: comprised DMT2 patients.

Table 3.1: Conceptual and operational definitions

Conceptual definition	Operational definition	Reference
Triglyceride: Present in the blood to enable the bidirectional transference of adipose fat and blood glucose from the liver and are a major component of human skin oils.	• ≤ 150mg/dl. Normal • 150- < 200 mg/dl. Borderline high • 200- < 500 mg/dl. High • ≥ 500 mg/dl. Very high	Miller*et al*. (2011).
HbA1c Determines the average level of blood sugar over the past 2 to 3 months.	• < 6.5. Normal • 6.5 - 7.5. Excellent • 7.5 - 8.5. Good • 8.5 - 9.5. Fair • > 9.5. Poor	Greci *et al*. (2003)
Blood Glucose Level	• <126. Controllable • ≥126. Not controllable	Sop*et al*. (2018).

Conceptual definition	Operational definition	Reference
Omega-3 index= %DHA+ %EPA	• <4%. Undesirable • 4%-8%. Intermediate • >8%. Desirable	Harris (2007)
Omega-3 FAs intake Determined by FFQ	The recommended dietary allowance (RDA) for ALA is 1.6 g/day for men and 1.1 gram/ day for women.	Shen *et al*. (2019).

3.8 Ethical Considerations and Accessibility

The study gained IRB approval from An-Najah National University and the permission from the PMoH to access the clinic (Appendix 3).

. A consent form with data collection tool (Appendix 1) was used to ensure the informed consent of participants in Nablus City after a full verbal explanation about confidentially and their right to withdraw at any time during the completion of the questionnaire**.** The approval from PMoH in Ramallah, Nablus and Balata (Appendix 5), and the approval from An-Najah University, Faculty of Graduate Studies (Appendix 4), were gained to conduct the study.

Chapter 4

Results

The following part presents descriptive statistics in terms of frequencies and percentagesof socio-demographic data analysis, medical history, biochemical tests and anthropometric measurements as well as a clinical omega-3 dietary survey among participants presented by tables.

4.1. Socio –demographic Data

Table 4.1: Distribution of participants according to their demographic characteristics

Demographic Characteristics	Category	No	%
Sex	Male	49	46.7
	Female	56	53.3
Marital Status	Married	104	99
	Single	1	1
Educational Level	Illiterate	30	28.6
	Secondary	22	21
	Bachelor	42	40
	Master or more	11	10.4
Occupational Status	Working	49	46.7
	Not working	56	53.3
Age category	<46 years	9	8.6
	46- 60 years	62	59
	>60 years	34	32.4
Mean age ± SD		(56.81± 8.13)	

Table 4.1 shows characteristics of sample participants presented as frequencies and percentages. Where 56 (53.3%) were females, 104 were married (99%), 42 participants (40%) got Bachelor’s degree. Regarding the

occupational status, around 56 (53.3%) are unemployed. 62 participants (59%) were between 46 and 60 years old, the mean age is 56.81 years old ± 8.13 SD.

4.2 Anthropometric Measurements

Table 4.2: Distribution of participants regarding their anthropometric measurements

Anthropometric measurements	**Category**	**No**	**%**	**Mean ±SD**
Waist Circumference (cm)	Increased	25	23.8	104.42±13.59
	High	36	34.3	
	Very high	35	33.3	
	Extremely high	9	8.6	
BMI (kg/m^2)	Normal	5	4.8	32.27±5.77
	Overweight	31	29.5	
	Obese class1	42	40	
	Obese class2	18	17.1	
	Obese class3	9	8.6	

Table 4.2 presents the anthropometric measurements of the participants. It shows that 40% of participants had a BMI of 42 kg/m^2 (obesity class 1) with a mean of 32.27 ± 5.77 kg/m^2. On the other hand, 67.6% had high and very high waist circumferences with a mean of 104.42±13.59cm.

4.3 Evaluation of Omega-3 FAs Intake

Table 4.3: Distribution of percentage of participants according to their omega-3 FAs intake from fish sources

Omega-3 Dietary Survey from fish	Level	No	%
How many times did you eat fish or shellfish in the past week?	0 times	23	21.9
	1-3 times	73	69.5
	>3 times	9	8.6
Do you take fish oil?	Yes	5	4.8
	No	100	95.2
Weekly intake	Once	2	40
	>2	3	60

Table 4.3 shows omega-3 FAs dietary survey from fish sources conducted among the participants. Out of the total sample, 73 (69.5%) ate fish or shellfish in the past week between 1-3 times. The table also shows that 5 participants (4.8%) took fish oil in the past week. Three participants (60%) took fish oil more than 2 times a week, and two participants took it only once.

Table 4.4: Distribution of percentage of participants regarding their average omega-3 FAs intake over the last 3 months

Food type	Level	No	%	Mean ±SD
Salmon	None	53	50.5	1.29±2.71
	<3 times	2	1.9	
	≥3 times	50	47.6	
Sardine	None	96	91.4	0.76±2.94
	< 3 times	6	5.7	
	≥3 times	3	2.9	
Tuna	None	57	54.3	0.68±0.93
	<3 times	34	32.4	
	≥3 times and more	14	13.3	
Nuts	None	50	47.6	4.33±4.15
	<3 times	40	38.1	
	≥3 times	15	14.3	
Mean intake of omega-3 FAs g/day				**1.04±0.90**

Table 4.4 outlines omega-3 FAs intake, it reveals that the mean intake of omega-3 FAs over the last 3 months was 1.04±0.90 g/ day. It alsoindicates that50 (47.6%) participants ate salmon more than 3 times with a mean of 1.29± 2.71 g. 9 participants (8.6%) ate sardines regularly at least once per month over the last 3 months with a mean of 0.76 ±. 2.94 g. Whereas, 48(45.7%) ate tuna regularly at least once per month with a mean of 0.68 ±.0.93g. In addition, 15 (14.3%) participants ate nuts more than 3 times with a mean of 4.33 ±.4.15 g.

4.4 Biochemical Tests

Table 4.5: Distribution of percentage of participants according to their controlling measurements

Biochemical test	Category	No	%	Mean ± SD
HbA1C	Normal < 6.5	12	12.6	8.08±1.64
	Excellent 6.5 - 7.5	28	29.5	
	Good 7.5 - 8.5	25	26.3	
	Fair 8.5 - 9.5	15	15.8	
	Poor > 9.5	15	15.8	
Blood Glucose level	Controllable <126	8	8.2	173.27±49.10
	Not controllable (≥126)	90	91.8	
Blood Triglycerides	Normal (<150 mg/dl)	33	34	158.29±63.60
	Borderline high (150- <200 mg/dl)	57	58.8	
	High (200- <500 mg/dl)	6	6.2	
	Very high (≥500 mg/dl)	1	1	

Table 4.5 presents the results of controlling measurements of the participants. The HbA1C test shows that 29.5% of participants had an excellent level with a mean of 8.08±1.64. On the other hand, blood glucose level test shows that 90 (91.8%) participants had uncontrollable blood glucose with a mean of 173.27±49.10 mg/dl. In addition, results of blood triglycerides test reveals that 57 (58.8%) participants had a borderline high triglyceride level with a mean of 158.29±63.60 mg/dl.

4.5 Evaluation of FAs and Omega-3 index

Table 4.6: Mean and SD values of FAs in plasma and omega-3 index of participants

Variable %	Mean	SD
LA	0.10	0.08
Oleic acid	0.05	0.07
ALA	0.05	0.07
DHA	0.00	0.00
EPA	0.26	2.15
Omega-3 index	0.26	2.15

Table 4.6 outlines the plasma levels of FAs, and the calculated omega-3 index of participants. The data shows that the mean percentage of LA was 0.10 % ± 0.08, oleic acid was 0.05%± 0.07, and LA was 0.05 % ± 0.07. Whereas, DHA plasma mean percentage was 0.00 %± 0.00, whereas, EPA mean percentage was 0.26%± 2.15 and therefore the subsequent omega-3 index was calculated as EPA % + DHA%, and was very low with a mean of 0.26%± 2.15.

4.6 Association between Omega-3 Index and Omega-3 FAs Intake

Table 4.7: Association between omega-3 index and omega-3 FAs intake using Pearson correlation coefficient

	Omega-3 index		
	N	*r	*P*- value
Omega-3 FAs intake (g/day)	105	0.047	0.635

Table 4.7 presents the association between omega-3 index and omega-3 FAs intake among the participants. There is a positive ($P \geq 0.05$) association (r= 0.047) between omega-3 index and omega-3 FAs intake.

4.7 Association between Omega-3 Index and Controlling Measurements

Table 4.8 Association between omega-3 index and controlling measurements using Pearson correlation coefficient

	Omega- 3 index		
Controlling measurement	N	*r	*P*-value
HbA1C	105	-0.021	0.839
Blood glucose	105	-0.14	0.281
Blood triglycerides	105	-0.11	0.286

Table 4.8 shows the association between omega-3 index and HbA1C, blood glucose and blood triglycerides levels among participants. According to the table, there are negative ($P \geq 0.05$) associations between omega-3 index and the controlling measurements (HbA1C, blood glucose and blood triglycerides) among different participants.

4.8 Association between Omega-3 FAs Intake and Controlling Measurements

Table 4.9: Association between omega-3 FAs intake and controlling measurementsusing Pearson correlation coefficient

	Omega-3 FAs intake (g/day)		
Controlling measurement	N	*r	*P*-value
HbA1C	105	-0.18	0.08
Blood glucose	105	-0.13	0.19
Blood triglycerides	105	-0.14	0.15

Table 4.9 presents the association between omega-3 FAs intake and HbA1C, blood glucose, blood triglycerides levels among participants. According to data, there are negative ($P \geq 0.05$) associations between omega-3 FAs intake and HbA1C, blood glucose and blood triglycerides among participants.

Chapter 5

Discussion

5.1 Description of the Study

This study was conducted to evaluate omega-3 index and intake among Palestinian adults diagnosed with DMT2. It aims also to investigate the relationship between omega-3 index and omega-3 FAs intake and evaluate the relationship between omega-3 index and controlling measurements (blood glucose and triglycerides levels and HbA1C).

Among participants, omega-3 index was extremely low, omega-3 FAs intake was within AMDR values, and there was a linear relationship between omega-3 FAs intake and omega-3 index. On the other hand, biochemical tests have shown that most of the participants had acceptable HbA1c test results, not controllable blood glucose level and borderline high blood triglycerides level. Furthermore, there were inverse relationships between each of the controlling measurements (blood glucose and triglycerides levels and HbA1C) and omega-3 index.

5.2 Evaluation of Anthropometric Measurements

According to table 4.2, 40% of participants were obese (class 1). In addition, 67.6% had high and very high waist circumferences.

It is well known that obesity complicate the symptoms of DMT2. BMI has a strong relationship to DMT2 and insulin resistance. In obese individuals, the amount of non-esterified FAs, glycerol, hormones, cytokines, pro-inflammatory markers, and other substances that are involved in the development of insulin resistance, is increased (Al-Goblan *et al*., 2014). The connection is also seen in the fact that weight-loss can improve control or cure DMT2. In addition to the degree of obesity, where the excess body fat is deposited is important in determining the risk of DMT2. The degree of insulin resistance and the incidence of DMT2 is highest in a person with an "apple" shape. These persons carry the majority of their excess body weight around their abdomen. In contrast, the "pear" shaped person carries most of their weight in the hips and thighs and this is not as likely to be associated with insulin resistance **(Rogers and Still, 2009).**

Furthermore, omega-3 FAs have beneficial effects in lowering triglyceride levels, especially in the post prandial state, including in patients with atherogenic dyslipidemia associated with the metabolic syndrome and diabetes. They are converted into a wide variety of bioactive eicosanoids and act as ligands for several nuclear transcription factors, thereby altering gene expression **(Durrington *et al*., 2001).**

When comparing tables 4.2 and with table 4.5, it seems that although omega-3 FAs intake (as shown in table 4.4) was sufficiently enough to alleviate increased blood glucose and triglyceride levels, yet participants' anthropometric measurements, as reflected by their BMI and waist circumference, were highly enough to complicate the consequences of DMT2.

5.3 Evaluation of Omega-3 FAs Intake

According to table 4.4, the total omega-3 FAs intake in g/day was estimated as 1.04±0.90, which indicates that the dietary intake of omega-3 FAs is within the AMDR (0.25-2 g/day) set by WHO and FAO (Joint FAO/WHO, 2008). Indicating that study participants are not likely to suffer from deficiency symptoms associated with EPA and DHA, such as the increased risk of fatal CHD and sudden cardiac death and other complications such as increased blood pressure, impaired cardiac diastolic function, inflammation, elevated triglycerides blood levels **(Mozaffarian and Rimm, 2006).**

The higher omega-3 FAs intake means higher intake of omega-3 rich foods especially those coming from fatty fish, which was consumed in large quantities; e.g. the mean intake of salmon was 1.29±2.71 g/day, where the amount needed to get 500 mg of EPA+DHA/day from salmon is 0.49 g/day, which is higher than required **(Buzby and Hyman, 2012).** In addition, the mean intake of tuna in g/day was 0.68±0.93, which is also higher than the required amount to get 500 mg of EPA+DHA/day (0.49 g/day). Apart from omega-3 FAs non-marine sources consumed by participants, these two (tuna and salmon) account for more than the required amount. This explains the higher intake of omega-3 FAs.

According to a study by Brostow *et al*. (2011) conducted among Chinese residents of Singapore, marine omega-3 FAs comprised approximately 31% of the population’s daily omega-3 and increased total omega-3 intake was associated with increased seafood intake and overall energy intake. Similar trends were observed in the present study,

5.4 Evaluation of Omega-3 Index

Data from table 4.6 indicates that omega-3 index value is extremely low, which lies within the high-risk level **(Harris, 2007).** In general, omega-3 index is higher in countries that consume more omega-3 FAs sources, especially those from fish **(Harris and Von Schacky, 2004).** e.g., In Japan, whose population has free access to abundant resources of fish and seafood, the average omega-3 index is 9-10% **(Harris and Von Schacky, 2004).** Although omega-3 FAs intake was relatively high among participants, their omega-3 index lies within the high-risk level set by Harris (2007). The most reasonable explanation for such findings may be attributed to the fact that omega-3 index was calculated from the sum of EPA% and DHA % found in plasma. Whereas, FAs in RBC are more superior since they indicate long-term FAs dietary intake **(Katan *et al.*, 1997; Harris, 2009)** and due to the fact that the half-life of RBC is 4 to 6 times longer than that of plasma, making FAs in RBC to be less affected by the daily dietary intake of omega-3 FAs **(Harris, 2009).**

5.5 Relationship between Omega-3 FAs Intake and Index

It is well known that omega-3 index increases with the increased intake of EPA and DHA (Sala-Vila *et al.*, 2011). A similar trend was observed in the current study, since a positive ($P \geq 0.05$) association was observed between omega-3 FAs intake and omega-3 index, and as previously mentioned, this could be explained by the fact that omega-3 index calculated from RBC reflects the long-term (3-4 months) consumption of omega-3 FAs, which was insufficient (unreliable) to reflect the long term consumption of omega-3 FAs.

Block*et al*. (2008) investigated clinical determinants of omega-3 index in 704 outpatients and found that capsules/fish intake together accounted for 47% of the index variability. The Index increased by 13% for each serving level increase in fish intake and EPA+DHA supplementation correlated with a 58% increase regardless of background fish intake.

5.6 Relationship between the Omega-3 Index and Controlling Measurements

5.6.1 Relationship between Omega-3 Index and Blood Glucose and HbA1c Levels.

According to table 4.5, 84.2% of the participants had from fair to excellent HbA1c levels. In this regard, only 15.8% of individuals had poor (>9) test results, which means that most of them had acceptable test results. At the same time, the participants belong to a high-risk group with regard to the omega-3 index (< 4) with nearly zero value. However, according to table 4.5, 91.8 % of participants had not controllable blood glucose levels.

In addition, according to data from table 4.8, an inverse relationship was found between omega-3 index and both blood glucose and HbA1c levels, concluding that higher omega-3 index is associated with decreased

HbA1c level, and therefore increased insulin sensitivity. Our findings are in agreement with Albert *et al*. (2014) regarding HbA1c, who found that higher omega-3 index was associated with increased insulin sensitivity and a more favorable metabolic profile in middle-aged overweight men when they conduct a study to assess whether omega-3 index was associated with insulin sensitivity and other metabolic outcomes in 47 overweight men aged.

A study by Takkunen *et al*. (2016) to examine the longitudinal associations of plasma FAs composition with DMT2, insulin secretion and insulin sensitivity was conducted over several years using a prospective cohort study. Their study concluded that serum long-chain omega-3 FAs were linearly associated with insulin sensitivity and consequently could lower the risk of DMT2 incidence in people at a high risk of diabetes.

5.6.2 Relationship between the Omega-3 Index and Blood Triglycerides Level.

According to biochemical tests (table 4.5), only 34% of participants had normal levels of blood triglycerides. Most of the participants had borderline high level (58.8%), and 7.2% have high or very high levels. In addition, table 4.8 provides a negative relationship between omega-3 index and the blood triglycerides level among participants. Since an inverse association exists, it means that the higher the omega-3 index, the lower is the triglyceride level. Indicating that since omega-3 index approaches zero for the majority, this was reflected in the borderline high triglyceride blood levels.

Block*et al*. (2008), investigated the clinical determinants of omega-3 index in 704 outpatients, and found that factors such as fish consumption frequency, triglyceride level, age, high cholesterol history, and smoking explained 59% of omega-3 index variability. Among these, they found that a 100 mg/dl decrease in serum triglycerides was associated with a 15% higher omega-3 index. Therefore, suggesting an inverse association between omega-3 index and blood triglyceride level which is in agreement with the finding of the current study. Furthermore, it is the influence of other factors that might affect omega-3 index rather than triglycerides alone, which may explain the fact that the majority of participants had borderline high triglycerides.

Due to participants' medical condition, high levels of triglycerides are consistent with their disease, which leads to dyslipidemia. Such lipid changes are connected to insulin resistance **(Mooradian, 2009).** In turn, dyslipidemia can lead to an increased risk of CVDs in DMT2 patients (Mooradian, 2009). Thus, it is important to consume more omega-3 FAs to increase the omega-3 index in DMT2 patients, which may help manage dyslipidemia. The fact that most of the participants are overweight or obese and have high glucose levels in their blood contributes to this theory.

5.7 Relationship between Omega-3 FAs Intake and Controlling Measurements

5.7.1 Relationship between Omega-3 FAs Intake and Blood Glucose and HbA1c Levels.

An inverse relationship was found between omega-3 FAs intake and HHbA1c among participants as shown in table 4.9. It seems that the increased intake of omega-3 FAs had a better glycemic control as shown in table 4.5, since 84.2% of the participants had from fair to excellent HbA1c levels. Never the less, the vast majority had non-controllable blood glucose levels.

According to the Montori *et al*. (2000), omega-3 FAs intake had no adverse effects on glycemic control in people with diabetes. The systematic review by Hartweg *et al*. (2009), reported that omega-3 supplementation was found to lower the plasma level of triglyceride but have no statistical effect on glucose or insulin. However, Brostow *et al*. (2011) highlighted an inverse association between the total intake of omega-3 FAs and the risk of developing DMT2. It is worth noting that in their study, Brostow *et al*. (2011) found that the association between omega-3 FAs from marine sources was null (EPA and DHA); at the same time, there was a strong inverse association between the risk of having diabetes and consumption of non-marine sources of omega 3 FAs (ALA) **(Brostow *et al*., 2011).**

A study conducted by Villegas *et al*. (2011) involving over 110000 Chinese citizens also found that there is an inversely proportional (negative) relationship between DMT2 among women and omega-3 FAs from fish and shellfish consumption. A study by Djousse *et al*. (2011) reached a similar conclusion. According to their results, there is a lower risk of DMT2 in people with the highest concentrations of ALA and long-chain omega-3 FAs.

Overall, the studies conducted by Brostow *et al*. (2011) and Villegas *et al*. (2011) had similar variables and reached a conclusion similar to that of our study. According to their research, there is an inverse relationship between omega-3 intake and the risk of developing DMT2 **(Brostow*et al*., 2011; Villegas *et al*., 2011).**

5.7.2 Relationship between the Omega-3 FAs Intake and Blood Triglycerides Level.

Table 4.9 shows that an inverse association was found between omega-3 FAs intake and blood triglyceride level. Although this relationship means that lower triglycerides should be associated with increased omega-3 FAs intake, yet data from table 4.5 shows inconsistent results. It shows that most participants had borderline high triglyceride blood levels despite their sufficient intake of omega-3 FAs.

Chen*et al*. (2015) conducted a study to systematically evaluate the effect of omega-3 FAs on glucose control and lipid levels. Among patients with omega-3 supplementation, triglyceride levels were significantly decreased. No marked change in total cholesterol, HbA1c, fasting plasma glucose, postprandial plasma glucose, BMI or body weight was observed.

High ratio of EPA/DHA contributed to a greater decreasing tendency in plasma insulin, HbA1c, triglycerides, and BMI measures, although no statistical significance was identified except for triglycerides.

Skulas-Ray *et al*. (2019) reported that treatment of very high triglycerides with 4 g/day, EPA+DHA agents reduced triglycerides by ≥30% with concurrent increases in low-density lipoprotein cholesterol, and concluded that prescription omega-3 FAs at a dose of 4 g/day (>3 g/day total EPA+DHA) was an effective and safe option for reducing triglycerides as monotherapy or as an adjunct to other lipid-lowering agents. These findings support our results, since an inversely proportional relationship was found between omega-3 FAs and triglyceride level.

5.8 Strengths of the Study

Importantly, it is the first study of this kind to be conducted in Palestine. It highlights the level of omega-3 index and the consumption of omega-3 FAs by DMT2 patients, which provides useful data that enables the Palestinian population to make informed dietary choices. As a result, it may help them deal with their medical condition.

5.9 Difficulties of the Study

- The access to the GC system is limited in Palestine, and it is very expensive to use. Thus, it took us a long time to find an association to empower this research.

- According to the association's regulations, the blood test had to prepared in advance in the An-Najah University Laboratory.

5.10 Conclusion

- It was concluded the higher the intake of omega-3 FAs, the higher is omega-3 index as that a linear relationship existed between omega-3 index omega-3 FAs intake
- It was also concluded that there was a negative relationship between omega 3 index and DMT2 control measurements, but the relationship was not significant.

5.11 Recommendations

- It is recommended to apply the study including patients with DMT2 from all cities of Palestine
- In addition, it is recommended to repeat the study findings of omega-3 index by analyzing omega-3 FAs from RBC rather than the plasma.

5.12 Implications of the Study

- Our study has the potential to increase the awareness of the importance of omega-3 FAs consumption in Palestine, especially among the Palestinian patients diagnosed with DMT2.
- There are many international studies that support the claim that omega-3 index and intake affect sensitivity to insulin. Thus, it is necessary to take

in consideration that it may lead to a decrease in the prevalence of DMT2 in Palestine.

- Importantly, such awareness, and as a result, regular consumption of omega-3 FAs has the potential to become a way to manage this medical condition.

5.13 Limitations of the Study

- Due to the lack of reference for the omega-3 index in Palestine, the current study is only a basis for subsequent comprehensive research.
- Analysis of EPA and DHA was based on their content in plasma, it should have been analyzed from RBC phospholipid membrane, since it reflects their long term content and doesn’t depend on the feeding status of participants.

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Appendices

Appendix 1. English Questionnaire

Al- Najah National University

Faculty of Graduate Studies

Department of Public Health

Questionnaire to Relationship of Omega-3 status with Diabetes Mellitus Type 2 Control Measurements in Nablus City

Dear Participant,

Peace of Allah, Mercy and blessings on you all

My name is Fatma Bakri, a student perusing my Master's degree of public health in An-Najah National University. Currently I am performing a study that assesses the relationship between omega 3 index and DMT2 control measurements in Nablus city. I would like to kindly request 10 minutes of your time to fill in this questionnaire. Please note that:

Your participation is voluntary and you could refuse or stop anytime with no problem. Your results are confidential and will not be in any way published, the results use will be purely for the researcher to perform and complete the research. (Your name isn't required on the pages of the questionnaire).

Thank you!

Personal Information

Please, circle the right answer.

1. Sex: a) Male b) Female
2. Residency Location: a) City b) Village c) Camp
3. Marital status: a) married b) single
   c) divorced d) widow
4. Educational Level: a) Illiterate b) Elementary
   c) Secondary d) Diploma
   e) Bachelor f) Masters or more
5. Monthly Income: a) < 2000 shekel b) 2000-3000 shekels
   c)3001– 4000 shekels d) 4001 or Above
6. Occupational status: a) Working b) Not Working

Information regarding the Medical History

7. Do you suffer from diabetes: a) Yes b) No
8. If "Yes", I suffer from diabetes:
   a) < 1 year b) between 1and 5 years c) more than 5 years
9. Do you have relatives suffering from diabetes:
   a) Yes b) No

10.I use the following medications to reduce diabetes:

a) b) c)

11.Do you suffer from chronic disease: a) Yes b) No

12. If "Yes", I suffer from:

a) pressure b) c)

12.I use the following medications in general:

a) pressure b) c)

13.I use the following nutritional supplements:

a) b) c)

14.Do you deal with certain herbs: a) Yes b) No

15.If "Yes", I deal with:

a) b) c)

16.Are you a smoker: a) Yes b) No

17.If "Yes", I am a smoker from:

a) < 1 year b) between 1and 10 years c) more than 10 years

18. I use to smoke daily: a) < 1 box b) between 1and 2 c) more than 2

Information regarding Biochemical Tests

Item	**Value**	**Level**		
		Normal Value	**Normal**	**High**
HbA1C				
Blood glucose level				
Blood triglycerides				
Omega-3 index				

Information regarding Anthropometric Measurements

Item	Value				
Weight/kg					
Height/m					
Body fat analyzer					
Circumference/cm					
BMI		Underweight = <18.5 ☐	Normal weight= 18.5–24.9 ☐	Overweight = 25–29.9 ☐	Obesity = BMI of 30 or greater ☐

Clinical Omega-3 Dietary Survey

20. How many times have you eaten fish or shellfish in the past week?

a) 0 times b) 1-3 times c) More than 3 times

21. Each time you ate fish or shellfish; how much did you eat?

a) Less than 50 g or half a fillet or less than 4 pieces/1-2 hand roll of sushi

b) 100 g or about 1 small fillet or 8 pieces of sushi/3 hand rolls

22. Do you takefish oil: a) Yes b) No

23. If "Yes", Itake brand: a) b) c)

24. Type name: a) b) c)

25. weekly intake: a) once b) twice c) more than

26. I take fish oil by: a) Grams b) Caps c) TBS

Please, mark the food(s) you eat regularly (i.e., at least once per month) over the last three (3) months and indicate:

• your average portion for each serve

• on average, how often you eat that type of food

Food type	average portion for each serve			how many times you often eat that type monthly		
	none	less than 30 grams	30 grams and more	none	less than 3 times	3 times and more
Fish						
Salmon						
Sardine						
Tuna						
Other Meals						
Beef						
Lamb						
Salami						
Egg						
Nuts						
Walnut						
Carbohydrates						

- **Modified from:**

Shen, W., Weaver, A. M., Salazar, C., Samet, J. M., Diaz-Sanchez, D., & Tong, H. (2019). Validation of a Dietary Questionnaire to Screen Omega-3 Fatty Acids Levels in Healthy Adults. *Nutrients*, *11*(7), 1470.

Physical Activity

27. Do you currently have a job or do any unpaid work outside your home?

a) Yes b) No

28. During the last 7 days on, how many days did you do vigorous physical activities like heavy lifting, digging, heavy construction, or climbing up stairs as part of your work? Think about only those physical activities that you did for at least 10 minutes at a time:

a) none b) 1 day c) between 2-4 days d) more than 4 days

29. During the last 7 days, on how many days did you walk for at least 10 minutes at a time as part of your work? Please do not count any walking you did to travel to or from work:

a) none b) 1 day c) between 2-4 days d) more than 4 days

30. How much time did you usually spend on one of those days walking as part of your work?

a) less than one hour b) between 1-3 hours c) more than 3 hours

31. How much time did you usually spend sitting on a weekend day?

a) less than one hour. b) between 1-3 hours c) more than 3 hours

Appendix 2. Arabic Questionnaire

العلاقة بين حالة اوميجا 3 وقياسات التحكم لمريض السكري النوع الثاني في مدينة نابلس

الجنس : (ذكر \ انثى) الطول : ....سم العمر : ....

الوزن : .... مؤشر كتله الجسم BMI=Wt.(kg)\Ht.(m)*2: ....

الخصر : ....

الموقع الجغرافي: ....

الحالهالاجتماعيه: متزوج \ اعزب

المرحلهالتعليمليه: ابتدائي \ ثانوي \ جامعي ..

الدخل :منخفض \ متوسط \ عالي

التاريخ الطبي :

...

هل تعاني من امراض مزمنه ؟؟ مثل المفاصل \ الضغط العالي ...

...

هل تعاني من مرض السكر ؟؟؟ نعم \ لا

اذا نعم .. كم من الوقت ؟؟

...

ما هي الادويهالمستعمله لتخفيض نسبه السكر في الدم ؟

...

ادويه مستعمله بشكل عام مثل ادويه الدهنيات \ الضغط العالي \ تمييع الدم ...:

...

مكملات غذائيه:

...

هل تتناول اعشاب معينه بشكل عام ؟؟اذا نعم اذكرها

....

اتباع حميه غذائيه معينه :

....

هل يوجد اشخاص مقربين لديهم مرض السكري؟؟

1) نعم .
2) لا .

Biochemical analysis	**Results**
نتائج تحليل الكيمياء الحيوية	
HbA1C	....
Blood glucose level	....
Blood triglycerides	....
Omega 3 index	....

تناول المصادر الغذائيه للاوميجا 3

كم مرة أكلت السمك في الأسبوع الماضي؟

1) ولا مره
2) 1-3 مرات
3) اكثر من 3 مرات

في كل مرة تأكل فيها السمك ، كم الكميه ؟

1) أقل من 50 غرام أو أقل من 4 قطع
2) 100 غرام أو حوالي 1 شريحة صغيرة

يرجى تحديد الطعام (الأطعمة) التي تتناولها بانتظام (مرة واحدة على الأقل شهريًا) خلال الأشهر الثلاثة (3) الأخيرة مع الإشارة إلى:

- **معدل الكميه المتناوله من الوجبه**

- **كم مرة تتناول هذا النوع من الطعام**

الاسماك

سلمون .... غم .... مره خلال الاسبوع \ الشهر

سردين .... غم .... مره خلال الاسبوع \ الشهر

تونه .... غم .... مره خلال الاسبوع \ الشهر

اطعمه اخرى

اللحوم

لحم البقر .... غم ....مره في الاسبوع \ الشهر

لحم الغنم ....غم .... مره في الاسبوع \ الشهر

البيض ....غم .... مره في الاسبوع \ الشهر

المكسرات

الجوز .... غم ....مره في الاسبوع \ الشهر

الكاربوهيدرات

الكميه المتناوله خلال الاسبوع (مثل البطاطا الأرز الباستا ...)

..

مكملات الاوميغا 3 \ زيت السمك

النوع ....

الجرعه ....

W-3

g/caps/TBS..............

times a day/week..............

النشاط البدني

- **هل لديك وظيفة حاليا أو تقوم بأي عمل غير مدفوع الأجر خارج منزلك؟**

1) نعم فعلا

2) لا

- خلال آخر 7 أيام ، كم عدد الأيام التي قمت فيها بنشاطات جسدية قوية مثل الرفع الثقيل أو الحفر أو البناء الثقيل أو تسلق السلالم كجزء من عملك؟ فكر فقط في الأنشطة البدنية التي قمت بها لمدة 10 دقائق على الأقل في كل مرة

1) .... أيام في الأسبوع

2) .... لا يوجد نشاط بدني قوي

- خلال آخر 7 أيام ، ما هو عدد الأيام التي سرت فيها لمدة 10 دقائق على الأقل كجزء من عملك؟

1) ....أيام في الأسبوع

2) .... لم اقم بهذه الفعاليه

- كم من الوقت تقضيه عادة من ايام الاسبوع في المشي كجزء من عملك ؟

1) .... ساعة في اليوم

2) .... دقائق في اليوم الواحد خلال اخر 7 ايام

- كم من الوقت تقضيه عادة جالس في عطلة نهاية الاسبوع ؟

1) .... ساعة في اليوم

2) .... دقائق في اليوم الواحد

- هل انت مدخن ؟؟

1) نعم . كم الفتره ....كم الكميه ؟؟ ....

2) لا .

Appendix 3. An-Najah National University: Institutional Review Board (IRB) Ethical Approval

An-Najah
National University
Faculty of medicine
&Health Sciences
Department of Graduate
Studies

جامعة النجاح
الوطنية
كلية الطب وعلوم الصحة
دائرة الدراسات العليا

REF:MAS

Approval Letter

Study Title:

"**Relationship of omega 3 index with DM type 2 control measurements in Nablus city**"

Submitted by:

Fatma Bakri

Supervisor:

Dr.Mariam Amer Al-Tell

Date Reviewed:

19th November 2018

Date Approved:

21st November 2018

Your Study titled ""**Relationship of omega 3 index with DM type 2 control measurements in Nablus city**"" with archived number (20) November was reviewed by An-Najah National University IRB committee and was approved on 21st November 2018

Hasan Fitian, MD

IRB Committee Chairman

An-Najah National University

نابلس - ص.ب 7 أو 707 || هاتف 2342902/4/7/8/14(09) (970) || فاكسميل 2342910 (09) (970)

Nablus - P.O Box :7 or 707 | Tel (970) (09) 2342902/4/7/8/14 | Faximile (970) (09) 2342910 | E-mail : hgs@najah.edu

Appendix 4. An-Najah National University – Graduate Studies Approval

التاريخ : 2019/9/12

السيد الأستاذ الدكتور عميد كلية الدراسات العليا المحترم،

الموضوع : تسهيل مهمة الطالبة فاطمة البكري , تخصص ماجستير صحة عامة.

تحية طيبة وبعد ...

الطالبة فاطمة البكري ,رقم تسجيل (11558545) ماجستير صحة عامة في كلية الدراسات العليا ,وهي بصدد اعداد الاطروحة الخاصة بها و التي تحمل عنوان :

Relationship of omega 3 index with DM type 2 control measurements in Nablus city

العلاقة بين مؤشر أوميجا 3 وقياسات التحكم لمريض السكري النوع الثاني في مدينة نابلس

يرجى من حضرتكم تسهيل مهمة الطالبة فاطمة في مختبرات جامعة النجاح التابعة للمراكز العملية من خلال التحليل الاولي وفصل الدهون من بلازما الدم لتكون جاهزة لقياس مؤشر اوميغا 3 و نقلها الى جمعية الجليل في الداخل الفلسطيني ، مع العلم بانه تم تزويد المختبر بالمواد اللازمة لاجراء التحليل وتحضير العينات التي تم شراؤها من حساب الطالبة المخصص لها من الجامعة كطالبة ماجستير .

مرفق اهداف الرسالة

شاكرين لكم حسن تعاونكم .

مشرفة الطالبة

الدكتورة مريم الطل

صادر

جامعة النجاح الوطنية

كلية الدراسات العليا

12. 09. 2019

الرقم المتسلسل

Appendix 5. Palestinian Ministry of Health's Letter of Approval

State of Palestine
Ministry of Health - Nablus
General Directorate of Education in Health

دولة فلسطين
وزارة الصحة- نابلس
الإدارة العامة للتعليم الصحي

Ref.: ....
Date:..................

الرقـــم: عتص/٩٧٤/٢٠١٩
التـاريخ: ٧/٦/٢٠١٩

الأخ مدير عام الادارة العامة للرعاية الصحية الأولية المحترم،،،
تحية واحترام...

الموضوع: تسهيل مهمة – جامعة النجاح

يرجى تسهيل مهمة **الطالبة: فاطمة هشام احمد بكري– تخصص ماجستير صحة عامة/ جامعة النجاح**، في عمل بحث بعنوان "**العلاقة بين مؤشر اوميجا 3 وقياسات التحكم لمريض السكري النوع الثاني في مدينة نابلس**"، من خلال السماح للطالبة بجمع معلومات تتعلق بالبحث من خلال تعبئة استبانة الدراسة من مرضى السكري، وسحب عينة دم لقياس مؤشر اوميجا 3 (بعد اخذ موافقتهم) ومراجعة ملفات المرضى، وذلك في:

- **عيادة السكري (المخفية) في مديرية صحة نابلس**

علما ان البحث تحت اشراف د. مريم الطل، والفنيين الذين سيقومون بسحب العينات هم:

- فني المختبر: علي عادل رضوان (مرفق مزاولة المهنة)
- الممرض: نادر محمد احمد عمرو (مرفق مزاولة المهنة)

كما انه سيتم الالتزام بمعايير البحث العلمي والحفاظ على سرية المعلومات.

مع الاحترام...

د. أمل أبو عوض
مدير عام التعليم الصحي

نسخة: عميد كلية الدراسات العليا المحترم/ جامعة النجاح

P.O .Box: 14
Tel.:09-2333901

ص.ب. 14
تلفون: 09-2333901

Appendix 6. The Distribution of Omega-3 Intake Regarding the Food Type Participants

Eat Regularly over the Last Three (3) Months

Serial Number	Salmon	Sardine	Tuna	Beef	Lamb	Eggs	Nuts	Average
1	0.00	1.26	0.20	0.04	0.04	0.00	8.26	1.40
2	0.00	0.00	0.20	0.04	0.00	0.12	8.26	1.23
3	1.94	0.00	0.20	0.04	0.04	0.12	0.00	0.33
4	0.00	0.00	0.20	0.00	0.00	0.12	0.00	0.05
5	0.00	0.00	0.20	0.04	0.00	0.12	0.00	0.05
6	0.00	0.00	0.20	0.04	0.00	0.18	8.26	1.24
7	0.00	0.00	0.20	0.00	0.42	0.18	8.26	1.29
8	0.00	1.26	0.20	0.00	0.00	0.12	8.26	1.41
9	1.94	0.00	0.00	0.00	0.00	0.18	8.26	1.48
10	1.94	0.00	0.20	0.04	0.00	0.18	8.26	1.52
11	0.00	0.00	2.01	0.00	0.00	0.18	8.26	1.49
12	1.94	0.00	0.00	0.00	0.00	0.12	8.26	1.47
13	0.00	12.60	0.20	0.04	0.00	0.18	0.00	1.86
14	0.00	0.00	0.00	0.00	0.00	0.18	8.26	1.21
15	19.38	0.00	0.20	0.42	0.00	0.00	8.26	4.04
16	0.00	1.26	0.20	0.00	0.00	0.12	8.26	1.41
17	0.00	0.00	0.00	0.00	0.00	0.12	8.26	1.20
18	19.38	0.00	0.00	0.00	0.00	0.12	0.00	2.79
19	0.00	0.00	0.00	0.00	0.00	0.18	0.00	0.03
20	1.94	0.00	0.00	0.00	0.00	0.12	8.26	1.47
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.20	0.00	0.00	0.18	0.00	0.05
24	1.94	12.60	0.20	0.42	0.00	0.18	8.26	3.37
25	1.94	0.00	0.00	0.00	0.00	0.18	0.00	0.30
26	0.00	0.00	2.01	0.42	0.00	0.12	8.26	1.55
27	0.00	0.00	0.00	0.00	0.00	0.18	8.26	1.21
28	0.00	0.00	2.01	0.42	0.00	0.18	8.26	1.55
29	0.00	0.00	0.00	0.00	0.00	0.18	0.00	0.03
30	0.00	0.00	0.00	0.00	0.00	0.18	0.00	0.03
31	0.00	0.00	0.00	0.00	0.00	0.18	0.00	0.03
32	0.00	0.00	2.01	0.42	0.00	0.18	0.00	0.37
33	0.00	0.00	0.00	0.00	0.00	0.12	0.00	0.02
34	0.00	0.00	0.00	0.00	0.00	0.18	0.00	0.03
35	0.00	0.00	0.00	0.00	0.00	0.18	8.26	1.21
36	1.94	12.60	2.01	0.42	0.42	0.18	8.26	3.69

Serial Number	Salmon	Sardine	Tuna	Beef	Lamb	Eggs	Nuts	Average
37	1.94	0.00	2.01	0.00	0.00	0.18	0.00	0.59
38	1.94	0.00	2.01	0.42	0.42	0.18	8.26	1.89
39	1.94	0.00	0.00	0.04	0.42	0.18	0.00	0.37
40	1.94	12.60	2.01	0.04	0.42	0.18	0.00	2.46
41	0.00	12.60	0.00	0.04	0.00	0.00	0.00	1.81
42	1.94	0.00	0.00	0.00	0.00	0.18	0.00	0.30
43	1.94	0.00	0.00	0.04	0.00	0.18	0.00	0.31
44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
45	1.94	0.00	0.00	0.00	0.00	0.18	0.00	0.30
46	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
47	1.94	0.00	0.00	0.04	0.04	0.18	8.26	1.49
48	1.94	12.60	2.01	0.04	0.04	0.18	8.26	3.58
49	1.94	0.00	0.00	0.00	0.04	0.18	8.26	1.49
50	1.94	0.00	2.01	0.00	0.04	0.00	0.00	0.57
51	0.00	0.00	0.00	0.00	0.00	0.12	0.00	0.02
52	1.94	0.00	2.01	0.42	0.42	0.18	8.26	1.89
53	1.94	0.00	0.00	0.00	0.42	0.18	8.26	1.54
54	1.94	0.00	2.01	0.42	0.00	0.18	0.00	0.65
55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
56	0.00	0.00	0.00	0.42	0.04	0.18	8.26	1.27
57	0.00	0.00	0.00	0.00	0.04	0.18	8.26	1.21
58	1.94	0.00	2.01	0.42	0.04	0.18	8.26	1.84
59	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
61	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
65	1.94	0.00	2.01	0.42	0.04	0.18	8.26	1.84
66	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
68	1.94	0.00	2.01	0.42	0.04	0.18	8.26	1.84
69	1.94	0.00	2.01	0.00	0.00	0.18	8.26	1.77
70	1.94	0.00	2.01	0.00	0.00	0.18	8.26	1.77
71	1.94	0.00	2.01	0.00	0.00	0.18	8.26	1.77
72	0.00	0.00	0.00	0.00	0.00	0.12	8.26	1.20
73	0.00	0.00	0.00	0.00	0.00	0.18	8.26	1.21
74	0.00	0.00	0.00	0.00	0.00	0.18	8.26	1.21
75	0.00	0.00	0.00	0.00	0.00	0.18	8.26	1.21
76	0.00	0.00	0.00	0.00	0.00	0.18	8.26	1.21
77	1.94	0.00	2.01	0.00	0.00	0.12	8.26	1.76
78	1.94	0.00	2.01	0.00	0.00	0.18	8.26	1.77

Serial Number	Salmon	Sardine	Tuna	Beef	Lamb	Eggs	Nuts	Average
79	1.94	0.00	2.01	0.00	0.00	0.18	8.26	1.77
80	1.94	0.00	2.01	0.00	0.00	0.18	8.26	1.77
81	1.94	0.00	2.01	0.00	0.00	0.18	8.26	1.77
82	0.00	0.00	0.00	0.00	0.00	0.00	8.26	1.18
83	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
84	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
85	1.94	0.00	2.01	0.42	0.42	0.18	8.26	1.89
86	1.94	0.00	2.01	0.00	0.00	0.18	8.26	1.77
87	1.94	0.00	2.01	0.00	0.00	0.18	8.26	1.77
88	1.94	0.00	2.01	0.00	0.00	0.18	8.26	1.77
89	0.00	0.00	0.00	0.00	0.00	0.12	8.26	1.20
90	1.94	0.00	0.00	0.00	0.00	0.18	8.26	1.48
91	1.94	0.00	0.00	0.00	0.00	0.18	8.26	1.48
92	1.94	0.00	0.00	0.00	0.00	0.18	8.26	1.48
93	1.94	0.00	0.00	0.00	0.00	0.18	8.26	1.48
94	1.94	0.00	2.01	0.00	0.00	0.18	8.26	1.77
95	0.00	0.00	0.00	0.00	0.00	0.18	0.00	0.03
96	0.00	0.00	0.00	0.00	0.00	0.18	0.00	0.03
97	1.94	0.00	2.01	0.00	0.00	0.18	0.00	0.59
98	1.94	0.00	0.00	0.00	0.00	0.18	0.00	0.30
99	1.94	0.00	2.01	0.00	0.00	0.18	0.00	0.59
100	1.94	0.00	0.00	0.00	0.00	0.00	0.00	0.28
101	0.00	0.00	0.00	0.00	0.00	0.18	0.00	0.03
102	1.94	0.00	2.01	0.00	0.00	0.18	0.00	0.59
103	1.94	0.00	2.01	0.00	0.00	0.12	0.00	0.58
104	1.94	0.00	2.01	0.00	0.00	0.12	0.00	0.58
105	1.94	0.00	2.01	0.00	0.00	0.18	0.00	0.59
Average of Omega-3 Intake								**1.04**

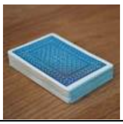
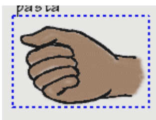
It is clear from the table above that the highest average of omega3 intake was 4.04, and the lowest was 0.00. This means that the participants did not eat any of these foods for the last three months. The average omega-3 intake for 46 (43%) participants is less than 1, while 53 (50%) have between 1 and less than 2, and only 5 (6%) have between 2 and 4.04.

Appendix 7.

قائمة المتناول من الطعام

كيفية تسجيل الكمية المتناولة من الاطعمة

كيفية تقدير حجم الوجبة المقدمة:

اللحوم 3 اونصات من اللحم = حجم علبة الشدة	
الفواكه حجم طابة التنس.= تفاحة متوسطة	
الحبوب كوب الارز = حجم قبضة اليد	
الاجبان اونصة من الجبن= حجم 4 قطع نرد	

جامعة النجاح الوطنية
كلية الدراسات العليـــا

العلاقة بين حالة أوميجا 3 وقياسات التحكم لمريض السكري النوع الثاني في مدينة نابلس

اعداد
فاطمة هشام بكري

إشراف
د. مريم الطل
د. نهال ناطور

قدمت هذه الأطروحة استكمالاً لمتطلبات الحصول على درجة الماجستير في برنامج الصحة العامة، بكلية الدراسات العليا، في جامعة النجاح الوطنية، نابلس- فلسطين

2020

العلاقة بين حالة اوميجا 3 وقياسات التحكم لمريض السكري النوع الثاني في مدينة نابلس

إعداد

فاطمة هشام بكري

إشراف

د. مريم الطل

د. نهال ناطور

الملخص

تشير دراسات مختلفة إلى أن الكمية الغذائية المستهلكة من أحماض أوميجا3 الدهنية تساعد على إمكانية منع حدوث امراض خطيرة، بما في ذلك مرض السكري من النوع الثاني. بالرغم أن مرض السكري من النوع الثاني هو أحد الأمراض المزمنة الرئيسية في فلسطين، فإن مؤشر أوميجا3لم يتم تقييمه بينالبالغين الفلسطينيين الأصحاء أو الذين تم تشخيصهم بمرض السكري من النوع الثانيعلى مستوى السكان.

هدف الدراسة:

هدفت الدراسة الى تقييم حالة أوميجا3 في مجموعة مختارة من البالغين الفلسطينيين الذين تم تشخيصهم بمرض السكري من النوع الثاني.

منهجية الدراسة:

أجريت دراسة مقطعية شملت عينة من 105 مريض سكري فلسطيني من النوع الثاني في مدينة نابلس. تم تقييم الاستهلاك الإجمالي لأحماض أوميجا 3 الدهنية خلال الأشهر الثلاثة الماضية باستخدام استبيان تواتر الغذاء. تم تحليل قياسات التحكم بما في ذلك الهيموغلوبين السكري ومستوى السكر في الدم ومستوى الدهون الثلاثية في الدم بعد الحصول على عينات الدم من كل مريض. بينما تم تحليل الاحماض الدهنية باستخدام كروماتوجرافيا الغاز.

النتائج

كان مؤشر أوميجا3 منخفضا للغاية بمتوسط 0.26 ± 2.15، وكان متوسط استهلاك أحماض أوميجا3 الدهنية 1.04 ± 0.90 غ/يوم وهو ما كان ضمن قيم نطاق توزيع المغذيات الكبيرة المقبول. بالإضافة إلى ذلك، كانت هناك علاقة إيجابية (r= 0.047) ولكن ليست ذات دلالة احصائية ($P \le 0.05$) بين الكمية المستهلكة من أحماض أوميجا3 الدهنية ومؤشر أوميجا3. ومن ناحية أخرى، كانت هناك علاقات سلبية ولكن ليست ذات دلالة إحصائية ($P \le 0.05$) بين مؤشر أوميجا3 وهيموغلوبين السكري (r=−0.021)، ومؤشر أوميجا3 ومستوى سكر الدم (r=−0.14) وبين مؤشر أوميجا3 ومستوى الدهون الثلاثية في الدم (r=−0.11).

الخلاصة

استنتجت الدراسة على وجود علاقة خطية بين مؤشر أوميجا 3 والمتناول من احماض أوميجا 3 الدهنية. أي أنه كلما زاد المتناول، كلما زاد مؤشر أوميجا 3. واستنتجت الدراسة ايضا الى ان الاستهلاك الكافي من احماض اوميجا 3 الدهنية له تأثير خافض على مستوى السكر في الدم، ونسبة هيموغلوبين السكري ومستوى الدهون الثلاثية في الدم.

التوصيات

نوصي أصحاب المصلحة بتقييم مؤشر أوميجا 3 بين مرضى السكري من النوع الثاني في كريات الدم الحمراء بدلا من البلازما وتطبيق الدراسة على مرضى السكري من النوع الثاني في كل مدن فلسطين.

الكلمات الأساسية

كمية احماض أوميجا3 المستهلكة، مؤشر أوميجا3، مرض السكري من النوع الثاني، كروماتوجرافياالغاز، قياسات التحكم.