An-Najah National University

Faculty of Graduate Studies

DEVELOPMENT AND VALIDATION OF SMART-PHONE APPLICATION FFQ SCREENER FOR ASSESSING CHOLESTEROL INTAKE AMONG PALESTINIAN POPULATIONS

By

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Dedication

This thesis is dedicated to my parents, who taught me that a person will be strong with his knowledge and education, and who provided me with all the support I needed to pursue higher education.

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First, I would like to thank Dr. Manal Badrasawi, my supervisor, for all the support and assistance throughout my work in completing this thesis.

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Declaration

I, the undersigned, declare that I submitted the thesis entitled:

DEVELOPMENT AND VALIDATION OF SMART-PHONE APPLICATION FFQ SCREENER FOR ASSESSING CHOLESTEROL INTAKE AMONG PALESTINIAN POPULATIONS

I declare that 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.

Student's Name: آمنة حسن أحمد عبد العال

Signature:

Date: 21/10/2023

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DEVELOPMENT AND VALIDATION OF SMART-PHONE APPLICATION FFQ SCREENER FOR ASSESSING CHOLESTEROL INTAKE AMONG PALESTINIAN POPULATIONS

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Abstract

Background: Cholesterol is an essential material existing in each animal cell and has many functions that are related to the body's health. However, additional intake of dietary cholesterol is related to elevate cardiovascular diseases (CVDs) incidence. The US Department of Agriculture (USDA) recommends cholesterol intake to be lower than 300 mg/day. On the other hand, using technology in diet assessment is considered an effective and alternative way to conventional procedures such as food frequency questionnaires (FFQ). The study aimed to develop and validate an FFQ screener of dietary cholesterol intake assessment using a smart phone app. among the Palestinian population.

Methodology: One hundred participants from Palestinian populations, were shared by convenient sampling, aged from 18-60 years. The study was done in five stages; stage 1: development of FFQ screener. Stage 2: development of the app (Pal Chol app ®). Stage 3: content validity. Stage 4: test and re-test reliability. Finally; stage 5: criterion validity. Correlation; was done by Pearson correlation to assess the reliability and validity, and the difference between means was done also for the validity test. P-value<0.05 is considered statistically significant.

Results: In the pilot study, there was a significant (strong) correlation (r=0.7, p-value=0.000) between the test and re-test results. For the validation study; the mean age was 26.24 ±7.15 years. The mean difference between cholesterol intake from the app. and 3 days of food recall was significant (p-value=0.000), and for a correlation; there was a correlation but week (r=0.31, p-value=0.006). Furthermore, the usability test of the app.

was compared with 3 days of food recalls; the majority of participants confirmed the usability of this app.

Conclusions: In our study, we were successful; in developing an FFQ screener; that specialized in the assessment of dietary cholesterol intake among the Palestinian population aged between 18 to 60 years. Nevertheless, we need further improvement and revision on the app.

Keywords: CVDs, dietary cholesterol, FFQ screener, validation studies

Chapter One

Introduction

1.1 Background

Cardiovascular diseases (CVDs) diseases that influence the heart and blood vessels, like coronary heart disease, stroke, and heart failure (1). CVDs considered one of the main reasons for impairment and even death in both genders in about all countries (2). Ischemic heart disease is considered the first cause of mortality among the top ten reasons for death globally in 2008, according to the classification of the World Health Organization (WHO); this estimated around 12.8% of deaths, the next reason is stroke and other cerebrovascular diseases in proportion about 10.8%(3). Risk factors for CVDS are many, and they can collect into two groups: modifiable risk factors and non-modifiable risk factors (1). Examples of the non-modifiable risk factors: genes, sex, age, and the human race (1). The second group is modifiable risk factors which contain obesity, high blood stress (hypertension), bad lipid profile (dyslipidemia), high blood sugar (diabetes), and life habits such as; smoking, poor dietary choices, and sedentary lifestyle (1,2).

Cholesterol is an important constituent present in each animal cell, with a chemical structure containing four combined circles of a steroid center (3). Cholesterol plays an important role in the membranes of animal tissues and other functions: a precursor for vitamin D and bile acids that help in the digestion and absorption of lipids, and various steroid hormones; adrenal and gonadal hormones (3–5). Foods that contain cholesterol are eggs, specifically the yolk (yellow part), beef, chicken, fish/seafood, ham, dairy products, butter, etc. (6). There are two types of cholesterol: endogenous cholesterol; which is synthesized in the body, specifically in the liver, and accounts for almost 70% of the total cholesterol, and exogenous cholesterol; which comes from the diets, then absorbed by the intestine and accounts for around 30% of the pool of cholesterol in the body (4,7). Due to the nature of cholesterol, it can't solve in blood and needs particles that package cholesterol to transfer in the blood; these molecules are called lipoproteins or Apo-lipoproteins: as HDL or high-density lipoprotein which is considered "well cholesterol", LDL or low-density lipoprotein and which is considered "bad cholesterol", VLDL or very-low-density lipoprotein, and chylomicron (3,4).

Cholesterol from the diet is related to elevating the cardiovascular disease risk (6). Therefore, the evaluation of diet consumption is considered the primary stage before any alteration of the therapeutic diet system (8). There are many methods of dietary evaluation, but there are three types popular used in this process: food record, 24-hour food recall, and food frequency questionnaire (FFQ) (9).

There are various screeners or dietary assessment tools produced in conditions that do not need to evaluate all diet intake (10). However, the researchers are concerned only with assessing the intake of specific foods or nutrients using a short questionnaire that has been developed and checks the validity by comparing it with methods of diet assessment: food record, 24-hour food recall, or FFQ (10). An example of these tools or "screeners" is MEDFICTS; a tool to evaluate compliance to the low total fat, saturated fat, and dietary cholesterol diets (10).

The traditional way to measure the consumption of diets depends on self-reported tools such as 24-hour diet recall, food records, and FFQ (11). Each of these instruments has disadvantages and weak points whether in reliability or validity (11). Utilizing technology in dietary assessment has many benefits as lowering the costs, and burdens of collecting and processing the data from diet intake; these technologies are user attractive, easy to access, and available (9,11). Using software on computer devices, applications on the web, or a smart-phone specialized in diet evaluation are examples of these technologies (11).

From this idea, the FFQ screener that is specific for assessing cholesterol intake was developed and then converted to the application among the Palestinian population, and that helps in first-degree heart disease patients.

1.2 Significance of the study

CVDs and CHD; are considered as main public health issues; globally (12). In the Middle East; death due to CVD is higher than death worldwide (12). Many risk factors are related to increasing the occurrence of CVDs, in Palestinian regions, particularly the occupied regions (13). Moreover, heart disease was recorded to be the first reason for mortality, with a proportion of 21.0% of total deaths in 2005 (13). According to the Palestinian Ministry of Health (MOH) documents, CVDs are considered the first leading cause of mortality among the ten fatal non-communicable diseases; in percent of 29.5% in 2014 (14).

However, diet and feeding; are considered the main risk causes for CVDs, such as dietary cholesterol (6,15). In many studies, compliance with healthy diets; is related to decrease CVD death (12).The dietary assessment considers the main step in the therapeutic diet system (8). There are many conventional ways; that assess the diet, such as 24-hour recalling, food recording, and FFQ; each method has advantages and disadvantages (16). Progression in the technology allowed the enhancement of these ways (16). Smartphone apps; are considered one of these technology (16). Furthermore, utilizing phone technology in diet assessment is helpful; in preventing and controlling diseases (16).

This study is considered the first that developed an FFQ screener specialized in assessing cholesterol intake in Palestinian society. Therefore, the Pal Chol app. will aid in the precise assessment; of dietary cholesterol; thus, people will pay attention and monitor their cholesterol intake. Furthermore, acquiring knowledge and awareness in many aspects like the normal limit of cholesterol intake, cholesterol from animal sources only, etc. However, the FFQ screener; will be used in researches, hospitals, and nutrition clinics to keep and control the patient's health (particularly heart patients). Additionally, develop effective diets or medicine for these patients.

1.3 Objectives

1.3.1 Main objective

To develop and validate an FFQ screener of dietary cholesterol intake assessment, using smart-phone adapting to Palestinian food culture.

1.3.2 Specific objectives

1 To determine and choose the Palestinian dishes, which contain cholesterol and exists only in animal sources.
2 To develop a food frequency questionnaire using a smart-phone app. for assessing dietary cholesterol intake among the Palestinian population.
3 To validate the FFQ screener using the smart-phone app.
4 To examine the usability and user satisfaction of using this app.

Chapter Two

Literature Review

2.1 Cardiovascular diseases definition and types

CVDs are chronic and non-communicable diseases that impact the heart and blood vessels (1,17). CVDs include many diseases, such as diseases that belong to the heart muscle and the circulatory system that provide support to all organs, especially to the heart and brain (18). Examples of these diseases are hypertension (an increase in blood pressure), coronary heart disease, failure of the heart, and stroke (1). Hypertension: existence of chronic high blood pressure over the normal limit (19). The normal values of blood pressure; are less than 120 mmHg for systolic blood pressure and less than 80 mmHg for diastolic blood pressure (20). Heart attack: incidence of coagulation of the blood in the veins, thus causing the stopping of the blood passage to the heart (myocardial infarction). When repeating this event, the cardiac muscle begins to die (21). Stroke: a mute infarction of mental, spinal, retinal, and even mute hemorrhages, according to the American Heart Association or American Stroke Association in 2013 (22). Coronary heart disease or coronary artery disease: formation of blood clots in the coronary veins of the cardiac muscle, so prevention of the passage of the blood then causes deterioration of the heart (23). Ischemic heart disease: insufficient access to oxygen to the cardiac muscle cells (23).

2.2 Burden of cardiovascular diseases

CVDs are the major reason for morbidity and mortality in the United States, there are approximately 62 million persons suffering from CVDs in this country (24). In the early twentieth century, CVDs were the reason for lower than 10% of deaths in the world, but in 2001 the percentage raised to 30 (18). In the year 2001, nearly above than 38 percent of deaths happened because of CVDs in the USA, and approximately 3/4 of these deaths were because of coronary heart disease (CHD) and stroke (25).In 2003, heart disease and stroke caused about 34.4 % of the 2.4 million deaths in the USA (26). In the year of 2009, around 811,940 people die because of CVDs; a ratio of 32.8 percent of all deaths in the USA (1). In the year 2014, the death ratio because of CVD was 295.63/100,000 people in rural regions and 261.99/100,000 people in urban regions, death because of CVD is higher in rural regions than urban regions since 2009(27). The percent of death in 2014 due to CVD was 44.60% and 42.51% of all deaths in rural and urban regions, sequentially

(27).Saudi Arabia, United Arabic Emirates, Bahrain, and Qatar countries with mortality rates from CVDs were 42%, 38%, 32%, and 23% subsequently (28). CVDs were documented as a primary reason for mortality in Palestine country in a range of 29.5% in 2014 (28). In the year 2016, ischemic heart disease was the reason for the death of about 1.7 million people, and the second leading reason of mortality in China (29). The expectation said by the year 2020, CVDs will be the most reason for morbidity and mortality in the world, predominantly in low and moderate-income countries (18). Ischemic heart disease (IHD), stroke, and congestive heart failure (CHF) are disorders that contribute at the minimum 80 percent of the load of CVD in all income areas (low or mid or high income), the fourth aspect is rheumatic heart disease (RHD), which contribute 3 percent of the load of CVD (18).

2.3 Risk factors of cardiovascular diseases

There are eight risk causes for CVDs according to the National Heart, Lung, and Blood Institute of the US National Institutes of Health (30). Risk factors can be classified into modifiable and non-modifiable risk factors (18,30). Modifiable risk factors can be classified into biological causes which include: hypertension, diabetes, and bad cholesterol, and lifestyle causes that include: smoking, lack of exercise, and obesity (30). Poor food choices, dyslipidemia (bad lipid profile), and bad emotional conditions (mood disorders including stress) are also related to the modifiable risk factors of CVDs (17,21). Diets contain a high ratio of fats, and calories leading to dyslipidemia (17). Furthermore, blood TG, TC, LDL, HDL, TC/HDL, and LDL/HDL proportions are independent risk factors for CVDs (17). The non-modifiable risk factors for CVDs are genes, age, sex, and human race (18,30).

2.3.1 Modifiable risk factors

2.3.1.1 Smoking

Epidemiologic studies confirm the existence of an association between tobacco and the occurrence of myocardial infarction and mortal coronary artery disease in both genders (31). Cigarette smoking enhances atherosclerosis, by influencing lipid profile(31). Smoker persons have significantly elevated cholesterol in the blood, triglyceride, low-density lipoprotein, and low levels of high-density lipoprotein in comparison with non-smoker persons (31). The INTERHEART conducted a case-control study; that registered

15152 as cases and 14820 as controls from 52 countries to assess the primary MI (32). The study found; the odds ratio for MI was 2.87 in recent smoker's persons with a comparison of persons who never smoked (32).

2.3.1.2 Diabetes

High blood sugar considers a strong and separate risk factor for cardiovascular diseases (33). Epidemiological studies revealed a relationship between high blood sugar and the incidence of cardiovascular disease in the United States, whether the people are young or old, from both sexes and strains (33). CVDs are the main reason of death and disability in people with type 1, and type 2 diabetes (34).

The INTERHEART case-control study tested the relationship between self-report of diabetes mellitus and the incidence of MI in 15152 cases and 14820 controls group in 52 countries; the odds ratio was 2.37 (35). Likewise, the INTERSTROKE case-control study studied the relationship between self-report of diabetes mellitus and the incidence of stroke in 13447 cases and 13472 controls in 32 countries; the odds ratio was 1.16 (35).

2.3.1.3 Obesity

Elevate body mass index (BMI) is related to the progression of cardiovascular risk factors such as high blood pressure, bad lipid profile, and diabetes thus, causing cardiovascular disease (36). However, BMI and obesity are reported as independent risk causes for CVD (36). Various studies revealed that elevated BMI is significantly related to co-morbidities of CVD as myocardial infarction (MI), failure of the heart, and even unexpected death (36).

The INTERHEART case-control study tested the relationship between abdominal obesity and the incidence of MI in 15152 cases and 14820 controls group in 52 countries; the odds ratio was 1.62 (35). Likewise, the INTERSTROKE case-control study studied the relationship between abdominal obesity and the incidence of stroke in 13447 cases and 13472 controls in 32 countries; the odds ratio was 1.44 (35).

2.3.1.4 Physical activity

The practice of physical training is related to a decreased risk of CHD, and even cardiovascular death in mid-age (37). Furthermore, the exercises are demonstrated to relate to a decreased risk of stroke (37). A meta-analysis study in occupational cohorts in the year 1991, briefs the effect of exercise on the mortality due to CHD; the relative risk (RR) was 1.9 for non-active persons compared with high active (37).

In another study on 40417 women ages between 55 to 69 years that follow-up of the study for 7 years after (37). A study found an elevating frequency of moderate exercises, such as light activities, and walking for a long time (four categories; from rare or never doing these sports to at least four times per week) was related to decreased risk of CVD death (RR was 1.0, 0.86, 0.74, and 0.53, respectively (37).

2.3.1.5 Stress

The INTERHEART researches, revealed that long-period exposure to stress is related to the risk of acute myocardial infarction, in addition to the exposure to traditional or normal risk causes like tobacco use, high blood insulin, high blood pressure, obesity, etc. (38). The odds ratio for persons who are exposed to long-period stress with traditional risk causes for MI was more than double (the elevation from 69 to 183) (38).

2.3.1.6 Dyslipidemia

Defined by a rising in total blood cholesterol, low-density lipoprotein cholesterol, or triglycerides and decreasing in the high-density lipoprotein cholesterol in the blood (17). Serum cholesterol elevation contributes to the rising cardiovascular risk (39). Also, the risk of stroke, coronary heart disease, and all cardiovascular mortality reduce with the reduction of total cholesterol in the blood (39). Researches demonstrated that improving high blood lipids reduces cardiovascular disability and deaths (40). A meta-analysis by Hokanson and Austin of 17 population-based prospective researches, found the RR=1.32 (95% confidence interval (CI) 126-1.39) for triglycerides in men and RR=1.76 (95% CI 1.50-2.07) in women (41). After that, HDL and many risk causes, were adjusted, and the RR becomes 1.14 (95% CI 1.05-1.28) in men and 1.37 (95% CI 1.13-1.66) in women (41). However, in women; triglyceride levels are twice as potent related to CHD risk (41).

2.3.1.7 Diet

The definition; of quality of the diet: is compliance with the advised dietary habits and/or, consumption of dietary habits related to a decreased risk of CVDs and other chronic diseases (42). Furthermore, Dietary Guidelines for Americans 2020-2025, AHA/ACC, and the NLA; advised high consumption of vegetables, fruits, whole cereals, legumes, seeds and nuts, low-fat dairy products, un-processed lean meats and chicken, and fish (42). Also, lower consumption of foods that contain saturated fats, added sugars, and sodium (42). These guidelines focused on saturated fat; in another mean, for general health (advised to intake less than 10% calories), for control of lipids or lipoproteins (advised to intake lower than 7% calories), and for control or stopping CVD (advised to intake from 5-6% calories) (42).

The INTERHEART case-control study tested the relationship between a healthy diet and the incidence of MI in 15152 cases and 14820 controls group in 52 countries; the odds ratio was 0.70 (35). Likewise, the INTERSTROKE case-control study studied the relationship between a healthy diet and the incidence of stroke in 13447 cases and 13472 controls in 32 countries; the odds ratio was 0.60 (35).

Trichopoulou et al. 2003 developed a Mediterranean Diet Score (MDS), which contains eight constituents features of a Greek Mediterranean diet (high ratio of monounsaturated fat to saturated fat, mild consumption of alcohol, high consumption of legumes, grains (such as bread and potato), vegetables, fruits, and low consumption of meat and meat products, milk and dairy products (42). Further constituents joined to the main MDS to achieve a ten-degree MDS (42). Trichopoulou et al. 2003determined that a two degree elevates in the ten degrees MDS was related to a significant decrease in the risk of all causes (HR 0.75, 95% CI 0.64-0.87), CHD (HR 0.67, 95% CI 0.47-0.94), and cancer (HR 0.76, 95% CI 0.59-0.98) death in a Greek cohort study (42).

Fung et al. 2008 developed the Dietary Approaches to Stop Hypertension score (DASH), which contains eight food and nutrient constituents such as vegetables, fruits, whole cereals, legumes and nuts, low-fat dairy products, red and processed meats, sugared drinks, and sodium (42). From the analysis of the data from the Nurses' Health Study; the high compliance to DASH score related to low risk of total CHD (RR 0.73, 95% CI 0.64-0.84), deathly CHD (RR 0.66, 95% CI 0.52-0.83), non-deathly CHD (RR 0.78, 95% CI

0.66-0.91), and total stroke (RR 0.83, 95% CI 0.71-0.96) in comparison with low compliance persons (42).

In a case-control study; by Amani et al. 2010 on 216 participants with CAD and those without CAD, results revealed the intake of trans fat and full-fat yogurt; was higher related to the risk of CAD (OR 2.12, 95% CI 1.23-3.64, and 2.35, 95% CI 1.32-4.18 respectively), and elevate consumption of seafood, vegetable oils, and black tea was higher related with lower risk of CAD (12).

Hu et al. 2000 demonstrated an elevating of Western dietary habits points (red meats, processed meats, refined cereals, confectionery and desserts, French fries, and high-fat dairy foods); related to elevated risk of CVD (12).

Moreover, Southern dietary habits are distinguished by (adding lipid, fried foods, eggs, organ, processed meats, and sugar-sweetened drinks) was associated with acute CVD with HR=1.56, 95% CI 1.17-2.08 for the highest quartile when compared with the lowest one (12).

In the Asian community, a diet rich in meats; is positively related to an elevated risk of CVD death (12). On the other hand, in the Middle East and North Africa areas, there is a higher relationship between Western dietary habits and elevated risk of CHD, strokes, and related risk causes among adults (12).

2.3.2 Non-modifiable risk factors

2.3.2.1 Genes

The existence of coronary heart disease in the ancestral tree, especially; from the original degree of a family (parents, children, brother, or sister) considered as the main risk cause of coronary heart disease (43).

2.3.2.2 Gender

Men have a high risk to developed coronary diseases than women, and in women, the risk is delayed around 10 to 15 years in comparison with men (43).

2.3.2.3 Age

The risk of developing coronary disease, elevated with the elevated age in both sexes (10). This is attributing to the advancing of bulk of fats in the arteries (causing hardness of the arteries) (43).

Whenever a person gets older, the cholesterol levels increase (44). However, in women before menopause, total cholesterol levels are low compared with men of the exact age (44). While after menopause; the LDL cholesterol levels will be high (44).

2.4 Dietary recommendations that maybe prevent CVDs

Some interventions will decrease CVD occurrence, such as stop of tobacco use, changing diet habits (decreasing lipids consumption; instead of this intake of mono-unsaturated fats from olive oil, intake of vegetables and fruits), and doing exercise that improves the heart muscle (18,45,46). Heart rehabilitation by physical activity is helpful for many patients that have CHD, thus decreasing future vascular diseases by around 15% (18). Furthermore, physical activity alone decreases vascular deaths by percent 24% (18).

Dietary recommendations advise many types of diet that improve health and decrease the risk of chronic disorders such as CVDs (47). These recommendations include eating wide kinds of vegetables, fruits, whole grains, low-fat dairy products, seeds, nuts, and vegetable oils (47). On the other hand, some nutrients should be limited intake as: saturated fat, added sugar, sodium, and even cholesterol according to some of the dietary guidelines (47).

According to the AHA/ACC Lifestyle Guideline to Reduce Cardiovascular Risk in 2013, there is potent evidence that confirms the intake of vegetables, fruits, whole grains, low-fat dairy products, legumes, poultry, fish, non-tropical vegetable oils, and nuts; further, limiting the consumption of sweets, sugar-sweetened drinks, and red meats is interesting for people who would decrease blood pressure and low-density lipoprotein (LDL) (47). Furthermore, AHA/ACC dietary guidelines limit saturated fat consumption to 5-6 percent of calories, and sodium to lower than 2400 mg per day is interest for people who would decrease LDL cholesterol, and blood pressure, respectively (47).

NLA advises food patterns that contain a wide types of plant and lean protein foods, like the Dietary Approaches to Stop Hypertension diet approach, US style Diet, AHA diet,

Mediterranean diet, or vegetarian/vegan diets, that control lipid profile (dyslipidemia) (47). Also, NLA advises restricting the intake of saturated fat to lower than 7% of calories, cholesterol to lower than 200 mg per day, and Trans fat to lower consumption (47). Dietary recommendations for Americans from 2015 to 2020, advised intake less saturated fats and replacing them with unsaturated fats, particularly polyunsaturated fats (47).

Evidence revealed people who intake much fruits and vegetables; have lesser development of CVD risk causes such as: high blood pressure, obesity, and type 2 diabetes (48). There is a relationship (opposite) between the consumption of fruits and vegetables and the prevalence of CVD like CHD and stroke (48). Vital mechanisms that make the fruits and vegetables like this not clearly defined, maybe because of the phytochemicals that founded in them, in addition to the existence of fiber, folate, potassium, and many nutrients; that are responsible to lower risk factors for CVDs (48).

2.5 Cholesterol definition and functions

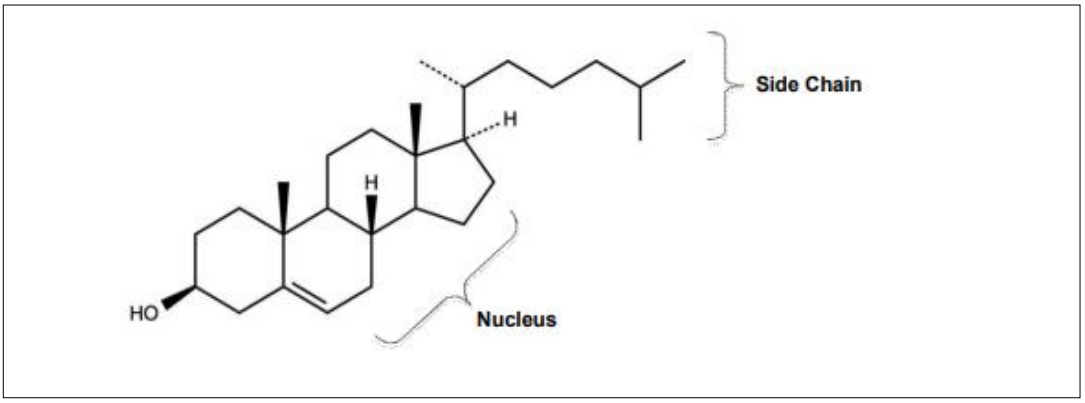
Cholesterol is a waxy material that exists in the membranes of the cells exactly in animal cells, thereby giving the hardness and strength of it (3,43,49). Cholesterol is important to do many functions such as making sex hormones (steroid hormones), a precursor of vitamin D, and bile acids that are important for the digestion of lipids (49).

2.6 Chemical structure of cholesterol

Cholesterol consists of four integrated circles with steroid nuclei; 3 circles contain 6 carbons, whilst the fourth one contains 5 carbons (3). Cholesterol is characterized as an amphiphilic/amphipathic particle that contains both hydrophobic tail (non-polar) and hydrophilic head (polar) regions (3). Figure 2.1illustrates the chemical structure of cholesterol (4).

Figure 2.1

Chemical structure of cholesterol



Kapourchali FR, Surendiran G, Goulet A, Moghadasian MH. The role of dietary cholesterol in lipoprotein metabolism and related metabolic abnormalities: a mini-review. Crit Rev Food Sci Nutr. 2016;56(14):2408–15.

2.7 Cholesterol types in the body

There are two origins of cholesterol: exogenous cholesterol (formed around 30 percent of the total cholesterol and we get from foods that contain cholesterol then absorbed via the intestine), and endogenous cholesterol (formed approximately 70 percent of the total cholesterol which is synthesized in the body specifically in the liver) (4,7,50).

In children, the most cholesterol in the body is obtained by the diets not from the body synthesis, because the body tissues and cells may be didn't evolved sufficiently (4). Likewise, in elderly people, the body cells perhaps aged and become ill (4).

Dietary cholesterol exists in two forms: free and esterified; the free one is easy to absorb, while the esterified need to hydrolyze to get fatty acids and cholesterol fractions (4). For instance, these fatty acids are palmitic and stearic fatty acids, which can enhance the synthesis of cholesterol (4).

The main holder of cholesterol from foods in the blood is chylomicron cholesterol molecules, whilst the main holder of synthesized cholesterol is LDL cholesterol molecules (which were synthesized by the liver and then changed to VLDL, and in the end to LDL molecules) (4).

2.8 The balance between the exo and endo/genous cholesterol

The body can make cholesterol, thereby does not need to consume cholesterol from the diet (5). However, the body regulates the process of intake and synthesis of exo and endo/genous to keep the balance of cholesterol (5). An elevation of dietary cholesterol (exogenous) is attached to reducing the cholesterol made by the body (endogenous) (4). In another mean, if a person digests little amount of dietary cholesterol (like in vegan people), the body will control the process of absorption and synthesis (3,5). Moreover, if the person intakes a large amount of cholesterol, the body will elevate the secretion of cholesterol and will reduce the synthesis else (3,5).

2.9 Cholesterol types in the blood (Lipo-proteins)

Cholesterol cannot join with blood because of its aquatic nature, therefore need molecules to hold and transport through blood called; lipoproteins (3,49). Lipoproteins or Apo-lipoproteins are protein-packaged particles made by the body to coat lipids (3). Many types of lipoproteins are present in blood as high-density lipoprotein, low-density lipoprotein, very low-density lipoprotein, and chylomicrons (43).

For physicians, a total serum cholesterol value of 200 mg/dl is considered a reference value. In other mean; for any increase in this value above 200 mg/dl, the physicians should do an assessment and/or intervention for these patients (51). According to the National Institutes of Health Consensus Development Conference on Lowering Blood Cholesterol to prevent Heart Disease for adults persons at moderate and high risk of CHD who need treatment or intervention: persons aged between 20 to 29 years with total serum cholesterol above 200mg/dl are considered at moderate risk of CHD and above 220 mg/dl for persons at high risk, while persons aged between 30 to 39 years, with total serum cholesterol above 220 mg/dl are considered at moderate risk and above 240 mg/dl for persons at high risk, and for persons ages 40 or above with total serum cholesterol >240 mg/dl considered at moderate risk and >260 mg/dl for persons at high risk (51).

On the other hand, the National Cholesterol Education Program advised two LDL values: all people should decrease their LDL level to lower than 160 mg/dl, while patients with heart attack, stroke, peripheral vascular disease, or any two of these risk causes (male, genes, hypertension, smokers people, HDL level <35 mg/dl, diabetes, or obesity); in these cases, LDL level should be <130 mg/dl (51).

2.9.1 High-density lipoprotein (HDL)

When the percentage of proteins to lipids in lipoproteins is large, this is called high-density lipoprotein or HDL (3). Forms around; 20 to 30 % of the total cholesterol in the blood (43). This type of cholesterol is associated with the risk of developing cardiovascular diseases oppositely; intended an increase in HDL cholesterol causes a decrease in cardiovascular risk (43). The presence of HDL cholesterol in blood works in defending against atherosclerosis in several studies (43). HDL cholesterol holds cholesterol from tissues to the liver which, in turn take out from the body (52).

2.9.2 Low-density lipoprotein (LDL)

When the percentage of proteins to lipids in lipoproteins is little, this is called low-density lipoprotein or LDL (3). Forms around; 60-70 % of total cholesterol in the blood (43). It is considered the main lipoprotein that causes atherosclerosis (43). LDL cholesterol holds cholesterol to the vessels and tissues (52).

2.9.3 Very low-density lipoprotein (VLDL)

Forms around; 10 to 15 % of total cholesterol in the blood (43). The liver makes VLDL; which in turn help of making LDL (43). There are many kinds of VLDL, VLDL residues; that enhance atherosclerosis and it is rich in cholesterol ester (43).

2.9.4 Chylomicrons

A type of lipoprotein that is full of triglycerides, it is synthesized by the intestine from food containing lipids, after consuming a food incorporated with lipids (43).

2.10 Recommendations for cholesterol intake

Recommendations of the National Lipid Association (NLA) for Patients-Centered Management of Dyslipidemia In 2015 and TLC Diet restrict intake of cholesterol to lower than 200 mg/day (43,47). In contrast, the US Department of Health and Human Services (HHS) and the US Department of Agriculture recommended cholesterol intake to be lower than 300 mg/day (47). Furthermore, American Heart Association advised the population without any disease to keep the cholesterol intake lower than 300 mg daily and lower than 200 mg daily for people with a high risk of developing CVD (4). According to the National Cholesterol Education Program, instructions advise cholesterol

intake to be lower than 300 mg daily (50).Saturated fats, Trans fat, and cholesterol in the diet elevate cholesterol levels (44). Therefore, decreasing the quantity of saturated fats, Trans fat, and cholesterol assists in decreasing cholesterol levels in the blood (44).

2.11 Sources of dietary cholesterol

All kinds of foods of animal sources include cholesterol such as meats, especially red meats, yellow part of eggs, seafood, dairy products, and animal butter (6,44). Food items that consist of cholesterol are beef, lamb, pork, chicken, convenience foods, and fish/sea foods (52). High amounts of cholesterol exist in meat organs such as (the brain, kidney, heart, liver, tongue, etc...), eggs in all types mostly, fish oils, and types of fish like (sardine, salmon, etc...) (52). National Health and Nutrition Examination Surveys (NHANES) information between US adults in 2001-2014; considered meat, as the first dietary origin of cholesterol and eggs, as the dominant origin among people with high consumption of cholesterol (52). Table 2.1 shows some foods that contain cholesterol in mg.

Table 2.1

Food groups, food items that contain cholesterol, and the amount of cholesterol in these foods

Food group	Food type is presented in household measurements and grams (gm) (55)	Cholesterol content in milligrams (mg)
Egg	One large egg boiled or	186
	Two large	424
Butter	One tablespoon	31
Meat	113.25 gm of beef liver	326
Meat	84 gm of ground beef broiled: (70 lean/30 fat before cooking) or (80 lean/20 fat before cooking) or (95 lean/5 fat before cooking) or (97 lean/3 fat before cooking)	75
Poultry	84 gm of a chicken drumstick, with skin, and roasted or	110
	84 gm of a chicken drumstick, without skin, and cooked	75
Poultry	84 gm of a chicken breast, with skin, and roasted or	71
	84 gm of a chicken breast, without skin, and roasted	72
Milk	One cup of milk (Full-fat) or	24
	One cup of milk (2% fat) or	20
	One cup of milk (1% fat) or	12
	One cup of milk (skimmed milk)	5
Dairy products	56 gm of cheese (cheddar)	59
Chocolate	42 gm of milk-chocolate bar	10
Ice-cream	One cup of ice cream (vanilla)	129
Seafood	84 gm of shrimp, cooked or	161
	84 gm of lobster, cooked or	124
	84 gm of salmon, cooked or	60
	113.25 gm of oysters	7

* Carson JAS, Lichtenstein AH, Anderson CAM, Appel LJ, Kris-Etherton PM, Meyer KA, et al. Dietary cholesterol and cardiovascular risk: a science advisory from the American Heart Association. Circulation. 2020;141(3):e39–53 .

* Connor WE, Connor SL. Dietary cholesterol and coronary heart disease. Curr Atheroscler Rep. 2002;4(6):425–32.

2.12 The relationship between cholesterol and the incidence of CVDs

Several modifiable risk causes are responsible for the progression of CVDs (4). One of these causes is the amount of cholesterol in serum, known as the main risk cause for the hardness of the arteries, and thus leads to CVD (4). Many studies demonstrated a relationship between total and LDL cholesterol levels and having coronary artery disease (CAD) (4). While; HDL cholesterol in an opposite relationship with the occurrence of CAD (4).

However, the influence of exogenous cholesterol on the elevation of CVD has not been completely determined. Moreover, some studies revealed a positive relationship, while other studies did not reveal this association (4).

The effect of exogenous cholesterol independently on the elevation of total cholesterol levels in the blood differs from person to person (4). In other meaning, some individuals are highly affected (hyper responders) by cholesterol; their bodies absorb exogenous cholesterol in an effective way more than lower affected people (hypo responders) (4). Furthermore, levels of LDL and HDL cholesterol in the blood for hyper responder's people were elevated after intake of exogenous cholesterol, while the proportion of LDL/HDL was not affected (4). Likewise, for hypo responder's people, the levels of cholesterol in the blood will not alter greatly (significantly) (4).

In Mayurasakorn et al. study in 2008 found an intake of 200 mg of cholesterol from foods daily perhaps increased the HDL cholesterol, with no alteration of LDL cholesterol thus, will decrease the proportion of LDL/HDL, so maybe decreasing the CV risk (4).

A study revealed an opposite relationship between HDL cholesterol and CHD risk, and a positive relationship between LDL cholesterol and CHD incidence (56).

Many studies have shown that increased consumption of dietary cholesterol is not related to the elevation of CV occurrence (6). Results from cohort studies were scattered, and restricted from conducting meta-analyses for CVD results (6). For intervention studies or tests, there was an influence (significantly) of cholesterol consumption on total serum cholesterol, low-density lipoprotein, and LDL/HDL proportion (6). This elevation in total and LDL cholesterol is not prolonged significant in studies with intervention quantities above 900 mg daily (6). As regards to, HDL cholesterol also elevated with elevated consumption of cholesterol, specifically in randomized searches and studies with intervention amounts between 650 to 900 mg daily (6). Furthermore, in very low-density lipoprotein and triglycerides, there is no relationship between them and elevated amounts of exogenous cholesterol (6).

A study that investigated the cholesterol from foods (exogenous cholesterol) doesn't elevate the risk of cardiac disease in a healthy population but many studies, have shown that saturated and Trans fats elevation the cardiovascular disease incidence (57).

Cholesterol from foods is popular in diets that contain saturated fats, due to this theory; it is believed that cholesterol is an atherogenic factor (57).

Most European countries have no guidelines about dietary cholesterol consumption but, they are concerned about decreasing saturated and Trans fats due to having a powerful influence on risk causes of CVD, particularly lipid and lipoproteins profiles (58).

Epidemiological and clinical trials show intake of one egg daily is not related to the risk of CHD or incidence of stroke in healthy populations, whilst intake of above seven eggs weekly is related to elevated risk in several investigations (58). There is a difference in patients with type 2 diabetes, whose elevates in consumption of dietary cholesterol relates with CV risk (58).

A meta-analysis in 2016 of seven prospective cohort studies evaluated the risk of CVD effects, with high egg consumption (almost one egg per day) compared with low egg consumption (lower than two eggs per week) (47). The results showed; association between egg consumption and CHD was not significant, while the risk of stroke decrease by 12 percent (RR 0.88, 95% CI 0.81-0.97) with higher egg intake (47).

A meta-analysis study of individual respondent data from six ethnically diverse US prospective cohorts demonstrated there was a positive relationship between both cholesterol from foods and egg intake and CVD risk (1.17, [95% CI: 1.09-1.26]) (53). In another mean, any further half-egg intake/day was related to a significant elevate in CVD risk (1.06, [95% CI: 1.03-1.10]) (53). However, the relationship between egg consumption and CVD is not important, after adjustment of cholesterol from diets (53).

Five researches tested the relationship between CHD mortality and cholesterol consumption; 3 researches revealed that elevated cholesterol consumption (from 378 to 500 mg daily versus from 81 to 189 mg daily) was related to a high risk of CHD (47). While, 2 researches demonstrated no relation (less quintile< 390 mg daily), and (mean 607 mg versus 83 mg daily) (47).

A meta-analysis of studies, testing the relation between ischemic stroke and hemorrhagic stroke had major homogeneity; the results demonstrated no significant relationship between cholesterol consumption and ischemic stroke (RR 1.13, 95% CI 0.99-1.28 n=5) or hemorrhagic stroke (RR 1.09, 95% CI 0.79-1.50 n=3) (47).

In a study that investigates the hazard ratio for CHD mortality, between high cholesterol intake groups (289-590 mg of cholesterol/1000 kcal) and low cholesterol intake groups (81-186 mg of cholesterol/1000 kcal) was higher in high cholesterol intake groups; with proportion of 38% (RR 1.38, 95% CI 1.00-1.90) (59).

2.13 Diet assessment definition and types

Collection of data about food items and beverages consumed by persons over a particular time, then processing these data by specific programs to analyze the compositions of foods such as energy and other nutrients (60). There are many methods to evaluate the diet, but there are 3 types popular used in this process: food record, 24-hour food recall, and FFQ (9). Each one has points of power and limitations (9).

2.13.1 Food record or diary

The replier records the quantity of all the food items and drinks that are consumed for several days, usually; the period was for one week (7 days), and the person records eating time to avoid forgetting what was eaten (9,10). This method can be done in 2 ways: estimate food record; estimate the amounts or quantity using images, models, etc., and weight/measure food record; weight the amounts of foods using a balance or household weights such as cups, spoons, plates, etc. (10). The advantages/Strengths of this method are many such as can reduce the error from reliance on memory (9,10). While examples of the disadvantages or limitations are: reactivity error (the person may alter the diet because of the food recording; the person may eat lower than the usual amount/simple food items to avoid the tired from recording, needing high performance in reading and writing skills, and requesting from the replier to register the foods and drinks that are consumed many times of the day, causing boring and thereby pulling out from the participation (9,10).

2.13.2 24-hour diet recall

The well-trained interviewer asks the replier to recall/remind all the food items and drinks that are consumed in the previous 24- hours or on the previous day, the interview can be conduct this process face to face or by calling the replier by telephone (9,10). An advantage of this method: does not need the knowledge ability and literacy skills of the person, while the weaknesses/limitations: reliance on memory and remembering, and

with regards to the serving size is not easy to determine accurately (9,10). The Automated Multiple-Pass Method (AMPM) is an example of a 24-hour day recall used in the United States by the U.S. Department of Agriculture; this method is reliable but high in cost (9,10).

2.13.3 Food frequency questionnaire (FFQ)

Questionnaire about habitual consumption of foods and drinks over a prolonged time usually: years (9). Furthermore, consists of a list of questions about the frequency and serving size of foods consumed by a person (9,10). The strength points of this way; it is self-conducted and easy to full without effort, while the weakness points; depend on memory and the ability of a person to recall the portion size and the frequency of the food intake, and maybe the participants alter their diets in this long period due to certain conditions like a sickness, and gestation (9,10).

2.13.4 Diet assessment tools/screeners

Multiple tools/screeners for diet evaluation are beneficial in states that don't need to evaluate all diet intakes (10). These screeners are helpful in many cases such as a short diet evaluation tool for certain food constituents, which can be utilized to sort large numbers of people in categories, to permit more care about these sets that maybe need more intervention or learning (10). Also, whether the assessment of diet consumption is accurate or not, this process could be important for the replier to learn about nutrition (10). Moreover, short tools have a benefit in clinical services, and in states of health improvement, and health learning is the aim (10).

Diet evaluation screeners/tools can be simple or for purposes (for aims), several brief diet assessment tools have been produced and check the validity by comparison with dietary assessment methods such as records of diet, 24-hour recall, FFQ, and/or biological marks (10). For instance, on this screeners or tools are: tools for the evaluation of fruit and vegetables, fats, calcium, sugars, etc... (10).

MEDFICTS is a dietary assessment tool that assesses fat intake from foods (compliance to the low total fat, saturated fat, and dietary cholesterol diets) and is a shortcut for Meats, Eggs, Dairy, Fried foods, In baked goods, Convenience foods, fats added to the Tables and Snacks (10).

Although screeners are useful and have many advantages; one of these advantages is the cost is not expensive, but they have weak points; such as: not being possible to get data about the whole diet and containing big estimation errors (10). Due to these weaknesses, the NCI Dietary Assessment Primer advised to use these screeners moderately, and even when used, be validated with precise tools like 24-hour diet recall (10).

2.14 Use the technology in diet assessment

Estimation of diet conventionally depends on self-report tools such as 24-hour diet recalls, food diaries, and food frequency questionnaires; every way of these ways has weak points in reliability and validity issue (11). With the progression in technology, there are many systems to estimate diet consumption like computers, website-based systems, personal digital assistants (PDA), smart phones or mobiles, video equipment, and tape machines (video tape recorders); these technologies are highly cost and need to low effort than conventional ways (that need to pens and papers to write it) (11). The technology helps in diet evaluation; can enhance the assessment of foods and components of food (nutrients) that are consumed (61). The strength points of computerized ways are rapidity, simple processing, and quick analysis of information (11,61). Furthermore, these technologies are user attractive, easy to access, and available (9,11). While the weak points involve requiring the mobile or computer apparatus, network connection, knowledge about computers and their programs, how to enter it, and typing talents (11,61).

2.15 Validation studies for several dietary assessment tools

Kris-Etherton et al. 2001, conducted a study to develop and validate MEDFICTS dietary evaluation tool for assessing compliance to total fat, saturated fat, and cholesterol advice from the NCEP step 1 and step 2 diets (step 1: decrease the intake of total fat to 30% or lower of daily calories, 8% to 10% of calories from saturated fat, and less than 300 mg of cholesterol daily, while for step 2: less than 7% of calories from saturated fat, and less than 200 mg of cholesterol daily); 16 subjects participated in the pilot study, which compared MEDFICTS questionnaire with 4 days food records, the results were as follows; correlation coefficients (r) calculated for % calories from total fat, saturated fat, and cholesterol consumption with MEDFICTS points: r=0.81, 0.97, and 0.52 for percent calories from total fat, saturated fats, and cholesterol, respectively, p-values were

significant for all (p-values <0.05) (62). While in the validation study: 2 follow-up validation studies for 22 persons participated in the first and 26 persons in the second; MEDFICTS compared with 3 days food record, and the results were as follows: p-values were significant for all <0.05 (62). In sum, MEDFICTS is a useful instrument that can be used by health experts, to fast evaluate compliance to the step 1 or step 2 diets (62).

Compared to another study that developed and validated the MEDFICTS dietary assessment tool, 164 persons shared in this study of active-duty US Army personnel. All of the participants filled out the two questionnaires: MEDFICTS and Block Food Frequency questionnaire (BFFQ), which was considered the gold standard. Correlation coefficients were calculated between MEDFICTS and Block FFQ for % consumption of fats, saturated fat, and cholesterol. The results were (r=0.52, 0.52, and 0.55 respectively), and the p-values were significant for all (p-values <0.0001) (63).

In a study that developed the modified MEDFICTS in South Africa, particularly on schoolchildren students, 39 children (boys and girls from the 6 class students) participated in the reliability test of the tool, and 93 children shared in the first validation study, and 72 parents assisted in complete the screener (second validation study) (64). The results were as follows: in the test re-test reliability, there is no significant difference between the children, whether complete only the first administration or both administrations (the second administration was around 6 weeks after the first one); the p-value was >0.05 (64). Additionally, MEDFICTS points showed a modest reliability (r=0.36, and p-value=0.02); r=0.26; p-value=0.29 for boys, and r=0.58; p-value=0.01 for girls) (64). For validation studies, the correlation coefficient (r) was calculated between MEDFICTS scores and 3 days of food records (64). The results were only significant for girls (p-value <0.05) (64).

Another study was conducted on 442 adult persons (249 women and 194 men) chosen from many departments of Hacettepe University in Ankara, Turkey, to check the reliability and validity of the MEDFICTS screener (65). A reliability test was conducted for 2 administrations (the second one after 2 weeks); the correlation coefficient result was r=0.891, which is power correlation (65). As regards to validation study (compared MEDFICTS screener with 3 days food records) results, the mean of total calories, total fat, saturated fat, and cholesterol for 3 days food record and MEDFICTS diet categories

was significant of all (p-value <0.001) (65). Finally, MEDFICTS is a medium-accurate tool (65).

Peters et al. 1994 conducted a study that developed The Eating Pattern Assessment Tool (EPAT) tool for evaluating dietary fat and cholesterol consumption (section1: distinguished by foods that are high in fats and cholesterol amount, and section 2: distinguished by foods that are low in fats and cholesterol quantity) (66). Around 436 adult participants (equal percent from men and women) shared in this study (66). The reliability test (test re-test) for the EPAT tool; was conducted between visits; 5 visits (v1, v2, v3, v4, v5), visits were recorded at weeks (zero, 1, 5, 13, and 17) and between v1 and v5 (the period between them were 4 months), and for the concurrent validity of the EPAT; they compare it with 4 days food records (66). Results for the reliability test were (r= 0.91 between all visits, and r=0.83 between visit 1 and visit 5), while the r between EPAT section scores (section 1: high-fat diet, and section 2: low-fat diet) and 4 days food records ranged from 0.54 to 0.56 for section 1 (66). In summary, EPAT is an uncomplicated, fast tool for evaluating dietary fat and cholesterol consumption; and is a reliable and valid instrument (66).

In a study by Mitchell et al. 1996 to develop the cholesterol-saturated fat index (CSI) scorecard: a dietary self-monitoring instrument for patients taking diet to decrease cholesterol, 12 dietitians participated in this study, 12 persons participated in the medication study (persons with high blood cholesterol levels), and 11 subjects shared in the assessment meetings (67). Validation study; for dietitians comparing the CSI scores (from low to high) with 5 food records (chosen from the 10th, 25th, 50th, 75th, and 90th percentiles of the 400 most popular food records and computed CSI scores), while for the subjects with elevated levels of cholesterol in the blood; comparing the scores estimated by subjects with 4 days food records (67). The results were as follows: the mean of the estimated CSI scores and computed scores were almost near to each other in the range of 25th and 75th percentiles (p-value not significant), while for the validation study; r was calculated between CSI and 4 days food records and was r=0.8, which is a strong correlation (67). So, CSI is a simple, fast, and precise assessment instrument (67).

In a study that developed an FFQ for assessing folate consumption; Folate-Intake Calculation-Food Frequency Questionnaire (FOI-IC-FFQ) on a grouping of Polish women aged between 20 to 30 years. These women were requested to record the diet for

3 days and fill the FOI-IC-FFQ two times (the first one FFQ1: immediately after doing the 3 days of food record, and the second one FFQ2: six weeks later after completing the first FFQ1). Results: Spearman rank correlation coefficient between the FOI-IC-FFQ1 and FOI-IC-FFQ2 folate consumption was significant (p-value=0.0000, R=0.7995). However, the FOI-IC-FFQ is perhaps considered a valid instrument for the evaluation of folate consumption among young Polish women (68).

Another study developed and validated an FFQ for the evaluation of calcium consumption in postmenopausal Vietnamese women aged between 50 to 70 years, the groups that are at high risk of osteoporosis. Validation was assessed of the FFQ by comparing it with 3 days of 24-hour diet recall, which is considered as gold standard in this study. The results revealed: no significant difference in the mean of calcium consumption between the two methods (FFQ, and 3 days of 24-hour diet recall), p-value was >0.05. As regards the Pearson correlation; was 0.84, which is considered a high correlation (69).

There is a study that developed and validated a short dietary evaluation tool for children aged between 2-5 years, completed by parents or primary caregivers, to aid the identification of young children taking high or low amounts of total fat, saturated fat, and/or cholesterol from foods. For validation study; the 17-item Child Dietary Fat Questionnaire (CDFQ) was compared with 4 days of food records (Pearson correlation was conducted to compare the child dietary consumption expected from the CDFQ administered at the primary visit with primary caregivers in personal and repeated the visit after 2 weeks by contacting with the primary caregivers on phone, and the mean of calculated dietary consumption from 4 days of diet records). Moreover, for cholesterol consumption; the correlation coefficient between the CDFQ and the dietary records was the highest (r=0.53 for the initial visit and r=0.55 for the second visit (2 weeks later), the p-value was <0.0001 for both administrations). For total fat consumption, the correlation was high, too; (r=0.54, and p-value<0.0001 for the administration by telephone and r=0.47, and p-value<0.001 for the administration in personal). Furthermore, the correlation coefficients between the CDFQ and the diet records for saturated fat were a little lower than that demonstrated for total fat and cholesterol (r=0.44 for the administration by telephone, and r=0.36 for the administration in personal, and p-value<0.01 for both). In conclusion; CDFQ is an easy and brief instrument that screens and determines the children with high or low dietary consumption of total fat, saturated fat, and cholesterol from foods (70).

In a study that developed and validated a new FFQ for the evaluation of dietary intake in the Peruvian Amazon population, to assess the validity of this FFQ, we compared the correlation between the average daily nutrient consumption values for the two FFQs (FFQ1, and FFQ2), and that for 3 days of 24-hour recall (106 persons fill out the 24-hour recall underwent the FFQ individual interview two times; the first one was after 2 months of the filling of the 24-hour recall, and the second was 5 months after). The results demonstrated, as regards the mean (the values calculated by the FFQs were significantly higher than estimated from 24-hour recall for calcium, phosphorus, potassium, iron, folic acid, and vitamins B12, C, and D). While the macronutrients and calorie intake (there are no significant differences between them). For comparison between the consumption of two FFQs, there is no significant differences were seen, excluding calcium, phosphorus, and riboflavin (71).

Furthermore, after analysis of Pearson correlation coefficients between 24-hour recall and FFQ1, the results showed: that r ranges between 0.65-0.87 for macronutrients, 0.55-0.89 for minerals, and 0.12-0.83 for vitamins (the highest one were for calories, sodium, thiamine, vitamin B6, and folic acid, while the lowest one were for vitamin A, and D). On the other hand, the Pearson correlation coefficients between 24-hour recall and FFQ2, were 0.87 for calories, 0.77-0.88 for macronutrients, 0.21-0.91 for minerals, and -0.11-0.84 for vitamins (71).

Chapter Three
Methodology

3.1 General study design

The study was conducted among Palestinian populations, particularly in West Bank regions on adult persons aged from 18 to 60 years. The study was done in five stages: development of the FFQ screener (primary FFQ screener), development of the application (FFQ screener for assessing the dietary cholesterol), content validity, test re-test reliability, and criterion validity.

The participants were selected by convenient sampling and were asked to participate in the study. The data was collected in May month of 2023.

- **Stage one: Development of the FFQ screener (primary FFQ screener)**

  The cholesterol content in Palestinian foods and dishes was taken from the Palnut Website (72): which is a Website that contains Palestinian foods (food composition database). The permission was obtained from the administration of the research center belongs to Al-Quds University. The other food items that are not found on the Planut Website (72), were taken from the USDA database (73).

  The primary FFQ screener was designed and classified into (1) Food groups that include (a) basic foods that contain cholesterol as meats (whether red or white meats), processed meats, fish, eggs, milk, dairy products, and (b) foods that may contain cholesterol/animal fat as baked goods, basic dishes with minced meats, basic dishes with yogurt, desserts, fast foods, drinks, sauces, and butter. (2) Food items were organized in subgroups as: meats include beef, lamb, goat, chicken, turkey, pigeon, processed meats include hotdog, luncheon meat, salami, fish that include shrimp, dines, salted fish (feseikh) and fatty fish like salmon, sardine, and tuna, eggs in all shapes (raw, boiled, fried with or without butter, emshat, omelet), milk from all sources (from cow's, sheep's) and in all shapes (liquid or dry), cheese whether local (from cow's or sheep's) or processed (mozzarella, cheddar, spreadable), drained yogurt, baked goods include croissant, doughnut, pastries, pizza, basic dishes with minced meats include pasta/macaroni, lazaniea, ouzi, stuffed in all types (squash, eggplant, cabbage, grape leaves, kubba, potato), basic dishes with yogurt (pasta/macaroni,

lazaniea, mansaf (cooked yogurt), shushbarak, makhshi (squash with yogurt), green bean with yogurt, potato), desserts include qataef, fteer, kullag, harriseh, pudding, cakes (black or white, cheese cake, French toast), chocolate (milk or white), biscuit, ice-cream, karabeeg halub, halva dessert, nammourah, aesh al-sarea sweets, zalabia, fast foods include shawerma and burger, drinks, sauces like mayonnaise, and butter. (3) Cholesterol content in milligrams per 100 grams was in the table also. The food items that contain cholesterol less than 5 mg /100 gm were neglected. Although the 20 mg/ 100 gm is labeled as low cholesterol food (74), in this study the cut score of 5 mg /100 gm were considered to be included in the software, because the consideration is to include or exclude that food item depends on both: cholesterol content and frequency of consumption. Depending on that food items that contain small amount of cholesterol but they are highly consumed in Palestinian food culture were included in the software. (4) Frequency of consumption for these food items was suggested depending on the Palestinian food culture (daily, weekly, monthly, and never). (5) The portion size was presented in this stage by images from the Palestinian food atlas book (75).

- **Stage two: Development of the application (FFQ screener for assessing the dietary cholesterol)**

  Food items from the Palestine food atlas book (75) were organized into groups and subgroups. The number of groups was 14 groups all containing cholesterol in different proportions. The groups are 1. Meats either red or white that include beef (were divided into subgroups: organs of beef such as (the brain, kidney, liver, tongue, etc.) and beef (cut, ground, short rib, steak, etc.)), lamb (was divided to subgroups also as like as beef), chicken (was divided to chicken organs and chicken (breast and thigh)), turkey (either ground or breast), pigeon. 2. Processed meats that include hotdogs, luncheon meat, and salami. 3. Fish such as dines, shrimp, and salted fish (feseikh) or fatty fish such as salmon, sardine, and tuna. 4. Eggs in all cases (raw, yolk raw, fried, fried with butter, hard-boiled, omelet, or emshat). 5. Milk of cows, sheep, or goats (either liquid or dry). 6. Dairy products that include a) cheese was divided into local such as (cow cheese (nabulsiea) or goat cheese) and processed such as (mozzarella, cheddar, cream cheese, cheese spread, or greatest), b) yogurt that includes (from goat, full or low fat, sour cream, greek or activia), and c) drained yogurt. 7. Baked goods that contain

croissants, doughnuts, (pastries or sweet pastries), or pizza. 8. Basic dishes with minced meat such as pasta, ouzi, squash, eggplant, cabbage, grape leaves, kubba, or potato. 9. Basic dishes with yogurt that contain lazaniea, mansaf, makshi, shushbarak, green bean, or potato. 10. Desserts were divided into (qataef, fteer, kullag, karabeeg halub, halva dessert, nammourah, aesh-alsarea sweets, zalabia, harriseh, or pudding), and (cakes (black or white, pop-cake, cheese cake), chocolate, biscuit, or ice-cream). 11. Fast food such as shawerma or burger. 12. Drinks that include coffee (with milk, or cream), cappuccino with cream, milk and starch drink (sahlab), or chocolate milk. 13. Mayonnaise sauce that contains egg. Finally: 14. Butter. The average of cholesterol was taken in mg per 100 grams and per serving size for these food items. The cholesterol content in these Palestinian food items was taken from the Palnut Website (72) and USDA database (73) as previously mentioned. The serving size was presented by images from the Palestine food atlas book (75), household measurements (spoon, cup, piece, etc.), and grams. The application was designed by a person who specialized in this field. The name of the app. is (Pal Chol app ®) an abbreviation for Palestine cholesterol application, this app. was contained a general introduction about it (what does it do, what does it consist of) and some information about cholesterol, the name of the user, age, and the gender. The language of the app. was the Arabic language.

- **Stage three: Content validity**

  The content validity of the FFQ screener (primary screener) was done through focus group discussions with researchers and experts in the field. The experts' qualifications were; 3 evaluators experts in nutrition and involved in academia and research (2 of them were Ph.D. holders, and the other one had master's degree) and 2 evaluators related to IT, design, and precedent experiences with health and technology (one of them had Ph.D. degree, and the other one holds master's).

  The experts were asked to assess and approve the food items categorization, suggested portions that were presented by photos, and the frequency of consumption for the food items. For the development of the primary FFQ screener: evaluators objected to the photos; they weren't clear enough and were difficult for the users to handle.

  After the development of the application; the food items and groups, serving size presented by household measurements and photos, and frequency of the intake were

presented easily and simply. The evaluators were not given any negative comments about the application. On the contrary, they confirmed the simplicity and usability.

- **Stage four: Test and re-test reliability**

  The reliability assessment was done by test and re-test; twenty persons from the participants in the study were chosen by convenience sampling aged from 18 to 60 years. The participants were given the newly developed FFQ (Pal Chol app ®), and they were asked to fill it out (this is called a test). After 1 week, the participants were asked to repeat the step and fill out the app. again (this is called a re-test). The values from the participants were taken and organized in the table for analysis after that. The correlation analysis between the test and re-test was done to determine the reliability.

- **Stage five: Criterion validity**

  One hundred persons were invited to join the study by convenience sampling, the participants were asked to use the app. and fill it then estimate their cholesterol intake. Also, the participants were interviewed by a trained research member (I was trained by a person specialized in this field) for dietary intake assessment using 3 days of diet recall Appendix A. Three days of diet recall were taken from the participants (two days of the week, and one day from the weekend). The interview with the participants occurred either face to face or online interviews via (WhatsApp, Messenger, and Instagram chats). For diet recall, the participants were asked about many things: 1) Name of the foods or beverages (for example egg) that are consumed on the previous day (from 4:00 am on the previous day to 4:00 am on the next day). 2) Describing these foods or beverages (for example egg fried or hard-boiled, etc.). 3) The place of eating these foods or beverages (for example at home, restaurant, work, etc.). 4) The approximate time of consuming these foods or beverages (for example 8:00 pm, 6:00 am, etc.). 5) The quantity that was consumed from these foods or beverages (was identified by images from the Palestine food atlas book (75).

  The 3 days diet recall was considered as a gold standard for cholesterol intake assessment. The data was analyzed, and an average from these 3 days of diet recall was taken. The results of cholesterol intake from the 3 days diet recall and the application were compared to examine the validity of this application.

3.2 Subjects characteristics

Palestinian adults aged between 18 to 60 years participated in the study, particularly from West Bank regions. These participants were chosen by convenience sampling.

3.2.1 Inclusion criteria

Palestinian adults aged 18-60 years old, from several West Bank regions that were using smart-phones and agreed to join the study.

3.2.2 Exclusion criteria

- Participants aged less than 18 years, and greater than 60 years.
- Participants are following a diet restrict their food options.

3.3 Sample size calculation

The sample size was calculated using MEDCALC software for a method comparison study, using the Bland-Altman plot. Type one error 0.05, type two 20%, expected mean difference (120 mg), expected standard deviation difference 50 from (previous study) (Göktaş et al .2021) allowed difference 50 mg. The required sample size is 90. Withdrawal from this study was considered; thereby the required sample is 100 participants.

3.4 The collection of data

A structured questionnaire was used to collect the data, this questionnaire contains many parts: part one; describes the socio-demographic information about the participants such as (1) age, (2) gender, (3) marital status, (4) educational level, (5) working status, and (6) living place. Part two; is information about lifestyle as (1) smoker or nonsmoker, (2) if you are a smoker what type of it, (3) physical activity or exercise (do you do any exercise? what type of it? where do you do these exercises? how many times a week do these exercises? and how long do you need to do these exercises?). Part three; is a medical history of these participants that includes (1) suffering from any disease, and the name of this disease if exists, (2) taking any medications, (3) if doing any surgeries, and what name of it. Part four; assesses the nutritional status by a) anthropometrics measurement like (1) height in cm, (2) weight in kg and b) diet assessment; 3 days diet recall method was used in this study (data was taken from the participants and then filled in the form consist of 3 tables (two days from the week, and one day from the weekend), these tables

include many of questions about (1) time of intake of foods or beverages, (2) place of intake whether in home, work, restaurant, etc. (3) name of the foods or beverages, (4) description of these foods or beverages and (5) the quantity of these foods or beverages was shown by symbol on the photo taken from Palestine atlas book (75). Tables were presented in **Appendix A**. Part five; is a questionnaire that compares 3 days diet recall taken and filling the FFQ screener (the application specialized in the assessment of cholesterol intake) by the participants, this questionnaire consists of some questions such as (1) Using the app saves time and the effort? (2) It is believed that the application was more accurate in determining the quantities consumed? (3) Using the application is easier than daily diet recall? (4) The application helps in the rapid analysis of data? (5) The app contributed to paying attention to eating habits and monitoring it (monitoring of cholesterol)? (6) The application is an alternative with better features than the theoretical recoding? (7) The application was comprehensive in displaying food products that contain cholesterol? The answers to these questions were taken as many choices as (totally agree, agree, no difference, object, and strongly objected). A questionnaire was presented in the Appendix B.

While for the FFQ screener for assessment the cholesterol intake (the application), the data was collected by filling the participants to this application or screener. The application consists of the beginning to (1) general background about the application and information about cholesterol then (2) name, age, and sex (3) the groups and subgroups of food items that contain cholesterol (4) the frequency of intake (daily, weekly, monthly, and never) (5) serving size which was presented by images and household measurements, and (6) the time of consumption of these food items. In the end, the daily cholesterol number in milligrams was shown. The FFQ application was presented in the Appendix C.

3.5 Statistical analysis

All statistical analyses were conducted using the Statistical Package for Social Sciences (SPSS) software, version 21. Alpha values (P-values) <0.05 was considered statistically significant. Variables were assessed for normality of distribution graphically by using the Kolmogorov-Smirnov test. The total intake of dietary cholesterol was computed. The paired t-test was conducted to compare the difference between the means (from app. and 3 days of diet recall). Correlations between daily cholesterol intake from app. and 3-days food recall were assessed using Pearson correlation. Correlations between test and re-test

results for reliability were evaluated using Pearson correlation also. Descriptive statistics were performed for socio-demographic variables.

3.6 Ethical considerations

The study protocol was certified by the Internal Review Board for Research Ethics (IRB) committee at Al-Najah National University with an approval letter, on 31th July 2022 and was shown in the Appendix D.

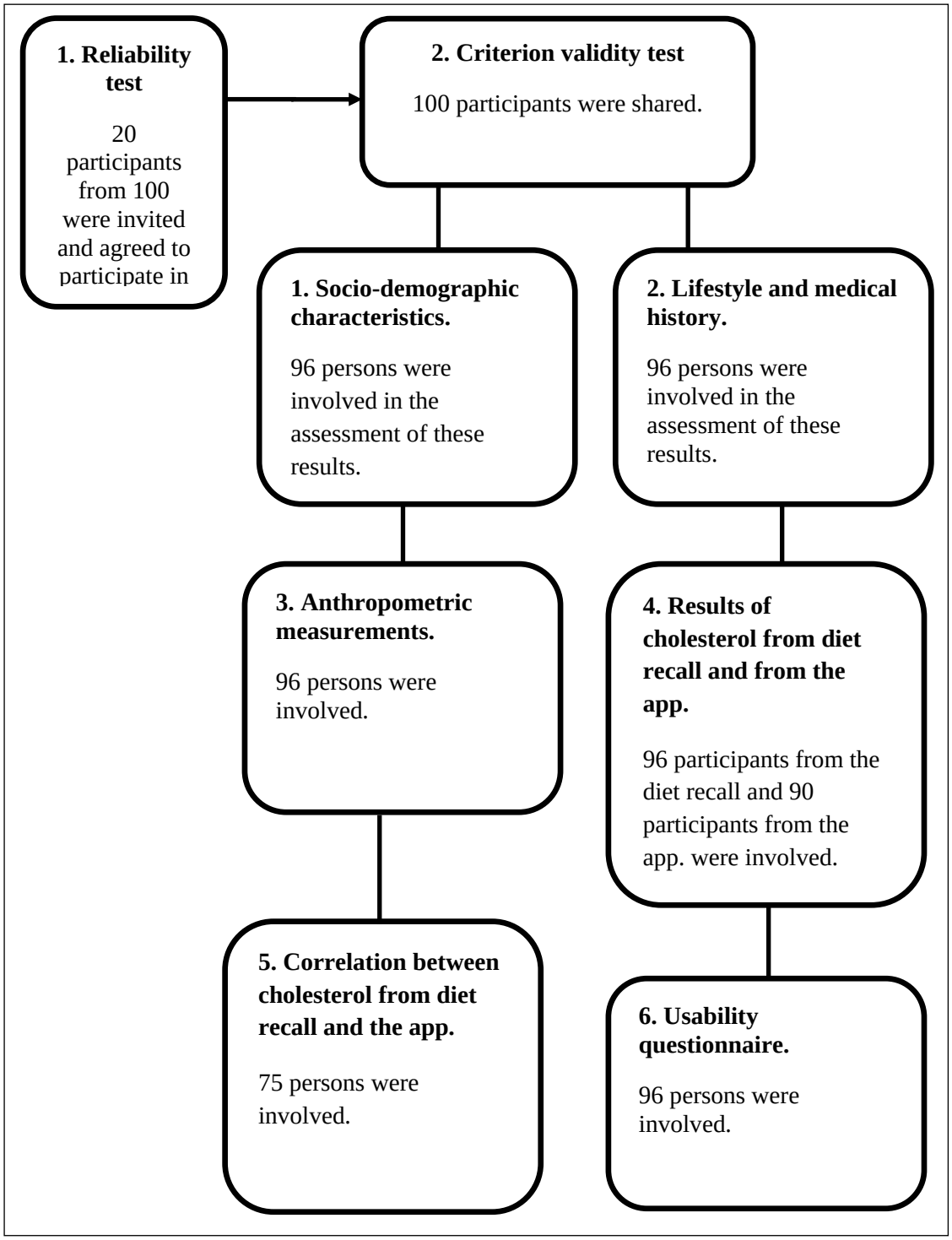
Chapter Four

Results

Twenty respondents shared in the pilot study to test the reliability (test and re-test) of 100 participants. Moreover; 100 persons participated in the criterion validity test. After analysis of data on SPSS: 4 respondents were excluded because the total calorie intake was less than 1000 kcal (because of under-reporting). So, 96 persons were involved in the assessment of the demographic characteristics, lifestyle, medical history, anthropometric measurements, cholesterol results from diet recall, and usability questionnaire results. On the other hand, outliers from the results of cholesterol from the app. were excluded (z-score > 3 was considered an outlier), and the number of outliers was 6. After performing the correlation test between the cholesterol results from diet recall and the app.: the mean difference was significant, and the correlation was not significant. Therefore, revision of the app. was done by computing a difference variable to show the difference between the results of cholesterol intake from the diet recall and the app. A difference of more than 400 was excluded. Therefore, 75 persons were involved. After this process, the correlation test was significant, while the mean difference was still significant. Figure 4.1 shows a flow chart of participant's recruitment.

Figure 4.1

Flow chart of participant's recruitment



4.1 Reliability results -Test and re-test results-

Results from the test re-test reliability are shown in table 4.1. The results show a significant high correlation between the two readings r=0.7 and p-value=0.000.

Table 4.1

Results of test and re-test reliability from the cholesterol screener

		Re-test
Test	Pearson correlation	0.747
	P-value	0.000

4.2 Criterion validity results

4.2.1 Socio-demographic characteristics results

Table 4.2 shows the socio-demographic features of the respondents. The mean age of these participants was 26.24 ±7.15 years. The minimum age was 18years, and the maximum was 54 years. Most of the participants were female (n=91, 94.8%), whilst the male (n=5, 5.2%). As regards marital status, (n=56, 58.3%) of participants were single, and (n=40, 41.7%) were married. All of the respondents were educated (n=96, 100%). The majority of the participants were not working (n=57, 59.4%), (n=27, 28.1% working in full-time work), and (n=12, 12.5% in part-time work). Most of these participants living with their families (n=56, 58.3%), follows that living with a spouse (n=34, 35.4%), (n=3, 3.1% living alone), and (n=3, 3.1% living with others).

Table 4.2

Results of demographic characteristics of the participants

Demographic characteristics		N	%
Gender	Male	5	5.2
	Female	91	94.8
Marital status	Single	65	58.3
	Married	40	41.7
	Other	0	0.0
Education	Educated	96	100
	Non-educated	0	0.0
Working status	Full time	27	28.1
	Part time	12	12.5
	Not working	57	59.4
	Retired	0	0.0
Living status	With spouse	34	35.4
	With family	56	58.3
	Alone	3	3.1
	Other	3	3.1

4.2.2 Lifestyle and medical history results

Table 4.3 demonstrates the results of lifestyle and medical history for these participants. The majority of respondents were non-smokers (n=75, 78.1%), and the remaining were smokers (n=21, 21.9%). The predominant type of smoking was a pipe (n=19, 19.8%), while cigarette alone was in the same percentage as cigarette and pipe together (n=1, 1.0% for both of them). Fifty-one participants were doing physical activity (53.1%), and 45 persons were not (46.9%). Walking was the dominant type of exercise (n=40, 41.7%), and 11 respondents practiced other types of exercises (11.5%). Most of the participants practiced these exercises in the house (n=25, 26.0%), 5 participants in the gym (5.2%), and 21 in other places (21.9%). Furthermore, the mean of times in a week doing these exercises was 3.67, with a standard deviation of 1.894, with minimum times 1 and maximum times 7. Thirty-one participants need 30 minutes to do these exercises (32.3%), ten persons need 60 minutes (10.4%), and nine need other times (9.4%). As for diseases existing, 87 participants have no diseases (90.6%), whilst nine persons have a disease (9.4%) distributed as follows (3 persons have hypertension 3.1%, 3 persons have an IBS 3.1%, 1 has a hypothyroidism 1.0%, and 1 has a hyperthyroidism 1.0%). For medications use, 82 participants did not use any medications (85.4%), and 14 participants used any

medications (14.6%). Furthermore, 19 participants did surgery (19.8%), while 77 persons did not do any surgery (80.2%). The name of the surgeries as follows (appendicitis operation, cesarean, nose flesh removal, open heart operation, orthopedic surgery, and tonsillectomy).

Table 4.3

Results of lifestyle and medical history of the participants

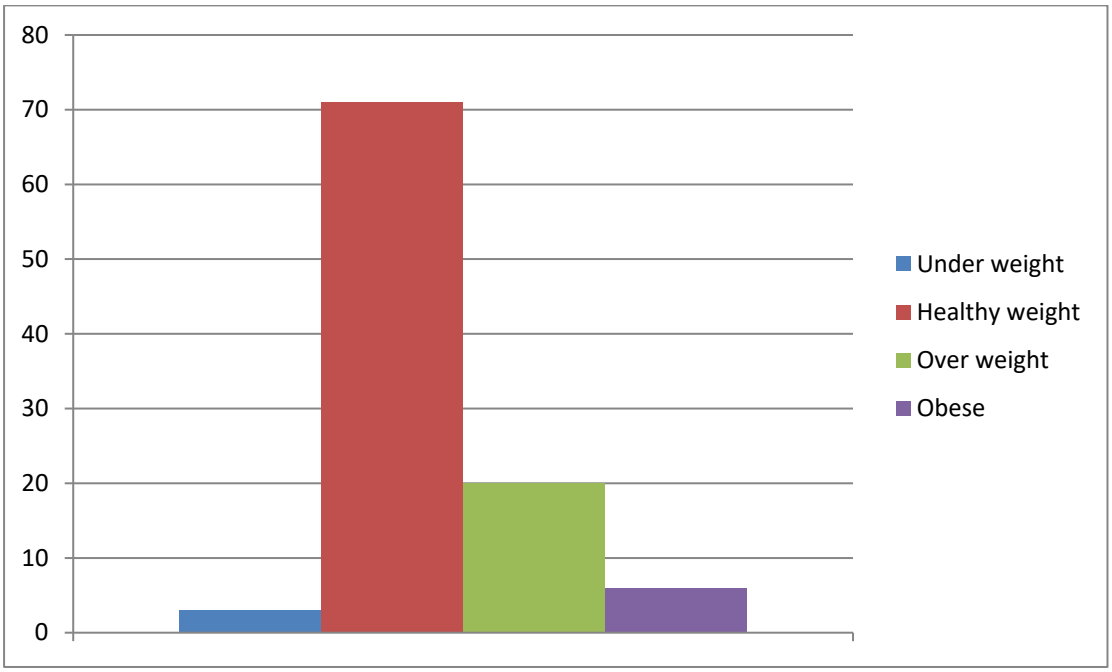
Variables		N	%
Smoking	Smoker	21	21.9
	Non smoker	75	78.1
Type of smoking	Cigarette	1	1.0
	Pipe	19	19.8
	Mix	1	1.0
Doing exercises	Yes	51	53.1
	No	45	46.9
Type of exercises	Walking	40	41.7
	Running	0	0.0
	Other	11	11.5
Place of doing these exercises	House	25	26.0
	Gym	5	5.2
	Other	21	21.9
The time that needs to do these exercises	30 min	31	32.3
	60 min	10	10.4
	Other	9	9.4
Diseases	Yes	9	9.4
	No	87	90.6
Medications	Yes	14	14.6
	No	82	85.4
Surgeries	Yes	19	19.8
	No	77	80.2

4.2.3 Anthropometrics measurement results

Figure 4.2 demonstrates the body mass index of respondents. BMI is defined as the weight in kg divided by the height in m^2 (76). BMI classification according to WHO was: underweight < 18.5 kg/m^2, healthy weight: 18.5-24.99 kg/m^2, overweight: 25-29.99 kg/m^2, and obese > or =30 kg/m^2 (76). Three persons were underweight from 100 respondents, 71 persons were healthy weight, 20 persons were overweight, and 6 persons were obese.

Figure 4.2

Body mass index of participants



4.2.4 Results of cholesterol consumption from diet recall and the application

Table 4.4 displays the cholesterol, total calories, carbohydrates, proteins, and fats of the 96 participants from the diet recall. The mean of the cholesterol from diet recalling was 210.27 mg, with a standard deviation of 119.57, the minimum value was 34.03, and the maximum value was 655.71. While the mean of the total calories from diet recall was 1650.07 calories with a standard deviation of 413.17, the minimum value was 1017.35, and the maximum was 2956.60 (total calories less than 1000 calories were excluded). As regards carbohydrate intake, the mean was 208.87 g with a standard deviation of 59.44, the minimum value was 112.46, and the maximum value was 415.98. For proteins, the mean was 62.54 g with a standard deviation of 17.42, the minimum value was 29.20, and the maximum was 112.87. Furthermore, the mean fat intake was 64.57 g with a standard deviation of 18.12, the minimum value was 22.03, and the maximum was 111.75.

Table 4.4

Exhibits the results of the cholesterol, total calories, carbohydrates, proteins, and fats from 3 days of diet recall

Variables from 3 days diet recall	Min	Max	Mean	St.deviation
Cholesterol (mg)	34.03	655.71	210.27	119.57
Total calories (Kcal)	1017.35	2956.60	1650.07	413.17
Carbohydrates (g)	112.46	415.98	208.87	59.44
Proteins (g)	29.20	112.87	62.54	17.42
Fats (g)	22.03	111.75	64.57	18.12

Table 4.5 shows the cholesterol intake from the application. The mean of the cholesterol from the application was 400.49 mg, with a standard deviation of 164.15; a minimum value was 115.08, and a maximum value of 929.90.

Table 4.5

Demonstrates; the mean, st. deviation, the min., and max. Values of the cholesterol intake from the application

Cholesterol from application	Min	Max	Mean	St.deviation
Cholesterol (mg)	115.08	929.90	400.49	164.15

4.2.5 Association between cholesterol from 3-days diet recall and the app. results

Table 4.6 exhibits the mean difference between the cholesterol from app. and 3 days diet recall. The mean of cholesterol from the app. was 349.97 with a standard deviation of 120.78, and a standard error was 13.94. While the mean of cholesterol from 3 days diet recall was, 216.33 with a standard deviation of 119.87 and a standard error was 13.84. However, the mean difference was significant (p-value=0.000).

Table 4.6

Paired sample t-test to show the mean difference between the cholesterol from app. and 3 days diet recall

		Mean	N	St.deviation	St.error mean
Pair 1	Cholesterol from app	349.97	75	120.78	13.94
	Cholesterol from recall	216.33	75	119.87	13.84

Table 4.7 shows the correlation between the cholesterol from the app. and from dietary recall, which considers the gold standard in this study. The results demonstrated a correlation between them, but this correlation was weak (r=0.31, p-value=0.006).

Table 4.7

Relationship between cholesterol intake from app. and 3 days diet recall

	Cholesterol from dietary recall	
Cholesterol from app.	Pearson correlation	0.314
	P-value	0.006

4.2.6 Usability questionnaire results

The usability questionnaire of the application was presented in Table 4.8 which demonstrated 8 questions about the use of the application in comparison with the diet intake. The first question was about using the app. saves time: 26 participants totally agreed about this question (27.1%), 62 participants agreed (64.1), 7 participants answered no difference between it (7.3%), and one participant objected (1.0%). The second question was about using the app. saves effort: 62 persons agreed to this question (64.6%), 24 persons totally agreed (25.0%), and 10 persons showed no difference (10.4%). As regards the third question, it is believed that the app. was more accurate in determining the quantities consumed; the answers are: 15 respondents totally agreed (15.6%), 56 respondents agreed (58.3%), 16 respondents answered no difference (16.7%), and 9 respondents objected (9.4%). The fourth question was using the app. was easier than daily diet recall: 23 participants totally agreed (24.0%), 56 participants agreed (58.3%), 12 participants didn't show any difference (12.5%) and 5 people objected (5.2%). Moreover, n=25 participants answered with totally agreed with the fifth question; app. helped in the

rapid analysis of data (26.0%), n=56 participants agreed (58.3%), n=13 participants revealed no difference (13.5%), and 2 participants objected (2.1%). The sixth question was app. contributed to paying attention to eating habits and monitoring it (especially cholesterol): 22 persons totally agreed (22.9%), 59 participants agreed (61.5%), 12 participants had no difference (12.5%), and 3 persons objected (3.1%). About the seventh question, app. is an alternative with better features than theoretical recording: 16 persons totally agreed (16.7%), most of the participants agreed (n=61, 63.5%), 15 persons had no difference (15.6%), 3 people objected (3.1%), and 1 person strongly objected (1.0%). The last question was; the app. was comprehensive in displaying food products that contain cholesterol: Most of the participants agreed to this question (n=61, 63.5%), n=18 totally agreed (18.8%), n=7 had no difference (7.3%), 8 person's objected (8.3%), and 2 persons strongly objected (2.1%).

Table 4.8

Shows the results of the usability of the app. in comparison with the diet recall

Questions	Options	N	%
1- Using the app. saves time	Totally agree	26	27.1
	Agree	62	64.6
	No difference	7	7.3
	Object	1	1.0
	Strongly objected	0	0.0
2- Using the app. saves effort	Totally agree	24	25.0
	Agree	62	64.6
	No difference	10	10.4
	Object	0	0.0
	Strongly objected	0	0.0
3- It is believed that the app. was more accurate in determining the quantities consumed	Totally agree	15	15.6
	Agree	56	58.3
	No difference	16	16.7
	Object	9	9.4
	Strongly objected	0	0.0
4- Using app. is easier than daily diet recall	Totally agree	23	24.0
	Agree	56	58.3
	No difference	12	12.5
	Object	5	5.2
	Strongly objected	0	0.0
5- App. helped in the rapid analysis of data	Totally agree	23	26.0
	Agree	56	58.3
	No difference	13	13.5
	Object	2	2.1
	Strongly objected	0	0.0
6- App. contributed to paying attention to eating habits and monitoring it (monitoring cholesterol)	Totally agree	22	22.9
	Agree	59	61.5
	No difference	12	12.5
	Object	3	3.1
	Strongly objected	0	0.0
7- App. is an alternative with better features than theoretical recording	Totally agree	16	16.7
	Agree	61	63.5
	No difference	15	15.6
	Object	3	3.1
	Strongly objected	1	1.0
8- App. was comprehensive in displaying food products that contain cholesterol	Totally agree	18	18.8
	Agree	61	63.5
	No difference	7	7.3
	Object	8	8.3
	Strongly objected	2	2.1

4.3 Discussion and Conclusions

The study is successful in showing the satisfactory reliability of the developed FFQ screener/application for assessing cholesterol intake among adult Palestinian populations from several regions of the West Bank aged from 18 to 60 years. A suitable sample size was reached to reply to the study questions and perform the necessary statistical analysis. Based on our information, this study is the first one that developed and validated an FFQ screener/application to evaluate cholesterol intake in Palestine. The major findings are shown in the coming paragraphs.

4.4 Development of the FFQ screener/application

Pal Chol app. was developed based on many steps; the first one is a categorization of the foods that contain cholesterol that we got from Planut. Website (72) and USDA database (73). However, the FFQ screener/application contained 14 groups and almost 101 food items, all containing cholesterol in various percentages. The second step is presenting the frequency of intake of cholesterol (daily, weekly, monthly, and never) based on the food culture of Palestine. The third step is determining the serving size, which was shown by images from the Palestinian Atlas book (75) and household measurements. The app. included all types of food items that may contain cholesterol; the cholesterol content was high in meats, especially organs of animals such as beef, lamb and chicken, eggs, butter, and fish and fatty fish. Furthermore, the app. contained food items with low cholesterol content, like drinks with sources of cholesterol. Compared to another study that demonstrated the development of a semi-quantitative food frequency questionnaire (SQ-FFQ) to evaluate cholesterol consumption in older people, food items were collected in two various methods: the first one collected 30 food items elevated in cholesterol content depending on the Indonesian database and similar studies, and the second method: evaluating of the accessibility of food items round the study region and discarded of items that are not accessible. Therefore, 25 food items were gathered to assess cholesterol consumption in this study (77). Another study that developed a screener specialist in evaluating fat and fruit and vegetable consumption which consist of two parts the one is about meat/snacks, which involved about 15 food items to estimate fats from foods, and the two is about fruit and vegetable which contained about 7 food items to estimate fruit and vegetable consumption, vitamins, minerals existing in fruits and vegetables (78). In a study for the development of a MEDFICTS screener that assesses total fat, saturated

fat, and cholesterol intakes, the FFQ involved three columns: the first one contains the food groups and two subgroups which are categorized based on total fat content, the subgroup one comprises of foods with elevated total fat content and the second subgroup comprises of foods with low total fat content. Moreover, the second column gives choices about weekly intake, which involve (infrequently/never, three or fewer servings/week, and four or more additional servings/week) and the third column the approximate serving size, which is reported as little, medium, and big (62). Another study developed and validated an FFQ for the evaluation of dietary calcium consumption in the general population; the primary FFQ was contained 190 items that considered as main sources of dietary calcium. Finally; FFQ included 30 items examined for 10 dairy products (milk, yogurt, and 8 kinds of soft and hard cheese), 4 kinds of pie, 2 cereal products, 2 kinds of nuts, 4 vegetable products, legumes, 4 fish products, eggs, in addition to ice-cream and chocolate. For the frequency of consumption; was as follows: never or rarely, or times/month, week, or day, as suitable. As regards to the portion size was as (natural units or standard amounts, but not real weights) and no images or food samples helped in determining the portion sizes (79). Furthermore, another study developed brief screeners for fat and fruit and vegetables for Hispanic populations; the fat screener contained 16 food items: eggs, full-fat milk, flour tortillas, hamburgers, tacos and burritos, other mixed dishes with meat, ham, fried chicken, pizza, refried beans, French fries, chips, cake, fats in cooking, and salad dressing. As regards to the frequency of intake was as follows: from less or one time/month to 5 or more times/week, while the fruit and vegetable screener contained 7 food items: fruit drink, other fruit, green salad, tomatoes or salsa, potatoes, soups or stews with vegetables and any other vegetables. As regards to the frequency of consumption was as follows: from less than one time/week to 2 or more times/day. Finally, portion sizes were not evaluated (80).

In another study that developed and validated a new FFQ for the assessment of dietary consumption of the Peruvian Amazon population, the FFQ contained 132 food items, which were classified into 10 groups: 1- dairy products, 2-eggs, meats, fish and seafood, 3-vegetables, 4-fruits, 5-cereals, legumes and dry fruits, 6-fats and oils, 7-creams, 8-sweets and snacks, 9-beverages, 10-spices. The frequency of consumption was estimated based on the amounts taken on day, week, or month. As regards the portion size, it was calculated in grams of the average servings using the mean of intake in the 24-hour recall (71).

In a study for the development and validation of an FFQ to evaluate usual dietary consumption among multi-ethnic Malaysian children aged between 7 and 12 years, a total of 94 food types were specified from the analysis and classified into 12 major food categories: (1) cereals and cereal products, (2) meat and meat products, (3) fish and seafood, (4) eggs, (5) legumes and legume products, (6) milk and dairy products, (7) vegetables, (8) fruits, (9) dessert, (10) drinks, (11) spreads, and (12) condiments and spices. Furthermore, the frequency of consumption of every food types was assessed according to usual consumption over the prior month and classified into 8 groups: (1) never, (2) 1 to 3 times/month, (3) one/week, (4) 2 to 4 times/week, (5) 5 to 6 times/week, (6) one time in a day, (7) 2 to 3 times/day, and (8) 4 times or more/day. As regards the portion size was determined using regional household measurements like dish, bowl, tablespoon, etc. based on the Nutrient Composition of Malaysian Foods and the Atlas of Food Exchanges and Portion Sizes (81).

4.5 Test and re-test reliability

The term reliability is used to assess the consistency of measures conducted at various times on the same persons (82). Correlation coefficients of reliability; range from 0.000 to 1.00; whenever the coefficient increases, the level of reliability increases, also (82). In our study, the app. was reliable; this was shown in the results of test-retest reliability ($r=0.7$, p-value=0.000). In a study; that validated the MEDFICTS dietary assessment tool that assesses fat and cholesterol consumption in the Turkish community, 442 adult respondents shared in this study from males and females that were recruited from Hacettepe Collage in Turkey, reliability test (test and retest) were conducted for two administrations (the second one after two weeks from the first one); the results were shown a reliable tool, r was 0.891 which is a strong correlation (65). In another study by Peters et al. 1994 to develop an EPAT tool to evaluate the consumption of fat and cholesterol, 436 persons shared in this study in equal percent; the test-retest reliability was measured between visits (five visits; visit 1, visit 2, visit 3, visit 4, and visit 5) the period between them was in this arrangement zero, 1, 5, 13, and 17, and between visit one and last visit (v 5), the period between them was four months (66). A correlation coefficient between all visits was =0.91, and between the first visit and last visit was 0.83 (66). In a study that developed and checked the reliability of brief dietary evaluation tools (fat, fruit and vegetables) for Hispanic populations; the interviewers made the test two

times (fat, fruit and vegetable screeners), and the time between the two tests was one month. The results were as follows: correlation coefficient for the fat screener r=0.85, and for fruit and vegetables r=0.64 and the p-values were significant for both <0.001 (80).

4.6 Correlation between cholesterol FFQ screener and 3 days diet recall

According to our study, results showed a significant correlation between the app. and the 3 days of food recall (the gold standard), but this correlation was weak (r=0.314, p-value=0.006). Furthermore, the mean difference between them was significant (p-value=0.0000). Three days of food recall; were chosen to ensure the participants didn't change their dietary intake on the previous days. Moreover, data cleaning was done to show the source of errors (outliers from the app.; notably, the app. overestimated the cholesterol intake, and regards to the calorie intake <1000 cal was excluded; due to under-reporting). However, Kris-Etherton et al. 2001 studied the validity of the MEDFICTS assessment tool by comparing this FFQ screener with three days of food record for two follow-up validation studies (22 participants for the first study and 26 for the second one); the results revealed a significant correlation between the percent calories from total fat, saturated fat, and cholesterol results from the FFQ and the three days food record (p-value<0.05 for all in two validation studies) (62). A study by Taylor et al. 2003 validated a MEDFICTS dietary assessment tool that evaluates total calories from fats, saturated fats, and cholesterol (63). A total of 164 participants shared in this study; the MEDFICTS screener was compared with the Block food frequency questionnaire, which was the gold standard for the validation study; correlation coefficients were r=0.52, 0.52, 0.55 for fats, saturated fat, and cholesterol, respectively and the p-values were significant for all (less than 0.0001) (63). In another study that validated an app. (Ghithaona app.); that evaluates the consumption of energy and macronutrients; a correlation was tested between the results of the app. and the results of the 3-day food record which was considered as gold standard, the correlation was significant (p-value < 0.05) and ranged from 0.261 to 0.582 for calories, carbohydrates, protein, and fat. Furthermore, the mean difference was not significant (p-value > 0.05) for calories, carbohydrates, protein, and fat (83). In a study; that developed and validated the FoodEapp. that evaluates dietary consumption: correlation was tested between the results of the app. and the results of the reference method (24-hour diet recall); the correlation and correlation coefficients were as follows: (r=0.88, p-value<0.001) for total calories (Kcal), (r=0.81, p-value<0.001) for protein (g),

(r-0.73, p-value<0.001) for total lipids (g), (r=0.68, p-value<0.001) for carbohydrates (g), (r=0.70, p-value<0.001) for iron (mg) and calcium (mg), and (r=0.66, p-value<0.001) for vitamin C (mg) (84).

In comparison with a study that developed and validated an FFQ screener to assess vitamin D consumption in adults in England, UK, FFQ was compared with four days of food record to evaluate the validity which was considered as a reference method. The results showed a strong significant correlation between the two methods; FFQ and 4 days of food record (r=0.609, p-value<0.0001), when divided by gender, there was a significant correlation in men (r=0.727, p-value=0.001) between the two methods when compared with women (r=0.536, p-value=0.001) (85).

4.7 Usability of the app

Most of the respondents that shared in this study responded with the "agree option" about all questions that assess the usability of the application. Therefore, the app. was usable and easy to handle, an alternative tool to traditional methods like three days of food recall, more accurate, saves time and even effort for the participants, comprehensive in presenting the food products that consist of cholesterol, and helped on monitoring the cholesterol. In contrast, another study to validate and assess the usability of the Keenoa app., specialized in the evaluation of dietary consumption compared with three-day food records (86). Nearly most of the respondents agreed that the app. was easy to handle (38 persons from 72 total, 52.8%) and didn't require any help from the specialist individual (54 from 72 total, 75.0%) (86). Moreover, (25 from 72 total, 34.7%) of the respondents were comfortable using the app. to follow up on their diet, while (7 of 72 total, 9.7%) were comfortable using the three days food record; (12 from 72, 16.7%) wants to experience the two ways too, (20 from 72, 27.8%) didn't confirm, and (8 from 72, 11.1%) they didn't want to experience anyways (86). Compared to another study that developed and tested the usability of the Ghithaona app., which specializes in the assessment of energy and macronutrient consumption; approximately half of the respondents in this study deeply agreed that the app. is easy to handle (48.6%), saves time (47.1%), help in monitoring the dietary intakes (52.9%). Moreover, half of the respondents agreed that the app. can be an alternative way to conventional dietary evaluation tools (44.3%), reducing the burden of the participants (48.6%), and accurate in determining the quantity of consumed foods (52.9%). On the other hand, 31 respondents (44.3%) were deeply

opposed to this comment (the app. is too tired to use and handle) (83). Furthermore, there is another study that assessed the usability of the Research Food Diary (RFD) app. in compared with another method (24-hour diet recall); most of the participants agreed or deeply agreed that: the RFD app. was easy to understand in proportion to 94%, was easy in proportion of 82%, comfortable to handle in proportion of 80%, and a barcode scanner character was beneficial in 77%. Moreover, majority of respondents were satisfied (80%) and liked using the app on using or completing 24-hour diet recall (83%). Approximately, 74% of the participants agreed that app. was more accurate than the recall method, and 50% reported that the app. was easy to calculate the portion sizes (87).

4.8 Study sample

Palestinian populations especially from West Bank regions, were invited and asked to share in this study by convenient sampling, aged between 18 to 60 years old. Although the majority of the respondents were females, the sample was representative. The possible cause of the majority of the sample was female; perhaps the females are more concerned about nutrition-related subjects.

As regards the dietary recall for the respondents, the interviews were both: face-to-face and/or online chats through (social media Apps), the online chats were higher than face-to-face interviews, because these technologies (Apps) facilitated the arrival of the respondents.

4.9 Conclusion

Bad dietary choices; consider as one of the main risk factors that cause non-communicable diseases, such as CVDs. However, cholesterol intake considers one of the modifiable risk factors, although of many functions of cholesterol on the body's health. Nevertheless; many dietary guidelines recommended keeping cholesterol intake lower than 300 mg/day. In our study, we were successful in developing an FFQ screener that is specialized in the assessment of cholesterol intake among the Palestinian population aged between 18 to 60 years.

Furthermore, the usability test of the app. shows positive outcomes; the app. considers as an alternative tool to conventional ways (pen and paper recording), simple and usable, comprehensive in presenting most food items that contain cholesterol, and aids in

cholesterol monitoring. Therefore, using the technology in the assessment of dietary cholesterol was effective.

Also, the app. was reliable (there was a significant correlation between test and re-test results in the pilot study). As regards the validity, there was a significant correlation between the results from the app. and 3 days of diet recall which is considered a gold standard in this study, but this correlation was weak.

4.10 Recommendations

Although this study reveals a reliable application, we need more studies to improve it, maybe by performing this study on a larger sample size and further age levels such as children, adolescents, etc. Further validation studies are required to demonstrate the relationship between the cholesterol intake from the app., and 3 days of food recall. Furthermore, revision of the app. is required, specifically in the structure, selected food items; maybe by modification of the presented serving size (household measurements or images) or adding other food items. Educational intervention studies are needed to aware people of the risk factors of CVDs, and the effect of diet particularly cholesterol on these diseases. In the end, this study is a pilot study; it still needs improvement and development into a more advanced app.

4.11 Limitations

It was noticeable that the app. overestimates cholesterol intake, and it showed through the outliers. Many of the participants need to explain how to fill out the app. As regards diet recall, some of the respondents have a problem recalling their diet intake, thereby creating diversity in 3 days of diet recall. Additionally, most participants were females, maybe because females are more interested in matters that relate to nutrition and diets. So, we need future studies that involve both genders in a balanced way.

List of Abbreviations

Abbreviations	Meaning
AHA/ACC	American Heart Association/American College of Cardiology
AMPM	Automated Multiple-Pass Method
BMI	Body Mass Index
CAD	Coronary Artery Disease
CHD	Coronary Heart Disease
CHF	Congestive Heart Failure
CI	Confidence Interval
Cm	Centimeter
CVDs	Cardiovascular diseases
DASH	Dietary Approaches to Stop Hypertension
FFQ	Food Frequency Questionnaire
gm	Gram
HDL	High-Density Lipoprotein
HHS	US Department of Health and Human Services
HR	Hazard Ratio
IBS	Irritable Bowel Syndrome
IHD	Ischemic Heart Disease
Kcal	Kilocalories
Kg	Kilogram
LDL	Low-Density Lipoprotein
Max	Maximum
MDS	Mediterranean Diet Score
Mg	milligram
MI	Myocardial Infarction
Min	Minimum
mmHg	Millimeter Hg
MOH	Ministry of Health
NCEP	National Cholesterol Education Program
NCI	National Cancer Institute
NHANES	National Health and Nutrition Examination Surveys

NLA	National Lipid Association
OR	Odds Ratio
PDA	Personal Digital Assistants
RHD	Rheumatic Heart Disease
RR	Relative Risk
SQ-FFQ	Semi Quantitative-Food Frequency Questionnaire
st.	standard
TC	Triglyceride
TG	Total Cholesterol
TLC	Therapeutic Lifestyle Changes
USA	United States of America
VLDL	Very-Low-Density Lipoprotein
WHO	World Health Organization

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Appendices

Appendix A

الوضع الغذائي للمبحوث

(24 Hour Dietary Recall)

Day 1

رقم المأكول/ المشروب	الساعة	مكان الأكل/الشرب	اسم الوجبة	اسم الصنف	وصف الصنف	الكمية التي أكلتها/ شربتها
1	2	3	4	5	6	7

Day 2

رقم المأكول/ المشروب	الساعة	مكان الأكل/الشرب	اسم الوجبة	اسم الصنف	وصف الصنف	الكمية التي أكلتها/ شربتها
1	2	3	4	5	6	7

Weekend

رقم المأكول/ المشروب	الساعة	مكان الأكل/الشرب	اسم الوجبة	اسم الصنف	وصف الصنف	الكمية التي أكلتها/ شربتها
1	2	3	4	5	6	7

Appendix B

General information of the participants

(استبيان معلومات عامة للمشاركين في الدراسة)

الأسئلة الردود 100 الإعدادات

يعتقد ان التطبيق كان ادق في تحديد الكميات المستهلكة ؟ *

- اوافق بشدة
- اوافق
- لا فرق
- اعترض
- اعترض بشدة

استخدام التطبيق اسهل من تذكر الغذاء يوميًا ؟ *

- اوافق بشدة
- اوافق

الأسئلة الردود 100 الإعدادات

يعد التطبيق بديل بمميزات افضل من التسجيل النظري ؟ *

- اوافق بشدة
- اوافق
- لا فرق
- اعترض
- اعترض بشدة

كان التطبيق شامل في عرض المنتجات الغذائية التي تحتوي على الكولسترول ؟ *

- اوافق بشدة
- اوافق

Appendix C

FFQ screener/application for assessment the cholesterol intake among Palestinian population

(تطبيق يختص بتقييم الكولسترول المأخوذ من الغذاء بين السكان الفلسطينيين)

Pal Chol app

معلومات عامة عن الكولسترول:

أجسامنا بحاجة الى الكولسترول، لكن بكميات قليلة، الكميات الكبيرة من الكولسترول مرتبطة بامراض كثيرة من أهمها أمراض القلب والشرايين.

الكولسترول: عبارة عن مادة دهنية موجودة في الاغشية الخلوية للخلايا الحيوانية، مثال على بعض المنتجات الموجود فيها الكولسترول: البيض، واللحوم وبخاصة (أعضاء الحيونات)، والحليب ومنتجاته وغيره.

للكولسترول وظائف عديدة ومهمة في جسم الانسان منها: يساعد في انتاج الهرمونات الجنسية (الهرمونات الستيرويدية) و فيتامين دال، واعطاء الغشاء الخلوي القوة والمرونة، و يساعد مع العصارة الحمضية في هضم الدهون في الجسم.

يتواجد نوعين من الكولسترول في جسم الانسان: النوع الاول يتم تصنيعه بالكبد ويسمى الكولسترول)المُصنع في الداخل(، والنوع الثاني يتم اخذه من الغذاء الذي يحتوي على الكولسترول ويسمى الكولسترول)المأخوذ من الخارج(، معاً يشكلان توازن في كمية الكولسترول في جسم الانسان.

Pal Chol app

معلوماتك

الاسم *

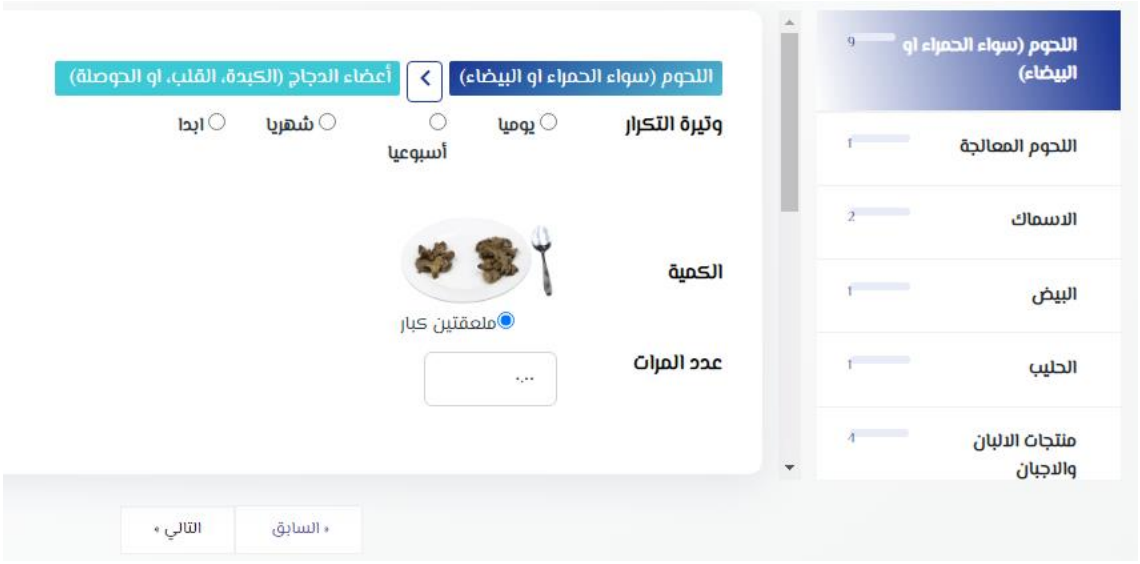
العمر *

الجنس *

- ذكر
- أنثى

السابق

ابدأ

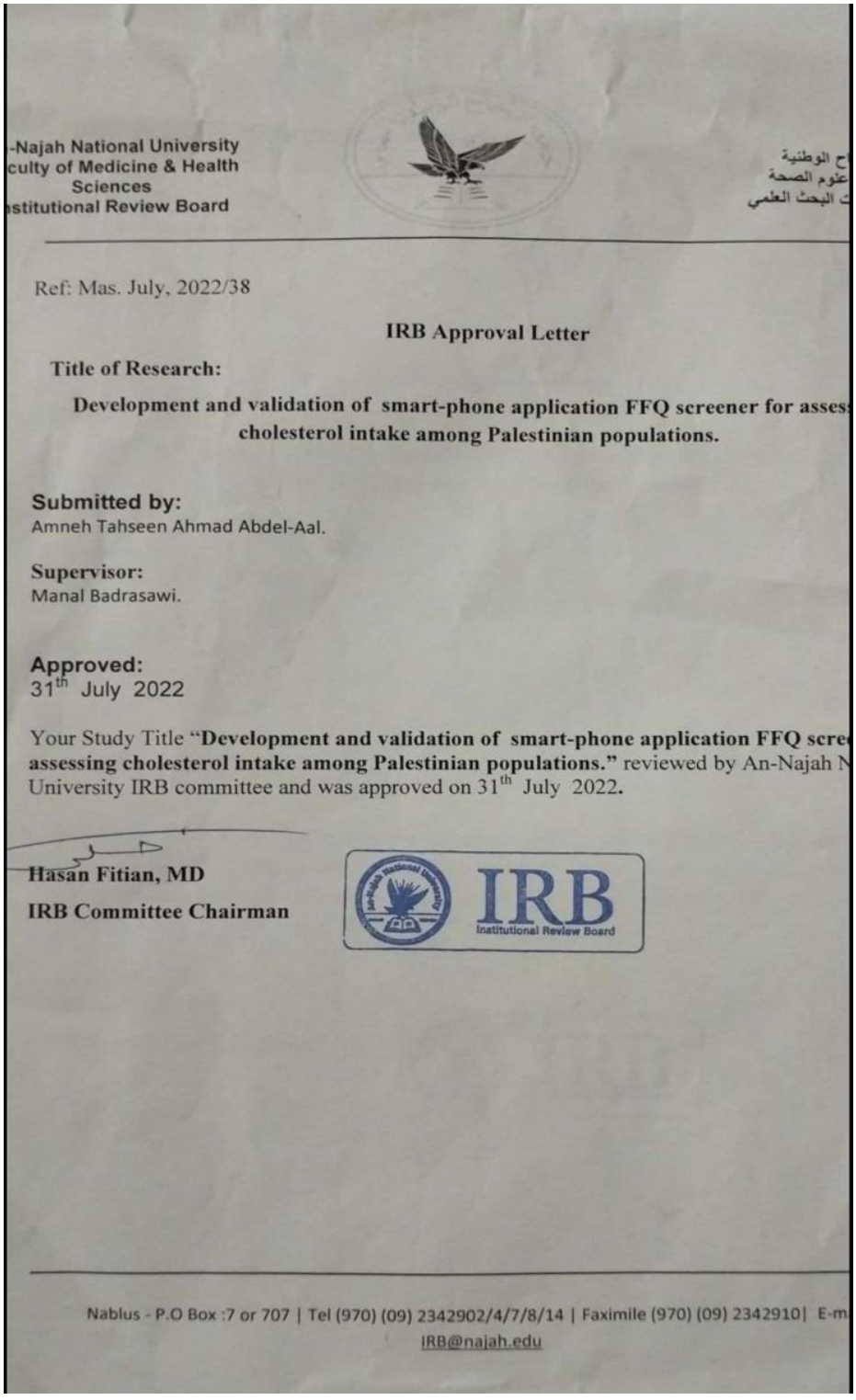


شكرا لمشاركتك ☻

الاستهلاك اليومي الكولسترول هو: 36.16 ملغم

Appendix D

Approval letter from Internal Review Board for Research Ethics (IRB) committee



-Najah National University
culty of Medicine & Health Sciences
stitutional Review Board

ح الوطنية
علوم الصحة
ث البحث العلمي

Ref: Mas. July, 2022/38

IRB Approval Letter

Title of Research:

Development and validation of smart-phone application FFQ screener for asses cholesterol intake among Palestinian populations.

Submitted by:
Amneh Tahseen Ahmad Abdel-Aal.

Supervisor:
Manal Badrasawi.

Approved:
31th July 2022

Your Study Title "**Development and validation of smart-phone application FFQ scre assessing cholesterol intake among Palestinian populations."** reviewed by An-Najah N University IRB committee and was approved on 31th July 2022.

Hasan Fitian, MD

IRB Committee Chairman

IRB
Institutional Review Board

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جامعة النجاح الوطنية

كلية الدراسات العليا

تطوير والتحقق من صلاحية تطبيق على الهاتف الذكي لتقييم استهلاك الكولسترول بين السكان الفلسطينيين

اعداد

آمنة عبد العال

إشراف

د. منال بدرساوي

د. رضوان قصراوي

قدمت هذه الرسالة استكمالا لمتطلبات الحصول على درجة الماجستير في التغذية وتكنولوجيا الغذاء، من كلية الدراسات العليا، في جامعة النجاح الوطنية، نابلس– فلسطين.

2023

تطوير والتحقق من صلاحية تطبيق على الهاتف الذكي لتقييم استهلاك الكولسترول بين السكان الفلسطينيين

اعداد

آمنة عبد العال

إشراف

د. منال بدرساوي

د. رضوان قصراوي

الملخص

الخلفية: الكولسترول هو مادة ضرورية موجودة في كل خلية حيوانية وله العديد من الوظائف التي ترتبط بصحة الجسم. على اية حال، استهلاك كميات اضافية من الكولسترول الغذائي يتعلق بارتفاع حدوث امراض القلب والشرايين. توصي منظمة الزراعة في الولايات المتحدة باستهلاك الكولستول لاقل من 300 ملغم/يومياً. في الجانب الآخر، استخدام التكنولوجيا في التقييم التغذوي يعتبر فعّال، وكطريقة بديلة عن الطريق التقليدية مثل استبيان تواتر الغذاء. هدفت الدراسة الى تطوير والتحقق من فاحص استبيان تواتر الغذاء الذي يختص بتقييم الكولسترول المأخوذ من الغذاء باستخدام تطبيق على الهاتف الذكي بين السكان الفلسطينيين.

المنهجية: تمت مشاركة 100 شخص من السكان الفلسطينيين، وتم اختيارهم عن طريق عينة ملائمة/مناسبة لهذه الدراسة، أعمارهم تتراوح بين 18–60 سنة. تمت هذه الدراسة على خمس مراحل، المرحلة الاولى: تطوير فاحص استبيان تواتر الغذاء. المرحلة الثانية: تطوير التطبيق .Pal Chol app المرحلة الثالثة: تحديد دقة وصلاحية المحتوى. المرحلة الرابعة: اختبار موثوقية التطبيق واعادة الاختبار. المرحلة الخامسة والاخيرة: دقة وصلاحية المعيار. تم فحص العلاقة عن طريق معامل ارتباط بيرسون (r) لتقييم الموثوقية والدقة، والاختلافات في الاوساط الحسابية تم اجراؤوها لتقييم الدقة أيضاً (p–value <0.05) .تعتبر ذات دلالة احصائية.

النتائج: في الدراسة التجريبية كان هناك علاقة كبيرة وقوية في نتائج اختبار موثوقية التطبيق واعادة الاختبار (p-value=0.000, r=0.7)، وبالنسبة لدراسة دقة وصلاحية المعيار، كان متوسط الاعمار 26.24 ±7.15 سنة. الاختلاف الوسطي كان كبير (p-value=0.000) اما بالنسبة للترابط كان هناك علاقة لكن ضعيفة بين نتائج التطبيق و3 ايام استذكار الغذاء (p-value=0.006, r=0.31) اضافة الى ذلك، فحص قابلية الاستعمال للتطبيق مقارنة مع 3 ايام استذكار الغذاء، غالبية المشاركين أكدوا على سهولة الاستخدام لهذا التطبيق.

الاستنتاجات: في هذه الدراسة، نجحنا في تطوير فاحص استبيان تواتر الغذاء المتخصص في تقييم الكولسترول الغذائي بين السكان الفلسطينيين الذين أعمارهم بين 18-60 سنة. ومع ذلك، يحتاج التطبيق الى المراجعة والتحسين.

الكلمات المفتاحية: أمراض القلب والشرايين، الكولسترول الغذائي، فاحص استبيان تواتر الغذاء، ودراسات لتحديد الدقة.