Universitat de les Illes Balears

Centro de Investigación Biomédica en Red
Fisiopatología de la Obesidad y Nutrición

DOCTORAL THESIS

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COMPARISON OF LIFESTYLES AMONG MEDITERRANEAN POPULATIONS: EASTERN VS WESTERN

JOANNE MAROUN KARAM

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University Professor

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"If we could give every individual the right amount of nourishment and exercise, not too little and not too much, we would have the safest way to health"

Hippocrates

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Joanne Maroun KARAM

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TABLE OF CONTENTS

ABBREVIATIONS

HDL	High density lipoprotein
LDL	Low density lipoprotein
MONICA	multinational monitoring of trends and determinants in cardiovascular disease
UNESCO	United Nations Educational, Scientific and Cultural Organization
Predimed	Prevention with Mediterranean Diet study
MUFA	Monounsaturated fatty acids
SFA	Saturated fatty acids
WHI	The women's health initiative study
SUN	The Seguimiento Universidad de Navarra study
MEDAS	Mediterranean diet adherence screener
SD	Standrard deviation
USDA	United States Department of Agriculture
BMI	Body mass index
HPLC	High performance liquid chromatography
IQR	Interquartile range
mg	Milligrams
Kcal	Kilocalorie
mg/d	Milligrams per day
ALA	Alpha linoleic acid
EPA	Eicosapentaenoic acid
DHA	Docosahexaenoic acid
EFSA	European food safety authority
WHO	World health organization
LA	Linoleic acid
TE	Total energy
g	Grams
DRI	Dietary reference intake

IOM	Institute of Medicine
WC	Waist circumference
WHtR	Waist-to-height ratio
µg/d	Micrograms per day
RDA	Recommended daily intake
F	Female
M	Male
TG	Total glycerides
TChol	Total cholesterol
FMI	Fat mass index
HGS	Handgrip strength test
AC	Arm curl test
BS	Back scratch test
8-f TUG	8 foot timed up and go
FRS	Framingham risk score
PA	Physical activity
SPSS	Statistical Package for the Social Sciences
LTPA	Leisure-time physical activity
KNHANES	Korean National Health and Nutrition Examination Survey
EWGSOP	European Working Group on Sarcopenia in Older People
Health ABC	Health, Aging and Body Composition
ASM	Appendicular skeletal muscle mass
ISAK	International Society for the Advancement of Kinanthropometry
ASMI	Appendicular skeletal muscle mass index

ASSESSMENT OF MEDITERRANEAN DIET IN A WESTERN AND EASTERN REGION OF THE MEDITERRANEAN SEA

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ABSTRACT

Introduction: The Mediterranean diet was proved to be beneficial in the prevention and prognosis of chronic diseases. Older adults are the age group with the highest incidence of chronic disease. The study was conducted in Spain and Lebanon, two Mediterranean countries.

Research content: In Mallorca, the nutritional content of the food consumed by 211 older adults was researched using two non-consecutive recall diets. The mean daily intake of polyphenols was 332.7 mg/d. Polyphenol intake was highest among alcohol drinkers, high educational level, high income, and physically active people. Flavonoids were the highest ingested polyphenols. Alcoholic beverages were the major contributors to the total polyphenol intake, mainly red wine.The mean daily intake of lipids was 68.6 g/day. Sex, age and educational level influenced fat intake. MUFA was the highest ingested fatty acid, and “oils & seeds” was the food group with highest contribution to lipid intake; both were in accordance with the Mediterranean diet pattern. However, the fatty acid intake did not abide by the recommendations in Mediterranean older adults. Calcium, copper, magnesium and iron were consumed in quantities lower than DRI. Female sex and an income ≥900euros were associated respectively with an increased and decreased probability of compliance with the DRI on a 5points scale. The intake of minerals should be adjusted to abide by the recommendations. Along with the

nutritional content of food, the correlation between age, body composition and biomarker variables on one hand and the physical fitness variables on the other hand were researched. Many physical fitness measurement variables correlated negatively with predictors of cardiovascular disease. Physical fitness might be essential in healthy aging. Physical condition and its association with sociodemographic, body composition and lifestyle habits were assessed. Overall, 36.8%, 24.5% and 0.3% of participants had low maximum 8-f TUG score, low maximum HGS and sarcopenia, respectively. Prevalence of these low values varies according to sociodemographic and body composition variables. In Lebanon, adherence to Mediterranean diet was assessed in 525 university students and 125 older adults using MEDAS. Among university students, the mean Mediterranean score estimated was 7.96. Men (7.99) had a slightly higher adherence to the Mediterranean diet than women (7.92). Nonsmokers had higher score than those who smoke. 59.05% of the sample had a score lower than adequate adherence but this did not affect their will to participate in research to ameliorate their health. 0.7% of the willingness to change diet depended on the score of adherence to Mediterranean diet and 28.58% of the participants were primarily worried about their health. Stratification of the questionnaire revealed a relatively high spread of olive oil usage in cooking (86.3%) although only 50.3% consume more than 4 teaspoons per day. The percentage of participants consuming food according to the Mediterranean diet standards was higher than 50% except for wine and fish. Positive correlations were found between the different components of MEDAS, in addition the percentage of participants who had an adequate score (≥9) was higher in non-smokers. Among older adults, mean Mediterranean score estimated was 8.48. Men (9) had a slightly higher adherence to the Mediterranean diet than women (8.3). Those who work had a higher adherence to Mediterranean diet than those who don’t. 52% of the sample had a higher

score than adequate adherence and the highest percentage of participants who had adequate score were primarily worried about their health and were willing to engage in physical activity, diet and research for a better health. The percentage of participants consuming food according to the Mediterranean diet standards was higher than 50% except for wine and fish. Positive correlations were found between the different components of MEDAS in older adults.

Conclusion: More studies must be conducted in the future to compare between Lebanon and Spain and develop strategies to increase adherence to Mediterranean diet in Lebanon for a better health.

Key words: Mediterranean diet, polyphenol, lipids, minerals, physical activity, physical fitness, adherence to Mediterranean diet, older adults, cardiovascular disease.

Universitat de les Illes Balears

EVALUACIÓN DE LA DIETA MEDITERRÁNEA DE UNA REGIÓN OCCIDENTAL Y UNA ORIENTAL DEL MAR MEDITERRÁNEO

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RESUMEN

Introducción: Se ha demostrado que la dieta mediterránea es beneficiosa para la prevención y el pronóstico de las enfermedades crónicas. Los adultos mayores son el grupo de edad con mayor incidencia de enfermedades crónicas. Este estudio se realizó en España y Líbano, dos países mediterráneos.

Contenido de la investigación: En Mallorca, la composición nutricional de los alimentos consumidos por 211 adultos mayores se investigó utilizando dos recordatorios de 24h en días no consecutivos. La ingesta diaria media de polifenoles fué de 332.7 mg/d. La ingesta de polifenoles fué más alta entre los bebedores de alcohol, alto nivel educativo, altos ingresos y personas físicamente activas. Los flavonoides fueron los polifenoles que se ingirieron en más cantidad. Las bebidas alcohólicas fueron las principales contribuyentes a la ingesta total de polifenoles, principalmente el vino tinto. La ingesta diaria media de lípidos fué de 68.6 g/día. El sexo, la edad y el nivel educativo influyeron en la ingesta de grasas. Los Ácidos Grasos Monoinsaturados (MUFA) fueron el tipo de ácido graso más altamente ingerido, y "aceites y semillas" fué el grupo de alimentos con mayor contribución a la ingesta de lípidos; ambos forman parte del patrón de dieta mediterránea. Sin embargo, la ingesta de ácidos grasos no cumplió con las recomendaciones en adultos mayores mediterráneos. El calcio, el cobre, el magnesio y el hierro se consumieron en cantidades inferiores a las IDR. Sexo

femenino e ingresos de ≥900 euros se asociaron respectivamente con una probabilidad mayor y menor de cumplimiento con los IDR en una escala de 5 puntos. La ingesta de minerales debe ajustarse para cumplir con las recomendaciones. Junto con la composición nutricional de los alimentos se investigó, por un lado, la correlación entre la edad, la composición corporal y las variables de biomarcadores y, por el otro, las variables de aptitud física. Muchas variables de medición de la aptitud física se correlacionaron negativamente con los predictores de enfermedad cardiovascular. La aptitud física podría ser esencial para un envejecimiento saludable. Se evaluó la condición física y su asociación con los hábitos sociodemográficos, la composición corporal y el estilo de vida. En general, el 36.8%, el 24.5% y el 0.3% de los participantes tenían una puntuación TUG máxima inferior a 8-f, un HGS máximo bajo y sarcopenia, respectivamente. La prevalencia de estos valores bajos variaba según las variables sociodemográficas y de composición corporal. En Líbano, se evaluó la adherencia a la dieta mediterránea en 525 estudiantes universitarios y en 125 adultos mayores usando el MEDAS. Entre los estudiantes universitarios, la puntuación media estimada de adherencia a la dieta mediterránea fué 7.96. Los hombres (7.99) tuvieron una adherencia ligeramente mayor a la dieta mediterránea que las mujeres (7.92). Los no fumadores tenían una puntuación más alta que aquellos que fuman. El 59,05% de la muestra tenía una puntuación inferior a la adecuada, pero esto no afectaba a su voluntad de participar en investigaciones para mejorar su salud. El 0.7% de la voluntad de cambiar la dieta dependía del grado de adherencia a la dieta mediterránea y el 28.58% de los participantes estaban preocupados principalmente por su salud. La estratificación del cuestionario reveló una difusión relativamente alta del uso de aceite de oliva en la cocina (86.3%), aunque solo el 50.3% consumía más de 4 cucharaditas por día. El porcentaje de participantes que consumían alimentos de acuerdo con los estándares de la

dieta mediterránea era superior al 50% a excepción del vino y el pescado. Se encontraron correlaciones positivas entre los diferentes componentes de MEDAS, además el porcentaje de participantes que tenían una puntuación adecuada (≥9) era mayor en los no fumadores. Entre los adultos mayores, la puntuación promedio estimada de adherencia a una dieta mediterránea fué de 8.48. Los hombres (9) tenían una adherencia ligeramente mayor a la dieta mediterránea que las mujeres (8.3). Aquellos que trabajaban tenían una mayor adherencia a la dieta mediterránea que aquellos que no lo hacían. El 52% de la muestra tenía una puntuación en adherencia superior a la adecuada y la mayor parte de participantes que tenían una puntuación adecuada estaban preocupados principalmente por su salud y estaban dispuestos a participar en programas de actividad física, dieta e investigación para mejorar su salud. El porcentaje de participantes que consumían alimentos de acuerdo con los estándares de la dieta mediterránea fué superior al 50% a excepción del vino y el pescado. Se encontraron correlaciones positivas entre los diferentes componentes de MEDAS en adultos mayores.

Conclusión: Se deben realizar más estudios en el futuro para comparar Líbano y España, así como desarrollar estrategias para aumentar la adherencia a un patrón de dieta mediterránea en Líbano, con el fin de mejorar la salud de la población.

Palabras clave: Dieta mediterránea, polifenoles, lípidos, minerales, actividad física, estado físico, adherencia a la dieta mediterránea, adultos mayores, enfermedad cardiovascular.

AVALUACIÓ DE LA DIETA MEDITERRÀNIA EN UNA REGIÓ OCCIDENTAL I UNA REGIÓ ORIENTAL DE LA MAR MEDITERRÀNIA

Universitat de les Illes Balears

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RESUM

Introducció: S'ha demostrat que la dieta mediterrània és beneficiosa en la prevenció i prognòstic de malalties cròniques. Els adults majors són el grup d'edat amb major incidència de malalties cròniques. L'estudi s'ha portat a terme a Espanya i el Líban, dos països mediterranis.

Continguts de recerca: A Mallorca, s'ha investigat la composició nutricional dels aliments consumits per 211 adults majors utilitzant dos recordatoris de 24h de dies no consecutius. La ingesta mitjana diària de polifenols va ser de 332.7 mg/d. La ingesta de polifenols va ser més elevada entre els bevedors d'alcohol, nivell educatiu elevat, ingressos elevats i persones físicament actives. Els flavonoides van ser els polifenols més ingerits. Les begudes alcohòliques van ser els principals contribuents a la ingesta total de polifenols, principalment el vi negre. La mitjana de consum diari de lípids va ser de 68.6 g/dia. El sexe, l'edat i el nivell educatiu van influir en la ingesta de lípids. Els Àcids Grassos Mono Insaturats (MUFA) van ser el tipus d'àcid gras més consumit, i "olis i llavors" va ser el grup alimentari amb major contribució a la ingesta de lípids; tots dos formen part d'un patró de dieta mediterrània. No obstant això, la ingesta d'àcids grassos no va complir amb les recomanacions per adults majors mediterranis. El calci, el coure, el magnesi i el ferro es van consumir en quantitats inferiors a les IDR. El sexe

femení i un ingrés ≥900 euros es van associar, respectivament, amb una probabilitat creixent i disminuïda del compliment de les IDR en una escala de 5 punts. La ingesta de minerals s'hauria d'ajustar per complir amb les recomanacions. Juntament amb la composició nutricional dels aliments, es va investigar la correlació entre les variables: edat, composició corporal i biomarcadors d'una banda i les variables d’aptitud física, de l’altra. Moltes variables de mesura d'aptitud física es van correlacionar negativament amb els predictors de malaltia cardiovascular. L'aptitud física pot ser essencial en l'envelliment saludable. Es va avaluar la condició física i la seva associació amb les variables sociodemogràfiques, la composició corporal i els hàbits de vida saludable.

En total, el 36.8%, el 24.5% i el 0.3% dels participants tenien una puntuació màxima de TUG inferior a 8-f, HGS màxim baix i sarcopenia, respectivament. La prevalença d'aquests valors baixos varia segons les variables sociodemogràfiques i de composició corporal. Al Líban, l'adhesió a la dieta mediterrània es va avaluar en 525 estudiants universitaris i 125 adults majors utilitzant MEDAS. Entre els estudiants universitaris, la mitjana de la puntuació d’adherència a un patró de dieta mediterrània va ser de 7.96. Els homes (7.99) tenien un grau d’adherència a la dieta mediterrània lleugerament superior a les dones (7.92). Els no fumadors tenien una puntuació més alta que els fumadors. El 59.05% de la mostra tenia una puntuació inferior a l'adherència adequada, però això no afectava la seva voluntat de participar en investigacions d'investigació per millorar la seva salut. El 0.7% de la voluntat de canviar de dieta depenia de la puntuació d'adhesió a la dieta mediterrània i el 28.58% dels participants es preocupaven principalment per la seva salut. L'estratificació del qüestionari va revelar una distribució relativament alta de l'ús de l'oli d'oliva en la cuina (86.3%) tot i que només el 50.3% consumia més de 4 culleradetes diàries. El percentatge de participants que consumien aliments d’acord amb un patró de dieta mediterrània era superior al 50%, excepte pel vi i el peix. Es van trobar

correlacions positives entre els diferents components de MEDAS. A més, el percentatge de participants que tenien una puntuació adequada (≥9) era major en els no fumadors. Entre els adults majors, la puntuació d'adhesió mitjana a un patró de dieta mediterrània va ser de 8.48. Els homes (9) tenien una adherència lleugerament superior a la dieta mediterrània que les dones (8.3). Els que treballaven tenien una major adhesió a la dieta mediterrània que els que no treballaven. El 52% de la mostra tenia una puntuació per sobre de l'adherència adequada i la major part dels participants que tenien una puntuació adequada estaven preocupats principalment per la seva salut i disposats a participar en programes d'activitat física, dieta i recerca per tal de millorar la seva salut i la de la població. El percentatge de participants que consumien aliments d'acord amb un patró de dieta mediterrània era superior al 50%, excepte pel vi i el peix. Es van trobar correlacions positives entre els diferents components de MEDAS en adults majors. ***Conclusió:*** Cal fer més estudis en el futur per comparar el Líban amb Espanya i desenvolupar estratègies per augmentar l'adhesió a la dieta mediterrània al Líban per a una millor salut.

Paraules clau: Dieta mediterrània, polifenol, lípids, minerals, activitat física, condicionament físic, adherència a la dieta mediterrània, adults majors, malaltia cardiovascular.

LIST OF PAPERS:

I. Karam J, Bibiloni MDM, Tur JA. Polyphenol estimated intake and dietary sources among older adults from Mallorca Island. PLoS One. 2018;13(1):e0191573.

II. Karam J, Bibiloni MDM, Pons A, Tur JA. Fatty acid estimated intake and dietary sources among Mediterranean older adults. (Submitted)

III. Bibiloni MDM, Karam J, Bouzas C, Aparicio-Ugarriza, R, Pedrero-Chamizo R, Sureda A, González-Gross M, Tur J. Association between Physical Condition and Body Composition, Nutrient Intake, Sociodemographic Characteristics and Lifestyle Habits in Older Spanish Adults. Nutrients. 2018;10(11):pii: E1608.

IV. Karam J, Bibiloni MDM, Tur JA. Estimation of minerals intake in older adults in a Mediterranean region. (Submitted)

V. Karam J, Bibiloni MDM, Tur JA. Association between cardiovascular risk predictors and physical fitness measurements in older adults living in a Mediterranean region. (Submitted)

VI. Karam J, Serhan M, Tur JA. Adherence to Mediterranean diet in a Lebanese University population: case of University of Balamand. (Submitted)

VII. Karam J, Serhan M, Tur JA. Adherence to Mediterranean diet and its association with age: comparison between Lebanese younger and older adults. (Submitted)

Introduction

1. The Mediterranean Area

The Mediterranean Sea, lies between the continents of Eurasia and Africa enclosed practically by land (1). Historically, the warm and temperate climate of the Mediterranean Sea region allowed numerous ancient people to establish themselves and develop traditions of philosophy, art, literature, and medicine which lie at the roots of modern Western and Middle Eastern culture. For the entire region, the Sea itself was the most important route for merchants and travelers of ancient times, allowing for trade and cultural exchange between emergent peoples of the region (Egyptians, Persians, Phoenicians, Greeks, Semitics, Mesopotamians) (2).

The term Mediterranean derives from the Latin *mediterraneus* which means the middle land; to the ancient Romans, the Mediterranean was the center of the earth. In the Old Testament, several names are found, it is called the "Hinder Sea," sometimes translated as "Western Sea," (Deuteronomy 6:24), and also the "Sea of the Philistines" (Exodus 12:81). However, the most common name found is "Great Sea" (Numbers 34:6, 7; Joshua 1:4, 9:1, 15:47). In Hebrew, it is called HaYam “the middle sea". In Turkish, it is Akdeniz, "the white sea." In Arabic, it is Al-Baħr Al-Abyad Al-Muttawasit, "the middle white sea" (2).

Twenty-one modern states have a coastline on the Mediterranean Sea. In Europe: Spain, France, Monaco, Italy, the island state of Malta, Slovenia, Croatia, Bosnia-Herzegovina, Montenegro, Albania, Greece. In Asia: Turkey, Syria, the island Republic of Cyprus, Lebanon and Palestine. In Africa: Egypt, Libya, Tunisia, Algeria and Morocco. Macedonia, Portugal, San Marino, Serbia, and the Vatican, althoughthey do not border the sea, are often considered Mediterranean countries in a wider sense due to their Mediterranean climate and their cultural affinity with other Mediterranean countries (1).

The eastern Mediterranean sea includes large islands of which Cyprus, Crete, Euboea, Rhodes, Lesbos, Chios, …; Sardinia, Corsica, Sicily, and Malta are located in the central Mediterranean; and Ibiza, Majorca and Minorca (the Balearic Islands) in the western Mediterranean (1).

The Mediterranean climate is generally one of wet winters and hot, dry summers. Crops of the region include olives, grapes, oranges, tangerines, and cork (2).

This thesis will be focusing on two Mediterranean countries; Spain, specifically Mallorca one of the Balearic islands from the west and Lebanon from the east.

1.1 Spain

1.1.1 Location

According to the encyclopedia Britannica, Spain is located in extreme southwestern Europe. It occupies about 85 percent of the Iberian Peninsula. The country is geographically and culturally diverse. In the northeast are the huge valley of the Ebro River, the mountainous region of Catalonia, and the coastal plain of Valencia. The Cantabrian Mountains are in the northwest. To the south is the citrus-rich of the valley of the Guadalquivir River. The southern region of the country is desert. The southeastern Mediterranean coast and the Balearic Islands enjoy a gentle climate lined with palm trees, rosemary bushes, and other vegetation. Spain’s countryside is marked with castles and ancient ruins, but its cities are modern. The Catalonian capital of Barcelona is famed for its secular architecture and maritime industry; the Andalusian capital of Seville for its musical culture and traditional folkways; and the national capital of Madrid for its winding streets and its around-the-clock lifestyle (3).

Spain is bordered to the west by Portugal; to the northeast it borders France, from which it is separated by the small principality of Andorra and by the great wall of the Pyrenees Mountains. Elsewhere the country is bounded by water: by the Mediterranean

Sea to the east and southeast, by the Atlantic Ocean to the northwest and southwest, and by the Bay of Biscay to the north (3).

1.1.2 Historical overview

The many and varied cultures that were involved the making of Spain—those of the Castilians, Catalonians, Lusitanians, Galicians, Basques, Romans, Arabs, Jews, and Gypsies, are renowned for their varied cuisines, customs, and prolific contributions to the world's artistic heritage. The country's Roman conquerors left their language, roads, and monuments, while many of the Roman Empire's greatest rulers were Spanish, among them Trajan, Hadrian, and Marcus Aurelius. The Moors, who ruled over regions of Spain for nearly 800 years, left a legacy of fine architecture, science, and lyric poetry; Roma contributed in the haunting music called the Cante Jondo. For generations Spain was possibly the richest country in the world (3).

1.1.3 Climate and crops

The large territory of Spain is close to the Atlantic Ocean and North Africa. This location expose it to both maritime and Saharan influences; and its mountainous relief, which not only produces its own climatic zones but also exaggerates local aridity through the creation of rain shadows on the mountains' sheltered sides. The climate is hence characterized by the overlap of one fundamental climatic division between humid and semiarid and arid in some parts and a threefold division of the peninsula into maritime, continental, and mountain climates (3).

Vegetables, fruits, and cereals are the principal crops, accounting for about three-fourths of Spain's agricultural production, with cereals the principal crops. Barley and wheat, the major crops in Spain, predominate on the plains of Castile-León, Castile–La Mancha, and Andalusia, while rice is grown in coastal Valencia and southern Catalonia. Corn grown in the north, is a major feed product. Other crops include cotton, tobacco, sugar beets, olives and legumes (beans, lentils, and chickpeas). Fruit growing is also significant, with citrus fruits, especially oranges being of greatest importance. Other fruit crops include apples, apricots, bananas, pears, peaches, and plums. Spain also produces tomatoes, onions, potatoes and almonds. Because Spain is one of the world's largest producers of wine, grape growing is of considerable importance. The raising of livestock accounts for only under half the value of Spain's total agricultural output. Pork leads meat production in Spain, followed by poultry, beef, and lamb. With about 8,000 km of coastline, Spain has an important fishing industry. The main fishing ports are in the northwest (3).

1.1.4 Cuisine

Spanish cooking varies greatly from a region to another, linked to local products and traditions. Galicia, for example, is famed for its seafood, including dishes of baby eels and Vizcayan-style codfish; Catalonia is renowned for meat and vegetable casseroles; and Valencia is the homeland of paella, a rice dish made with seafood, meats, and vegetables. From Andalusia comes gazpacho, a delicious cold soup made of tomatoes, garlic, and cucumber, while the cattle-producing region of Castile boasts succulent roasts and air-dried hams. Spanish food is often considered to be very spicy, but, apart from a few dishes that contain small amounts of a mild chili pepper, the most piquant ingredient in general used is paprika. Otherwise, dishes are likely to be flavored with such spices as tarragon and saffron. The most broadly eaten meats are pork, chicken, and beef, but in much of the country lamb is eaten on special occasions. Spaniards are among the world's largest consumers of seafood. Legumes, especially lentils and chickpeas, also form an important part of the Spanish diet. The most well-known bar food, known as tapas, usually consists of prepared dishes, many of which are quite elaborate and are often smaller versions of main-course dishes. There are hundreds of different tapas, but classic ones are mushrooms in garlic sauce, marinated seafood, Spanish omelets (tortilla), lamb brochettes, and octopus in paprika sauce. Spaniards frequently drink wine and beer with their meals. They also commonly drink bottled mineral water, even though in most parts of the country the tap water is perfectly safe. At breakfast and after meals, strong coffee is the almost universal drink. Few people drink tea, but herbal infusions such as chamomile are popular. Soft drinks, both domestic and imported, are widely available (3).

1.1.5 Mallorca

Mallorca, the largest Balearic Island, is known as the “wooded Isle”, “Tranquil Isle” and “Golden Isle” despite its dependence on mass tourism. This Mediterranean island is known for its beautiful climate all over the year, the coasts and sandy beaches, the many areas of natural beauty, the castles, caves and churches. Many cultural events and festivals are held in Mallorca of which Revetlla de Sant Antoni Abat, Festes de Sant Sebastià, Festa de Sant Bartomeu, Festa de Sant Jaume, Festa de L’Àngel… Mallorquin cuisine has several highlights typical for the island as the Pa amb Oli, frit Mallorquí and Llom amd Col, Tumbet, Sopes Mallorquines, Ensaimadës (4) etc…

1.2 Lebanon

1.2.1 Location

Lebanon is located on the eastern shore of the Mediterranean and is one of the world’s smallest sovereign states. It is bounded to the east and north by Syria, to the west by the Mediterranean Sea and to the south by Palestine (5).

1.2.2 Historical overview

Historically, Lebanon is heir to a long succession of Mediterranean cultures (Phoenician, Greek, and Arab). The Phoenicians arrived in the land that became Phoenicia about 3000 BCE. In 64 BCE, Phoenicia was incorporated into the Roman province of Syria, though Aradus, Sidon, and Tyre retained self-government. During the period of the Roman Empire, the native Phoenician language disappeared and was replaced by Aramaic. The ottoman ruled then Lebanon for 400 years and was replaced by French mandate. In 1946, Lebanon became wholly independent. The cultural milieu continues to show manifestations of a rich and diverse heritage. The cultural awakening after the civil war encouraged the revival of national folk arts, particularly song, “dabkah” (the national dance), and “zajal” (folk poetry), and the refinement of traditional crafts. Beirut, the capital, has several museums and a number of private libraries, and research institutions. The National Museum houses a collection of artifacts from Phoenician, Hellenistic, Roman, and Byzantine eras (5).

The largest festivals that take place yearly in Lebanon are The Baalbek International Festival, the Byblos International Festival, Beiteddine Art Festival, Beirut Holidays Festival, Al-Bustan Festival, Ehdeniyat International Festival, Batroun International Festival, Zouk Mikael International Festival.

1.2.3 Climate and crops

Climate, soils, and vegetation undergo some sharp and striking changes within short distances due to the mountainous region complexity and variety. Four different geographic regions may be distinguished in Lebanon; a narrow coastal plain along the Mediterranean Sea, the Lebanon Mountains, its maximum elevation is at Qurnat al Sawda 3088 m above sea level in the north of Lebanon, Al-Bikaa valley, and the Anti-Lebanon and Hermon ranges running parallel to the Lebanese Mountains (5).

There are sharp local contrasts in the country’s climatic conditions. Lebanon is included in the Mediterranean climatic region. The climate of Lebanon is generally subtropical and is characterized by hot, dry summers and mild, humid winters. All precipitation falls in winter, averaging 750 to 1,000 mm on the coast and rising to more than 1,270 mm in higher altitudes. Al-Bikaa is drier and receives 380 to 640 mm. On the higher mountaintops, this precipitation falls as heavy snow (5).

The climate and the relatively abundant water supply from springs favor the intensive cultivation of a variety of crops on mountain slopes and in the coastal region. On the coastal plain, market vegetables, bananas, and citrus crops are grown. In the foothills the major crops are olives, grapes, tobacco, figs, and almonds. At higher elevations peaches, cherries, plums, apricots, apples and pears are planted. Sugar beets, cereals, and vegetables are the main crops cultivated in Al-Bikaa. Poultry is a major source of agricultural income, and goats, sheep, and cattle are also raised. The production of hemp, the source of weed, has flourished in Al-Bikaa valley and is exported illegally through ports along the coast (5).

1.2.4 Cuisine

Lebanon is much appreciated for its cuisine which is among the most savory and varied in the world. Lebanese food is associated with the mezze a spread of uncountable small dishes that form the traditional opener to a meal, among which are hummus, moutabal (eggplant and sesame paste dip), warak arish (stuffed vine leaves), tabbouleh (a salad of parsley, tomatoes and crushed wheat), sambousek (hot cheese or meat pastries), labneh (strained yogurt seasoned with olive oil and garlic), fattoush (green salad with dried bread), kebbi (ground meat with crushed wheat and flavorings) and many more. Next comes the seafood or grills lamb, kabab, chicken brochettes or kafta. Other typical dishes include kebbi bi laban, moujaddara, sayyadiyeh. The meal is generally accompanied by arak, the national drink of distilled grape juice flavored with anis or local wine. White coffee is popular in Lebanon (infusion of orange flower water) as well the turkish coffee. Typical fast food in Lebanon includes mankoushe, lahem bi ajin, falafel, shawarma (6).

2. Elderlies

Traditionally the term "elderly" has referred to those 65 years of age and older because of the definition used to target public programs such as the Older Americans Act and Titles XVIII (Medicare), XIX (Medicaid), and XX (Social Services) of the Social Security Act (7). As the number of elderly has grown, many differences among them have become apparent. It is increasingly clear that there are at least two major subgroups of the elderly: those aged 65-74, known as the "young old" and are generally very fit and active, and those 75 and older, the "old old", who have a much higher prevalence of illness and disability (7).

Improved standards of living brought social changes of which is population aging. In the near future, the number of children younger than 14 years will be less than older people (8). Life expectancy has increased dramatically from 47.3 years in 1900 to 72.5 years in 1975 (9). There is more than a 50% probability that by 2030, national female life expectancy will break the 90 year barrier, a level that was deemed unattainable by some at the turn of the 21st century (10). The continuous increase in longevity requires careful planning for health and social services and pensions (10). The per capita expenditure of older people for all types of health services exceeds that of all other segments of the population. Several demographic factors have important influences on the health of the elderly population, their utilization of health services, and their contribution to health care expenditures (7).

2.1. Elderlies Health

With age, physiologic reserve decreases making the body more susceptible to chronic illnesses and disabilities. Psychological crises as retirement, loss of income, widowhood affect health as well (7). When assessing health in the elderlies, the term illness is more common than disease, for it includes not only the disease but as well the perception and behavioural reaction of the individual towards the disease (7). There is tendency to judge the elderlies to have relatively a poorer health (11), but when judging themself despite the presence of multiple chronic conditions and disabilities, elderlies consider themselves in good or excellent health (9). It is hard to recognize which changes are age-related and occur in everyone and which ones are pathologic and indicate the development of disease (7).

Malnutrition, depression, senility are not normal concomitants of aging and they should be carefully evaluated and appropriately treated. Elderlies living alone have a higher risk of under nutrition (12). Old people report their symptoms differently than younger population; they often delay in seeking health care due to a fear from doctors, health cares, nursing homes and death or due to a repressing of emotions (7). Clinical signs are complicated in elderlies; myocardial infarction or a perforated ulcer may occur without pain, pneumonia and other infections may be present without fever (7). Several features of the prevalence of disease and disability distinguish the elderly from younger people. Disease and death increase with age especially after the age of 75 are mostly due to chronic diseases (9). They do not suffer from one isolated condition as young people but from multiple coexistent chronic conditions upon which illnesses are superimposed (7). The diseases elderlies suffer from are mainly diseases of the heart and the circulatory system, malignant neoplasms, cerebrovascular disease, influenza and pneumonia, arteriosclerosis, diabetes mellitus, cirrhosis of the liver, cataract, diseases of the nervous system, arthritis, ulcer, renal problems, mental disorders and sarcopenia (13).

Frailty and heart disease are the two most typical types of diseases elderlies suffer from. Frailty is a state, independent from the normal aging process, with impaired homeostatic reserve and low ability of the organism to withstand stress. It is characterised by physical weakness, reduced physical activity and performance, and thus increased vulnerability to adverse health outcomes including falls, hospitalisation, institutionalisation and mortality (14, 15). The general concept of frailty goes, however, beyond physical factors to encompass psychological and social dimensions as well, including cognitive status, social support and other environmental factors (16).

A key component of frailty is sarcopenia, a progressive loss of skeletal muscle mass and low muscle strength or performance that occurs with advancing age (15, 16). It represents an impaired state of health with a high personal toll (i.e. mobility disorders, increased risk of falls and fractures, impaired ability to perform daily life activities, disabilities, loss of independence and increased risk of death) (15). Under normal circumstances, muscle homeostasis is maintained in a delicate balance between new muscle cell formation, hypertrophy and protein loss (16). This balance is influenced by nutritional factors and physical activity level (16), but also by the chronic diseases and certain drug treatments (15). Early identification of a decline in the physical condition and appropriate interventions could help in preventing functional impairments, such as impairments in walking and stairs climbing that often result in falls and physical frailty (17). Sarcopenia is defined as a low muscle mass accompanied by either low muscle strength or low physical performance, whereas severe sarcopenia is defined as a low muscle mass, a low muscle strength and low physical performance (15).

The leading cause of death in older adults is heart disease, presenting challenges in diagnosis and treatment (18). Normal aging is associated with a decreased compliance of the central arteries due to a number of age-related changes in the structure of the artery (19). The amount of collagen in the arterial wall increases with age causing cross linkages with other collagen products making it more resistant to breakdown and turnover (20). In addition, the matrix metalloproteinase increases transforming growth factor-beta 1 and angiotensin II and leads to endothelial dysfunction (20). Decreased vascular compliance and elasticity is commonly encountered in clinical practice as isolated systolic hypertension. The syndrome is characterized by increased systolic pressure, decreased diastolic pressure, and thereby a widened pulse pressure (21).

Elderlies suffer from different types of heart diseases of which: first, valvular heart disease that includes aortic valve stenosis its symptoms include heart failure, angina or syncope, these patients need surgical valve replacement if their state allows (18), and includes as well mitral valve disease that needs surgical intervention too (18). Second, the coronary heart disease which is the leading cause of death in elderly men and women. Risk factors include diabetes, hypertension, tobacco smoking, dyslipidaemia, obesity, family history, and physical inactivity (22). Coronary heart disease includes the asymptomatic diseases: hypertension and dyslipidaemia. Hypertension was once considered a necessary physiologic compensation for age-related vascular changes; trials on hypertension treatment in the elderly demonstrate that blood pressure control leads to significant reductions in clinical end points of myocardial infarction, stroke, and cardiovascular death (18). Dyslipidaemia is common in elderlies and is associated with other conditions as stroke and peripheral artery disease, statin is used for treatment of this condition (18). Symptomatic coronary heart diseases include chronic stable angina which has become a debated topic in recent years, its treatment consists of antiplatelet therapy, lipid-lowering drugs, and antihypertensive and anti-anginal medications, and unstable angina or non ST (ST segment of the electrocardiogram) elevation myocardial infarction. Third, arrhythmia, two types exist the atrial fibrillation and the ventricular arrhythmias. Atrial fibrillation is the most common clinically significant arrhythmia in the elderly and the incidence of atrial fibrillation increases with age. In treating atrial fibrillation the two most important issues are rate-control versus rhythm-control strategies and anti-coagulation. The symptoms of ventricular arrhythmias include sudden cardiac death. Another disease is systolic heart failure; treatment includes angiotensin-converting enzyme inhibitors, angiotensin II receptor blockers, beta-blockers, aldosterone antagonists, vasodilator therapy (nitrates and hydralazine), digoxin and diuretics. Finally, heart failure with normal ejection fraction or diastolic heart failure; its most common risk factor is systolic hypertension, despite the prevalence of this problem, no pharmaceutical trials have shown a mortality benefit (18).

2.2 Importance of Early Awareness about Health

Chronic diseases are preventable diseases; their prevention must take place throughout one's life. Prevention includes health promotion activities and early detection efforts as screening, management of existing diseases and related complications (23).

Quitting smoking for example drops the risk of heart attack by half and cause an improvement in lung function after only two weeks of quitting, more improvements are observed later throughout the life (24). Lifestyle changes in diet and exercise can prevent the onset of type two diabetes mellitus for people at high risk (25). Regular screening for colorectal cancer can reduce the number of death caused by this disease, and yearly mammograms in women older than 40 reduce the mortality from breast cancer (26). Among diabetic patients, foot and eye exams reduce vision loss and amputations (27). Self-management activities and early diagnosis of arthritis help in decreasing pain, improving function and staying productive (23). Health in old age is related to health in earlier years of life; obese children have the risk to develop in the future chronic diseases as diabetes, circulatory disease, cancer, respiratory and musculo-skeletal disorders (28).

As Hippocrates states “the function of protecting and developing health must rank even above that of restoring it when it is impaired”.

Prevention as mentioned earlier has to start at early ages. Several policies are adopted. School health programs that promote healthy behaviour are the most efficient and cost effective ways to reduce the risk of chronic diseases in students and their family member. This program requires a strong coordination and planning among school personnel, health workers, community leaders, parents and students. Second, civil society organizations; these organizations play an important role in preventing chronic diseases by influencing decision makers in the government and the private sector. The civil society includes many groups as consumer groups, registered charities, intergovernmental organizations, professional associations, and advocacy groups. Third, the workplace health programs offer also opportunities for early detection, management and prevention of chronic diseases for both employers and workers. These programs reduce sickness and absenteeism, protect earning capacity, and prevent disability, increase productivity and results in lower expenditures on chronic disease acute care. Prevention and control of chronic diseases are important for maintaining a healthy population and achieving economic growth. Various strategies can be implemented as mentioned earlier and would protect people from financial hardship caused by chronic disease (29).

2.3 Physical Activity

Regular exercise and physical activity were proven to have many benefits for the health of older adults. The American college of sports medicine developed practice guidelines including behavioral recommendations, exercise program structure and risk management strategies for exercise in older adults (30). Regular exercise reduces the risk of many adverse health outcomes, additional benefits occur as the amount of physical activity increases (longer duration, greater frequency, higher intensity) (31).

With age, functional and structural deterioration take place in physiological systems even in the absence of disease (32). This affects a broad range of tissues and organs which affects daily living in older adults (33). In addition, the body composition changes with age as for example the gradual accumulation of body fat and its redistribution to visceral and central depots, the loss of muscle known as sarcopenia (34). Aging includes primary aging, secondary aging and the genetic factors (32). The impact of physical activity on aging is difficult to observe or assess, but it was shown that regular exercise increases life expectancy in those suffering from chronic diseases (secondary aging) (33).

Physical activity affects the quality of life. Quality of life is defined as a “conscious cognitive judgment of satisfaction with one’s life” (35). In aging research, quality of life has been used as an umbrella term to describe a number of outcomes that clinicians believe is important in the lives of older adults (36). Quality of life includes functioning (physical abilities, dexterity, cognition, ability to perform activities of daily living) and well-being (symptoms and bodily states, emotional wellbeing, self-concept, global perception related to health and overall life satisfaction) (36).

Evidence proves the effectiveness of regular physical activity in the primary and secondary prevention of chronic diseases. The benefits of physical activity are especially obvious in previously sedentary individuals (37). Fit people with risk of cardiovascular diseases are at lower risk of premature death than those who are sedentary and have no risk factors of cardiovascular disease (38-39). Aerobic and resistance types of exercise are associated with decreased risk of type 2 diabetes mellitus and are effective in the management of diabetes (37). In addition, there is compelling evidence that routine physical activity is associated with reductions in colon and breast cancers (37). Resistance exercise including weight lifting appears to have the greatest effects on bone mineral density and in the prevention of osteoporosis especially in postmenopausal women. All these changes are achieved by improving body composition (reduced abdominal adiposity, improved weight control), better lipid lipoprotein profiles (decreased triglycerides, increased high density lipoprotein (HDL) cholesterol levels and decreased low density lipoprotein (LDL) to HDL ratios, improved glucose homeostasis and insulin sensitivity, reduced blood pressure, decreased blood coagulation). Physical activity is also associated with improved psychological wellbeing by decreasing stress, anxiety and depression (37).

Physical activity is hence very important in achieving a healthy status in elderlies.

2.4 Diet

The relationship between coronary heart disease and dietary factors has been an important focus of research in the past decades. Studies have shown that some foods protect from cardiovascular diseases as the vegetables, nuts, monounsaturated fatty acids. On the other hand, other foods are considered harmful or represent a risk factor including those with a high glycemic index and trans fatty acids. A causal relationship between coronary heart disease and the intake of fish, folate, whole grains, vitamins E and C, beta carotene, alcohol, fruits, fiber, meat, eggs and milk and was found as well

(40). The dietary Guidelines for Americans from the United States departments of health and human services and agriculture recommend a reduced consumption of saturated and Trans fatty acids and an increased intake of fruits, vegetables and whole grains (41).

Not only specific foods affect the health status specifically coronary heart disease but the holistic approach is gaining more and more attention. A strong evidence of a causal link between coronary heart disease and dietary patterns was shown in many studies. The dietary patterns take in account the complex interactions and cumulative effects of different nutrients within the entire diet, making it easier to observe effects than one single nutrient (42). The Mediterranean diet reduces cause specific and all-cause mortality in patients with coronary heart disease (43). High quality dietary patterns protect from cardiovascular diseases (40). A prudent pattern reduces the risk of cardiovascular and total mortality, and a western pattern increases these risks in healthy women (40-44).

3. The Mediterranean Diet

The Mediterranean diet was first illustrated in the time of the ancient Egyptian civilization on a sculpture on the tomb of Ramses the second showing the association of cereals, vine and olive trees. In 1634, Castelvetro an Italian living in England complained about people eating too much meat and not eating enough fruits and vegetables and praised the diet adopted in his country of origin and its effect on health (45). In the 1960s a study on seven countries in the Mediterranean region showed a relation between lower mortality rates for cardiovascular disease and a particular dietary pattern in these countries differently from other European countries. Observational studies have highlighted the probable health benefits gained by adhering to the Mediterranean diet through reduction of risk factors for many diseases including metabolic syndrome, type 2 diabetes mellitus, cardiovascular disease, cancer, depression and mental disorder (46). In the 1970s, the multinational monitoring of trends and determinants in cardiovascular disease (MONICA study) observed lower mortality rate in the south of Spain and France compared to the north of these countries (45).

The Mediterranean diet was inscribed in 2010 by the United Nations Educational, Scientific and Cultural Organization (UNESCO) in the representative list of intangible cultural heritage of humanity (46).

The Mediterranean diet does not consist on the consumption of one single nutrient; rather it's a holistic approach including a whole pattern that is reflected positively on the health. According to the Predimed (Prevention with Mediterranean Diet) website (www.predimed-es.weekly.com) the old pyramid of the Mediterranean diet consists from bottom to top on:

a. Consumption of olive oil as the main source of fat preferably extra virgin olive oil
b. Consumption of fruits and vegetables rich in vitamins, minerals, antioxidants. These should constitute the main part of every meal.
c. Consumption of nuts, legumes and seeds rich in proteins, healthy fats and fibers.
d. Herbs and spices consumption as a way to flavor food and reduce salt intake.
e. Fish and seafood consumption rich in proteins, it is recommended not to fry them. Blue fish is the most recommended due to its high content in omega 3.
f. Cheese and yogurt should be consumed moderately.
g. Eggs should be consumed moderately as well.
h. Meat should be consumed occasionally.
i. Wine can be beneficial if it is consumed moderately.

j. Water and exercise to maintain a healthy lifestyle.

k. Good company while eating.

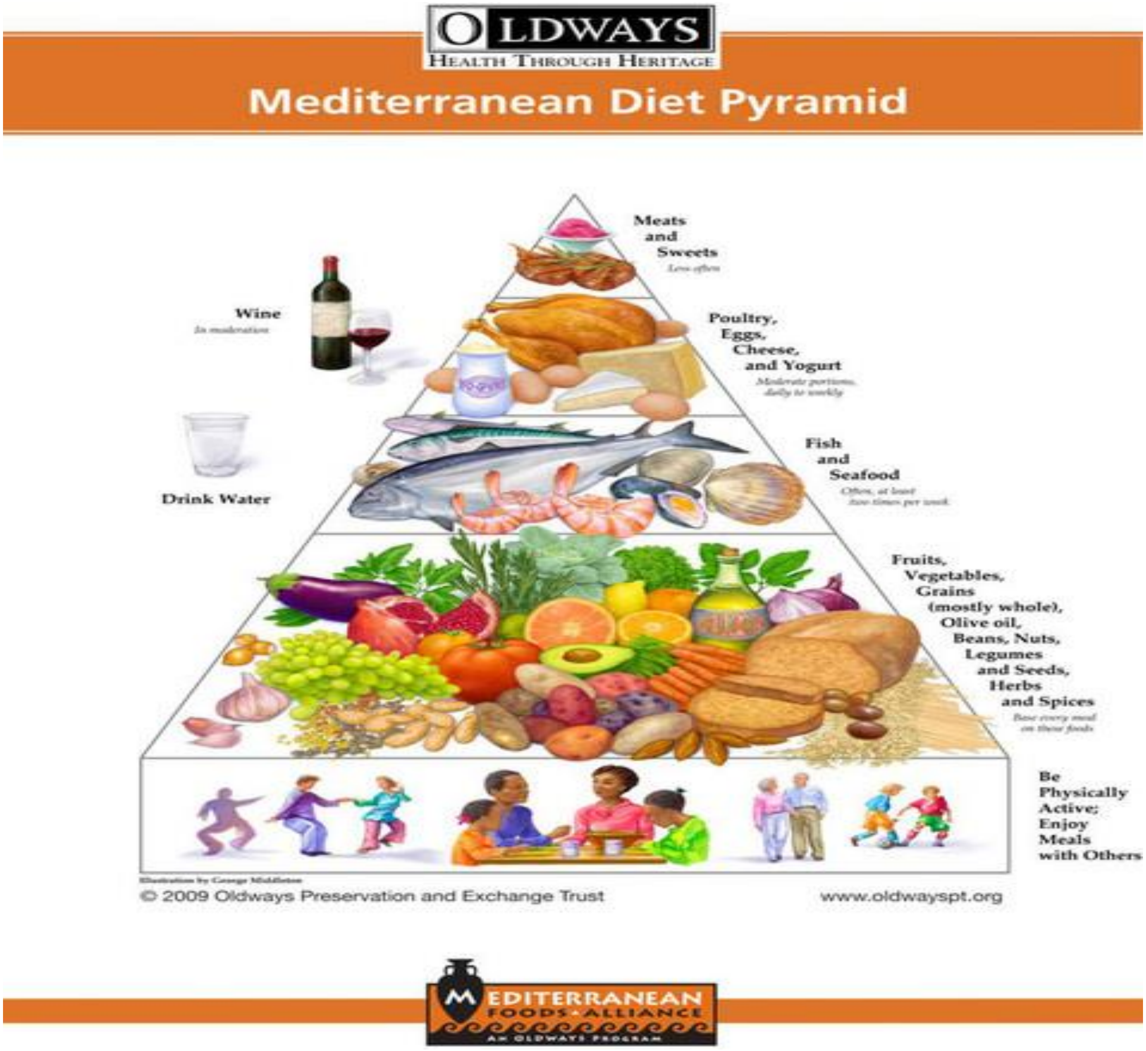

Figure 3.1. Old pyramid of the Mediterranean diet (Retrieved from http://predimed-es.weebly.com/piraacutemides.html)

The Mediterranean diet foundation (Fundacion Dieta Mediterranea) updated the pyramid as following:

a. Olive oil consumption should exceed 4 tablespoons per day.

b. Vegetables consumption should exceed two portions a day.

c. Fruits consumption should exceed three portions per day.

d. Red meat should not exceed one portion per day.

e. Butter should be consumed less than one portion a day.

f. Sweetened drinks consumption should be less than one portion a day.

g. Seven or more glasses of wine should be consumed weekly.

h. Legumes consumption should exceed 3 portions per week.

i. Fish and seafood consumption should exceed 3 portions per week.

j. Processed deserts and sweets consumption should be less than 3 portions per week.

k. Dried fruits and nuts consumption should be more than 3 portions per week.

l. White meat should be consumed more than red meat.

m. Sofrito should be consumed.

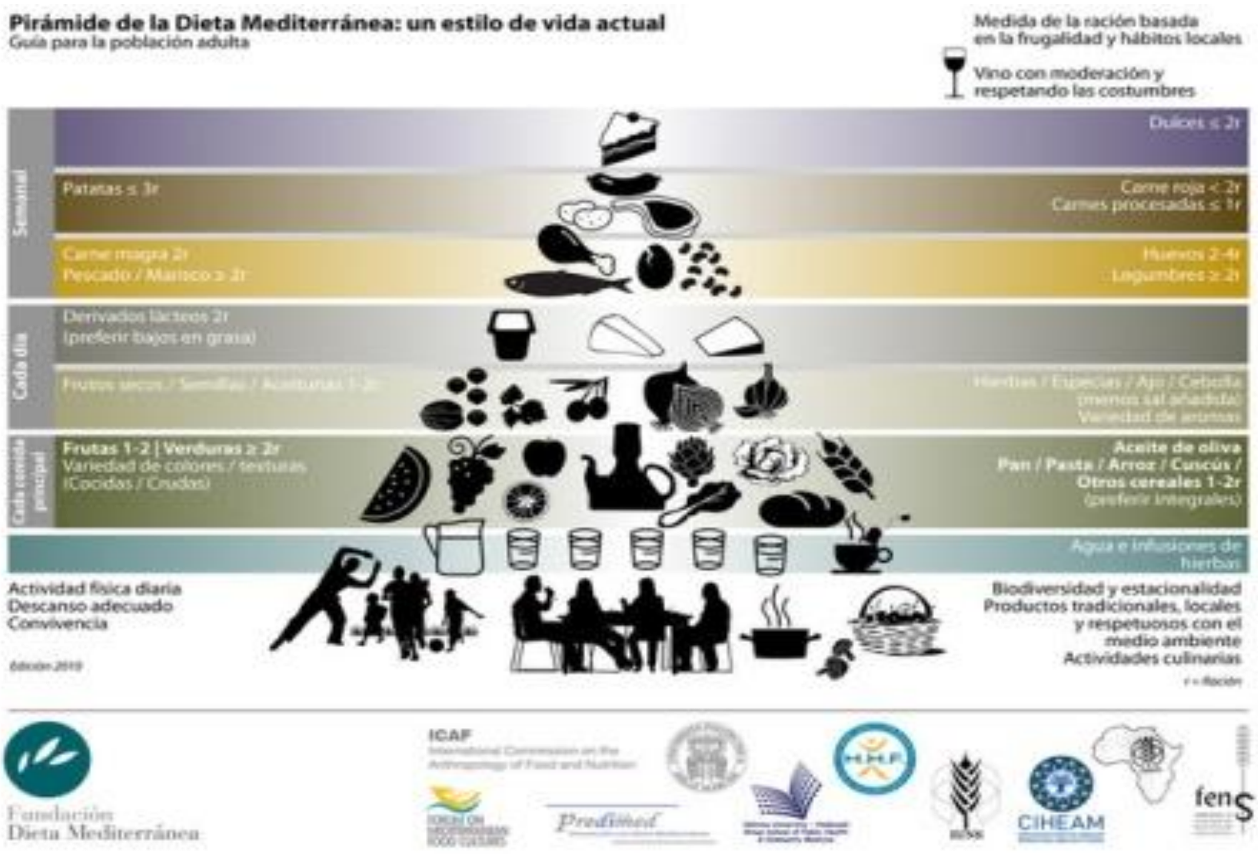

Figure 3.2. Mediterranean diet pyramid updated byMediterranean diet foundation

(Retrieved from http://predimed-es.weebly.com/piraacutemides.html)

3.1 Benefits

The benefits of the Mediterranean diet may be due to the synergistic combination of a balanced ratio of n-6 and n-3 essential fatty acids, high amounts of dietary fibers, high oleic acid, and polyphenols consumption. All this results in an antithrombotic and anti-inflammatory properties and improved lipid profile in people adopting this pattern (46). The ratio of monounsaturated fatty acids MUFA and saturated fatty acids SFA was observed to be the main reason behind the health benefit of the Mediterranean diet (47), in addition alpha linoleic acid was observed to prevent post myocardial infarct death (48). Due to the rich diversity of plant foods in the Mediterranean diet, many phenolic compounds are found including phenolic acids, stillbenes, lignans and flavonoids. The polyphenols in olive oil were found to protect low density lipoprotein LDL particles from oxidative damage (45). Non- nutritional aspects, linked in one way or another to food consumption have been suggested to contribute to the beneficial effect of the Mediterranean diet. These include physical activity, consumption of fresh and local products, eating in groups. The socio-cultural aspect differentiate the Mediterranean diet from other diets, the food is not only consumed for fulfillment but also for the identity created by its symbolic value related to heritage (46).

In the meta-analysis of Sofi et al (49), results showing the effect of Mediterranean diet on all-cause mortality were illustrated. The women's health initiative WHI study (50) and the Seguimiento Universidad de Navarra SUN study (51) support these findings as well. Many more observational and interventional studies published supporting evidence on the benefit of the Mediterranean diet on cardiovascular disease prognosis, diabetes, mortality, cancer, favorable health status, better biochemical profile and quality of life (52-60). The PREDIMED (Prevencion con Dieta Mediterranea) intervention study was designed to assess the long term effects of the Mediterranean diet (61).

3.2 Adherence to the Mediterranean Diet Scoring

It is important to assess the degree of adherence to the Mediterranean diet through accurate measurement tools such as dietary scores (62). 28 adherence scores were found internationally (63). The most important was created in 1995 and developed in its final form in 2003 by Trichopoulou et al (64). A significant protection against mortality (8% reduction of death from any cause), occurrence of cardiovascular diseases (10% reduction of incidence or death caused by cardiovascular disease) and major chronic degenerative diseases was conferred when adherence to the Mediterranean diet increased by two points (64). In Spain, a 14points Mediterranean diet adherence screener (MEDAS) was developed by Prevención con Dieta Mediterránea (PREDIMED) study in elderlies and was shown to correlate with validated food frequency questionnaire in 7146 participants. The estimated coronary artery disease risk decreased as the PREDIMED score increased (65).

Objectives

The current prevalence and the expected increase of elderly population is an important health challenge in our society. In 2050, almost 30% of the European population will be over 65 years (66); this requires careful planning for health. Older adults suffer from several diseases of which cardiovascular disease, diabetes, sarcopenia, arthritis. Chronic diseases are preventable diseases; their prevention must take place throughout one's life.

The Mediterranean diet consists on a holistic approach where a combination of food and healthy habits were proven, in several studies, to improve health specifically chronic diseases.

Spain and Lebanon are two Mediterranean countries in which the Mediterranean diet pattern is being replaced by westernized patterns negatively affecting health. For further clarification, studies were conducted to assess the food intake, physical condition in older adults in Spain (Mallorca) and assess the adherence to the Mediterranean diet in Lebanon (Beirut).

1. Overall Aim

The aim of this study is to assess the micronutrient and macronutrient intake in a western region of the Mediterranean Sea (Mallorca) and assess the physical condition of older adults there. This study aims as well to set a base for future studies in Lebanon to be able to compare healthy behaviors in western and eastern regions of the Mediterranean Sea by assessing the adherence to Mediterranean diet among older adults and younger ones in the capital Beirut.

2. Sub-aims

The specific aim for each study was:

a. Due to the great abundance of polyphenols in the diet and their proven benefits, their total intake and energy adjusted intake was assessed according to sociodemographic and lifestyle characteristics in the diet of older adults in Mallorca. In addition, the distribution of polyphenols among food groups (oils and seeds, nonalcoholic beverages, alcoholic beverages, cereals, sweets, fruits, nuts, legumes and vegetables) and the main food contributors to their intake were assessed.

b. The intake of total lipids in older men and women in Mallorca was assessed according to the physical activity status, the body mass index, the educational level and the age group. Then the intake of different fatty acids (saturated fatty acids SFA, monounsaturated fatty acids MUFA, polyunsaturated fatty acids PUFA, alpha linoleic acid ALA, eicosapentaenoic acid EPA, docosahexaenoic acid DHA) and their contribution to total energy intake was assessed in the total sample and according to the sex. The daily contribution of oils and seeds, dairy products, fish and fish products, eggs and meat, nuts, sweets, commercial foods and other fats to the intake of total lipids, ALA, EPA, DHA, cholesterol, MUFA and PUFA was described. Finally, the intake of fatty acids was compared to the Spanish recommendations and those set by the world health organization WHO and the European food safety authority EFSA.

c. The intake of minerals and the percentage of their intake relatively to the dietary recommended intake were assessed in Mallorca among older men and women. The intake of different minerals in compliance with dietary recommended intake was ranked on a 5points scale and was assessed depending on socioeconomic and body composition variables.

d. The correlation between the body composition and biochemical parameters in one hand and the physical fitness variables on the other hand were assessed in Mallorca in older adults. Spearman correlation coefficients among age body composition biochemical parameters and physical fitness variables in men and women were calculated and Multiple linear regression model was also done to assess correlation after adjusting for cofounders.

e. Physical condition and its association between sociodemographic, body composition and lifestyle habits in older Spanish adults were studied. Occurrence of presarcopenia, high 8f TUG and/or low HGS, sarcopenia and severe sarcopenia were assessed in the sample. In addition, maximum HGS and maximum 8-f TUG score were assessed among the participants according to sociodemographic (marital status, educational level, income), body composition (body mass index, overfat, abdominal obesity) and lifestyle variables (smoking habit and physical activity status) stratified by sex. Finally, prevalence of normal/low maximum HGS and normal/high 8-f TUG score according to sociodemographic, body composition and lifestyle variables were studied.

f. Adherence to the Mediterranean diet among Lebanese younger adults and older adults in Beirut was assessedusing a 14-item Mediterranean Diet Adherence Screener according to sociodemographic variables. Correlations among the components of the Mediterranean diet were investigated.

Material and Methods

1. Study Design

The study was split into two parts. In Spain, the study carried out was part of a broader cross sectional study investigating the effect of lifestyle factors on the health of older adults living in Mallorca; it was conducted between the years of 2013 and 2014. In Lebanon, the study was a preliminary one, investigating broadly the adherence to Mediterranean diet to set a base for future studies.

2. Study Population

2.1.Older adults

In Spain, the sample consisted of 211 participants living in Mallorca. Men aged between 55 and 80 and women aged between 60 and 80 were recruited in social and municipal clubs, health centers and sport clubs in 2013-2014. Exclusion criteria included previously documented cardiovascular disease, being institutionalized, suffering from a physical or mental illness which would have limited their participation in physical fitness or their ability to respond by themselves to questionnaires, chronic alcoholism or drug addiction and intake of drugs for clinical research over the past year.

In Lebanon, 125 adults (32 men and 93 women) aged 45 years and above living in Beirut, the capital of Lebanon were asked to answer by themselves a short questionnaire in the presence of the main investigator to help in any clarification needed in February 2018.

2.2.Younger adults

525students from three different campuses of the University of Balamand in Lebanon (faculty of Health Sciences, Beirut; ALBA, Sin el Fil and main campus, Koura) were asked to answer by themselves a short questionnaire in the presence of the main investigator to help in any clarification needed during the spring semester 2018.

3. Global questionnaire

In Spain, a specific questionnaire developed by the EXERNET network (67) including the following questions was used: age, marital status, educational level, income, and smoking habits. The respondents were grouped as follow: (a) marital status: single (single, unmarried, divorced or widowed), and in a relationship (i.e. including married and unmarried, divorced or widowed living actually with a partner); (b) educational level: illiterate, primary (≤6 years), and secondary or college-level education (>6 years); (c) participants' income: <900 €/month, and ≥900 €/month; and (d) smoking habits: smoker (≥1 cigarette/day) and non-smoker.

In Lebanon, the questionnaire was divided into three parts: (a) general information (sex, marital status, age class, working status, smoking status and major for younger adults), (b) assessment of the adherence to the Mediterranean diet using a 14-item Mediterranean Diet Adherence Screener (MEDAS) developed by PREvencion con DietaMEDiterranea (PREDIMED) for immediate feedback (68) and extra information (number one worrying issue, willingness to change diet, increase physical activity and participate in future studies).

4. Diet assessment

Dietary intake was assessed by two non-consecutive 24 h recalls. Licensed dietitians administered the recalls and verified and quantified the food records. Volumes and portion sizes were reported in natural units, household measures, or with the aid of a book of photographs (69). Conversion of food into energy intakes, total fat and fatty acids and minerals content was made using a self-made computerized program based on Spanish food composition table (70). Conversion of food to polyphenol content was done using the polyphenol explorer (http://phenol-explorer.eu/).

5. Anthropometric measurements

Anthropometric measurements (i.e. height, waist circumference (WC), body weight, body fat and appendicular skeletal muscle mass (ASM)) were performed by licensed observers. Height and WC were performed according to the International Standards for Anthropometric Assessment of the International Society for the Advancement of Kinanthropometry (ISAK) (71). Height was determined using a mobile anthropometer (Seca 213, SECA Deutschland, Hamburg, Germany) to the nearest millimetre, with the subject's head in the Frankfurt plane. WC was measured as the smallest horizontal girth between the costal margins and the iliac crests at minimal respiration using a flexible, non-extensible plastic tape with 0.1 cm precision (Kawe 43972, Kirchner & Wilhelm GmbH + Co. KG, Asperg, Germany). Body weight, body fat and ASM were determined using a Segmental Body Composition Analyzer (Tanita BC-418, Tanita, Tokyo, Japan). The participants were weighed in bare feet and light clothes, and subtracting 0.6 kg for their clothes. Weight and height measures were used to calculate body mass index (BMI, kg/m^2). According to the anthropometric reference parameters for the Spanish elderly (72,73), the prevalence of overweight and obesity was defined as BMI $\geq$27.0 kg/m^2. WC and height measures were used to calculate waist-to-height ratio (WHtR). Abdominal-obesity was defined as a WHtR$\geq$0.5 (74). ASM and height measures were used to calculate appendicular skeletal muscle mass index (ASMI, kg/m^2) and low ASMI was defined as <7.26 kg/m^2 in men and <5.5 kg/m^2 in women (75).

6. Physical activity assessment

Physical activity data was analyzed using the validated Spanish version of the Minnesota Leisure Time Physical Activity Questionnaire (76,77), and the participants were classified according to their leisure-time physical activity (LTPA) in the past 5 years. Individuals with ≤1.5 hours/week of physical activity were categorised as “inactive”. Individuals who practice ≥4 hours/week of physical activity were categorised as “active”. People who could not be included into the “inactive” and “active” groups were categorised as “slightly active”.

Physical condition assessment included the following tests:

Handgrip strength test (HGS): Grip muscular strength was measured using a digital handheld dynamometer (TKK 5401 Grip-D; Takey, Tokyo, Japan). Participants were instructed to stand up-right with the dynamometer beside, but not against their body. Measurements were performed two times for each hand. The best of all attempts was used to perform the analysis (78).

Arm curl test (AC): used to define the upper body strength. After the signal, participants were instructed to flex and stand the holding hand weight (men: 4 kg; women: 2.5 kg) through the complete range of motion, as many times as possible in 30 seconds. Measurements were performed one time in their dominant arm (79).

30-s chair stand test: used to assess lower body strength. This test consists of standing up and sitting down from a chair as many times as possible within 30 seconds. The test starts with participants sitting on the chair with their back in an upright position and looking forward, after the signal, they start rising with their arms folded across their chest (79).

Back scratch test (BS): used to assess general shoulder range of motion. Test was completed for both the right and left sides where one hand reached over the shoulder with the other up the middle of the back. Distance (cm) between extended middle fingers was assessed and the average of right and left sides was taken as an overall measure (80).

Chair sit and reach test: used to test lower body flexibility. Test was completed from a sitting position at the front of a chair with one leg extended and hands reaching towards toes with the distance (cm) between extended fingers and tip of toe being assessed. The average of right and left sides was taken as an overall measure of flexibility (80).

8-f TUG test: used to assess agility/ dynamic balance. Participants were instructed to rise from a chair without the use of arms, walk around the cone placed 2.45 m from the chair, and return to the original sitting position. Further instructions were to complete the test as quickly as possible but without running.Measurements were performed two times and the best of all attempts was used to perform the analysis (79).

30-m walking speed: walking speed was performed over 30 m at the participants' usual place. Participants were instructed to complete the test as quickly as possible, while taking care not to run. Measurements were performed two times and the best of all attempts was used for performance analysis (81).

*6-min walking:*Aerobic ability was measured as the total distances that participants were able to walk in 6-min. Participants were instructed to walk as far as possible for 6 min (79).

7. Biochemical measurements

Venous blood samples were obtained from the antecubital vein in suitable vacutainers at 08:00 AM during the interview after having fasted for 12h. The samples of coagulated blood were centrifuged (10 min at 3000 rpm) immediately after their arrival to the laboratory. Tryglicerides (TG), total cholesterol (TChol), high-density lipoprotein cholesterol (HDL-chol), low-density lipoprotein cholesterol (LDL-chol), non HDL cholesterol (Non-HDL-chol) were determined by colorimetric methods using the DAX-72 autoanalyser (Technicon, Bayer Diagnostics, New York, NY, USA) (82,83).

Ethics

The study involving Spanish participants was conducted according to the guidelines laid down in the Declaration of Helsinki, and all procedures involving human subjects were approved by the Balearic Islands Ethics Committee. Written informed consent was obtained from subjects both in Spain and Lebanon. Oral consent form was obtained from participants who filled the questionnaire in Lebanon.

Results & Discussion

Manuscript I

Estimated intake of polyphenols and their dietary sources among old adults in the island of Mallorca.

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PLOS ONE

RESEARCH ARTICLE

Polyphenol estimated intake and dietary sources among older adults from Mallorca Island

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Abstract

The aim was the assessment of the polyphenol estimated intake and dietary sources among older adults from Mallorca Island. The study was carried out (2013–2014) in 211 participants dwelling women ($n = 112$) and men ($n = 99$). Polyphenol intake was calculated from two non-consecutive 24-h recall diets using the Polyphenol Explorer. The mean daily intake of polyphenol was 332.7 mg/d (SD: 237.9; median: 299 mg/d). Highest polyphenol intake was observed among females, 64–67 y.o. people, higher income and educational level, alcohol consumers, and physically active people. Most polyphenols consumed were flavonoids, and among them the major subclass was flavanols. Alcoholic beverages were the major contributors to the total polyphenol intake (118.3 mg/d, SD: 127.5), and red wine contributed 17.7% of total polyphenols consumed. Polyphenol intake was highest among alcohol drinkers, high educational level, high income, and physical active people. Flavonoids were the highest ingested polyphenols. Alcoholic beverages were the major contributors to the total polyphenol intake, mainly red wine.

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Introduction

Unhealthy and stressful lifestyles may promote radical oxygen species formation [1]. Oxidative stress appears in the body when the radical formation exceeds the endogenous antioxidant mechanisms which leads to the appearance of diseases (i.e.: neurodegenerative diseases, cardiovascular diseases, cancer, atherosclerosis and diabetes) [2,3].

Polyphenols are found abundantly in our diets, and the increasing interest in these phytonutrients is due to their role in health. Polyphenols trap and scavenge free radicals, regulate nitric oxide, decrease leukocyte immobilization, induce apoptosis and exhibit phytoestrogenic activity according to in vitro studies [4,5]. This may contribute to their potential benefits on human health, including decreased risk of diabetes [6], certain cancers [7] and cardiovascular disease occurrence and mortality [8–10].

All polyphenols have at least one aromatic ring structure with one or more hydroxyl group [7]. They can be classified in several classes and subclasses according to the number of rings

analyses, or interpretation of the data; in the writing of the manuscript, and in the decision to publish the results.

Competing interests: The authors have declared that no competing interests exist.

and the structural elements that bind them to one another [11]. The polyphenol content in the plants differs depending on the plant type. Cinnamic acid is found in all parts of fruits although it is mostly concentrated in the outer layer. Flavanones are found in tomatoes and aromatic plants. Isoflavones are found in leguminous plants mainly soybeans, and they have structural similarities to estrogens, which confer them pseudohormonal properties including the ability to bind to estrogen receptors. Flavanols exist as monomers and polymers and are found in fruits, red wine, green tea and chocolate. Finally, stillbenes are found in wines [11]. Nevertheless, polyphenols are affected by many factors as the ripeness at the time of harvest [11,12], environmental factors as the soil type, the exposure to sun and light, the rainfall, the green house agriculture, and are also affected by processing, storage and culinary preparation [11].

Great focus is on polyphenols and their benefits; however, data regarding their consumption at the population level is not enough to suggest optimal intake levels and set dietary recommendations [13]. Polyphenol intake has been assessed in Mediterranean area, including Spain [14], France [15], Sicily [16], but also in other countries as Poland [17], Denmark [18], Japan [19], and Brazil [20]. Some studies relied on the United States Department of Agriculture (USDA) database to estimate the polyphenol intake [21]; however, the Phenol Explorer database release 3.6 holds data on polyphenol content in 555 food items and introduces data on the effects of food processing on the polyphenol content [22] which provides more accuracy.

Oxidative stress accumulates with age and causes diseases [23]; hence, the aim of this study was to assess the polyphenol estimated intake and dietary sources among old adults from Mallorca Island (a Mediterranean region), who are more vulnerable to diseases caused by oxidative stress.

Methods

Study population

The sample consisted of 211 participants (53% women) engaged in a study conducted from 2013 to 2014 in Mallorca island. The study assesses the effect of lifestyle factors on the health of older adults living in Mallorca Island. Men aged between 55 and 80 and women aged between 60 and 80 were recruited in the study. Exclusion criteria included being institutionalized, suffering from a physical or mental illness which would have limited their participation in physical fitness or their ability to respond to questionnaires, chronic alcoholism or drug addiction and intake of drugs for clinical research over the past year.

Sociodemographic and lifestyle characteristics were collected from each participant. Educational level was ranked into primary school studies, secondary school studies and university graduate. The income was considered low if it was lower than 600 euros per month, medium if it was between 600 and 900 euros per month and high if it was higher than 900 euros per month. The participants were classified as well as smokers and nonsmokers, alcohol drinkers and nondrinkers, and physically active and inactive. Individuals with $\leq$1.5 hours/week of physical activity (n = 105) were categorised as "inactive" and they were recruited in social and municipal clubs, and health centres. Individuals who practice >1.5 hours/week of physical activity (n = 106) were categorised as "active" and they were recruited in social and municipal clubs, health centres and sport clubs. The study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures were approved by the Balearic Islands Ethics Committee (approval reference number n° IB/2251/14 PI). Written informed consents were obtained from all participants.

Anthropometric measurements

Anthropometric measurements were performed by well-trained dieticians who underwent identical and rigorous training as an effort to minimize the effects of inter-observer variation. Height was measured using an anthropometer (Kawe 44444, Asperg, Germany) with the subject's head in the Frankfurt plane. Body weight was determined using a digital scale (Tefal, sc9210, Rumilly, France). The participants were weighed barefoot, noting and subtracting the weight of the clothes. Weight and height measures were used to calculate body mass index (BMI, kg/m^2). According to the anthropometric reference parameters for the Spanish elderly [24,25], the prevalence of normal-weight, overweight, and obesity were defined as BMI $\leq$26.9 kg/m^2, BMI 27.0–29.9 kg/m^2, and BMI $\geq$30.0 kg/m^2 respectively for those older than 65 and BMI $\leq$25.0kg/m^2, BMI 25.0–29.0 kg/m^2, and BMI $\geq$29.0 kg/m^2 respectively for younger participants.

Assessment of polyphenol content

Polyphenol content was assessed by two non-consecutive 24-h recalls. Licensed dieticians administered the recalls and verified and quantified the food records. Volumes and portion sizes were reported in natural units, household measures or with the aid of a manual of photographs [26]. The recall diets yielded 449 food items including food recipes. After excluding animal foods, commercial food products, deserts with high sugar content and dairy products that have no traces of polyphenols, food items were researched using polyphenol explorer (http://phenol-explorer.eu/). The polyphenol explorer provides the polyphenol content of food using data obtained by five analytical methods (chromatography, chromatography with hydrolysis, Folin assay, pH differential methods and normal phase HPLC) [27]. The very few food items that were not found in the polyphenol database were researched using the United States Department of Agriculture´s National nutrient database [21], and the polyphenol content of mustard was found in the literature [28] because it was not found elsewhere. Ingredients from different food recipes were taken separately and then summed to obtain the polyphenol content of the recipe. The total polyphenol intake was calculated as the sum of polyphenol classes. Energy intakes ranged between 1082–3428 kcal/day for men and 870–2701 kcal/day for women.

Statistical analysis

Statistics were performed using statistical software SPSS for Windows version 21 (IBM, Chicago, USA). Data are shown as mean, standard deviation (SD), median and interquartile range (IQR). Total polyphenol intake (expressed per mg) and energy adjusted polyphenol intake (expressed as mg per 1000 kcal) were assessed in the total sample and according to sociodemographic and lifestyle factors. The polyphenol intake increases with a higher consumption of food; hence adjusting the polyphenol intake to the energy intake gives a clearer illustration of the polyphenol intake. Non-parametric tests (Mann-Whitney U test or Kruskal-Wallis test) were used because the sample is not normally distributed. Results were considered statistically significant if p-value <0.05.

Results

Polyphenol intake (Table 1)

Polyphenol contents were found in 245 food products. The mean and median daily intake of polyphenol were 332.7 mg/d (SD: 197.4) and 299.5 mg/d (IQR: 250.4) respectively; and 187.5 mg/d (SD: 100.5) and 172.9 mg/d (IQR: 140.3) respectively after adjusting the variable for

Table 1. Total polyphenol intake and energy adjusted polyphenol intake according to sociodemographic and lifestyle characteristics (n = 211).

		Polyphenol intake			Energy adjusted Polyphenol intake		
	n	mean (SD)	median (IQR)	*p*-value	mean (SD)	median (IQR)	*p*-value
Total Population	211	332.7 (197.4)	299.5 (250.4)		187.5 (100.5)	172.9 (140.3)	
Sex							
Men	99	375.8 (217.6)	343.2 (317.8)	0.006	187.1 (103.1)	161.8 (155.9)	0.889
Women	112	294.7 (169.8)	276.6 (188.5)		187.8 (98.7)	173.2 (134.9)	
Age Class							
50–63	74	284.4 (159.4)	260.2 (196.9)	0.045	149.8 (75.6)	129.9 (98.3)	<0.001
64–67	67	364.3 (212.8)	347.6 (265.6)		205.5 (105.5)	189.4 (122.9)	
≥68	70	353.5 (211.0)	304.0 (211.0)		209.9 (108.2)	201.0 (159.6)	
Educational Level							
Primary School	95	284.3 (156.3)	258.4 (207.6)	0.014	168.8 (85.7)	163.2 (108.8)	0.085
Secondary School	75	365.9 (200.1)	334.1 (312.2)		198.6 (108.1)	184.3 (116.1)	
University Graduate	41	384.4 (250.5)	343.2 (294.2)		210.3 (112.2)	191.2 (142.1)	
Income							
Low (<600 euros/month)	60	272.48 (167.3)	242.6 (221.6)	0.006	179.9 (101.2)	163.93 (134.8)	0.464
Medium (600–900 euros/month)	23	305.15 (167.3)	307.0 (265.3)		169.2 (86.7)	158.92 (141.8)	
High (>900 euros/month)	128	332.7 (208.9)	332.2 (282.9)		194.3 (102.5)	178.19 (141.3)	
BMI Range							
Normal	82	350.1 (196.5)	317.7 (258.4)	0.518	202.7 (99.6)	190.2 (140.7)	0.100
Overweight	86	324.8 (204.8)	290.7 (239.3)		182.1 (101.5)	163.3 (131.7)	
Obese	43	315.4 (185.7)	299.5 (267.4)		169.3 (98.4)	150.5 (155.6)	
Smoking Status							
No	194	335.2 (188.3)	308.1 (248.8)	0.147	189.1 (98.0)	175.1 (149.3)	0.188
Yes	17	305.0 (287.8)	263.0 (162.0)		169.3 (128.4)	149.1 (121.5)	
Alcohol Drinking							
No	95	261.5 (162.7)	223.1 (209.4)	<0.001	160.6 (97.5)	137.0 (127.0)	<0.001
Yes	116	391.1 (204.7)	353.0 (279.0)		209.5 (98.0)	201.8 (130.7)	
Physical Activity							
Inactive	105	293.4 (190.7)	263.03 (195.2)	0.001	169.9 (98.3)	150.5 (117.9)	0.005
Active	106	371.7 (197.2)	348.02 (291.7)		204.9 (100.1)	100.1 (153.1)	

Abbreviations: SD, standard deviation; IQR, interquartile range; BMI, body mass index.
Statistical analysis using Mann-Whitney U test or Kruskal-Wallis test.

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energy intake. The polyphenol intake was also calculated according to different sociodemographic factors. Men have higher polyphenol intake than women (median 343.2 mg/d for men and 276.6 mg/d for women); however, women showed higher polyphenol intake (median 173.2 mg/d for women and 161.8 mg/d for men) after adjusting for energy intake. Differences in polyphenol intake were also found according to age, educational level, and income; however, differences remained significant only for age after adjusting for energy intake. Alcohol drinkers' showed higher polyphenols intake than non-drinkers, and physically active people consumed higher than physically inactive people. No significant differences in polyphenol intake were found for BMI range, and between smokers and non-smokers.

Polyphenol intake from foods (Table 2)

The most ingested polyphenols were flavonoids (170.3 mg/d, SD: 144.4); among the flavonoids the major subclass was flavanols (46.0 mg/d, SD: 57.7). Among the phenolic acid class,

Table 2. Distribution (mg/recall) of the polyphenol classes and subclasses from food sources.

Polyphenol class	Food sources										
	Total Foods	Oils and seeds	Nonalcoholic beverages	Alcoholic beverages	Cereals	Sweets	Fruits	Nuts	Legumes	Others[1]	Vegetables
Total Polyphenols	332.7 (237.9)	26.2 (46.5)	32.1 (71.8)	118.3 (127.5)	25.2 (39.9)	17.3 (37.8)	98.6 (126.3)	28.1 (178.3)	8.0 (10.6)	11.1 (31.0)	68.5 (99.0)
Flavonoids	170.3 (144.4)	0.7 (5.5)	24.1 (71.5)	86.4 (97.9)	0.1 (0.6)	15.1 (34.3)	71.2 (88.5)	0.1 (0.3)	7.2 (10.6)	7.6 (28.0)	16.3 (28.2)
Flavanols	46.0 (57.7)	0	2.1 (5.3)	49.5 (55.7)	0	12.5 (32.0)	9.3 (19.6)	0.1 (0.3)	2.5 (5.2)	0.03 (0.1)	1.0 (4.0)
Flavonols	22.7 (29.9)	0.2 (1.7)	0.1 (0.4)	7.2 (8.1)	0	1.0 (2.5)	4.7 (7.0)	<0.01	1.9 (5.7)	2.3 (18.0)	11.4 (20.6)
Flavanones	30.7 (50.6)	0	3.1 (14.8)	1.0 (1.0)	0	0.1 (0.4)	29.2 (50.4)	0	0	0.1 (0.5)	0.1 (0.1)
Flavones	10.7 (20.3)	0.2 (0.9)	0.5 (2.2)	0	0.14(0.6)	1.5 (2.1)	2.0 (5.0)	0	0.2 (0.3)	2.2 (3.9)	5.1 (19.5)
Anthocyanin	36.7 (61.9)	0.3 (2.8)	0	23.0 (26.7)	0	0	25.7 (60.1)	0	1.9 (6.9)	0	0
Dihydrochalcones	0.3 (1.8)	0	0	0	0	0	0.3 (1.9)	0	0	0	0
Isoflavonoids	19.3 (71.1)	0	18.4 (70.3)	0	0	0	0	0	0.6 (2.0)	0.7 (11.5)	0
Phenolic Acids	100.0 (130.0)	5.0 (17.0)	7.7 (7.4)	21.9 (20.0)	0.4 (2.1)	2.0 (3.5)	21.7 (57.8)	27.3 (178.4)	0.8 (1.0)	1.1 (2.3)	47.4 (74.5)
Benzoic Acid	17.5 (90.6)	0.5 (1.8)	3.0 (5.0)	9.5 (8.6)	0.1 (0.1)	0.01 (0.1)	1.4 (4.5)	19.3 (176.9)	0.1 (0.2)	0.1 (0.2)	2.6 (11.1)
Cinnamic Acid	82.2 (92.9)	4.5 (15.9)	4.7 (7.0)	12.1 (11.5)	0.4 (2.0)	2.0 (3.5)	20.3 (55.9)	8.0 (29.2)	0.7 (0.9)	1.0 (2.2)	44.8 (73.2)
Alkylphenols	25.3 (39.2)	0	0.02 (0.03)	<0.01	25.3 (39.6)	0.1 (0.2)	0	0	0	0	0
Alkylmethoxyphenols	0.1 (0.2)	0	0.02 (0.03)	0.1 (0.3)	0	<0.01	0	0	0	<0.0	0
Lignans	7.2 (15.6)	2.3 (14.4)	<0.01	0	0.04 (0.1)	<0.01	4.8 (7.1)	<0.01	0	0.1 (0.4)	0.4 (1.4)
Stillbenes	2.6 (4.4)	0	0	4.7 (5.1)	0	<0.01	0.1 (0.2)	<0.01	0.02 (0.03)	0	0
Tyrosol	20.6 (21.9)	17.5 (21.1)	0.04 (0.3)	4.5 (4.4)	0	0.0 (0.1)	0	0	0	1.9 (2.6)	0
Other polyphenols	2.4 (3.8)	0.5 (1.6)	0.2 (0.9)	1.0 (0.9)	0	0.0 (0.0)	0.8 (2.2)	0.7 (1.0)	0	0.3 (2.4)	<0.01

Values are expressed as mean (standard deviation).

[1]Others include appetizers, pastries and salted pastries, broth, chocolate, biscuits, sauces, condiments, precooked dishes, desert, jam.

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cinnamic acid intake (82.2 mg/d, SD: 92.9) was higher than benzoic acid intake (17.5 mg/d, SD: 90.6).

Alcoholic beverages were the highest contributors (118.3 mg/d, SD: 127.5) to the total polyphenol intake; but fruits also were important contributors (98.6 mg/d, SD: 126.3). Food groups provided polyphenols differently. Flavonoids´ main sources were alcoholic beverages and fruits. The stilbene intake was mainly provided by alcoholic beverages and phenolic acids by vegetables. Tyrosol was provided mainly by oils and seeds, and alkylphenols mainly by cereals.

Different intake of polyphenol subclasses was also observed according to food groups: flavanols intake was mainly provided by alcoholic beverages; flavonols, flavones and cinnamic acid intake was mainly provided by vegetables. Flavanones and anthocyanin were highly obtained from fruits; and isoflavonoids mainly from nonalcoholic beverages. Benzoic acid was mostly found in nuts.

Table 3. Main food contributors: Percentage of contribution to polyphenol classes and subclasses.

	1st	2nd	3rd
Total Polyphenols	red wine 17.7%	artichoke 6.2%	soy milk 5.4%
Flavonoids	red wine 26.8%	soy milk 10.8%	orange 9.5%
Flavanols	red wine 56.5%	pure chocolate 8.7%	plum 4.9%
Flavonols	red wine16.6%	spinach 13.0%	apple 11.9%
Flavanones	orange 52.6%	orange juice31.3%	commercial orange juice10.0%
Flavones	artichoke 43.8%	orange juice 13.7%	oli d´inca whole wheat cookies 5.2%
Anthocyanin	red wine 33.7%	black grapes 22.1%	cherry 17.5%
Dihydrochalcones	peach juice 80.0%	peach and grapes juice 10.3%	apple juice 9.7%
Isoflavonoids	soy milk 95.59%	soy yogurt 3.9%	soy sprouts 0.5%
Phenolic Acids	potato 16.5%	artichoke 15.5%	red wine 9.0%
Benzoic Acid	walnuts 23.5%	chestnuts19.4%	red wine 17.4%
Cinnamic Acid	potato 21.0%	artichoke 19.7%	red wine 6.7%
Alkylphenols	whole wheat bread 44.5%	rice cereals breakfast bars 19.2%	corn cereals breakfast bar 7.3%
Alkylmethoxyphenols	beer 74.4%	coffee beans 42.4%	powder coffee 1.8%
Lignans	melon 20.7%	mandarine 20.0%	orange 19.5%
Stillbenes	red wine 91.9%	white wine 3.8%	black grapes 1.5%
Tyrosol	virgin olive oil 31.4%	green olives 24.3%	olive oil 19.2%
Other polyphenols	walnuts 42.1%	orange juice 14.4%	green olives 11.7%

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Main food contributors of polyphenols (Table 3)

Red wine was the highest contributor of polyphenols intake (17.7%), as well as the highest contributor of flavonoids (26.8%) and most of their subclasses. The major contributors of flavanones, flavones, dihydrochalcones and isoflavonoids were orange, artichoke, peach juice and soy milk, respectively. Potatoes were the highest contributors of the phenolic acids. Further information is included in S1 Table.

Discussion

Several studies have used different methodologies to assess polyphenol intake in the past [14–20]; some of them were assessed in younger adults [15] and others in older adults [14,17,19,20]. However, to the best of our knowledge, this is the first study to assess the polyphenol intake in Spanish older adults using recall diets. In comparison with previous data, and despite the different methodologies used, the calculated mean polyphenol intake (332.8 mg/d) was relatively low compared to other studies in Sicily (663.7 mg/d) [16], Spain (820 mg/d) [14], France (1193 mg/d) [15], and Poland (1765 mg/d) [17], but higher than the intake estimated in Denmark (1–100 mg/d) [18], and similar to that observed in Brazil (377.5 mg/d) [20]. Alcohol drinkers in this study had higher intake than non-drinkers. Unlike the results obtained in Poland [17], no differences in polyphenol intake were registered between smokers and non-smokers.

Flavonoids were the main ingested polyphenol class in this study, similarly to previous Polish and Spanish studies [14,17] whereas phenolic acids were the main polyphenol class among French adults [15]. Moreover, phenolic acids and flavonoids were the main ingested polyphenols among Sicilian and Brazilian adults [16,23].

Nonalcoholic beverages were the main source of polyphenols among the French and Polish adults [15,17]; fruits and nuts among Spanish and Sicilian adults, respectively [14,16]; and coffee was the main contributor to the intake of other populations [14,15,19,20]. However, in the present study alcoholic beverages were the main source of polyphenols, being wine the highest food contributor. Flavonoid intake was mainly provided by red wine in this study as well; differently to a Polish study in which tea was the main source of flavonoids [17], and another Spanish study a Japanese study in which coffee and green tea were the main sources [19]. In another Spanish study on adult population [14], coffee was the main source of flavonoids; however, the present study has shown higher consumption of red wine than coffee consumption among the studied population (i.e. coffee mean intake was 35.8 mL/d, and red wine mean intake was 168.0 ml/d).

The polyphenol intake may differ according to the usual food intake in a region, but also according to the age, educational level, and lifestyle factors that impact on the eating habits; hence it is difficult to compare between populations. However, some results are coherent due to the fact that people with healthy lifestyle will have a healthy diet leading to high polyphenol intake (i.e. women tended to have as well higher awareness in nutrition than men) [29]. Adult population of Mallorca Island, the region where the study was conducted, showed different dietary pattern than other regions; hence, in the studied population red wine was the major source of polyphenols, differently from other populations that showed higher consumption of beverages containing caffeine (tea or coffee).

Strengths and limitations

The present study has several important strengths. First, the polyphenol intake was estimated using recall diets instead of food frequency questionnaires that have been questioned in epidemiological studies [30,31]. Moreover, analyses were done per person (Table 1) and per recall (Table 2) to have a fair representation of the polyphenol intake in the sample without underestimating the difference of eating habits between people and the different dietary consumption in different days. Secondly, the Phenol Explorer database release 3.6 that introduces data on the effects of food processing on the polyphenol content was used [22]. The very few food items that were not found in the Polyphenol Explorer were researched using the USDA database to avoid the underestimation of their polyphenol contents.

This study has also several limitations that must be acknowledged. First, a limitation of the study was the relatively small sample size; for this reason, these findings cannot be generalized to the broader community based on this study alone. Second, food frequency questionnaires that have been questioned in epidemiological studies [32,33], but using two 24-h recall diets tend to underestimate the food intake over a large period. Third, despite the guidance of licensed dietitians, diet was self-reported. Moreover, conducting studies on polyphenols is faced with many limitations knowing that this phytonutrient is not very stable, and while the content of some products may be underestimated, the contents of others may be overestimated or misestimated.

Thus, the polyphenol contents were overestimated in 53 recipes, in which the polyphenol contents were calculated as the sum of the different ingredients in the recipe. Standard recipes were adopted; however, the effect of processing was not taken in consideration. Many of the recipes are typical from the region where the study was conducted (*coca de patata*, *coca de quarto*, *empanadas*, *turron de jijona*, *greixonera de brossat*, *galetes d´inca or whole wheat & olive oil cookies*. . .), however some of them are not (*mayonnaise*, *croissant*, *crepe*, *pizza*. . .). Moreover, the polyphenol contents of some commercial products may be underestimated due to the fact that estimating their polyphenol contents is not doable due to a lack of information on the exact recipes and ingredients (*yogurt with fruits*, *cookies*, *chips*, *Ketchup*. . .). An inaccurate estimation of polyphenols contents might have been done in 29 foods for they were not found so it was necessary to replace them by very similar products to estimate the polyphenol contents as for different brands of cereal bars, jams and fruit juices. Finally, 12 food products were not found in the Polyphenol Explorer, in the USDA database or the literature leading to an underestimation of their polyphenol contents (*algae*, *oat milk*, *linseed oil*, *nutmeg*. . .).

Conclusions

Total polyphenol intake, the intake of different classes and subclasses of polyphenols, and their major food contributors have been assessed in adults living in a Mediterranean region as accurately as possible. Mean daily intake of polyphenol was calculated according to different socio-demographic factors including alcohol drinking, educational level, income, physical activity and age which were shown to be statistically significant. Flavonoids were the highest ingested polyphenols. Alcoholic beverages were the highest contributors of total polyphenol intake, mainly red wine. According to the importance of polyphenols in the diet and their probable benefits on health, further studies should be done to investigate the polyphenol intake, as well as the effect of food processing and the environmental factors on its content in the food. Furthermore, studies should investigate the polyphenol absorption by the body.

Supporting information

S1 Table. Food contributors table.
(PDF)

Author Contributions

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Manuscript II

Fatty acid estimated intake and dietary sources among Mediterranean older adults.

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(Submitted)

Fatty acid estimated intake and dietary sources among Mediterranean older adults.

Joanne Karam, Maria del Mar Bibiloni, Antoni Pons, Josep A. Tur

ABSTRACT

***Objectives*:** To assess fatty acids intake and their food sources among Mediterranean older adults, and finally compare it to national and international recommendations.

Methods: The study was conducted in 211 participants dwelling women (*n*= 112) and men (*n*= 99). Lipid and fatty acid intake were calculated from two non-consecutives 24-h recall diets using a Spanish food database.

Results:The mean daily intake of lipids was 68.6 g/day (SD: 24.6; 34.4%, SD: 7.0 of total energy consumed). Men, younger participants and those with higher education ingested more lipids than their peers. Fatty acids were ingested as follows: MUFA (16.7%, SD: 4.1), SFA (9.6%, SD: 2.6) and PUFA (5.0%, SD: 1.7). Oils & seeds were the highest contributors in the intake of lipids (38.8%, SD: 16.0), MUFA (53.9%, SD: 18.7) and PUFA (33.0%, SD: 16.4). The intake of fatty acids did not abide by the International (PUFA) and Spanish recommendations (SFA, MUFA). ALA, EPA and DHA intake were lower than recommendations, but cholesterol intake (243.9 mg, SD: 140.4) was within the range of recommendations.

***Conclusions**:*Sex, age and educational level influenced fat intake. MUFA was the highest ingested fatty acid, and “oils & seeds” was the food group with highest contribution to lipid intake; both are in accordance with the Mediterranean diet pattern.

However, the fatty acid intake did not abide by the recommendations in Mediterranean older adults.

Keywords: Lipid; fatty acids; older adults; food groups; health outcomes.

Introduction

Food patterns have been changing in the past 40 years in Europe; the proportion of fat increased at the expense of carbohydrates [1]. The greatest changes have occurred in Mediterranean countries where energy available from carbohydrates decreased by 20.5% and that of lipids increased by 48.1% [1] which affects the consumption patterns. Spain, a Mediterranean country, is undergoing changes in dietary habits. Economic factors, more than healthy habits, are considered by Spanish people, however, some healthy dietary habits are preserved by food shopping from the traditional markets [2].

Fat, a macronutrient present in the diet, provides a unique flavor and texture to food [3]. Fats are essential in the body function and are the most energy-dense nutrient providing 37kJ/g (9 kcal/g) [4]. Fats help in absorbing and transporting carotenoids and fat-soluble vitamins [5], are precursors to signaling molecules and are an essential component of cell membranes [6].

Fat can be found either saturated, monounsaturated or polyunsaturated. Studies have shown that different type of fats have different effects on cardiovascular health; diets rich in saturated fats (SFA) increase the risk of coronary heart disease [7], but monounsaturated fats (MUFA) and polyunsaturated fats (PUFA) reduce cardiovascular risk [8,9]. A recent systematic review showed that replacing saturated fat with PUFA and MUFA will lower cardiovascular disease occurrence [10]. Intake of total fat and each type of fat was associated with higher concentrations of total cholesterol and LDL-cholesterol, which are markers of cardiovascular disease [11]. Alpha linoleic acid (ALA) and linoleic acid (LA) both polyunsaturated fatty acids are essential fatty acids; these fatty acids cannot be synthetized by the body and need to be consumed in the diet

[12]. ALA is an omega 3 fatty acid and protects from cardiovascular disease [12]. LA is an omega 6 fatty acid and has a potent cholesterol lowering effect [13]. Eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) are omega 3 fatty acids found mainly in the fish and fish products were shown to have cardiovascular benefits [14].

Based on the importance of fat and its effect on cardiovascular health, dietary reference values and recommendations on the intake of total fat and different fat types were issued by organizations and authorities [15]. The World Health Organization (WHO) recommended 15-35% of total energy (TE) to be consumed from fat, less than 10% TE from SFA and 6-10% TE from PUFA [16]. The European Food Safety Authority (EFSA) issued similar guidelines however they recommended an intake of SFA as low as possible and the intake of EPA + DHA to be of 250 mg/d [17]. The Spanish Society of Community Nutrition also issued guidelines in 2011 setting daily nutritional objectives including guidelines for the intake of total lipids and different fatty acids [18].

Studies assessing fat intake in different populations were conducted in different age groups, such as in the United States [5], Ireland [15], Australia [19], Mexico [20], and Hong Kong [21]. Assessment for the intake of trans fatty acid was assessed in Spanish kids [22]. However, up to our knowledge, there is very scarce data on the assessment of the intake of fat in older adults, specifically for EPA, DHA and ALA that were shown to affect cardiovascular health, even though the Mediterranean diet is well known to be an ALA rich diet [23]. Thirty-one percent of the Spanish population suffers from heart disease according to the World Health Organization (WHO) [24] and knowing that coronary heart disease is specifically associated with older age groups [25], hence the aim of this study is to assess fatty acids intake and their food sources among

Mediterranean older adults, and finally compare it to national and international recommendations.

Subjects and Methods

Study sample

The sample consisted of 211 participants (53% women) engaged in a study conducted from 2013 to 2014 in the University of Balearic Islands. The study investigates the effect of lifestyle factors on the health of older adults living in Mallorca, one of the Balearic Islands. Men aged between 55 and 80 and women aged between 60 and 80 were recruited in social and municipal clubs, health centers and sport clubs. Exclusion criteria included being institutionalized, suffering from a physical or mental illness which would have limited their participation in physical fitness or their ability to respond to questionnaires, chronic alcoholism or drug addiction and intake of drugs for clinical research over the past year.

Sociodemographic and lifestyle characteristics were collected from each participant. Educational level was ranked into primary school studies and higher education. Individuals with ≤1.5 hours/week of physical activity (n=105) were categorised as "inactive" and they were recruited in social and municipal clubs, and health centres. Individuals who practice >1.5 hours/week of physical activity (n=106) were categorised as "active" and they were recruited in social and municipal clubs, health centres and sport clubs. The study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures were approved by the Balearic Islands Ethics Committee (approval reference number nº IB/2251/14 PI). Written informed consents were obtained from all participants.

Anthropometric measurements

Anthropometric measurements were performed by well-trained dietitians who underwent identical and rigorous training as an effort to minimize the effects of inter-observer variation. Height was measured using a stadiometer (Kawe 44444, Asperg, Germany), with the subject’s head in the Frankfurt plane. Body weight was determined using a digital scale (Tefal, sc9210, Rumilly, France). The participants were weighed barefoot, noting and subtracting the weight of the clothes. Weight and height measures were used to calculate body mass index (BMI, kg/m^2). According to the anthropometric reference parameters for the Spanish elderly [27,28], the prevalence of normal-weight and overweight were defined as BMI ≤26.9 kg/m^2 and BMI ≥27.0 kg/m^2 respectively for those older than 65 and BMI ≤24.9 kg/m^2 and BMI ≥25.0 kg/m^2 respectively for younger participants.

Dietary fatty acid assessment

Dietary intake was assessed by two non-consecutive 24 h recalls. Licensed dietitians administered the recalls and verified and quantified the food records. Volumes and portion sizes were reported in natural units, household measures, or with the aid of a book of photographs [29]. Conversion of food into energy intakes, total fat and fatty acids content was made using a self-made computerized program based on Spanish food composition table [30]. Very few recipes typical from the island Mallorca were not found in the book, as a result their fat content was calculated as the sum of fat of different food items according to standard recipes. Energy intakes ranged between 1082-3428 kcal/d for men and 870-2701 kcal/d for women. Under-reporters (EI/basal metabolic rate <0.96) were 10.4% (14 men and 8 women) [31], however, when total fatty acid intake was compared between under-reporters and non-under-reporters, no statistical significant differences were found. Then, under-reporters were not excluded from the present analysis.

Statistical Analysis

Statistics were performed using statistical software SPSS for Windows version 21 (IBM, Chicago, USA). Data are presented as mean, standard deviation (SD), median and interquartile range (IQR). A non-parametric test (Mann-Whitney U test) was used because the sample was not normally distributed. Results were considered statistically significant if p-value <0.05.

Results

Fatty acids intake (Table 1)

In the sample studied, the mean intake of lipids was 68.6 g/day (SD: 24.6) and the median was of 62.2 g/day (IQR: 37.6). As shown in Table 1, men consumed more lipids than women. Younger participants (aged <67 years) consumed more lipids than older ones (aged ≥67 years), and younger women consumed more lipids than older. Participants with higher education level consumed more lipids than those with primary school studies in the total sample and in women. Results for physical activity level and BMI range were not significant.

Fatty acids intake from foods (Table 2)

Mean fatty acid intake is assessed in Table 2. Overall, total lipids contributed in the intake of 34.4% (SD: 7.0) of total energy (TE) consumed. Men consumed more SFA, MUFA, PUFA, ALA (all of them expressed as g) and cholesterol (expressed as mg) than women. No significant differences were found between sexes when fatty acid intake was expressed as % of TE as shown in Table 2.

Main food contributors of lipid intake (Table 3)

Mean contribution of different food groups to total lipid intake is elucidated as percentages in Table 3. Overall, 38.8% (SD: 16.0) of the total amount of lipids ingested was provided by oils & seeds which also were the main source of MUFA (53.9%, 18.7) and PUFA (33.0%, SD: 16.4). The sources of SFA were eggs & meat, oils & seeds, dairy products and other fats. Nuts and eggs & meat were the main contributors of ALA intake, while fish & fish products were the highest contributors of EPA (78.2%, SD: 36.7) and DHA (87.5%, SD: 27.6) intake. As shown as well, 58.9% (SD: 28.1) and 34.3% (SD: 25.8) of cholesterol ingested were provided by eggs & meat, and fish & fish products respectively. Men and women have similar main food contributors to the total lipid intake of the assessed.

Fatty acid intake and recommendations (Table 4)

The fatty acids intake per person compared with EFSA/WHO and Spanish recommendations is shown in Table 4. The intake of total lipids (34.4%, SD: 7.0) abided the International recommendations and by the Spanish ones. The intake of SFA (9.6%, SD: 2.6) abided International recommendations only. The intake of MUFA (16.7%, SD: 4.1) was lower than the Spanish recommendations (20%) but abided the International ones (≥12%). The intake of PUFA (5.0%, SD: 1.7) was similar to the Spanish recommendations but was lower than those set by EFSA and WHO (6-10%). The intake of ALA, EPA and DHA were lower than both recommendations. The intake of cholesterol was within the Spanish recommendations (<300 mg/day). The same applies for both men and women except for the intake of EPA and DHA: women met the International recommendations unlike men.

Discussion

This study aimed to describe the total fat and fatty acid intake in a Mediterranean region in Spain using recall diets. The results obtained were compared to other studies assessing fat intake by similar methods, using recall diets [4,5,15,32,33] or food frequency questionnaires [20,21,34]. When available, the results were compared to other studies assessing fat intake in the same age group [5,15,20] or to adults in general without focusing on older adults when data was not available [4,32,33,34].

The calculated mean fat intake in the total sample (68.6 g/day), in men (78.6g/day) and women (59.9g/day) were lower than the ones obtained in the Irish study (71.9 g/day), in men (84.5 g/day) and women (65.5g/day) older than 65 years old [15] but higher than those obtained in the United States in the total sample (66 g/day), in men (77g/day) and women (57g/day) above 60years [5]. Similarly to the Irish study, men were shown to consume more lipids than women [15]. Participants younger than 65 years old had the highest lipid intake, just as the Irish study [15], this might be due to a decrease in nutrient consumption including fat for one third of people over 65 have reduced saliva production, causing difficulties in eating that may impair appetite [35]. The fact that participants with a higher level of education had a higher lipid intake is probably related to a higher consumption of healthy fats including oils and seeds, nuts, avocado,…Oils & seeds were the highest contributors in the lipid intake; it contributed by 38.8% of total lipid intake whereas in Ireland it only contributed by 8.4% of lipid intake and the highest contributors were meat products (fresh meat, meat products and meat dishes) [15].

The main fat source in Ireland [15] and Mexico [20] were SFA, followed by MUFA and PUFA in elderlies. In this study, MUFA were shown to be the main source of fat, followed by SFA and PUFA. This may be due to high adherence to the Mediterranean diet, which is high in MUFA [36]. Furthermore, the main source of MUFA and PUFA were oils & seeds (53.9% and 33% respectively), and eggs & meat were the main source of SFA (29.5%). According to Li et al. (2016), MUFA (15.6%) and SFA's (12.3%) main source were fresh meat, and the main PUFA sources (17.1%) also were spreading fats and oils [15]. In addition, the intake of total lipids and SFA was similarly to the intake registered among the Chinese population [21] for both men and women, but a higher MUFA intake was shown in the Chinese population compared to the one obtained in this study. The PUFA intake was similar to studies conducted in Australia [37] and South Korea [34], but the PUFA and cholesterol intake was lower in our findings compared to China for both sexes [21]. The cholesterol intake was similar to the one registered in the United States (253 mg) [5].

EPA intake (87.3 mg) was lower than those in Ireland (159.1 mg) and South Korea (215 mg) and the DHA consumption (147.4 mg) was lower as well than those in Ireland (216 mg) and South Korea (204 mg) [15, 36]. EPA intake constitutes 0.05% of TE whereas in Irish elderlies it constitutes 0.093% of TE; the DHA intake constitutes 0.12% of TE in Ireland and 0.1% in this study [15]. In the present study, the main source of omega-3 fatty acids (EPA and DHA) was fish & fish products, similarly to the Irish study [15]. The ALA intake (0.3% of TE) was similar to the intake in Hungary [32], but was lower than the intake in Finland [4] and the United Kingdom [33]. Mean intake of ALA in this study was lower than the results found in the USA for both men and women [5].

The intake of total lipids, cholesterol and PUFA abided by the Spanish recommendations, the intake of ALA, DHA and MUFA was lower than those recommendations and the SFA intake was higher than recommended for both sexes. The intake of total lipids, cholesterol, MUFA and SFA abided by recommendations set by EFSA and WHO. MUFA intake in this study was adequate, similarly to the one registered in Ireland in 2011 [15]. EPA and DHA intake in Ireland fit the recommendations for elderlies, whereas in this study the consumption was only adequate by women. ALA and PUFA intake were lower than recommendations as well unlike the study in Ireland for both men and women [15].

Thirty-one percent of the Spanish population suffers from heart disease according to the WHO [24]. Information from the National Statistics Institute of Spain reveals that the mortality rate in the Balearics in 2015 was 900.3 deaths per 100,000 inhabitants, of these, 266.49 were caused by heart attacks and strokes [38]. In Balearic Islands, dietary interventions are recommended to control the cardiovascular risk factors [39]. In this line, the present study has a relatively small sample size and findings cannot be generalized to the broader community based on this study alone but they reflect how rapid urbanization processes and the reduced proportion of females in the household have led to changes in the food patterns and a shift from the traditional Mediterranean food pattern to unhealthy food trends (fast food, ready to go meals, decreased consumption of fruits and vegetables…) [40]. Then, dietary surveillance programs should be adopted to assess how well recommendations are being met on a regular basis [41]. It is also important to set up initiatives to reduce intake of SFA [42] for a better health. As for example, blood cholesterol is lowered by 10-15% if the intake of 60% of SFA was replaced by other fats and if 60% of dietary cholesterol was avoided in the typical British diet [43].

Strengths and limitations

This study has several strengths. Our results, firstly, showed the intakes of ALA, EPA and DHA, which are scantily reported in previous studies in older adults to our knowledge. Our research also provides information about dietary intakes of fatty acids in comparison to national and international recommendations, which may provide a reference for related public policies in Spain.

However, this study has also several limitations that must be acknowledged. Firstly, a limitation of the study was the relatively small sample size. For this reason, these findings cannot be generalized to the broader community based on this study alone. Secondly, the fatty acid intake was estimated using recall diets instead of food frequency questionnaires that have been questioned in epidemiological studies [44, 45]. We hence used the average of both recalls to calculate the intake of each person and have a fair representation of the fatty acid intake in the sample (Tables 1, 2 and 4) and used each recall by itself to avoid underestimation of consumption of fatty acid in any food group (Table 3). However, two 24-h recall diets tend to underestimate the food intake over a large period compared to foo d frequency questionnaires, and imply a considerable day-to-day variation in fat intake. Moreover, despite the guidance of licensed dietitians, diet was self-reported.

Conclusion

Sex, age and educational level influenced fat intake among Mediterranean older adults. MUFA was the highest ingested fatty acid, and oils & seeds was the food group with highest contribution to lipid intake; both are in accordance with the Mediterranean diet pattern. However, the fatty acid intake did not abide by the recommendations in

Mediterranean older adults. This information along with known association between lipid intake and cardiovascular diseases, especially in older age, should lead public health campaigns to encourage consumers to decrease saturated fatty acids intake [7], and adhering more to the Mediterranean diet pattern to decrease health risks [46].

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Authors' contribution

MMB and JAT designed the study and wrote the protocol. MMB and JK collected data and conducted literature searches and provided summaries of previous research studies. MMB conducted the statistical analysis. MMB, JK, AP and JAT wrote the first draft of the manuscript. All read and approved the final manuscript.

Declaration of Conflicting Interests

The authors declare that they have no conflict of interest.

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Table 1. Total lipid intake among Mediterranean older adults (n=211)

	Total Lipid Intake (g/day)				Men				Women			
	N	Mean (SD)	Median (IQR)	*p*-value	N	Mean (SD)	Median (IQR)	*p*-value	N	Mean (SD)	Median (IQR)	*p*-value
Total population	211	68.6 (24.6)	62.2 (37.6)		99	78.6 (24.7)	78.2 (40.8)		112	59.9 (21.1)	57.5 (25.4)	<0.001
Age Class (men/women)												
<65/67	89	74.4 (25.5)	69.8 (38.5)	0.005	51	81.5 (27.0)	80.9 (40.8)	0.300	38	64.8 (19.8)	61.7 (22.5)	0.032
≥65/67	122	64.5 (23.2)	59.1 (33.4)		48	75.5 (21.8)	75 (36.6)		74	57.3 (21.4)	54.6 (29.6)	
Educational Level												
Primary School	95	62.0 (24.2)	57.5 (39.2)	<0.001	35	73.4 (22.9)	75 (38.9)	0.188	60	55.3 (22.5)	50.3 (27.4)	0.002
Higher Education	116	74.1 (23.7)	68.5 (35.6)		64	81.4 (25.4)	80.9 (40.5)		52	65.2 (18.1)	61.8 (17.7)	
BMI range												
Normal	74	69.1 (24.9)	62.5 (29.1)	0.878	24	81.7 (29.2)	78.4 (44.7)	0.514	50	63.1 (20.3)	59.9 (22.1)	0.082
Overweight	137	68.4 (24.6)	62.1 (39.7)		75	77.6 (23.2)	78.2 (39.9)		62	57.3 (21.5)	54.6 (26.8)	
Physical Activity												
Active	106	71.8 (26.3)	67.9 (38.9)	0.118	48	83.8 (27.9)	80.9 (45.8)	0.084	58	61.9 (20.3)	59.4 (23.8)	0.179
Inactive	105	65.4 (22.5)	60.4 (32.4)		51	73.6 (20.3)	74.2 (34)		54	57.7 (21.9)	55.2 (27.3)	

Abbreviations: SD, standard deviation; IQR, interquartile range; BMI, body mass index.
Differences between lipid intake and descriptive characteristics were performed by Mann-Whitney U test.

Table 2. Mean (standard deviation) of estimated fatty acid intake per person and its contribution to total energy intake.

	All (*n* = 211)	Men (*n* = 99)	Women (*n* = 112)	*p*-values
Total Lipids (g/day)	68.6 (24.6)	78.6 (24.7)	59.9 (21.1)	<0.001
Total Lipids (%TE)	34.4 (7.0)	34.8 (6.7)	34.1 (7.2)	0.329
SFA (g/day)	19.3 (8.4)	22.3 (8.8)	16.6 (7)	<0.001
SFA (%TE)	9.6 (2.6)	9.8 (2.6)	9.4 (2.7)	0.467
MUFA (g/day)	33.3 (12.7)	37.9 (12.6)	29.2 (11.3)	<0.001
MUFA (%TE)	16.7 (4.1)	16.8 (3.9)	16.6 (4.4)	0.415
PUFA (g/day)	10.0 (4.5)	11.6 (5)	8.5 (3.3)	<0.001
PUFA (%TE)	5.0 (1.7)	5.2 (1.9)	4.9 (1.5)	0.394
C18:3 ALA (g/day)	0.6 (0.5)	0.7 (0.6)	0.5 (0.3)	0.004
C18:3 ALA (%TE)	0.3 (0.2)	0.3 (0.3)	0.3 (0.2)	0.669
C20:5 EPA (mg/day)	87.3 (188.8)	78.1 (132.8)	95.4 (227.5)	0.876
C20:5 EPA (%TE)	0.05 (0.1)	0.03 (0.05)	0.06 (0.1)	0.708
C22:6 DHA (mg/day)	147.4 (337.5)	128.6 (247.3)	163.9 (401.2)	0.956
C22:6 DHA (%TE)	0.1 (0.2)	0.05 (0.09)	0.1 (0.2)	0.595
Cholesterol (mg/day)	243.9 (140.4)	280.0 (155.8)	212.1 (117.1)	0.001

Abbreviations: TE, total energy; SFA, saturated fatty acid; MUFA, monounsaturated fatty acid; PUFA, polyunsaturated fatty acid; ALA, α-linolenic acid; EPA, eicosapentaenoic acid; DHA, docosahexaenoic acid.

Table 3. Mean daily contribution (standard deviation) of foods to total amount of lipids, ALA, EPA, DHA, cholesterol and MUFA, PUFA.

		Oils & seeds	Dairy Products	Fish & fish products	Eggs & Meat	Nuts	Sweets	Commercial foods	Other fats[1]	Others[2]
All	Consumption per % of recalls	98	92	47	86	25	78	99	13	100
	Total Lipids (% of total g)	38.8 (16.0)	11.5 (10.5)	7.1 (8.9)	24.5 (15.5)	11.8 (8.9)	9.9 (10.8)	8.0 (12.9)	13.5 (8.8)	1.5 (3.2)
	SFA (% of total g)	23.6 (13.5)	21.8 (17.4)	5.8 (8.8)	29.5 (18.7)	5.3 (4.7)	14.7 (15.4)	8.4 (12.5)	22.5 (12.7)	1.0 (2.8)
	MUFA (% of total g)	53.9 (18.7)	6.5 (7.1)	4.6 (7.2)	21.8 (15.3)	10.7 (10.1)	7.8 (9.4)	7.9 (14.5)	8.2 (6.6)	0.6 (2.8)
	PUFA (% of total g)	33.0 (16.4)	2.6 (3.7)	14.6 (15.8)	24.0 (16.1)	25.8 (17.3)	6.7 (9.7)	8.4 (13.7)	7.1 (10.3)	3.6 (6.6)
	C18:3 ALA (% of total mg)	14.3 (16.2)	8.3 (10.0)	12.8 (17.4)	23.8 (19.0)	30.5 (28.5)	9.8 (15.3)	8.9 (14.4)	10.6 (9.8)	5.7 (11.1)
	C20:5 EPA (% of total mg)	0	5.9 (22.7)	78.2 (36.7)	6.6 (23.5)	7.4 (25.1)	0.3 (5.2)	9.1 (26.0)	46.5 (44.5)	0.3 (4.8)
	C22:6 DHA (% of total mg)	0	0	87.5 (27.6)	14.7 (35.1)	0	0.6 (7.9)	15.3 (32.4)	0.1 (0.5)	0
	Cholesterol (% of total mg)	<0.01	15.3 (17.1)	34.3 (25.8)	58.9 (28.1)	0	12.2 (17.9)	7.2 (13.7)	16.3 (13.9)	0.03 (0.6)
Men	Consumption per % of recalls	80	65	43	66	21	68	78	0	100
	Total Lipids (% of total g)	38.5 (16.6)	11.6 (11.4)	6.1 (8.4)	23.3 (14.1)	13.3 (10.1)	8.6 (10.2)	6.8 (11.7)	0	1.4 (3.5)
	SFA (% of total g)	23.8 (14.3)	22.2 (17.8)	5.2 (8.6)	27.6 (16.7)	5.7 (5.3)	13.6 (15.7)	7.2 (11.2)	0	1.0 (3.1)
	MUFA (% of total g)	53.1 (19.6)	6.6 (8.4)	3.7 (6.9)	20.5 (13.7)	11.5 (10.1)	6.4 (8.4)	6.6 (12.9)	0	0.5 (3.0)
	PUFA (% of total g)	32.5 (16.4)	2.8 (4.8)	12.7 (15.0)	24.3 (15.3)	29.1 (19.1)	5.6 (9.3)	7.3 (13.2)	0	3.8 (7.0)
	C18:3 ALA (% of total mg)	13.8 (16.2)	8.5 (11.8)	11.5 (17.6)	23.9 (17.3)	36.9 (31.8)	7.7 (13.1)	7.6 (12.6)	0	5.8 (11.0)
	C20:5 EPA (% of total mg)	0	6.9 (25.3)	68.7 (40.9)	4.9 (19.4)	10.7 (31.5)	0	8.0 (25.0)	0	0.4 (6.3)
	C22:6 DHA (% of total mg)	0	0	78.7 (35.2)	13.3 (34)	0	0	18.4 (36.2)	0	0
	Cholesterol (% of total mg)	<0.01	14.2 (17.3)	34.3 (28.1)	58.7 (27.2)	0	9.8 (16.9)	6.2 (11.9)	0	0.02 (0.3)
Women	Consumption per % of recalls	100	100	51	94	29	88	100	24	100
	Total Lipids (% of total g)	38.9 (15.7)	11.4 (10.0)	7.8 (9.2)	25.9 (16.3)	10.9 (8.0)	10.7 (11.1)	8.8 (13.6)	13.5 (8.8)	1.5 (2.7)
	SFA (% of total g)	23.5 (13.0)	21.7 (17.2)	6.2 (9)	31.2 (19.6)	5.0 (4.3)	15.4 (15.2)	9.2 (13.1)	22.5 (12.7)	1.0 (2.2)
	MUFA (% of total g)	54.3 (18.1)	6.4 (6.3)	5.3 (7.4)	23.1 (16.1)	10.2 (10.1)	8.8 (10.0)	8.8 (15.4)	8.2 (6.6)	0.6 (2.4)
	PUFA (% of total g)	33.3 (16.5)	2.5 (2.9)	16.0 (16.3)	24.5 (16.9)	23.7 (15.8)	7.5 (9.9)	9.0 (13.9)	7.1 (10.3)	3.5 (6.0)
	C18:3 ALA (% of total mg)	14.7 (16.3)	8.2 (8.9)	13.7 (17.2)	24.4 (20.0)	26.4 (25.6)	11.2 (16.5)	9.6 (15.3)	10.6 (9.8)	5.7 (11.1)

C20:5 EPA (% of total mg)	0	5.3 (21.0)	84.5 (32.3)	7.4 (25.3)	5.7 (21.4)	0.6 (7.0)	9.7 (26.6)	46.5 (44.5)	0.1 (1.5)
C22:6 DHA (% of total mg)	0	0	93.7 (18.5)	15.7 (36.0)	0	1.0 (10.2)	13.8 (30.2)	0.1 (0.5)	0
Cholesterol (% of total mg)	<0.01	15.9 (17.0)	34.3 (24.2)	58.8 (28.5)	0	13.8 (18.4)	7.9 (14.6)	16.3 (13.9)	0.04 (0.7)

Abbreviations: SFA, saturated fatty acid; MUFA, monounsaturated fatty acid; PUFA, polyunsaturated fatty acid; ALA, α-linolenic acid; EPA, eicosapentaenoic acid; DHA, docosahexaenoic acid.

[1]Others include fruits, vegetables, legumes, flours, cereals, rice, beverages (alcoholic and non-alcoholic).

[2]Other fats include lard and butter.

Table 4. Fatty acids intake compared with EFSA/WHO and Spanish recommendations.

		Intake	EFSA and WHO recommendations	Spanish recommendations
All	Total Lipids (%)	34.4 (7.0)	15-35 %	30-35 %
	SFA (%)	9.6 (0.2)	≤10 %	7-8 %
	MUFA (%)	16.7 (4.1)	≥12 %	20 %
	PUFA (%)	5.0 (1.7)	6-10 %	5 %
	C18:3 ALA (%)	0.3 (7.0)	0.5 %	1-2 %
	C20:5 EPA (mg/day)	87.3 (188.8)	EPA + DHA >250 mg/day	—
	C22:6 DHA (mg/day)	147.4 (337.5)	EPA + DHA >250 mg/day	300 mg/day
	Cholesterol (mg/day)	243.9 (140.4)	—	<300 mg/day
Men	Total Lipids (%)	34.8 (6.7)	15-35 %	30-35 %
	SFA (%)	9.8 (2.6)	≤10 %	7-8 %
	MUFA (%)	16.8 (3.9)	≥12 %	20 %
	PUFA (%)	5.2 (1.9)	≥6 %	5 %
	C18:3 ALA (%)	0.3 (0.3)	0.5 %	1-2 %
	C20:5 EPA (mg/day)	78.1 (132.8)	EPA + DHA >250 mg/day	—
	C22:6 DHA (mg/day)	128.6 (247.3)	EPA + DHA >250 mg/day	300 mg/day
	Cholesterol (mg/day)	280.0 (155.8)	—	<300 mg/day
Women	Total Lipids (%)	34.1 (7.2)	15-35 %	30-35 %
	SFA (%)	9.4 (2.7)	≤10 %	7-8 %
	MUFA (%)	16.6 (4.4)	≥12 %	20 %
	PUFA (%)	4.9 (1.5)	≥6 %	5 %
	C18:3 ALA (%)	0.3 (0.2)	0.5 %	1-2 %
	C20:5 EPA (mg/day)	95.4 (227.5)	EPA + DHA >250 mg/day	—
	C22:6 DHA (mg/day)	163.9 (401.2)	EPA + DHA >250 mg/day	300 mg/day
	Cholesterol (mg/day)	212.1 (117.1)	—	<300 mg/day

Abbreviations: ALA, α-linolenic acid; EPA, eicosapentaenoic acid; DHA, docosahexaenoic acid; MUFA, monounsaturated fatty acid; PUFA, polyunsaturated fatty acid; SFA, saturated fatty ac

Manuscript III

Cross-sectional associations of physical condition with sociodemographic, body composition and lifestyle habits in Spanish older adults.

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Article

Association between Physical Condition and Body Composition, Nutrient Intake, Sociodemographic Characteristics, and Lifestyle Habits in Older Spanish Adults

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Abstract: In this study, we assessed physical condition and its association with body composition, nutrient intake, sociodemographic characteristics, and lifestyle habits in older Spanish adults. In this cross-sectional study, we investigated 380 individuals (54% women; men aged 55–80 years and women aged 60–80 years) with no previously documented cardiovascular disease. A general questionnaire was used, and body weight, height, fat, appendicular skeletal muscle mass, and waist circumference were assessed. Physical condition measurements included handgrip strength (HGS) and agility/dynamic balance by eight-foot time up-and-go (8-f TUG) test. The lowest maximum HGS score (kg) was found in older participants, inactive men, and men with abdominal obesity. The highest maximum 8-f TUG score (s) was found in older and inactive, low education, low income, and abdominal obesity and overfat participants; 24.5% of participants had low maximum HGS and 36.8% had a high 8-f TUG score. Sex- and/or age-adjusted odds ratio (OR) for low maximum HGS in women, older participants, overweight and overfat participants were 4.6, 2.9, 0.6 and 0.6 respectively. Sex and/or age adjusted OR for high maximum 8-f TUG in women, overweight, overfat, and abdominally obese participants were 2.4, 1.6, 1.7, and 3.4, respectively; in participants with higher education, those who earned €900 or more per month, and slightly active and active participants had OR values of 0.4, 0.4, and 0.3, respectively. Sarcopenia incidence was 0.3%; however, 4.5% of men and 19.1% of women registered low physical condition (high and low scores in 8-f TUG and HGS tests, respectively). Overall, 36.8%, 24.5%, and 0.3% of participants had high maximum 8-f TUG score, low maximum HGS, and sarcopenia, respectively. Prevalence of these low values varies according to sociodemographic and body composition variables.

Keywords: physical condition; handgrip muscle strength; 8-foot time up-and-go; body composition; sarcopenia

1. Introduction

The current prevalence of and the expected increase in the elderly population is an important health challenge in our society. In 2050, almost 30% of the European population will be over 65 years old [1], and in Spain, it is estimated that 37% of the population will be over 64 years old by 2052 [2]. With an aging population, an increase in age-related diseases, including frailty, is expected.

Adverse health outcomes of aging, including falls, hospitalisation, institutionalization, and mortality, are the effect of impaired homeostatic reserve and reduced capacity of the organism to withstand stress, characterised by physical weakness, reduced physical activity, and performance that usually accompany frailty [3,4]. A key component of frailty is sarcopenia—a progressive loss of skeletal muscle mass and low muscle strength or performance that occurs with advancing age [4,5]. Sarcopenia is defined as a low muscle mass accompanied by either low muscle strength or low physical performance [4]. Low handgrip strength (HGS) and high eight-foot time up-and-go (8-f TUG) are used in the diagnosis of sarcopenia [4]; however, the prevalence of sarcopenia varies depending on the criteria used for diagnosis [6,7]. The European Working Group on Sarcopenia in Older People (EWGSOP) differentiated between presarcopenia (low muscle mass), sarcopenia (low muscle mass plus low muscle strength or physical condition), and severe sarcopenia (low muscle mass plus low muscle strength plus physical condition) [8].

Muscle strength has been described as a strong predictor of mortality and hospitalization in people aged 80 years and older [9]. Muscle homeostasis, under normal circumstances, is influenced by nutritional factors and level of physical activity [5], and also by chronic diseases and certain drug treatments [4]. Accordingly, moderate-to-vigorous physical activity may reduce the risk of severe sarcopenia and sarcopenic obesity among older men. Reducing sedentary time and increasing light physical activity and sedentary breaks may also protect against sarcopenic obesity [10]. Body composition and body measurements were shown to be associated with physical function; the Health, Aging, and Body Composition (Health ABC) study cohort reported poorer physical function in women due to their higher proportion of body fat compared to men [11]. In addition, increased body mass index (BMI) and waist circumference are associated with decreased cardiorespiratory fitness [12]; hence, a direct relation exists between BMI, waist circumference, body fat, and physical condition.

Early declines in physical condition can be detected through observation of a decline in the ability to perform mobility tasks activities of daily living, instrumental activities of daily living, or increased time to complete them. These symptoms need to reach a threshold before being recognized as a problem [13]. Early identification of a decline in the physical condition and appropriate interventions could help prevent functional impairments, such as impairments in walking and stairs climbing that often result in falls and physical frailty [14]. Therefore, the aim of this work was to assess physical condition, using HGS and 8-f TUG, and its association with nutrient intake, body composition, sociodemographic characteristics, and lifestyle habits in older Spanish adults.

2. Methods

2.1. Study Design, Population, and Ethics

The sample consisted of 380 participants (54% women) in a cross-sectional study conducted from 2013 to 2014 into two different areas (Balearic Islands, n = 211, and Madrid, n = 169) assessing the effect of lifestyle factors on health of older adults living in Spain [15]. Men aged between 55 and 80 and women aged between 60 and 80 [16] were recruited in social and municipal clubs, health centers, and sport clubs. Exclusion criteria included previously documented cardiovascular disease, being institutionalized, suffering from a physical or mental illness that would have limited participation in physical fitness or ability to respond for themselves to our questionnaires, chronic alcoholism or drug addiction, and intake of drugs for clinical research over the past year. The study was conducted according to the Declaration of Helsinki guidelines, and all procedures were approved by the Ethical

Committee of the Technical University of Madrid. Written informed consent was obtained from all participants.

2.2. Body Composition

Anthropometric measurements (height, waist circumference (WC), appendicular skeletal muscle mass (ASM), body weight, and body fat) were recorded by licensed observers. Height and WC measurements were performed according to the International Standards for Anthropometric Assessment of the International Society for the Advancement of Kinanthropometry (ISAK) [17]. Height was determined using a mobile anthropometer (Seca 213, SECA Deutschland, Hamburg, Germany) to the nearest millimeter, with the subject's head in the Frankfurt plane. WC was measured as the smallest horizontal girth between the costal margins and the iliac crests at minimal respiration using a flexible, non-extensible plastic tape with 0.1 cm precision (Kawe 43972, Kirchner & Wilhelm GmbH + Co., KG, Asperg, Germany). Body weight, body fat, and ASM were determined using a Segmental Body Composition Analyzer (Tanita BC-418, Tanita, Tokyo, Japan). One measurement was taken without excessive exercise 12 h before the measurement and/or no excessive eating and drinking the day before measurement. The participants were weighed in bare feet and light clothes, and subtracting 0.6 kg for their clothes. Weight and height measures were used to calculate body mass index (kg/m^2). Further information may be found in the technical leaflets of this analyser [18]. According to the anthropometric reference parameters for the Spanish elderly [19,20], the prevalence of overweight and obesity was defined as BMI $\geq$ 27.0 kg/m^2. Overfat (excessive body fat) was defined according to body fat ranges for Standard Adults reported by Gallagher et al. [21]. WC and height measures were used to calculate waist-to-height ratio (WHtR). Abdominal obesity was defined as a WHtR $\geq$ 0.5 [22]. ASM and height measures were used to calculate appendicular skeletal muscle mass index (ASMI, kg/m^2) and low ASMI was defined as <7.26 kg/m^2 in men and <5.5 kg/m^2 in women [23].

2.3. Socioeconomic and Lifestyle Determinants

A specific questionnaire developed by the EXERNET network [24] that included the following questions was used: age, marital status, educational level, income, and smoking habits. The respondents were grouped in binary categories as follow: (a) age: <65 (men) and <67 (women) years old, and $\geq$65 (men) and $\geq$67 (women) years old; (b) marital status: single (single, unmarried, divorced, or widowed), and in a relationship (i.e., including married and unmarried, divorced or widowed living with a partner); (c) educational level: illiterate or primary ($\leq$6 years), and secondary or college-level education (>6 years); (d) participants' income: <€900 /month, and $\geq$€900/month; and (e) smoking habits: smoker ($\geq$1 cigarette/day) and non-smoker.

Physical activity data were analyzed using the validated Spanish version of the Minnesota Leisure Time Physical Activity Questionnaire [25,26], and the participants were classified according to their leisure-time physical activity (LTPA) in the past 5 years. Individuals with $\leq$1.5 h/week of physical activity were categorised as "inactive". Individuals who completed $\geq$4 h/week of physical activity were categorised as "active". People who could not be included into the "inactive" and "active" groups were categorised as "slightly active".

2.4. Physical Condition and Sarcopenia Definition

The physical condition assessment included muscle strength based on HGS and agility/dynamic balance based on the 8-f TUG test.

2.4.1. Handgrip Strength Test (HGS)

Grip muscular strength was measured using a digital handheld dynamometer (TKK 5401 Grip-D; Takey, Tokyo, Japan). Participants were instructed to stand upright with the dynamometer beside, but not against, their body. Measurements were performed two times for each hand. The best of all attempts was used to perform the analysis [27]. According to Cruz-Jentoft et al. [4], low handgrip strength was defined as <20 kg in women and <30 kg in men.

2.4.2. Agility/Dynamic Balance Test (8-f TUG)

Participants were instructed to rise from a chair without the use of arms, walk around the cone placed 2.45 m from the chair, and return to the original sitting position. Further instructions were to complete the test as quickly as possible but without running. Measurements were performed two times and the best of all attempts was used to perform the analysis [28]. Low execution time in the 8-f TUG test was defined using the cut-off points for age and sex presented in the study by Rikli and Jones. Since there is no cut-off for men aged 55–60 years we used the same cut-offs of men aged 60–64 years [29].

The algorithm provided by EWGSOP was adopted to determine whether the study individuals were sarcopenic [4]. Presarcopenia was defined as a low ASMI. Sarcopenia was defined as a low ASMI and either high 8-f TUG score or low HGS. Finally, severe sarcopenia was defined as a low ASMI combined with a high 8-f TUG score and low HGS [23].

2.5. Dietary Intake Assessment

Dietary intake was assessed by two non-consecutive 24 h recalls. Volumes and portion sizes were reported in natural units, household measures, or with the aid of a book of photographs [30]. Conversion of food into energy intakes and macronutrient content (carbohydrate, protein, total fat, polyunsaturated fatty acids (PUFA), monounsaturated fatty acids (MUFA), saturated fatty acids (SFA), cholesterol, and fiber) was completed using a self-made computerized program based on Spanish food composition table [31]. Energy intakes ranged between 1021 and 3515 kcal/day for men and 652 and 2996 kcal/day for women. Under-reporters (energy intake/basal metabolic rate <0.96) were 23.9% (50 men and 41 women) [32]; however, when macronutrient intake was compared between under-reporters and non-under-reporters, statistically significant differences were found only for protein in both sexes, and SFA and fiber in women. As such, under-reporters were not excluded from the present analysis.

2.6. Statistics

Analyses were performed with the SPSS statistical software package version 24.0 (SPSS Inc., Chicago, IL, USA). Maximum HGS and the maximum 8-f TUG test were calculated for men and women according to different sociodemographic, body composition, and lifestyle variables. The normality of the data was assessed using the Kolmogorov-Smirnov test. We found that dependent variables (maximum HGS and maximum 8-f TUG) were not normally distributed for sex and many sociodemographic, body composition, and lifestyle variables. Results are expressed as the median (interquartile range, IQR). The Mann-Whitney *U* test was used to compare the median of two independent groups, and the Kruskal-Wallis test was used to compare the median of three independent groups (i.e., LTPA physical variable). The differences in prevalence across normal and low maximum HGS, and normal and high maximum 8-f TUG score participants, according to sociodemographic, body composition, and lifestyle variables, were examined by using the Chi-square test. Logistic regression analyses, with the calculation of corresponding odds ratio (OR) and the 95% confidence interval (95% CI), were used to compare participants with low maximum HGS or high maximum 8-f TUG and the other participants as reference value (dependent variable) in selected sociodemographic, body composition, and lifestyle variables. Univariate analysis was first carried out for all the sociodemographic, body composition, and lifestyle variables (crude OR). Secondly, results were adjusted for sex and age to control for confounders. Results were considered statistically significant if $p < 0.05$ (two-tailed). Scatter plots were used to illustrate the correlations between the outcome measures used for sarcopenia diagnosis (HGS and 8-f TUG test). Analyses were stratified by sex.

3. Results

The maximum HGS and 8-f TUG score among Spanish older adults are shown in Table 1. Median maximum HGS was 37.2 kg (IQR: 11.1) in men and 21.8 kg (IQR: 6.0) in women. Median maximum HGS was lowest in men and women aged 65 and 67 or older, respectively. There were no significant differences in other sociodemographic variables. Men with abdominal obesity (p = 0.017) had lower maximum HGS. In men, significant differences in maximum HGS were also found by LTPA groups, with the lowest median maximum HGS in inactive men (35.6 kg, IQR: 6.2).

Table 1. Maximum handgrip strength (HGS) and maximum eight-foot time up-and-go (8-f TUG) score among older adults according to sociodemographic, body composition and lifestyle variables stratified by sex.

Variable	N	Maximum HGS (kg)		Maximum 8-f TUG (s)	
	Men/Women	Men	Women	Men	Women
Sociodemographics					
All	176/204	37.2 (11.1)	21.8 (6.0)	4.6 (1.1)	5.2 (1.0)
Age (years)					
<65 (men)/67 (women)	83/96	40.9 (9.7)	22.7 (5.4)	4.4 (1.0)	5.0 (1.2)
≥65 (men)/67 (women)	93/108	36.3 (9.0)	20.3 (6.6)	4.9 (1.1)	5.3 (1.0)
p		<0.001	0.007	<0.001	0.003
Marital status					
Married/Coupled	153/130	37.2 (11.3)	22.0 (5.9)	4.7 (1.1)	5.3 (1.1)
Single	23/74	36.7 (7.8)	21.5 (6.5)	4.6 (1.3)	5.2 (1.0)
p		0.448	0.629	0.242	0.794
Educational level					
Primary	61/100	36.5 (9.7)	21.4 (6.3)	4.9 (1.1)	5.5 (1.1)
Secondary or college	115/104	38.1 (11.0)	22.2 (5.4)	4.6 (1.1)	5.0 (0.9)
p		0.124	0.398	0.011	<0.001
Income					
<900 €	27/106	36.3 (13.4)	21.9 (6.2)	4.9 (1.3)	5.4 (1.2)
≥900 €	149/98	37.4 (10.9)	21.8 (5.9)	4.6 (1.0)	5.0 (0.9)
p		0.253	0.662	0.040	<0.001
Body composition					
BMI (kg/m^2)					
<27.0	74/113	36.8 (13.0)	21.4 (6.0)	4.4 (1.1)	5.1 (1.0)
≥27.0	102/91	37.5 (9.6)	22.5 (5.8)	4.8 (0.9)	5.4 (1.2)
p		0.989	0.202	0.128	0.007
Overfat					
No	59/83	41.1 (12.2)	20.4 (6.4)	4.3 (1.0)	5.1 (0.8)
Yes	117/121	36.7 (8.1)	22.5 (5.6)	4.8 (0.9)	5.3 (1.2)
p		0.063	0.143	<0.001	0.010
Abdominal obesity					
No	23/62	43.3 (10.2)	20.2 (6.3)	4.2 (0.9)	5.0 (0.7)
Yes	153/142	36.9 (10.5)	22.4 (5.9)	4.7 (1.0)	5.3 (1.0)
p		0.017	0.140	<0.001	0.002
Lifestyle variables					
Smoking habit					
Non-smoker	161/191	37.2 (11.3)	21.7 (5.5)	4.6 (1.1)	5.2 (1.0)
Smoker	15/13	37.4 (9.6)	22.9 (6.4)	4.7 (1.3)	5.2 (1.7)
p		0.836	0.216	0.717	0.652

Table 1. *Cont.*

Variable	*N*	Maximum HGS (kg)		Maximum 8-f TUG (s)	
	Men/Women	Men	Women	Men	Women
LTPA					
Inactive	66/92	35.6 (6.2) [a,b]	20.9 (6.2)	5.0 (1.0) [a,b]	5.5 (1.1) [a,b]
Slightly active	43/59	38.7 (10.7)	22.1 (6.3)	4.4 (1.0)	5.2 (0.9)
Active	67/53	40.9 (10.2)	22.4 (5.5)	4.4 (1.0)	4.8 (1.1)
p		0.001	0.310	<0.001	<0.001

Abbreviations: BMI, body mass index; LTPA, leisure-time physical activity. Values are expressed as median (interquartile range, IQR). Significant differences in maximum HGS and 8-f TUG medians between sociodemographic, body composition and lifestyle variables groups in men and women were tested by Mann-Whitney U test or Kruskal-Wallis test. Significant differences between ($p < 0.05$) [a] Inactive vs. Slightly active, and [b] Inactive vs. Active were obtained.

Median maximum 8-f TUG was 4.6 s (IQR: 1.1) for men and 5.2 s (IQR: 1.0) for women. Men older than 65 and women older than 67 had higher median maximum 8-f TUG score than younger participants. Whereas no significant differences in maximum 8-f TUG score were found in marital status, educational and income levels had an impact on 8-f TUG. Men and women with a primary education had higher maximum 8-f TUG score than high-education participants. Lower income was also associated with higher maximum 8-f TUG score for men and women. Participants with overweight, overfat, and abdominal obesity had higher median maximum 8-f TUG score than their leaner counterparts (results were significant except for BMI in men). Significant association with LTPA groups was found, with inactive men and women showing the highest median maximum 8-f TUG score.

Prevalence of normal and low maximum HGS and 8-f TUG score among Spanish older adults according to sociodemographic, body composition, and lifestyle variables is shown in Table 2. Overall, 24.5% of the participants had low maximum HGS. More women (36.8%) than men (10.2%) were below the cut-off values established for the HGS ($p < 0.001$). More men and women older than 65 and 67, respectively, showed low maximum HGS than younger counterparts ($p < 0.001$). Prevalence of low maximum HGS was higher in participants who were single (35.1%) and those with an income lower than €900 (33.1%) compared to married or coupled participants (20.8%) and those with an income of €900 or higher (19.8%) ($p < 0.010$). No significant differences in prevalence of low HGS and educational level were found. Overweight, overfat, and abdominally obese participants had lower prevalence of low maximum HGS than leaner counterparts. Despite the lack of statistical significance, participants who were slightly active and active showed lower prevalence of low maximum HGS than inactive participants (21.2% and 29.1%, respectively, $p = 0.076$).

Sex, age, marital status, income, overweight, overfat, and abdominal obesity status were significantly associated with low maximum HGS in univariate logistic regressions. Results in sex- and/or age-adjusted analysis illustrate that the odds of low maximum HGS were 4.6 (95% CI: 2.6–8.2) and 2.9 (95% CI: 1.7–4.8) times higher for women and older participants, respectively, compared with men and younger participants. In both overweight and overfat participants, the odds of low maximum HGS were 0.6 times lower for overweight (95% CI: 0.4–1.0) and overfat (95% CI: 0.3–1.0) participants compared with their leaner counterparts. However, the OR for low maximum HGS lost its statistical significant association with the income variable after adjusting for sex and age.

Table 2. Prevalence of low/normal maximum HGS and high/normal 8-f TUG score according to sociodemographic, body composition, and lifestyle variables.

Variables		Maximum HGS					Maximum 8-f TUG				
	n	Normal	Low	*p*	Crude OR (95% CI) †	Sex- and/or Age-Adjusted OR (95% CI) ‡	Normal	High	*p*	Crude OR (95% CI) †	Sex- and/or Age-Adjusted OR (95% CI) ‡
Sociodemographics											
All	380	287 (75.5)	93 (24.5)				240 (63.2)	140 (36.8)			
Sex											
Men	176	158 (89.8)	18 (10.2)	<0.001	1.00 (ref.)	1.00 (ref.)	128 (72.7)	48 (27.3)	<0.001	1.00 (ref.)	1.00 (ref.)
Women	204	129 (63.2)	75 (36.8)		5.10 (2.90–8.98)	4.59 (2.56–8.23)	112 (54.9)	92 (45.1)		2.19 (1.42–3.37)	2.38 (1.52–3.72)
Age (years)											
<65/67	179	151 (84.4)	28 (15.6)	<0.001	1.00 (ref.)	1.00 (ref.)	106 (59.2)	73 (40.8)	0.133	1.00 (ref.)	1.00 (ref.)
≥65/67	201	136 (67.7)	65 (32.3)		2.58 (1.56–4.25)	2.85 (1.68–4.82)	134 (66.7)	67 (33.3)		0.73 (0.48–1.10)	0.72 (0.47–1.10)
Marital status											
Married/Coupled	283	224 (79.2)	59 (20.8)	0.005	1.00 (ref.)	1.00 (ref.)	180 (63.6)	103 (36.4)	0.758	1.00 (ref.)	1.00 (ref.)
Single	97	63 (64.9)	34 (35.1)		2.05 (1.24–3.40)	1.08 (0.61–1.91)	60 (61.9)	37 (38.1)		1.08 (0.67–1.73)	0.90 (0.54-1.49)
Educational level											
Primary	161	119 (73.9)	42 (26.1)	0.531	1.00 (ref.)	1.00 (ref.)	83 (51.6)	78 (48.4)	<0.001	1.00 (ref.)	1.00 (ref.)
Secondary or college	219	168 (76.7)	51 (23.3)		0.86 (0.54–1.38)	1.22 (0.73–2.05)	157 (71.7)	62 (28.3)		0.42 (0.27–0.64)	0.43 (0.27–0.66)
Income											
<900 €	133	89 (66.9)	44 (33.1)	0.004	1.00 (ref.)	1.00 (ref.)	65 (48.9)	68 (51.1)	<0.001	1.00 (ref.)	1.00 (ref.)
≥900 €	247	198 (80.2)	49 (19.8)		0.50 (0.31–0.81)	1.00 (0.58–1.71)	175 (70.9)	72 (29.1)		0.39 (0.25–0.61)	0.44 (0.27–0.71)
Body composition											
BMI (kg/m²)											
<27.0	185	128 (69.2)	57 (30.8)	0.005	1.00 (ref.)	1.00 (ref.)	124 (67.0)	61 (33.0)	0.128	1.00 (ref.)	1.00 (ref.)
≥27.0	195	159 (81.5)	36 (18.5)		0.51 (0.32–0.82)	0.59 (0.35–1.00)	116 (59.5)	79 (40.5)		1.38 (0.91–2.11)	1.61 (1.04–2.49)
Overfat											
No	142	98 (69.0)	44 (31.0)	0.023	1.00 (ref.)	1.00 (ref.)	99 (69.7)	43 (30.3)	0.041	1.00 (ref.)	1.00 (ref.)
Yes	238	189 (79.4)	49 (20.6)		0.58 (0.36–0.93)	0.58 (0.34–0.98)	141 (59.2)	97 (40.8)		1.58 (1.02–2.46)	1.72 (1.10–2.72)
Abdominal obesity											
No	85	55 (64.7)	30 (35.3)	0.008	1.00 (ref.)	1.00 (ref.)	66 (77.6)	19 (22.4)	0.002	1.00 (ref.)	1.00 (ref.)
Yes	295	232 (78.6)	63 (21.4)		0.50 (0.30–0.84)	0.57 (0.31–1.03)	174 (59.0)	121 (41.0)		2.42 (1.38–4.23)	3.38 (1.87–6.09)
Lifestyle variables											
Smoking habit											
Non-smoker	352	263 (74.7)	89 (25.3)	0.193	1.00 (ref.)	1.00 (ref.)	222 (63.1)	130 (36.9)	0.898	1.00 (ref.)	1.00 (ref.)
Smoker	28	24 (85.7)	4 (14.3)		0.49 (0.17–1.46)	0.61 (0.19–1.95)	18 (64.3)	10 (35.7)		0.95 (0.43–2.12)	0.97 (0.43–2.19)
LTPA											
Inactive	158	112 (70.9)	46 (29.1)	0.076	1.00 (ref.)	1.00 (ref.)	77 (48.7)	81 (51.3)	<0.001	1.00 (ref)	1.00 (ref.)
Slightly active/Active	222	175 (78.8)	47 (21.2)		0.65 (0.41–1.05)	0.79 (0.47–1.32)	163 (73.4)	59 (26.6)		0.34 (0.22–0.53)	0.33 (0.21–0.52)

Abbreviations: BMI, body mass index; HGS, handgrip strength; 8-f TUG, 8-foot time up-and-go; LTPA, leisure-time physical activity; OR, odds ratio; CI, confidence interval. † Logistic regression analysis considering the effect of one explanatory variable. ‡ Logistic regression analysis considering the effect of one explanatory variable and adjusted for sex and age.

Conversely, 36.8% of participants had a high 8-f TUG score. More women (45.1%) than men (27.3%) were above the cut-off values established for the 8-f TUG test ($p < 0.001$). Prevalence of high 8-f TUG was higher in participants with primary education (48.4%) and an income lower than €900 (51.1%) than more educated participants (28.3%) and those with higher income (29.1%) ($p < 0.001$). More overfat (40.8%) and abdominal obese (41.0%) participants had a higher 8-f TUG score than leaner participants (30.3% and 22.4%, respectively, $p < 0.050$). Inactive participants also had a higher prevalence of high 8-f TUG than slightly active and active ones ($p < 0.001$). Age group, marital status, BMI status, and smoking habits were not significantly associated with 8-f TUG prevalence.

Sex, educational level, income, overfat, abdominal obesity, and LTPA were significantly associated with high maximum 8-f TUG in univariate logistic regressions. Results in sex- and/or age-adjusted analysis illustrated that the odds of a high maximum 8-t TUG were, respectively, 2.4 (95% CI: 1.5–3.7), 1.6 (95% CI: 1.0–2.5), 1.7 (95% CI: 1.1–2.7) and 3.4 (95% CI: 1.9–6.1) times higher for women, overweight, overfat, and abdominal obesity participants compared with the reference groups. In more educated participants, participants with an income of 900 euros or higher per month, and slightly active and active, the odds of a high maximum 8-f TUG were 0.4 (95% CI: 0.3–0.7), 0.4 (95% CI: 0.3–0.7), and 0.3 (95% CI: 0.2–0.5) times lower compared with the reference groups, respectively. Furthermore, educational and income levels maintained statistical significant association with high maximum 8-f TUG in multivariable analysis adjusted by sex and age (secondary or college: OR: 0.50, 95% CI: 0.32–0.80; income ≥ €900/month: 0.56, 95% CI: 0.34–0.94).

Figure 1 illustrates the correlation between 8-f TUG and HGS among men (Figure 1A) and women (Figure 1B). The frequency of presarcopenia was 2.6% (n = 10), and was more frequent in men (4.5%; n = 8) than women (1.0%; n = 2). The frequency of sarcopenia and severe sarcopenia was 0.3% (n = 1) and 0.5% (n = 2) in men and women, respectively. Eight men showed high 8-f TUG and low HGS scores (including severe sarcopenic participants), and 39 women registered high and low scores in both physical tests ($p < 0.001$).

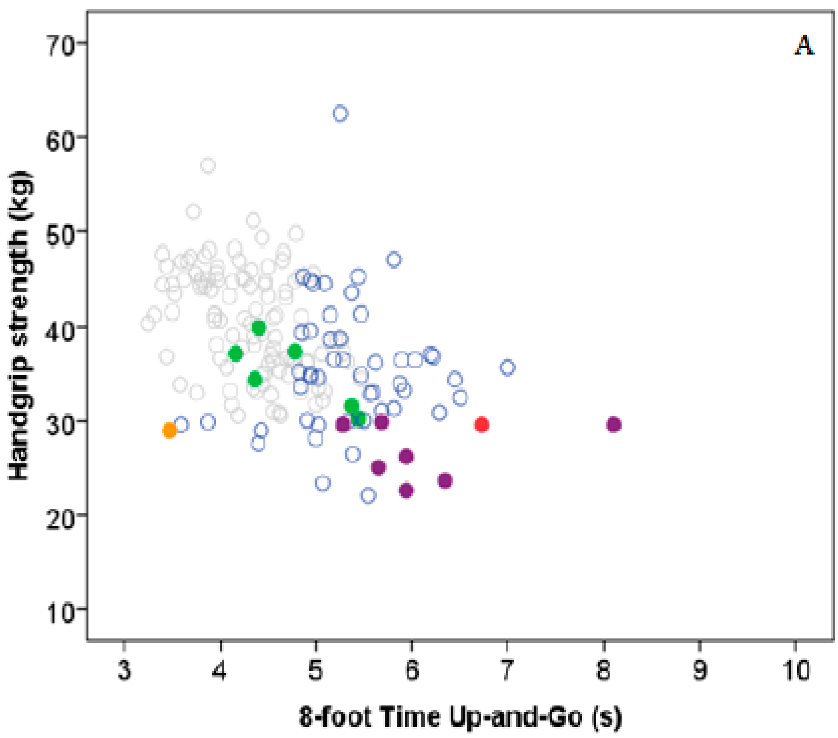

Figure 1. *Cont.*

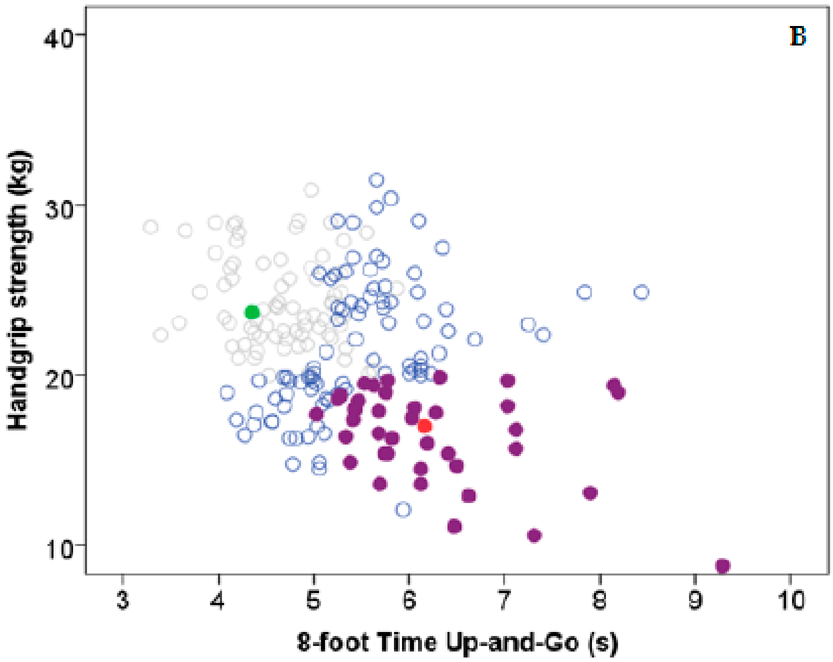

Figure 1. Scatter plot of variables used for diagnosis of sarcopenia: (**A**) men and (**B**) women. Grey open circles denote normal appendicular skeletal muscle index (ASMI, kg/m^2), 8-foot Time Up-and-Go (8-f TUG, s), and handgrip strength (HGS, kg). Grey solid circles denote presarcopenia. Grey open triangles denote high 8-f TUG or low HGS. Grey solid triangles denote high 8-f TUG and low HGS. Black open squares denote sarcopenia, and black solid squares denote severe sarcopenia.

Concerning macronutrients intake (Table 3), women with low HGS had significantly lower intake of calories, total fats, MUFAs, cholesterol, and fiber than women with low HGS, and significantly higher intake of carbohydrates. No differences between groups were observed for protein, PUFA, or SFA intake. No statistically significant differences between low/normal HGS groups were found in macronutrient intake in men. Additionally, no statistically significant differences between high/normal 8-fTUG groups were found in macronutrient intake in both sexes.

Table 3. Energy and macronutrient intake according to low/normal HGS and high/normal 8-f TUG score.

Variables	Maximum HGS			Maximum 8-f TUG		
	Normal (n = 287)	Low (n = 93)	p	Normal (n = 240)	High (n = 140)	p
All (n = 380)						
Energy intake (kcal/day)	1679 (1394–2046)	1547 (1269–1833)	0.007	1708 (1394–2043)	1559 (1277–1844)	0.004
Carbohydrate intake (% total energy)	44.7 (38.2–50.0)	47.3 (41.5–53.6)	0.003	44.9 (38.0–50.0)	46.6 (40.3–51.4)	0.201
Protein intake (% total energy)	16.0 (14.2–18.6)	16.1 (13.4–19.0)	0.738	16.2 (14.4–18.7)	15.8 (13.2–18.8)	0.149
Fat intake (% total energy)	35.0 (30.0–40.0)	32.5 (28.6–37.6)	0.025	34.3 (29.8–39.8)	34.0 (29.4–38.6)	0.520
PUFA (% total energy)	4.2 (3.5–5.1)	4.2 (3.5–5.7)	0.369	4.3 (3.5–5.4)	4.1 (3.3–5.0)	0.084
MUFA (% total energy)	16.0 (13.4–18.6)	14.0 (12.3–16.9)	0.001	15.8 (13.2–18.6)	15.1 (12.7–17.8)	0.254
SFA (% total energy)	10.0 (8.2–12.5)	9.6 (7.3–11.2)	0.058	9.8 (8.0–12.0)	10.1 (8.1–11.9)	0.600
Cholesterol intake (mg/1000 kcal)	261.9 (177.4–383.9)	211.1 (127.3–309.6)	0.054	253.8 (170.4–384.2)	245.7 (160.5–356.5)	0.993
Fiber intake (g/1000 kcal)	65.6 (51.2–82.5)	58.7 (45.3–71.2)	0.006	64.5 (51.3–82.3)	60.5 (45.1–78.1)	0.625
Men (n = 176)	n = 158	n = 18		n = 128	n = 48	
Energy intake (kcal/day)	1926 (1579–2255)	1789 (1527–1892)	0.068	1914 (1606–2202)	1817 (1507–2265)	0.528
Carbohydrate intake (% total energy)	43.8 (37.8–49.6)	43.6 (34.5–53.4)	0.914	44.2 (37.6–49.7)	43.6 (38.5–50.2)	0.847
Protein intake (% total energy)	15.7 (13.9–18.2)	16.0 (14.1–19.7)	0.461	15.9 (14.3–18.5)	14.9 (12.9–18.2)	0.092
Fat intake (% total energy)	34.8 (29.8–39.6)	32.5 (29.6–40.8)	0.907	34.1 (29.6–39.6)	35.6 (31.2–40.1)	0.361
PUFA (% total energy)	4.3 (3.5–5.1)	5.0 (3.6–6.3)	0.160	4.3 (3.5–5.3)	4.2 (3.6–5.0)	0.515
MUFA (% total energy)	16.1 (13.5–18.3)	14.9 (12.9–18.3)	0.646	16.0 (13.2–18.3)	16.0 (13.8–18.3)	0.740
SFA (% total energy)	10.2 (8.2–12.5)	9.5 (7.3–11.6)	0.470	9.8 (7.8–12.2)	10.6 (8.9–13.1)	0.059
Cholesterol intake (mg/1000 kcal)	149.6 (101.7–210.7)	193.4 (94.1–277.3)	0.372	141.2 (101.1–205.9)	158.0 (102.6–220.5)	0.570
Fiber intake (g/1000 kcal)	9.4 (7.2–12.2)	10.2 (7.9–13.8)	0.449	9.8 (7.6–12.7)	8.5 (6.8–10.1)	0.040
Women (n = 204)	n = 129	n = 75		n = 112	n = 92	
Energy intake (kcal/day)	1456 (1236–1721)	1515 (1235–1820)	0.486	1463 (1286–1774)	1486 (1193–1735)	0.525
Carbohydrate intake (% total energy)	46.3 (38.5–51.1)	48.3 (43.4–54.0)	0.018	46.3 (38.9–51.3)	47.4 (41.4–52.8)	0.265
Protein intake (% total energy)	16.7 (14.5–19.5)	16.1 (13.3–18.7)	0.155	16.7 (14.6–19.1)	16.1 (13.4–19.1)	0.374
Fat intake (% total energy)	35.2 (30.3–40.3)	32.5 (28.5–36.8)	0.016	34.7 (30.2–40.2)	33.6 (29.0–37.7)	0.147
PUFA (% total energy)	4.1 (3.4–5.2)	4.2 (3.4–5.3)	0.700	4.3 (3.5–5.5)	4.0 (3.3–5.1)	0.106
MUFA (% total energy)	15.8 (13.4–18.7)	13.7 (12.2–16.5)	0.001	15.6 (13.2–18.6)	14.7 (12.4–17.2)	0.132
SFA (% total energy)	10.0 (8.3–12.1)	9.6 (7.3–11.2)	0.158	9.9 (8.2–11.5)	9.8 (7.7–11.2)	0.567
Cholesterol intake (mg/1000 kcal)	159.6 (119.6–232.0)	123.2 (91.4–179.6)	0.004	147.0 (111.0–202.2)	142.3 (92.9–227.1)	0.613
Fiber intake (g/1000 kcal)	10.9 (8.5–13.6)	11.1 (9.6–14.4)	0.159	11.1 (9.0–13.3)	10.6 (9.0–14.5)	0.779

Abbreviations: HGS, handgrip strength; 8-f TUG, 8-foot time up-and-go. Values are expressed as median (interquartile range, IQR). Significant differences in nutrient medians between low and normal HGS and 8-f TUG score were tested by Mann-Whitney *U* test.

4. Discussion

The main findings of this study were that maximum HGS was lower among older participants, non-overweight women, inactive men, and men with abdominal obesity. Moreover, 24.5% of the participants had low maximum HGS and this risk increased in women, adults older than 65 and 67 for men and women, respectively, and decreased in overweight and overfat older adults. The maximum 8-f TUG score was higher among older participants, those with lower education, lower income, and inactive participants, those with abdominal obesity and overfat, and women with a BMI $\geq$27 kg/m^2. Additionally, 36.8% of participants had high 8-f TUG score and this risk increased in women, and overweight, overfat, and abdominal obese participants; and decreased in highly educated participants, those with an income of €900 or more per month, and slightly active and active participants. Presarcopenia, sarcopenia, and severe sarcopenia prevalence was 2.6%, 0.3%, and 0.5% among the studied population, respectively. However, 4.5% of men and 19.1% of women registered low physical condition (assessed by high scores in 8-f TUG and low scores in HGS tests) but not low ASMI.

HGS for men was higher in this study than in a sample of Japanese men (n = 742) aged 70 $\pm$ 9 years (33.4 kg, SD: 7.5) from the Nomura study, but it was similar for women (n = 937) aged 70 $\pm$ 8 years (21.3 kg, SD: 4.1) [33]. In a cross-sectional analysis of the baseline data from a cohort study conducted in 2012 that included 1971 functionally-independent, community-dwelling Japanese adults aged 65 years or older (977 men, 994 women), HGS means were 34.8 kg (SD: 6.0) for men and 22.4 kg (SD: 3.9) for women [34]. The Hertfordshire Cohort reported different values of HGS among men (44.3 kg) and women (26.7 kg) older adults [35]. Patiño et al. [8] reported dissimilar HGS and 8-f TUG in community-dwelling persons over 60 years old from a northern Spanish city. These differences between studies are possibly due to difference in muscle strength among different populations [36] and to differences in healthy aging among different populations [37], reflected in the minor but existent differences in HGS.

The prevalence of low HGS (24.5%) and high 8-f TUG (36.8%) scores in this study was lower than reported in a northern Spanish city (13.2% and 13.6%, respectively). Compared to the Patiño et al. findings [8], in which participants with a low HGS had higher body fat (%) than participants with normal HGS, our study revealed a lower prevalence of low maximum HGS among those with a BMI $\geq$27 kg/m^2 and those who showed abdominal obesity and overfat. However, similar to the Patiño et al. findings, in which participants with a high 8-f TUG score had higher body fat (%) than participants with normal test results, our study also revealed that overfat and abdominal obese participants had a higher prevalence of a higher maximum 8-f TUG score. This might be due to the fact that fat affects mobility and balance in older people [38]. A systematic review [39] concluded that although muscle and fat mass are considered important factors of age-related decline in physical function, studies examining the association between fat and muscle mass and functionality have produced inconsistent results.

The frequency of sarcopenia (0.3%) in this study was lower than in a northern Spanish city (2.4%), and unlike this northern Spanish city, women were more prone to being affected (19.1% of women registered low physical condition) [2]. This is reflected positively in the population studied, as the low frequency of sarcopenia implies a decreased risk of adverse health outcomes, including falls, loss of independence, and disability. As such, this decreases the socioeconomic burden in the studied population [40].

To the best of our knowledge, data on the association between sociodemographic characteristics and lifestyle habits, and physical condition in older adults are scarce. Physical activity has a major effect on physical condition [41]. Physical activity behavior is affected by two major components of socioeconomic status (SES): educational level and income. Educational level plays a primary role in the level of physical activity; an age-related decline in physical activity was observed among low-education individuals [42]. Lower education was associated with sarcopenia in the Korean National Health and Nutrition Examination Survey KNHANES [43] and in Invecchiare in Chianti (Aging in the Chianti area Study; InCHIANTI) [44]. Our results showed higher prevalence of high 8-f TUG among participants with lower education. Income plays a major role in determining he physical activity; individuals with higher income were more engaged in physical activity according to several studies [45,46]. Income was reported to be lower among those with sarcopenia [43]. In our study, prevalence of low HGS and high 8-f TUG scores was higher among those with a lower income, despite the lack of significance when OR was sex- and age-adjusted in HGS analysis. Our findings showed that inactive participants had higher 8-f TUG scores than active or slightly active participants. Notably, 8-f TUG assesses the agility and dynamic balance in older people, which is important in tasks that require quick accomplishment, such as alighting from a bus in time [14] that are easier to perform by active people. Finally, being single was also associated with higher prevalence of low HGS (despite the lack of significance when OR was sex- and age-adjusted), which agrees with studies that associated single relationship status with sarcopenia [47,48].

An adequate nutritional intake is an important element of any strategy to preserve muscle mass and strength during aging. Muscle wasting is a multifactorial process. A loss of fast twitch fibers, insulin resistance, glycation of proteins, and lipid deposition in muscle cells play important roles in the loss of muscle strength and development of sarcopenia [49,50]. Protein intake is crucial for muscle health and an intake of 1.0–1.2 g/kg of body weight per day is optimal for older adults [50]. High-fat diets may compromise aged muscle, diminishing overall muscle quality and composition [49]. Along this line, the findings of Charlton et al. [51] provide support regarding the importance of physical activity and adequate dietary protein intake for optimal body composition and the maintenance of strength and physical function. Sarti et al. [52] provided evidence that physical performance declines with advancing age, even in healthy women, and this decline in physical activity could lead to a lower intake of calories, carbohydrates, fats, and proteins. People, as they age, eat less and make different food choices. Lower food intake among the elderly has been associated with lower intakes of calcium, iron, zinc, B vitamins, and vitamin E [53]; this also negatively affects health.

Strengths and Limitations

The main strength of this study is due to its strict protocol through validated measurement tools and the objective measurement of physical condition. The assessment method for sarcopenia according to the EWGSOP can be used in clinical practice and as a screening method in public health [54,55], which supports the reliability and accuracy of our results. Height and weight are frequently used to determine BMI and nutritional status in epidemiological research on older adults; however, BMI is an imperfect measure of overweight and obesity. Overfat and abdominal obesity (measured by WHtR that may be the single best clinical indicator of health risk) were also assessed in the present study [56].

However, this study has some limitations. Firstly, the present cross-sectional design limits the ability to elucidate a causal relationship between HGS and 8-f TUG scores and nutrient intake, body composition, sociodemographic characteristics, and lifestyle habits. Secondly, physical activity was not measured objectively, such as using an accelerometer, and sedentary leisure time activities as well as sleep habits were not measured either. Thirdly, height was measured using a stadiometer, which is the established gold standard, but this assessment may not be feasible for studies conducted in elderly populations with mobility limitations [57]. Fourthly, the macronutrient intake was estimated using recall diets instead of food frequency questionnaires that have been questioned in epidemiological studies [58,59]. Two 24-h recall diets tend to underestimate the food intake over a large period compared to food frequency questionnaires, and demonstrate a considerable day-to-day variation in macronutrient intake. Fifth, underreporting was calculated using energy intake/basal metabolic rate and medications types (e.g., antidepressants, influence weight, etc.) that might influence basal metabolic rate, and lifestyle factors and physical activity were not considered in the present study. Finally, the results potentially lack generalizability due to the selecting participants from only two sites as well as the sample size obtained.

5. Conclusions

Overall, 36.8%, 24.5%, and 0.3% of participants had high maximum 8-f TUG score, low maximum HGS, and sarcopenia, respectively. Additionally, 4.5% of men and 19.1% of women registered low physical condition assessed by high and low scores in 8-f TUG and HGS tests, respectively. Prevalence of low maximum HGS differed according to sex, age, weight, and fat status; and high maximum 8-f TUG differed according to sex, educational level, income, presence of extra weight, fat, and abdominal obesity, and LTPA practice. Strategies for early identification of decline in physical condition and appropriate interventions should be adopted to avoid physical impairments.

Author Contributions: M.d.M.B., M.G.-G., and J.A.T. designed the study and wrote the protocol. R.A.-U., C.B., R.P.-C., A.S., J.K., and M.d.M.B. collected data, conducted literature searches, and provided summaries of previous research studies. J.K. and M.d.M.B. conducted the statistical analysis. J.K., M.d.M.B., and J.A.T. wrote the first draft of the manuscript. All authors read and approved the final manuscript.

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Availability of Data and Materials: The data analyzed in this paper can be made available to researchers. Requests for access to the dataset used in this paper should be directed to the corresponding author.

Abbreviations

ASMI	appendicular skeletal muscle index
BMI	Body mass index
CI	Confidence interval
EWGSOP	European Working Group on Sarcopenia in Older People
8-f TUG	8-foot time up-and-go test; HGS: handgrip strength test
ISAK	International Society for the Advancement of Kinanthropometry
LTPA	Leisure-time physical activity
OR	Odds ratio
SPSS	Statistical Package for the Social Sciences
WHO	World Health Organization

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Manuscript IV

Association between cardiovascular risk predictors and physical fitness measurements in older adults living in a Mediterranean region.

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(Submitted)

-Manuscript IV-

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ABSTRACT

Objectives: This study examined the correlation between age, body composition and biomarker variables on one hand and the physical fitness variables on the other hand in older adults in a Mediterranean region.

Methods: The study was conducted in 211 participants dwelling women (*n*= 112) and men (*n*= 99). Trained staff measured body composition (BMI, FMI, WHtR), biomarkers (TG, TChol, HDL- chol, LDL-chol, Non-HDL-chol) and physical fitness measurements (HGS, arm curl, 30-s chair stand, BS, Chair sit-&-reach, 8-f TUG, 30-m walking speed, 6-min walking).

Results: In men, age was negatively correlated with handgrip strength, 30-s chair stand, chair sit-&-reach, 6-min walking and positively correlated with 8-f TUG and 30-m walking speed. Body composition variables were negatively correlated with 6-min walking and positively correlated with 8-f TUG and 30-m walking speed. WHtR was negatively associated with handgrip strength and chair sit-&-reach, FMI was negatively associated with handgrip strength. TG and TG/HDL-chol ratio were negatively correlated with 30-s chair stand; LDL-chol was negatively correlated with 30-m walking speed and positively associated with 6-min walking; TG/HDL-chol ratio was negatively correlated with 6-min walking. A negative association was found between handgrip strength and TChol, LDL-chol and non-HDL-chol after adjusting for age + age^2 and the additional body composition covariates. In women, age was negatively correlated with handgrip strength and positively correlated with 8-f TUG. Body composition variables were positively correlated with 8-f TUG and 30-m walking (except for WHtR), and negatively correlated with 6-min walking (except for BMI). After adjusting for age + age^2 and the additional body composition covariates, 6-min walking was positively associated with TG, TChol (as well before adjusting), non-HDL-chol and TG/HDL-chol ratio.

Conclusions:Many physical fitness measurement variables correlated negatively with predictors of cardiovascular disease (biochemical and body composition parameters). Physical fitness might be essential in healthy aging.

Keywords: older adults, body composition, biomarkers, physical fitness, Mediterranean.

Introduction

Many factors are included in the process of aging of which are genetics, lifestyle factors and chronic diseases [1]. In 2050, almost 30% of the European population will be over 65 years [2], and in Spain, it is estimated that 37% of the population will be over 64 years in 2052 [3]. The fastest growing segment of the society will be people aged 85 years and older [1]. Hence, it is imperative to find healthy aging approaches to decrease the burden on the society. Studies are being conducted to determine the effects of exercise and physical activity on health, functional capacity and the quality of life [1].

Major causes of morbidity in older adults need to be identified to adopt strategies in order to develop more effective chronic disease prevention [4]. The assessment of the protective factors should not be based uniquely on disease outcome but also should include biomarkers and body composition variables.

One of the most powerful contributor in the prediction of cardiovascular disease are serum lipid values [5]. Total glycerides (TG), total cholesterol (TChol), high-density lipoprotein cholesterol (HDL-chol), low-density lipoprotein cholesterol (LDL-chol), non HDL cholesterol (Non-HDL-chol) are important biomarkers. Body composition variables are also an important predictor in cardiovascular disease. Obesity is traditionally defined based on body mass index (BMI) and it was identified as a major risk factor for heart disease [6]. Waist circumference-to-height ratio (WHtR) have also been associated with cardiovascular disease [7-8], in addition, fat mass index was shown to be better in the screening for the presence of metabolic syndrome, a cluster of risk factor for cardiovascular disease, than BMI and percentage of body fat in both men and women [9].

Studies suggest that only 20% of older adults are active enough to gain health benefits [10]. Physical fitness can be assessed by several tests including handgrip strength, arm curl, 30-s chair stand, back scratch, chair sit--&-reach, 8-f TUG, 30-m walking speed and 6-min walking.

The aim of this study is to evaluate the correlation between body composition and biochemical parameters on one hand and the physical fitness variables on the other hand in older adults in a Mediterranean region.

Methods

Study design, population and ethics

The sample consisted of 211 participants engaged in a study in the University of Balearic Islands. The study investigated the effect of lifestyle factors on the health of older adults living in Mallorca. It was conducted between the years of 2013 and 2014. Men aged between 55 and 80 and women aged between 60 and 80 were recruited in the study. Exclusion criteria included being institutionalized, suffering from a physical or mental illness which would have limited their participation in the physical fitness tests or their ability to respond to questionnaires, chronic alcoholism or drug addiction and intake of drugs for clinical research over the past year. The study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures were approved by the Balearic Islands Ethics Committee (approval reference number nº IB/2251/14 PI). Participants provided written consents.

Socioeconomic and lifestyle determinants

A specific questionnaire developed by the EXERNET network [11] including the following questions was used: age, marital status, educational level, income, and smoking habits. The respondents were grouped in binary categories as follow: (a) marital status: single (single, unmarried, divorced or widowed), and in a relationship (i.e. including married and unmarried, divorced or widowed living actually with a partner); (b) educational level: illiterate or primary, and secondary or college-level education; (c) participants' income: <900 €/month, and ≥900 €/month; and (d) smoking habits: smoker (≥1 cigarette/day) and non-smoker.

Anthropometric measurement

Anthropometric measurements were performed by well-trained observers in order to minimise the inter-observer coefficients of variation. Height was determined using a mobile anthropometer (Seca 213, SECA Deutschland, Hamburg, Germany) with the subject's head on the Frankfurt plane. Body weight and body fat were determined using a Segmental Body Composition Analyzer (Tanita BC-418, Tanita, Tokyo, Japan). The subjects were weighed barefoot and 0.6 Kg were subtracted from the weight obtained to account for their clothes. Waist circumference (WC) was measured as the smallest horizontal girth between the costal margins and the iliac crests at minimal respiration using a flexible, non-extensible plastic tape with 0.1 cm precision (Kawe 43972, Kirchner & Wilhelm GmbH + Co. KG, Asperg, Germany). Weight and height measures were used to calculate body mass index (BMI, Kg/m^2), height and fat mass measures were used to calculate fat mass index (FMI, Kg/m^2) and waist circumference and height were used to calculate waist to height ratio (WHtR).

Biochemical measurements

Venous blood samples were obtained from the antecubital vein in suitable vacutainers at 08:00 AM during the interview after having fasted for 12h. The samples of coagulated blood were centrifuged (10 min at 3000 rpm) immediately after their arrival to the laboratory. Tryglicerides (TG), total cholesterol (TChol), high-density lipoprotein cholesterol (HDL-chol), low-density lipoprotein cholesterol (LDL-chol), non HDL cholesterol (Non-HDL-chol) were determined by colorimetric methods using the DAX-72 autoanalyser (Technicon, Bayer Diagnostics, New York, NY, USA) [12,13].

Physical characteristics

Physical condition assessment included the following tests:

Handgrip strength test (HGS): Grip muscular strength was measured using a digital handheld dynamometer (TKK 5401 Grip-D; Takey, Tokyo, Japan). Participants were instructed to stand up-right with the dynamometer beside, but not against their body.

Measurements were performed two times for each hand. The best of all attempts was used to perform the analysis [14].

Arm curl test (AC): used to define the upper body strength. After the signal, participants were instructed to flex and stand the holding hand weight (men: 4 kg; women: 2.5 kg) through the complete range of motion, as many times as possible in 30 seconds. Measurements were performed one time in their dominant arm [15].

30-s chair stand test: used to assess lower body strength. This test consists of standing up and sitting down from a chair as many times as possible within 30 seconds. The test starts with participants sitting on the chair with their back in an upright position and looking forward, after the signal, they start rising with their arms folded across their chest [15].

Back scratch test (BS): used to assess general shoulder range of motion. Test was completed for both the right and left sides where one hand reached over the shoulder with the other up the middle of the back. Distance (cm) between extended middle fingers was assessed and the average of right and left sides was taken as an overall measure [16].

Chair sit and reach test: used to test lower body flexibility. Test was completed from a sitting position at the front of a chair with one leg extended and hands reaching towards toes with the distance (cm) between extended fingers and tip of toe being assessed. The average of right and left sides was taken as an overall measure of flexibility [16].

8-f TUG test: used to assess agility/ dynamic balance. Participants were instructed to rise from a chair without the use of arms, walk around the cone placed 2.45 m from the chair, and return to the original sitting position. Further instructions were to complete the test as quickly as possible but without running.Measurements were performed two times and the best of all attempts was used to perform the analysis [15].

30-m walking speed: walking speed was performed over 30 m at the participants' usual place. Participants were instructed to complete the test as quickly as possible, while taking care not to run. Measurements were performed two times and the best of all attempts was used for performance analysis [17].

6-min walking: Aerobic ability was measured as the total distances that participants were able to walk in 6-min. Participants were instructed to walk as far as possible for 6 min [15].

Statistical analysis

Statistics were performed using statistical software SPSS for Windows version 21 (IBM, Chicago, USA). Descriptive characteristics were assessed by calculating frequencies, median and interquartile range (IQR). All variables were checked for normality of distribution using the Kolmogorov-Smirnov test. The BMI, FMI, WHtR, chair sit-&-reach, 8-f TUG, and 30-m walking speed values showed normal distribution in both sexes. The differences between descriptive characteristics and sexes were performed using the Mann-Whitney U test and χ^2 test. After inspection of correlation results (Spearman correlations) among the main studied variables, the association of biochemical parameters with physical fitness were analysed by linear regression models. Thus, a series of linear regression models were consecutively tested: model I included the physical fitness variable as the dependent variable, the biochemical parameter as the independent variable, and age + age^2 was entered to account for possible linear and non-linear effects of age; for model II, BMI was entered into the model (age + age^2 + BMI); for model III, FMI was entered into the model instead of

BMI (age + age^2 + FMI); for model IV, WHtR was entered into the model instead of BMI (age + age^2 + WHtR). Separate models were used for each body composition variable to determine how each one influenced the association between biochemical parameters and physical fitness variables. The normality of distribution of each unstandardized residual was also checked using the Kolmogorov-Smirnov test. Values of $p<0.05$ were considered statistically significant.

Results

Basic descriptive information concerning sociodemographic and lifestyle factors, body composition, biochemical parameters, and physical fitness is shown in Table 1.

Table 2 shows the Spearman correlation coefficients among age, body composition, biochemical parameters and physical fitness variables. In men, age was negatively correlated with handgrip strength, 30-s chair stand, chair sit-&-reach and 6-min walking. It was positively correlated with 8-f TUG and 30-m walking speed. Body composition variables (BMI, FMI and WHtR) were negatively correlated with 6-min walking and positively correlated with 8-f TUG and 30-m walking speed. FMI and WHtR were also negatively associated with handgrip strength, and WHtR was also negatively associated with chair sit-&-reach. No statistical significant correlations were found between age, body composition, arm curl and back scratch. There were significant associations between TG, TG/HDL-chol ratio, and LDL-chol, and some physical fitness variables: TG and TG/HDL-chol ratio were negatively correlated with 30-s chair stand; LDL-chol was negatively correlated with 30-m walking speed and positively associated with 6-min walking; and TG/HDL-chol ratio was also negatively correlated with 6-min walking. In women, age was negatively correlated with handgrip strength and positively correlated with 8-f TUG. Body composition variables (BMI, FMI and WHtR) were positively correlated with 8-f TUG and 30-m walking (except for WHtR), and negatively correlated with 6-min walking (except for BMI). No statistical significant correlations were found between age, body composition, arm curl, 30-s chair stand, back scratch and chair sit-&-reach. TChol was the only biochemical parameter associated with a physical fitness variable in women, specifically it was positively correlated with 6-min walking test.

Results for the multiple linear regression models are presented in Table 3. In men, a significant negative association was found between handgrip strength (dependent variable) and TChol, LDL-chol and non-HDL-chol (independent variables) after adjusting for age + age^2 and the additional body composition covariates (BMI, FMI, and WHtR). A significant negative association was found between 30-s chair stand and TG after adjusting for age + age^2 and the additional body composition covariates (BMI: β= –0.299, SE=0.136, p=0.032; FMI: β= –0.270, SE=0.136, p=0.052; WHtR: β= –0.284, SE=0.136, p=0.040). In women, 6-min walking was positively associated with TG, TChol, non-HDL-chol and TG/HDL-chol ratio after adjusting for age + age^2 and the additional body composition covariates (BMI, FMI, and WHtR) (significant association). Walking speed was also negatively associated with TG when WHtR was entered into the model (β = –0.194, SE = 0.090, p = 0.034). Additionally, 8-f TUG was negatively associated with TG/HDL-chol ratio when WHtR was entered into the model (β= –3.297, SE=1.632, p=0.047).

Discussion

Older men are shown to have weaker grip muscular strength, lower body strength, lower body flexibility and aerobic ability but stronger agility/dynamic balance and are faster. In men, the higher the BMI, FMI and WHtR are the lower the aerobic ability is but the better the agility/dynamic balance is, higher values of the body composition variables (BMI, FMI, WHtR) were associated as well with a faster speed. The grip muscular strength is decreased when the fat increases (Higher FMI and WHtR), lower body flexibility decreases with higher WHtR. The lower body is weaker when the TG and TG/HDL- chol ratio are higher. The walking speed is slower but the aerobic ability is stronger when the LDL- chol is higher. Aerobic ability decreases with higher TG/HDL-chol ratio. After adjusting for age + age^2 and the additional body composition covariates, higher values of TChol, LDL-chol and non-HDL-chol were correlated with weaker grip muscular strength, higher TG value was associated with weaker lower body strength.

In women, the older age is correlated with weaker grip muscular strength and better agility/dynamic balance. Increased BMI and FMI are correlated with better agility/dynamic balance and walking speed, increased WHtR and FMI are correlated with decreased aerobic ability. A better aerobic ability is found in women with higher TChol. After adjusting for age + age^2 and the additional body composition covariates, higher values of TG, TChol, non-HDL-chol and TG/HDL-chol ratio were associated with better aerobic ability, higher TG values were associated with slower walking speed and higher TG/HDL-chol ratios were associated with weaker grip muscular strength.

Decreased physical activity was associated with improved cardiovascular risk factors for some variables, this might be due to confounders or the fact that specific physical activity measurements are not related to cardiovascular outcome as the agility/dynamic balance, walking speed and the aerobic ability.

Other physical activity measurements were associated with better cardiovascular risk predictor as in the case of grip muscular strength, lower body flexibility, lower body strength assessed by HGS, chair sit and reach test and 30-s chair stand test respectively. Many studies in the literature supported the findings; older people who have a low physical activity level had significantly higher cardiovascular risk factor as BMI, WC compared to those who have medium and high PA [18, 19], and higher HDL [19,20] and triglycerides in men [19]. Higher relative grip strength was significantly associated with lower systolic blood pressure, triglycerides and higher HDL ($p<0.05$) [21]. In older women, those who had low level of 6min walking test had a higher BMI and a greater amount of fat mass [22].

Increasing physical fitness hence lead to better cardiovascular disease predictors for specific physical fitness measurements, which leads to a better aging process and might be used in strategies implementation for the prevention of chronic diseases.

Physical fitness measurements might be added as well to the the Framingham risk score FRS to predict disease outcome as demonstrated for the HGS [23], however further studies need to be conducted to elect specific physical activity variables that are consistently correlated with cardiovascular risk factors.

Conclusions

Older men have decreased lower body strength and flexibility, weaker muscular grip and lower aerobic ability than younger ones. Lower aerobic ability, lower grip muscular strength and lower lower body flexibility is observed in higher body composition variables (BMI, FMI, WHtR; not all inclusive for all the physical fitness variables). The lower body is weaker when the TG and TG/HDL-chol ratio is higher and aerobic ability decreases with TG/HDL ratio, the walking speed is slower when LDL-chol value is higher. Weaker grip muscular strength and weaker lower body strength are observed after adjusting for age + age^2 and the additional body composition covariates when some biomarkers have higher values. In women, older age is correlated with weaker muscular grip strength; increased WHtR and FMI are correlated with decreased aerobic ability. After adjusting for age + age^2 and the additional body composition covariates higher TG values were associated with slower walking speed and higher TG/HDL-chol ratios were associated with weaker grip muscular strength. As shown, many physical fitness variables correlate negatively with indicators of cardiovascular disease (biochemical parameters and body composition). It implied that large scale screening for muscle strength and providing resistance training programs would greatly benefit overall cardiovascular health [23]. Strategies should be adopted to increase physical fitness in older adults to contribute in healthy aging and hence decrease the burden on the society.

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Declaration of Conflicting Interests

The authors declare that they have no conflict of interest.

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Table 1.Descriptive characteristics of the sample according to sociodemographic, lifestyle, body composition and physical fitness variables.

	Men (n=66)	Women (n=71)	*P*
Sociodemographic and lifestyle factors			
Age (years)	64.0 (8.0)	66.0 (6.0)	0.009
Coupled	55 (83.3)	48 (67.6)	0.026
Uncoupled	11 (16.7)	23 (32.4)	
Educational level			
Primary	25 (37.9)	39 (54.9)	0.042
Secondary or college	41 (62.1)	32 (45.1)	
Income			
<900 €	9 (13.6)	40 (56.3)	<0.001
≥900 €	57 (86.4)	31 (43.7)	
Smoking habit			
Non-smoker	61 (92.4)	66 (93.0)	0.581
Smoker	5 (7.6)	5 (7.0)	
Body composition			
BMI (kg/m^2)	27.7 (3.6)	25.9 (4.7)	0.004
FMI (kg/m^2	7.0 (2.5)	9.2 (3.3)	<0.001
WHtR	0.6 (0.1)	0.5 (0.1)	<0.001
Biochemical parameters			
TG (mg/dL)	97.0 (47.5)	80.0 (37.0)	0.003
TChol (mg/dL)	199.0 (31.8)	211.0 (39.0)	0.015
HDL-chol (mg/dL)	131.0 (36.3)	134.0 (33.0)	0.350
LDL-chol (mg/dL)	47.5 (12.3)	62.0 (14.0)	<0.001
Non-HDL-chol (mg/dL)	149.5 (32.3)	152.0 (40.0)	0.861
TG/HDL-chol ratio	2.0 (1.5)	1.3 (0.8)	<0.001
Physical fitness			
Handgrip strength (kg)	36.4 (11.3)	20.3 (5.9)	<0.001
Arm curl (reps)	19.0 (6.0)	17.0 (5.0)	0.001
30-s Chair stand (reps)	15.0 (4.3)	13.0 (5.0)	0.006
Back scratch (cm)	-6.0 (13.0)	1.0 (9.0)	0.001
Chair sit-&-reach (cm)	0.0 (12.1)	0.0 (12.0)	0.957
8-f TUG (s)	4.8 (1.0)	5.3 (1.0)	<0.001
30-m Walking Speed (s)	14.3 (3.3)	16.7 (3.7)	<0.001
6-min Walking (m)	623.3 (112.6)	533.6 (87.4)	<0.001

Abbreviations: BMI, body mass index; FMI, fat mass index; WHtR, waist-to-height ratio; TChol, total cholesterol; HDL-chol, high density lipoprotein cholesterol; LDL-chol, low density lipoprotein cholesterol; TUG, time up-and-go.

Variables were expressed as: *n* (%) or median (interquartile range, IQR). Differences between descriptive characteristics and sexes were performed by Mann-Whitney U test and χ^2 test.

Table 2. Bivariate correlations (Spearman correlation coefficients) among age, body composition, biomarkers and physical fitness variables

	Handgrip strength (kg)	Arm curl (reps)	30-s Chair stand (reps)	Back scratch (cm)	Chair sit-&-reach (cm)	8-f TUG (s)	30-m Walking Speed (s)	6-min Walking (m)
Men (*n* = 66)								
Age (years)	–0.370**	–0.233	–0.251*	–0.233	–0.248*	0.304*	0.246*	–0.377**
BMI (kg/m^2)	–0.099	0.041	–0.063	0.041	–0.177	0.294*	0.278*	–0.352**
FMI (kg/m^2)	–0.278*	–0.130	–0.192	–0.130	–0.188	0.319**	0.347**	–0.436***
WHtR	–0.310*	–0.109	–0.168	–0.109	–0.317**	0.412**	0.421***	–0.520***
TG (mg/dL)	0.059	–0.190	–0.298*	–0.190	–0.021	0.142	0.074	–0.141
TChol (mg/dL)	–0.087	–0.043	0.015	–0.043	–0.022	–0.118	–0.159	0.178
HDL-chol (mg/dL)	–0.167	–0.069	–0.032	–0.069	–0.065	–0.032	–0.064	0.091
LDL-chol (mg/dL)	0.003	–0.015	0.183	–0.015	0.108	–0.224	–0.246*	0.326**
Non-HDL-chol (mg/dL)	–0.163	–0.098	–0.112	–0.098	–0.078	0.027	–0.017	0.008
TG/HDL-chol ratio	–0.014	–0.180	–0.325**	–0.180	–0.060	0.225	0.183	–0.253*
Women (*n* = 71)								
Age (years)	–0.254*	–0.046	–0.195	–0.046	0.083	0.279*	0.153	–0.138
BMI (kg/m^2)	0.011	–0.005	–0.150	–0.005	–0.110	0.329**	0.275*	–0.302
FMI (kg/m^2)	0.015	–0.059	–0.234	–0.059	–0.102	0.390**	0.316**	–0.350**
WHtR	0.061	0.016	–0.221	0.016	–0.066	0.315**	0.205	–0.276*
TG (mg/dL)	0.211	–0.006	0.022	–0.006	0.035	–0.019	–0.111	0.167
TChol (mg/dL)	0.147	0.040	0.111	0.040	0.094	–0.033	–0.117	0.292*
HDL-chol (mg/dL)	0.084	0.000	0.056	0.000	0.090	0.013	–0.049	0.189
LDL-chol (mg/dL)	0.083	0.011	–0.024	0.011	0.091	–0.004	–0.095	0.112
Non-HDL-chol (mg/dL)	0.106	–0.009	0.059	–0.009	0.072	0.015	–0.062	0.197
TG/HDL-chol ratio	0.149	0.012	0.038	0.012	–0.002	–0.036	–0.037	0.082

Abbreviations: BMI, body mass index; FMI, fat mass index; WHtR, waist-to-height ratio; TG, triglycerides; TChol, total cholesterol; HDL-chol, high density lipoprotein cholesterol; LDL-chol, low density lipoprotein cholesterol; TUG, time up-and-go. *p< 0.05, **p< 0.01, ***p< 0.001.

Table 3. Linear regression coefficients showing the association between biochemical parameters with handgrip strength (kg) in men and 6-min walking (m) in women

	Men (n = 66)			Women (n = 71)		
	Handgrip strength (kg)			6-min Walking (m)		
	β	SE	p	β	SE	p
TG, per 10 mg/dL increase						
Age + Age^2	–0.018	0.239	0.942	6.253	2.524	0.016
Age + Age^2 + BMI	0.049	0.244	0.841	8.254	2.417	0.001
Age + Age^2 + FMI	0.128	0.238	0.593	7.951	2.359	0.001
Age + Age^2 + WHtR	0.103	0.237	0.665	9.229	2.480	<0.001
TChol, per 10 mg/dL increase						
Age + Age^2	–0.400	0.281	0.159	4.508	2.243	0.049
Age + Age^2 + BMI	–0.608	0.296	0.044	4.475	2.159	0.042
Age + Age^2 + FMI	–0.602	0.274	0.032	4.745	2.117	0.028
Age + Age^2 + WHtR	–0.656	0.279	0.022	4.470	2.179	0.044
HDL-chol, per 10 mg/dL increase						
Age + Age^2	0.493	0.721	0.497	5.215	6.232	0.406
Age + Age^2 + BMI	0.069	0.848	0.935	–0.184	6.487	0.977
Age + Age^2 + FMI	–0.357	0.792	0.654	0.421	6.205	0.946
Age + Age^2 + WHtR	–0.503	0.832	0.548	–1.041	6.838	0.879
LDL-chol, per 10 mg/dL increase						
Age + Age^2	–0.619	0.318	0.056	3.456	2.509	0.173
Age + Age^2 + BMI	–0.766	0.323	0.021	4.052	2.415	0.098
Age + Age^2 + FMI	–0.744	0.305	0.018	4.326	2.375	0.073
Age + Age^2 + WHtR	–0.767	0.307	0.015	4.092	2.439	0.098
Non-HDL-chol, per 10 mg/dL increase						
Age + Age^2	–0.514	0.289	0.080	4.044	2.332	0.087
Age + Age^2 + BMI	–0.592	0.290	0.046	4.872	2.241	0.033
Age + Age^2 + FMI	–0.564	0.278	0.047	5.097	2.201	0.024
Age + Age^2 + WHtR	–0.586	0.279	0.040	5.013	2.269	0.031
TG/HDL-chol, per 0.10 increase						
Age + Age^2	–0.410	0.844	0.628	19.264	11.710	0.105
Age + Age^2 + BMI	–0.058	0.905	0.949	33.193	11.601	0.006
Age + Age^2 + FMI	0.335	0.877	0.703	30.189	11.181	0.009
Age + Age^2 + WHtR	0.295	0.879	0.738	39.784	12.194	0.002

Abbreviations: BMI, body mass index; FMI, fat mass index; WHtR, waist-to-height ratio; TG, triglycerides; TChol, total cholesterol; HDL-chol, high density lipoprotein cholesterol; LDL-chol, low density lipoprotein cholesterol.

Manuscript V

Estimation of minerals intake in older adults in a Mediterranean region.

Joanne Karam, Maria del Mar Bibiloni, Josep A. Tur

(Submitted)

-Manuscript V-

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ABSTRACT

***Objectives*:** Investigate the dietary mineral intake in older adults according to socioeconomic and body composition variables and evaluate the number of participants consuming minerals in compliance with daily recommendations.

Methods: The study was conducted in 211 participants dwelling women (*n*= 112) and men (*n*= 99). Lipid and fatty acid intake were calculated from two non-consecutives 24-h recall diets using a Spanish food database.

Results:Calcium was the only mineral consumed in quantities lower than DRI, 2/3 DRI and 1/3 DRI, magnesium was consumed is quantities lower than DRI and 2/3 DRI, copper and iron were both consumed in quantities lower than DRI by both men and women. On average, 9 men and 29.7 women consumed more than 5 minerals in compliance with DRI, 31.3 of those whose income is lower than 900 euros and 12.5 of those whose income is ≥900 euros consumed more than 5 minerals in compliance with DRI. The female sex was associated positively with the number of minerals consumed in compliance with DRI even after adjusting for socioeconomic and body composition variables, an income ≥900euros was associated with a decreased outcome of intake of minerals in compliance with DRI.

***Conclusions**:* Overall calcium, copper, magnesium and iron were consumed in quantities lower than DRI. Female sex and an income ≥900euros were associated respectively with an increased and decreased probability of compliance with the DRI on a 5points scale. The intake of minerals should be adjusted to abide by the recommendations for a better health.

Keywords: Minerals, intake, elderly, DRI.

Introduction

The human body contains the most common mineral elements found on earth: sodium, potassium, calcium, magnesium, iodine, phosphorus, sulfur, iron, zinc and cobalt. Although minerals compose less than 1% of the weight of the protoplasm, they have an active role in the human body [1]. Protein, carbohydrates, fats and water alone cannot make the body function, the presence of minerals is essential in calibrating biochemical reactions and acting as electrolytes [1]. These micronutrients are present in every tissue including blood, skin, muscle, skeleton, cartilage, and nerve tissue [1]. Investigations about the importance of minerals in the body started back in the 1880s when Sydney Ringer proved the importance of calcium, potassium and sodium in the heart function [2]. Studies have shown as well that low Selenium concentrations are associated with an increased risk of cardiovascular disease [3], and dietary magnesium was proved to reduce mortality from cardiovascular disease [4]. More studies were conducted later and up to recent days studies are being published showing the relation between minerals and heart disease [5-6]. Knowing their importance in normal body functioning, dietary reference intake DRI were issued by the Institute of Medicine IOM, DRI of these trace elements is different for every mineral [7]. For adults, 900 µg/day of copper is recommended, 150 µg/day of iodine, 8mg/day of iron, 700 mg/day of phosphorus, 55 µg/day of selenium and 11 mg/day of zinc. The recommendations for magnesium and zinc depend on the sex. Men are recommended an intake of 420 mg/day of magnesium, and 11 mg/day of zinc; whereas women are recommended an intake of 320 mg/day and 7 mg/day of the above mentioned minerals respectively. Men aged above 70 and women are recommended to consume 1200mg/day of calcium, men younger than 70 are recommended to consume 1000mg/day [7].

Among elderlies, heart disease is the leading cause of death [8] and the presence of minerals is essential in heart function [2-3-4-5-6]. Hence, the aim of this study is to investigate the dietary mineral intake in older adults in a Mediterranean region, assess it according to DRI in the total sample and according to socioeconomic and body composition variables.

Subjects and Methods

Study population

The sample consisted of 211 participants engaged in a study conducted in 2013-2014 in the University of Balearic Islands investigating the effect of the lifestyle factors on the health of elderlies living in Mallorca. Men aged between 55 and 80 and women aged between 60 and 80 were recruited in the study. Exclusion criteria included being institutionalized, suffering from a physical or mental illness which would have limited their participation in physical fitness activities or their ability to respond to questionnaires, chronic alcoholism or drug addiction and intake of drugs for clinical research over the past year. Recruited people provided a written consent. Sociodemographic and lifestyle characteristics were collected from each participant. The respondents were grouped in binary categories as follow: (a) age: <65 (men) and <67 (women) years old, and ≥65 (men) and ≥67 (women) years old; (b) marital status: single (single, unmarried, divorced or widowed), and in a relationship (i.e. including married and unmarried, divorced or widowed living actually with a partner); (c) educational level: primary or secondary, and university graduate; (d) participants' income: <900 €/month, and ≥900 €/month; and (e) smoking habits: smoker (≥1 cigarette/day) and non-smoker. Individuals were ranked as well according to their level of physical activity (active, intermediately active, inactive) depending on weekly hours of physical activity.

Anthropometric measurements

Anthropometric measurements were performed by well-trained dieticians who underwent identical and rigorous training as an effort to minimize the effects of inter-observer variation. Height was measured using an anthropometer (Kawe 44444, Asperg, Germany) to the nearest millimeter. Body weight was determined to the nearest 100g using a digital scale (Tefal, sc9210, Rumilly, France). The participants were weighed barefoot, noting and subtracting the weight of the clothes. Weight and height measures were used to calculate body mass index (BMI, kg/m^2). According to the anthropometric reference parameters for the Spanish elderly [9-10]. Participants were classified as obese or not, obesity was defined as BMI ≥30.0 kg/m^2 for those older than 65 and BMI ≥29.0 kg/m^2 for younger participants. Waist circumference (WC) was measured as the smallest horizontal girth between the costal margins and the iliac crests at minimal respiration using a flexible, non-extensible plastic tape with 0.1 cm precision (Kawe 43972, Kirchner & Wilhelm GmbH + Co. KG, Asperg, Germany). WC and height measures were used to calculate waist-to-height ratio (WHtR). Abdominal-obesity was defined as a WHtR≥0.5 [11]. Body fat was determined using a Segmental Body Composition Analyzer (Tanita BC-418, Tanita, Tokyo, Japan) and participants were classified according to their percentage of fat as overfat or not.

Mineral Content Assessment

Dietary intake was assessed by using two non-consecutive 24 h recalls. Well-trained dietitians collected the recalls while verifying and quantifying the food records. The recall diets yielded 449 food items. Minerals content of the food were evaluated using the DIAL database. Energy intakes ranged between 1082-3428 kcal/d for men and 870-2701 kcal/d for women.

Statistical Analysis

Analyses were performed with the SPSS statistical software package version 24.0 (SPSS Inc., Chicago, IL, USA). Minerals intake (expressed as mg/d or µg/d) and energy adjusted minerals intake (expressed as intake/1000Kcal) were calculated for men and women as median (interquartile range, IQR) and assessed as percentage of DRI levels. Number of participants who consume more than 5 minerals in quantities abiding to DRI was assessed according to the socioeconomic and body composition variables; crude odds ratio (OR) and the 95% confidence interval (95% CI) was measured to indicate the strength of association between the variables. Results were also adjusted for the socioeconomic and body composition variables. Results were considered statistically significant if $p<0.05$.

Results

Intake of minerals (Table 2)

The intake of minerals in older adults living in Mallorca is illustrated in Table 2. Among men, the intake of iodine is 45% lower than the recommendations and the intake of phosphorus is 82.8% higher than the recommendations. Among women, the intake of iodine is 52.2% lower than the recommendations and the intake of phosphorus is 52.8%

higher than the recommendations. When adjusting for the energy intake, the intake of iodine (42.3 µg/d/1000kcal by men and 48 µg/d/1000kcal by women) becomes farther from the recommendations but the one of phosphorus (642.1mg/d/1000kcal by men and 706.5mg/d/1000kcal by women) becomes closer to the recommended quantities by the IOM.

87%, 5% and 2% of men participants consume calcium, copper and iron respectively in quantities lower than the DRI. 37% of them consume calcium in quantities lower than 2/3 DRI and 23% consume magnesium as such. Only 1% of men consume calcium in quantities lower than 1/3 of DRI. Among women, calcium, copper and iron are consumed in quantities lower than DRI by respectively 95.5%, 24.3% and 12.6% of women participants. 62.2% and 7.2% consume calcium and magnesium respectively in quantities lower than 2/3 DRI and only 8.1% of women consume calcium in quantities lower than 1/3 DRI. Results are statistically significant for the above mentioned values.

Intake of minerals according to socioeconomic and body composition variables (Table 3)

Among the 211 participants, the intake of different minerals in compliance with DRI was ranked on a 5points scale. 169 participants consumed less than 5 minerals in quantities that comply with DRI and 42 of them consumed 5 or more minerals in quantities that comply with DRI. A mean of 9 men and 29.7 women consumed more than 5 minerals in quantities than comply with DRI, the association was shown to be positive and significant even after adjusting for the socioeconomic and body composition variables for women only. A mean of 31.3 of participants whose income is lower than 900 euros and 12.5 of those whose income is ≥900euros consume more than 5 minerals in quantities as recommended. The odds ratio is lower than 1 when the income is ≥ 900euros, hence an income ≥900euros is associated with lower odds of an intake of more than 5 minerals in compliance with DRI.

Discussion

The daily consumption of Calcium expressed as median (748.6 mg/d) is lower than the recommendations set by IOM [7] and the intake in Netherlands (944mg/d) [12] for both men and women. 1% of men and 8.1% of women consume this mineral in quantities lower than 1/3 RDA, this might be alarming knowing that inadequate intake of calcium might be a factor in the development of hypertension [13].

The intake of copper is higher than the IOM recommendations by both men and women, however it is very similar to the intake in Ireland; intake of copper in Ireland is 1.5mg/d and 1.2mg/d by men and women respectively [14]. Despite the fact that the median intake is higher than the recommendations, 5% of men participants and 24.3% of women participants have an intake lower than DRI.

The median intake of iodine is lower by 45% in men 52.2 % in women than the IOM recommendations, the intake of Selenium is higher than those recommendations (77.8% by men and 29.5% by women) [7].

The intake of iron (13.5mg/d M 11.9mg/d F) is higher than the recommendations (8mg/d) but similar to the intake in Germany, and similarly to the indicated study men (14-19mg/d) consume more iron than women (12-14mg/d) [15]. This high intake might be reflected negatively on cardiovascular health for studies have shown that an increased intake of heme iron is associated with an increased risk in myocardial infarction in men [16]. However, 2% of men and 12.6% of women consume iron in quantities lower than DRI.

The intake of magnesium by men (360mg/d) is lower than the recommendations (420mg/d) but similar to the intake in Germany (353mg/d), women consume in quantities slightly lower than recommendations but higher than the consumption in Germany (288mg/d) [17]. 23% of men and 7.2% of women consume magnesium is quantities lower than 2/3 DRI affecting negatively the health prognosis due to the importance of this mineral in preventing mortality from heart disease [4].

Phosphorus consumption is 52.8% and 82.8% higher than recommendation for women and men respectively but lower than the intake in Netherlands for both sexes (1480mg/d) [18]. Dietary Phosphorus was shown to be a significant determinant of blood pressure in adults without a cardiovascular disease history [19].

The intake of zinc is 21.8% and 13.8% lower than recommendations by men and women respectively; it is lower than the intake in the UK for both sexes as well. Mean intake of zinc in UK is 11.4mg/d and 8.4mg/d respectively for men and women [20].

Calculations were made to assess the number of participants consuming different minerals in compliance with DRI. 9 out of 99 men and on average 29.7 women out of 112 consumed more than 5 minerals in compliance with DRI. Being a woman was associated with an increased probability of eating more than 5 minerals in compliance with DRI. On average, 31.3 of the 42 people who consume more than 5 minerals in compliance with DRI have an income lower than 900euros; the remaining ones have an income higher than 900 euros. Earning an income higher than 900 euros was associated with decreased odds of consuming minerals in compliance with DRI. Other studies have shown that participants with higher education, from higher social class and those who are physically active have a nutrient dense diet [21], however the results calculated are only significant for sex and income in this study.

Conclusion

Calcium is the only mineral consumed in quantities lower than DRI, 2/3 DRI and 1/3 DRI, magnesium is consumed is quantities lower than DRI and 2/3 DRI, copper and iron are both consumed in quantities lower than DRI by both men and women. 9 men and 29.7 women consume more than 5 minerals in compliance with DRI, 31.3 of those whose income is lower than 900 euros and 12.5 of those whose income is ≥900 euros consume more than 5 minerals in compliance with DRI. The minerals are very important in the health of individuals specifically in the cardiovascular health; awareness should me more spread specially in older people to adjust their intake of specific minerals, by reducing or increasing their intake of food to abide by the recommendations for a better health.

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Declaration of Conflicting Interests

The authors declare that they have no conflict of interes

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Table 1. Socioeconomic and body composition characteristics of the sample (*n* =211) expressed as percentages.

	All	Men	Women	*p*
Age group (men/women)				
<65/67	53.6	53.0	54.1	0.878
≥65/67	46.4	47.0	45.9	
Marital status				
single	74.9	86.0	64.9	<0.001
In a relationship	25.1	14.0	35.1	
Educational level				
Primary or secondary	80.6	74.0	86.5	0.022
University	19.4	26.0	13.5	
Income				
<900 €	39.3	17.0	59.5	<0.001
≥900 €	60.7	83.0	40.5	
Obesity				
No	79.1	77.0	81.1	0.466
Yes	20.9	23.0	18.9	
Overfat				
No	35.5	26.0	44.1	0.006
Yes	64.5	74.0	55.9	
Abdominal obesity				
No	23.2	14.0	31.5	0.003
Yes	76.8	86.0	68.5	
Smoking habit				
Not a smoker	91.9	91.0	92.8	0.633
Current smoker	8.1	9.0	7.2	
Physical activity				
Inactive	49.3	48.0	50.5	0.935
Intermediate	25.1	26.0	24.3	
Active	25.6	26.0	25.2	

Table 2. Assessment of the minerals intake in a sample of older adults in a Mediterranean region (*n* =211)

	Median (IQR)				% of sample		
	Intake	Intake/1000 kcal	% DRI	DRI	< DRI	<2/3 DRI	<1/3 DRI
Men (*n*=100)							
Calcium (mg/d)	748.6 (285.9)	369.6 (132.3)	74.1 (29.9)	≤70 y: 1000 >70 y: 1200	87.0*	37.0***	1.0*
Copper (µg/d)	1445.4 (571.6)	739.7 (257.2)	160.0 (63.5)	900	5.0***	0.0	0.0
Iodine (µg/d)	82.6 (45.1)	42.3 (21.6)	55.0 (30.0)	150	89.0	68.0	13.0
Iron (mg/d)	13.5 (7.3)	7.2 (2.8)	168.6 (91.3)	8	2.0**	0.0	0.0
Magnesium (mg/d)	360.0 (142.2)	178.0 (63.8)	85.7 (33.9)	420	71.0	23.0**	0.0
Phosphorus (mg/d)	1279.6 (376.8)	642.1 (153.5)	182.8 (53.8)	700	1.0	0.0	0.0
Selenium (µg/d)	97.8 (55.7)	49.5 (24.7)	177.8 (101.2)	55	6.0	0.0	0.0
Zinc (mg/d)	8.7 (3.0)	4.3 (1.3)	79.2 (27.0)	11	83.0	24.0	0.0
Women (*n*=111)							
Calcium (mg/d)	692.9 (342.6)	439.5 (245.1)	57.7 (28.5)	1200	95.5*	62.2***	8.1*
Copper (µg/d)	1095.3 (510.0)	725.9 (240.8)	121.7 (56.7)	900	24.3***	2.7	0.0
Iodine (µg/d)	71.6 (38.6)	48.0 (23.7)	47.8 (26.4)	150	95.5	79.3	18.9
Iron (mg/d)	11.9 (5.4)	7.6 (2.6)	148.7 (67.5)	8	12.6**	0.0	0.0
Magnesium (mg/d)	305.6 (87.0)	194.7 (76.0)	95.5 (27.2)	320	61.3	7.2**	0.0
Phosphorus (mg/d)	1069.5 (314.7)	706.5 (185.1)	152.8 (45.0)	700	3.6	0.9	0.0
Selenium (µg/d)	71.2 (29.9)	46.6 (22.5)	129.5 (54.3)	55	19.8	0.9	0.0
Zinc (mg/d)	6.9 (2.4)	4.6 (1.3)	86.2 (29.9)	8	73.0	17.1	0.0

*p < 0.05, **p < 0.01, ***p < 0.001.

Table 3. Compliance of the participants to the recommendations depending on socioeconomic and body composition variables (≥5 points *vs.*<5 points)

	<5 points (*n*=169)	≥5 points (*n*=42)	*P*	Crude OR (95% CI)	Adjusted OR (95% CI)
Sex					
Men	91.0	9.0	<0.001	1.00 (ref.)	1.00 (ref.)
Women	70.3	29.7		4.28 (1.93-9.49)***	4.08 (1.52-11.00)**
Age group (men/women)					
<65/67	78.8	21.2	0.602	1.00 (ref.)	1.00 (ref.)
≥65/67	81.6	18.4		0.83 (0.42-1.65)	0.70 (0.32-1.50)
Marital status					
Single	80.4	19.6	0.858	1.00 (ref.)	1.00 (ref.)
In a relationship	79.2	20.8		1.07 (0.50-2.32)	0.94 (0.38-2.37)
Educational level					
Primary or secondary	79.4	20.6	0.613	1.00 (ref.)	1.00 (ref.)
University	82.9	17.1		0.79 (0.33-1.94)	1.32 (0.49-3.59)
Income					
<900 €	68.7	31.3	0.001	1.00 (ref.)	1.00 (ref.)
≥900 €	87.5	12.5		0.31 (0.16-0.63)**	0.59 (0.24-1.43)
Obesity					
No	82.0	18.0	0.169	1.00 (ref.)	1.00 (ref.)
Yes	72.7	27.3		1.71 (0.79-3.71)	1.23 (0.46-3.30)
Overfat					
No	80.0	20.0	0.980	1.00 (ref.)	1.00 (ref.)
Yes	80.1	19.9		0.99 (0.49-2.01)	0.68 (0.27-1.71)
Abdominal obesity					
No	87.8	12.2	0.125	1.00 (ref.)	1.00 (ref.)
Yes	77.8	22.2		2.05 (0.81-5.20)	3.01 (0.99-9.13)
Smoking habit					
Not a smoker	79.4	20.6	0.534	1.00 (ref.)	1.00 (ref.)
Current smoker	88.2	11.8		0.51 (0.11-2.34)	0.41 (0.08-2.07)
Physical activity					
Inactive	74.0	26.0	0.071	1.00 (ref.)	1.00 (ref.)
Intermediate	83.0	17.0		0.58 (0.25-1.35)	0.60 (0.24-1.52)
Active	88.9	11.1		0.36 (0.14-0.93)*	0.36 (0.13-1.05)

*p < 0.05, **p < 0.01, ***p < 0.001.

Manuscript VI

Adherence to Mediterranean diet in a Lebanese University population: case of University of Balamand.

Joanne Karam, Mireille Serhan, Josep A. Tur

(Submitted)

Adherence to Mediterranean diet in a Lebanese University population: case of University of Balamand.

Joanne Karam, Mireille Serhan, Josep A. Tur

ABSTRACT

Objective: Assessment of the adherence to Mediterranean diet among University students in Lebanon.

Methods: 525 students from three different campuses and majors of the University of Balamand in Lebanon filled a questionnaire in spring semester 2018; adherence to Mediterranean diet was assessed using a 14-item Mediterranean Diet Adherence Screener.

Results: The mean Mediterranean score estimated was 7.96. Men (7.99) had a slightly higher adherence to the Mediterranean diet than women (7.92). Nonsmokers, those aged between 22-25, those who study and work and engineers had higher score than other participants. 59.05% of the sample had a score lower than adequate adherence but this did not affect their will to participate in research investigation to ameliorate their health. Engineering and related sciences students had higher degree of adherence than other majors Women in the Faculty of Health Sciences, had the highest degree of adherence. 0.7% of the willingness to change diet depended on the score of adherence to Mediterranean diet and 28.58% of the participants were primarily worried about their health. Stratification of the questionnaire revealed a relatively high spread of usage of olive oil in cooking (86.3%) though only 50.3% consumed more than 4 teaspoons per day. The percentage of participants consuming food according to the Mediterranean diet standards was higher than 50% except for wine and fish. Positive correlations were found between the different components of MEDAS.

Conclusions: Men, nonsmokers, those aged between 22-25, those who study and work and engineers had higher score than other participants. The adherence to the Mediterranean diet was lower than the adequate one specifically for wine and fish. A correlation was found among the different questions of adherence to Mediterranean diet. Awareness should be spread among University students to highlight the benefits of Mediterranean diet and encourage its adherence.

Keywords: Mediterranean diet, dietary habits, University students, Lebanon.

Introduction

In Lebanon, the prevalence of overweight and obesity has attained alarming rates in adults, adolescents and children due to an energy dense diet and lack of physical activity (1). Nutrition epidemiologists have been assessing dietary quality not through single nutrient consumed but through dietary patterns (2). To assess dietary patterns two approaches are used the a priori and a posteriori methods (3). The first is based on compliance to already defined national or international recommendations associated to positive health, example of this method is Mediterranean diet score, Alternative health Eating Index (AHEI) (2). The a posteriori method is not pre-defined but is based on empirical data of populations being examined (2). In Lebanon, according to a study conducted on Lebanese aged between 20 and 55 years, four major dietary patterns were found (4). The traditional Lebanese pattern (high intake of vegetables, olives, fruits, burgul and legumes), the western pattern (high consumption of pizzas, pies, fried food, fast food sandwishes, sweets and soda drinks), the prudent pattern (low fat dairy, breakfast cereals, light soda, whole bread) and the fish and alcohol pattern (4).

The university phase is the first phase where most teenagers start making their own food choices along with other choices. Dietary habits of young adults are affected by the fast-food market; this is reflected by increased overweight and obesity among this age group (5). However, universities may provide an ideal forum for reaching out to a large number of young adults through nutrition education programs that may positively influence students' eating habits (5).

Observational studies have highlighted the probable health benefits gained by adhering to the Mediterranean diet through reduction of risk factors for many diseases including metabolic syndrome, cardiovascular disease, cancer, depression and mental disorder (6). Many interventional studies as well published supporting evidence of the benefit of the Mediterranean diet on cardiovascular disease prognosis, diabetes, mortality, cancer, favorable health status, better biochemical profile and quality of life (7, 8, 9, 10, 11, 12, 13, 14, 15).

Few studies described eating habits among University students in Lebanon (5). No study was found to assess adherence to Mediterranean diet among this age group. Health in old age is related to health in earlier years of life (16), it is hence important to assess the adherence to Mediterranean diet among university students to be able to make adequate future interventions and change the eating habits of the future older generation for a better health.

Methods

Study population and assessment

525 students from three different campuses of the University of Balamand in Lebanon (Faculty of Health Sciences, Beirut; ALBA, Sin el Fil and Main campus, Koura) were asked to answer by themselves a short questionnaire in the presence of the main

investigator to help in any clarification needed during the spring semester 2018. The questionnaire is divided into three parts: general information (sex, marital status, age class, working status, smoking status and major), adherence to Mediterranean diet questions and extra information (number one worrying issue, willingness to change diet, increase physical activity and participate in future studies). Adherence to Mediterranean diet was assessed using a 14-item Mediterranean Diet Adherence Screener (MEDAS), developed by PREvencion con DietaMEDiterranea (PREDIMED) for immediate feedback (17). Those who agreed to participate in the study gave their oral consent.

Statistical analysis

Statistics were performed using statistical software SPSS for Windows version 21 (IBM, Chicago, USA). Data are shown as mean, median and standard deviation (SD). Score of adherence was calculated by summing the points of the 14 questions (YES answer is one point, NO is zero points). Correlation among the 14 questions was calculated using Pearson's correlation and Linear regression analysis of the worrying issues and future intentions according to the adherence score was tested (stepwise and enter methods). Non parametric tests (Mann- Whitney U test or Kruskal- Wallis test) were used because the sample is not normally distributed. Results were considered significant if p- value <0.05.

Results

Adherence score to Mediterranean diet according to various variables (Table 1)

Minimum adherence score among University students was 0, maximum adherence score was 14. The mean adherence score is 7.96, the mean adherence score for men and women respectively is 7.99 and 7.92. The mean score of adherence for students aged 22-25 (8.22) is higher than the one of those aged 18-21 (7.81) (p=0.033). University students who work in parallel and men students who work in parallel have a higher degree of adherence than those who only study (p value <0.05). University students who don't smoke have a higher degree of adherence than those who smoke (8.1>7.66) (p-value =0.043). Engineering and related sciences students have higher degree of adherence than other majors (8.28) (p value =0.018). Women in the Faculty of Health Sciences, Beirut, have the highest degree of adherence (8.47 p- value= 0.047).

Stratification of adherence to Mediterranean diet (Table 2)

86.3% of students do use olive oil for cooking and 19.6% consume 7 glasses or more of wine weekly. The two questions with the highest adherence to Mediterranean diet in the total sample are usage of olive oil for cooking and consumption of cooked vegetables, pasta, rice with tomato, onion, garlic and olive oil twice or more a week. The two questions with the lowest adherence to Mediterranean diet in the total sample are wine consumption and fish and fish products consumption. Adherence to Mediterranean diet is best with olive oil for cooking in men and women (85.3% of men and 87.4% of women got a yes (1point of adherence on this question)). Only 22.7% of men and 16.2% of women adhered to Mediterranean diet in the consumption of wine.

Adequacy of adherence to Mediterranean diet according to different variables (Table 3)

59.05% of the participants have a score lower than 9/14. The highest percentage of participants have an inadequate score of adherence to Mediterranean diet (lower than 9) as follow: 31.62% are men, 58.48% are single, 39.24% are aged 18-21, 50.67% are University students, 37.52% do not smoke, 46.67% are registered in the main campus, 27.81% are worried mainly about their future, 48.57% are willing to change their diet, 51.43% are willing to increase physical activity and 44.19% are not willing to participate in research.

Correlation among adherence to Mediterranean diet questions (Table 4)

As shown in Table 4, quantity of olive oil used per day is strongly correlated with usage of olive oil for cooking and is negatively correlated with the preference of chicken over meat. Consumption of vegetables is strongly correlated with the consumption of fruits, legumes, nuts, and cooked vegetables, pasta, rice with olive oil, onion, garlic and tomato. Along with the consumption of vegetables, fruits consumption is correlated with the consumption of less than one sugary drink per week, consumption of nuts and legumes. Consumption of less than one portion of red meat is strongly correlated with the consumption of less than one sugary drink per week and is correlated with the consumption of legumes, consumption of processed deserts less than twice a week and with the preference of chicken over meat. Consumption of less than one sugary drink is also correlated with the consumption of less than one portion of butter or margarine per day, consumption of legumes and the consumption of processed deserts less than twice a week. Consumption of wine is correlated with the consumption of legumes and strongly correlated with the consumption of fish and fish products. Along with the above mentioned variables, consumption of legumes is correlated with the consumption of nuts. And finally along with the consumption of wine, consumption of fish and fish product is correlated with the consumption of processed deserts less than twice a week.

Linear regression analysis of the worrying issues and future intentions according to the adherence score (Table 5)

1.2% of number one worrying issue depends on the adherence score (p-value 0.013). 0.7% of willingness to change diet depends on the adherence score (p value 0.049).

Discussion

The 14 points adherence to the Mediterranean diet questionnaire (MEDAS) was adapted from Estruch et al. (18), this short questionnaire was used by the PREDIMED group for immediate feedback (17) in Spain. MEDAS was also used in a study in the United Kingdom (17), Germany (19) and Manchester (20) in people at high risk of cardiovascular disease, in adult women between 18 and 75 years in selected consultation centers of the German Consortium of Hereditary Breast and Ovarian Cancer in Kiel, Cologne and Munich, and in heart or lung transplant recipients aged 16 years or more, at least 6-months post-transplant and clinically stable patients in Manchester respectively. It should be noted that this questionnaire was not validated in Lebanese students before conducting this investigation. The mean Mediterranean score estimated 7.96 was higher than the one observed in high risk of cardiovascular disease sample (5.47) (17) and in heart or lung transplant recipient (6.6) (20), but it was lower than adequate adherence defined as ≥ 9 (21). Men (7.99) had a slightly higher adherence to the Mediterranean diet than women (7.92) similarly to a study done in Spain among nondiabetic and diabetic males and females (22). Nonsmokers have better dietary habits reflected by higher score than those who smoke as shown as well in a study associating smoking with unhealthy food habits (23). 59.05% of the sample has a score lower than adequate adherence (higher than percentage of participants with a non- adequate score in a coronary artery disease study among older adults (49.8%) (24)) but this does not affect their will to participate in research investigation to ameliorate their health (44.19% of the participants are not interested in doing it though their score is lower than the adequate score). 0.7% of the willingness to change diet depends on the score of adherence to Mediterranean diet and 28.58% of the participants are primarily worried about their health. This should be taken in consideration in planning strategies to increase the level of adherence to Mediterranean diet for students should be aware of the importance of health and the major role eating habits play in health. Stratification of the questionnaire revealed a relatively high spread of usage of olive oil in cooking (86.3%) though only 50.3% consume more than 4 teaspoons per day. The percentage of participants consuming food according to the Mediterranean diet standards is higher than 50% except for wine and fish. The consumption of wine and fish should me more widespread among students. This stratification revealed slight difference in the eating habits between men and women unlike another study done among university students in Lebanon (5). For questions Q3, Q4, Q 9, Q14 higher percentage of participants in this study answered YES than a study on coronary artery disease study (24). In both studies, less than 50% of participants have an adequate intake of wine conforming to Mediterranean diet standards; the intake of fish and fish products differs greatly between both studies (28.8% of university students answered YES compared to 59% in coronary artery disease study) (24). The low consumption of fish confirms the outcome of another study showing a low consumption of fish among the adult population living in Beirut, Lebanon (25). Positive correlations were found between the different components of MEDAS, this might be explained from one side by a healthier lifestyle consisting on the consumption of healthy food along with healthy habits, as it is observed the mean adherence score of those who smoke is lower than those who don’t, in addition the percentage of participants who have an adequate score (≥9) is higher in non-smokers. On the other hand, some foods from a sensory perspective are consumed together as fish and wine (26) (strong correlation found in between).

Conclusion

Among university students, the mean Mediterranean score estimated was 7.96. Men (7.99) had a slightly higher adherence to the Mediterranean diet than women (7.92). Nonsmokers had higher score than those who smoke. 59.05% of the sample had a score lower than adequate adherence but this did not affect their will to participate in research investigation to ameliorate their health. 0.7% of the willingness to change diet depended on the score of adherence to Mediterranean diet and 28.58% of the participants were primarily worried about their health. Stratification of the questionnaire revealed a relatively high spread of usage of olive oil in cooking (86.3%) though only 50.3% consumed more than 4 teaspoons per day. The percentage of participants consuming food according to the Mediterranean diet standards was higher than 50% except for wine and fish. Positive correlations were found between the different components of MEDAS, in addition the percentage of participants who had an adequate score (≥9) is higher in nonsmokers. Awareness should be spread among university students to highlight the benefits of Mediterranean diet and encourage its adherence specifically for the consumption of fish and fish products and wine.

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Table 1: Adherence score to Mediterranean diet according to various variables

	Score of adherence											
	All				Men				Women			
	N	Mean	Median	P	N	Mean	Median	P	N	Mean	Median	P
Total sample	525	7.96	8		278	7.99	8		247	7.92	8	
Marital status				0.559				0				0.543
Single	521	7.95	8		278	7.99	8		244	7.91	8	
Married	3	8.67	8		0				3	8.67	8	
Age				0.033				0.22				0.073
18-21	335	7.81	8		161	7.83	8		174	7.78	8	
22-25	190	8.22	8		117	8.2	8		73	8.25	8	
Working Status				0.018				0.049				0.219
University student	434	7.89	8		221	7.86	8		213	7.88	8	
University student and worker	91	8.38	9		57	8.47	9		34	8.23	8	
Smoking habits				0.043				0.078				0.216
Yes	176	7.66	8		120	7.66	8		56	7.68	8	
No/ didn’t smoke in the past 5years	349	8.1	8		158	8.24	8		191	7.99	8	
Major				0.018				0.069				0.284
Engineering and related Sciences	219	8.28	8		167	8.3	8		52	8.23	8	
Health and health sciences	133	8.04	8		45	7.82	8		88	8.15	8	
Business and hotel management	40	7.7	8		25	7.68	8		15	7.73	8	
Social sciences and education	16	8.06	8		4	8.75	8.5		12	7.83	8	
Arts	72	7.46	7.5		17	7.59	7		55	7.42	8	
Others	45	7.1	7		20	6.35	7		25	7.72	7	

Campus				0.093				0.975				0.047
Main Campus, north of Lebanon	412	7.97	8		245	7.98	8		167	7.96	8	
FHS, Beirut	51	8.35	9		19	8.16	8		32	8.47	9	
Alba, Sin el Fil	62	7.55	7.5		14	8	7.5		48	7.42	7.5	

Evaluated by Mann-whitney U test or Kruskal- Wallis test

Table 2: Stratification of adherence to Mediterranean diet in the total sample, men and women

	All				Men				Women			
	Yes		No		Yes		No		Yes		No	
	N	%	N	%	N	%	No	%	N	%	No	%
Q1:Olive oil for cooking	453	86.3	72	13.7	237	85.3	41	14.7	216	87.4	31	12.6
Q2:Quantity of olive oil per day	264	50.3	261	49.7	150	54	128	46	114	46.2	133	53.8
Q3:Vegetables portion per day	351	66.9	174	33.1	173	62.2	105	37.8	178	72.1	69	27.9
Q4:Fruits portion per day	281	53.5	244	46.5	155	55.8	123	44.2	126	51	121	49
Q5:Red meat per day	295	56.2	230	43.8	159	57.2	119	42.8	136	55.1	111	44.9
Q6:Butter/ margarine portion per day	353	67.2	172	32.8	185	66.5	93	33.5	168	68	79	32
Q7:Sugary drinks portion per day	272	51.8	253	48.2	137	49.3	141	50.7	135	54.7	112	45.3
Q8:Wine portion per week	103	19.6	422	80.4	63	22.7	215	77.3	40	16.2	207	83.8
Q9:Legumes portion per week	365	69.5	160	30.5	184	66.2	94	33.8	181	73.3	66	26.7
Q10:Fish and fish products portion per week	151	28.8	374	71.2	97	34.9	181	65.1	54	21.9	193	78.1
Q11:Processed deserts portion per week	266	50.7	259	49.3	143	51.4	135	48.6	123	49.8	124	50.2
Q12:Nuts portion per week	254	48.4	271	51.6	153	55	125	45	101	40.9	146	59.1
Q13:Chicken or meat?	351	66.9	174	33.1	173	62.2	105	37.8	178	72.1	69	27.9
Q 14:Cooked veggies, pasta, rice with olive oil , onion, garlic and tomato per week	418	79.6	107	20.4	212	76.3	66	23.7	206	83.4	41	16.6

Table 3: Adequacy of adherence to Mediterranean diet according to different variables

	Score ≥9		Score <9	
	N	%	N	%
Total sample	215	40.95	310	59.05
Sex				
Men	112	21.33	166	31.62
Women	103	19.62	144	27.43
Marital status				
Single	214	40.76	307	58.48
Married	1	0.19	2	0.38
Age				
18-21	129	24.57	206	39.24
22-25	86	16.38	104	19.81
Working Status				
University student	168	32	266	50.67
University student and worker	47	8.95	44	8.38
Smoking habits				
Yes	63	12	113	21.52
No/ didn't smoke in the past 5years	152	28.95	197	37.52
Major				
Engineering and related Sciences	96	18.29	123	23.43
Health and health sciences	58	11.05	75	14.28
Business and hotel management	15	2.86	25	4.76
Social sciences and education	7	1.33	9	1.71
Arts	24	4.57	48	9.14
Others	15	2.86	30	5.71
Campus				
Main Campus, north of Lebanon	167	31.81	245	46.67
FHS, Beirut	26	4.95	25	4.76
Alba, Sin el Fil	22	4.19	40	7.62
Worrying issue				
Health	75	14.29	75	14.29
Economy	19	3.62	34	6.48
Political problems	6	1.14	20	3.81
Family	28	5.33	35	6.67
Future	87	16.57	146	27.81
Willingness to change diet				
Yes	183	34.86	255	48.57
No	32	6.09	55	10.48
Willingness to increase physical activity				
Yes	189	36	270	51.43
No	26	4.95	40	7.62
Willingness to participate in research				

Yes	82	15.62	78	14.86
No	133	25.33	232	44.19

Table 4: Correlation among adherence to Mediterranean diet questions (Pearson correlation)

	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14
Q1:Olive oil for cooking		0.213**												
Q2:Quantity of olive oil per day	0.213**												-.093*	
Q3:Vegetables portion per day				0.196**					0.263**			0.131**		0.156**
Q4:Fruits portion per day			0.196**				0.095*		0.121**			0.153**		
Q5:Red meat per day							0.140**		0.091*		0.104*		0.088*	
Q6:Butter/ margarine portion per day							0.115**							
Q7:Sugary drinks portion per day				0.095*	0.140**	0.115*			0.107*		0.245**			
Q8:Wine portion per week									0.098*	0.121**				
Q9:Legumes portion per week			0.263**	0.121**	0.091*		0.107*	0.098*				0.094*		
Q10:Fish and fish products portion per week								0.121**			0.097*			
Q11:Processed deserts portion per week					0.104*		0.245**			0.097*				
Q12:Nuts portion per week			0.131**	0.153**					0.094*					
Q13:Chicken or meat?		-.093*			0.088*									
Q 14:Cooked veggies, pasta, rice with olive oil , onion, garlic and tomato per week			0.156**											

Table 5: Linear regression analysis of the worrying issues and future intentions according to the adherence score

	R square	P value
Number one worrying issue	0.12	0.013
Willingness to change diet	0.007	0.049
Willingness to increase physical activity	0.001	0.424
Willingness to participate in research	0.005	0.101

Manuscript VII

Adherence to Mediterranean diet and its association with age: comparison between Lebanese younger and older adults.

Joanne Karam, Mireille Serhan, Josep A. Tur

(Subnitted)

-Manuscript VII-

Adherence to Mediterranean diet and its association with age: comparison between Lebanese younger and older adults.

Joanne Karam, Mireille Serhan, Josep A. Tur

ABSTRACT

Abstract

Objectives: Assess the adherence to the Mediterranean diet among Lebanese younger adults and older adults in Beirut.

Methods:238 volunteers were recruited via emails to staff and students of the University of Balamand in Beirut, Lebanon. 113 participants (aged 18 to 25 years) and 125 participants aged 45 years and above filled a questionnaire in February and March 2018; adherence to Mediterranean diet was assessed using a 14-item Mediterranean Diet Adherence Screener.

Results:Mean score of adherence to the Mediterranean diet in the total sample, among younger adults and older adults was respectively 8.21, 7.91 and 8.48. The highest percentage of younger adults showed adherence to the Mediterranean diet in the consumption of olive oil in cooking, the highest percentage of older adults showed adherence in the consumption of Sofrito. The lowest adherence is observed in the wine consumption in the sample. 47.48% of the sample had an adequate adherence to the Mediterranean diet. Men, older adults, non-smokers, those who were primarily worried about political problems and who were not willing to change their diet had higher adequate scores. Among younger adults, a strong correlation was found between Q3 and Q1, Q4, Q9 and Q12; and between Q7 and Q11 and Q9 and Q12. Among older adults, a strong correlation was found between Q2 and Q1, Q9; and between Q6 and Q7; and a negative strong correlation was found between Q5 and Q14.

Conclusions:younger adults had a lower adherence to Mediterranean score than older adults. 47.48% of the sample had an adequate adherence to the Mediterranean diet. The correlation between the questions of adherence to Mediterranean diet was different between both age groups.

Keywords:Mediterranean diet, score of adherence, association with age, Lebanon.

Introduction

Lebanese restaurants are found in Europe, United States, Canada, South America, Africa, and Australia under the banner of healthful, vegetable-rich, diversified food (1). Lebanese in Lebanon have been undergoing nutrition transition similar to the one experienced by other traditional societies, where healthy traditional diets are being replaced by westernized diet high in sugar, saturated fats and processed food (1). In Lebanon, the prevalence of overweight and obesity has attained alarming rates in adults, adolescents and children due to an energy dense diet and lack of physical activity (2). According to a study conducted on Lebanese aged between 20 and 55 years, four major dietary patterns were found; the traditional Lebanese pattern (high intake of vegetables, olives, fruits, burgul and legumes), the western pattern (high consumption of pizzas, pies, fried food, fast food sandwishes, sweets and soda drinks), the prudent pattern (low fat dairy, breakfast cereals, light soda, whole bread) and the fish and alcohol pattern (3). Traditional Lebanese cuisine is an example of the typical Mediterranean diet. It is rich in fresh local ingredients, animal fat is only used in some desserts as it is considered a luxury item, unripe grape juice, garlic, lemon, sour pomegranate concentrate, powdered sumac berries and olive oil are consumed at every meal, their combination constitute the typical Lebanese flavor (1). Vegetables are eaten raw, pickled, or cooked. Foods are generally grilled, baked or sautéed with olive oil (1).

The Mediterranean diet was first illustrated in the time of the ancient Egyptian civilization on a sculpture on the tomb of Ramses the second showing the association of cereals, vine and olive trees. In 1634, Castelvetro an Italian living in England complained about people eating too much meat and not eating enough fruits and vegetables and praised the diet adopted in his country of origin and its effect on health (4). The Mediterranean diet was inscribed in 2010 by the United Nations Educational, Scientific and Cultural Organization (UNESCO) in the representative list of intangible cultural heritage of humanity (5). The Mediterranean diet does not consist on the consumption of one single nutrient; rather it's a holistic approach including a whole pattern that is reflected positively on the health (5).

It is important to assess the degree of adherence to the Mediterranean diet through accurate measurement tools such as dietary scores (6). 28 adherence scores were found internationally (7). A significant protection against mortality (8% reduction of death from any cause), occurrence of cardiovascular diseases (10 % reduction of incidence or death caused by cardiovascular disease) and major chronic degenerative diseases were conferred when adherence to the Mediterranean diet increased by two points (8).

The aim of this study is to assess the adherence to Mediterranean diet among younger adults (university students) and older adults (aged 45 and above) in Beirut, the capital of Lebanon.

Methods

Study population and assessment

113 participants (aged 18 to 25 years) and 125 participants aged 45 years and above in Beirut area were asked to answer by themselves a short questionnaire in the presence of the main investigator to help in any clarification needed in February and March 2018. The questionnaire is divided into three parts: general information (age, sex, smoking habits), adherence to Mediterranean diet questions and extra information (number one worrying issue, willingness to change diet). Adherence to Mediterranean diet was assessed using a 14-item Mediterranean Diet Adherence Screener (MEDAS), developed by PREvencion con DietaMEDiterranea (PREDIMED) for immediate feedback (9). Those who agreed to participate in the study gave their oral consent.

Statistical analysis

Statistics were performed using statistical software SPSS for Windows version 21 (IBM, Chicago, USA). Data are shown as mean, median and standard deviation (SD). Score of adherence was calculated by summing the points of the 14 questions (YES answer is one point, NO is zero points). Correlation among the 14 questions was calculated using Pearson's correlation. Non parametric tests (Mann- Whitney U test or Kruskal- Wallis test) were used because the sample is not normally distributed. Results were considered significant if p- value <0.05.

Results

Adherence score to Mediterranean diet according to various variables (Table 1)

Mean score of adherence to the Mediterranean diet in the total sample is 8.21. Mean score of adherence among younger adults is 7.91; mean score of adherence among older adults is 8.48.

Stratification of adherence to Mediterranean diet (Table 2)

Among younger adults, 83.2% of the participants answered yes for the usage of olive oil for cooking whereas 77.6% of older adults answered yes for this question. 84% of older adults and 77.9% of younger adults consume cooked vegetables, pasta, rice with tomato, onion, garlic and olive oil twice or more a week. The lowest adherence is observed in question Q8, 16% of older adults and 19.5% of younger adults consume 7 or more glasses of wine per week.

Adequacy of adherence to Mediterranean diet according to different variables (Table 3)

47.48% of the sample has an adequate adherence to the Mediterranean diet (Score ≥9). 50.77% of men and 53.18% of women have score of adherence lower than 9. 52% of older adults and 42.48% of younger adults have a score ≥9. 46.25% of smokers and 48.2% of those who don't or haven't smoked in the past 5 years have a score of adherence ≥9. 52.94% of participants who are primarily worried about their health, 35%, 71.43%, 43.24% and 40% of those who are primarily worried about economy, political problems, family and future respectively have a score of adherence ≥9. 52.53% of those who are willing to change their diet for a better health and 52.5% of those who are not willing to change their diet for a better health have score of adherence <9.

Correlation among adherence to Mediterranean diet questions (Figure 1)

Among younger adults, a strong correlation was found between Q3 (consumption of 2 or more portions of vegetables per day) from one side and Q1 (usage of olive oil for cooking), Q4 (consumption of 3 or more portions of juices per day), Q9 (consumption of a portion of legumes

3 or more times a week) and Q12 (consumption of a portion of nuts 3 or more times a week) from the other side. A strong correlation was found between Q7 (consumption of less than one sugary drink a day) and Q11 (consumption of processed deserts less than twice a week), and a strong correlation was found between Q9 (consumption of a portion of legumes 3 or more times a week) and Q12 (consumption of a portion of nuts 3 or more times a week). Among older adults, a strong correlation was found between Q2 (consumption of more than 4 teaspoons of olive oil per day) from one side and Q1 (usage of olive oil for cooking) and Q9 (consumption of a portion of legumes 3 or more times a week) from the other side. A strong correlation was found between Q6 (consumption of less than one portion of butter or margarine per day) and Q7 (consumption of less than one sugary drink per day) and a negative strong correlation was found between Q5 (consumption of less than one portion of red meat a day) and Q14 (consumption of twice or more a week of cooked vegetables, pasta, rice with cooked tomato, onion, garlic and olive oil (sofrito)).

Discussion

The 14 points adherence to the Mediterranean diet questionnaire (MEDAS) was adapted from Estruch et al. (10); this short questionnaire was used by the PREDIMED group for immediate feedback (9) in Spain. This questionnaire was not validated among Lebanese participants before conducting this investigation. MEDAS was also used in several other studies. Mean score of adherence among younger adults (7.91); mean score of adherence among older adults (8.48) were higher than the one observed in the United Kingdom in a high risk of cardiovascular disease sample (5.47) (11) and in heart or lung transplant recipients aged 16 years or more, at least 6-months post-transplant and clinically stable patients in Manchester (6.6) (12), but it was lower than adequate adherence defined as ≥ 9 (13). Older adults had a higher score than younger ones due to better dietary habits with age similarly to a study conducted among Michigan adults; younger ones were found to have bad eating habits (14). 47.48 % of the sample has an adequate adherence to the Mediterranean diet (Score ≥9) compared to 50.2% of participants having adequate score in a coronary artery disease study among older adults (15). However, 52% of older adults have an adequate score of adherence confirming healthier habits among this age group. More men have adequate score of adherence to Mediterranean diet than women due to the effect of gender on food choices influenced by the effect of the superior temporal sulcus stimulation (16). A higher percentage of adherence to Mediterranean diet was found for questions Q1, Q5, Q6, Q7, Q8, Q10, Q11 and Q13 among coronary artery disease study than Lebanese participants (15); older adults in Beirut, Lebanon had higher percentage of adherence for questions Q2, Q3, Q4, Q9, Q12 and Q14. It should be noted that the consumption of butter and margarine is highest among Lebanese older adults (adherence 37.6% compared to 90% in the coronary artery disease study and 73.5% among older adults) who probably use it in the traditional foods (1). The low consumption of fish confirms the outcome of another study showing a low consumption of fish among the adult population living in Beirut, Lebanon (17). The correlation among the questions differs in the two age groups due to different eating habits.

Conclusion

Mean score of adherence to the Mediterranean diet in the total sample, among younger adults and older adults was respectively 8.21, 7.91 and 8.48. The highest percentage of younger adults showed adherence to the Mediterranean diet in the consumption of olive oil in cooking, the highest percentage of older adults showed adherence to the Mediterranean diet in the consumption of cooked vegetables, pasta, rice with tomato, onion, garlic and olive oil twice or more a week. The lowest adherence is observed in the wine consumption in the sample. 47.48% of the sample had an adequate adherence to the Mediterranean diet (Score ≥9). Men, older adults, non-smokers, those who were primarily worried about political problems and who were not willing to change their diet had higher adequate scores.The correlation between the questions of adherence to Mediterranean diet was different between older adults and younger ones. There is a crucial need for awareness to be spread on the importance of Mediterranean diet specifically among younger adults who will become the future older adults. Therefore, the need for those findings to be promoted in clear public health messages is a must.

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Table 1: Adherence score to Mediterranean diet according to different variables

	Score of adherence											
	All				Younger adults				Older adults			
	N	Mean	Median	P	N	Mean	Median	P	N	Mean	Median	P
Total sample	238	8.21	8		113	7.91	8		125	8.48	9	
Sex				0.199				0.651				0.136
Men	65	8.54	8		33	8.09	8		32	9	9	
Women	173	8.09	8		80	7.84	8		93	8.3	8	
Smoking habits				0.756				0.756				0.409
Yes	80	8.16	8		36	8	8		44	8.29	8.5	
No/ didn’t smoke in the past 5years	158	8.23	8		77	7.87	8		81	8.58	9	

Evaluated by Mann-whitney U test or Kruskal- Wallis test

Table 2: Stratification of adherence to Mediterranean diet in the total sample, in younger and older adults

	All				Younger adults				Older adults			
	Yes		No		Yes		No		Yes		No	
	N	%	N	%	N	%	N	%	N	%	N	%
Q1:Olive oil for cooking	191	80.3	47	19.7	94	83.2	19	16.8	97	77.6	28	22.4
Q2:Quantity of olive oil per day	132	55.5	106	44.5	53	46.9	60	53.1	79	63.2	46	36.8
Q3:Vegetables portion per day	186	78.2	52	21.8	82	72.6	31	27.4	104	83.2	21	16.8
Q4:Fruits portion per day	131	55	107	45	53	46.9	60	53.1	78	62.4	47	37.6
Q5:Red meat per day	140	58.8	98	41.2	60	53.1	53	46.9	80	64	45	36
Q6:Butter/ margarine portion per day	130	54.6	108	45.4	83	73.5	30	26.5	47	37.6	78	62.4
Q7:Sugary drinks portion per day	149	62.6	89	37.4	60	53.1	53	46.9	89	71.2	36	28.8
Q8:Wine portion per week	42	17.6	196	82.4	22	19.5	91	80.5	20	16	105	84
Q9:Legumes portion per week	182	76.5	56	23.5	89	78.8	24	21.2	93	74.4	32	25.6
Q10:Fish and fish products portion per week	75	31.5	163	68.5	33	29.2	80	70.8	42	33.6	83	66.4
Q11:Processed deserts portion per week	126	52.9	112	47.1	51	45.1	62	54.9	75	60	50	40
Q12:Nuts portion per week	120	50.4	119	49.6	55	48.7	58	51.3	65	52	60	48
Q13:Chicken or meat?	157	66	81	34	71	62.8	42	37.2	86	68.8	39	31.2
Q 14:Cooked veggies, pasta, rice with olive oil , onion, garlic and tomato per week	193	81.1	45	18.9	88	77.9	25	22.1	105	84	20	16

Yes indicates adherence to mediterranean diet, No indicates absence of adherence

Table 3: Adequacy of adherence to Mediterranean diet according to different variables

	Score ≥9		Score <9	
	N	%	N	%
Total sample	113	47.48	125	52.52
Sex				
Men	32	49.23	33	50.77
Women	81	46.82	92	53.18
Age group				
Younger adults	48	42.48	65	57.52
Older adults	65	52	60	48
Smoking habits				
Yes	37	46.25	43	53.75
No/ didn't smoke in the past 5years	76	48.2	82	51.8
Worrying issue				
Health	63	52.94	56	47.06
Economy	7	35	13	65
Political problems	5	71.43	2	28.57
Family	16	43.24	21	56.75
Future	22	40	33	60
Willingness to change diet				
Yes	94	47.47	104	52.53
No	19	47.5	21	52.5

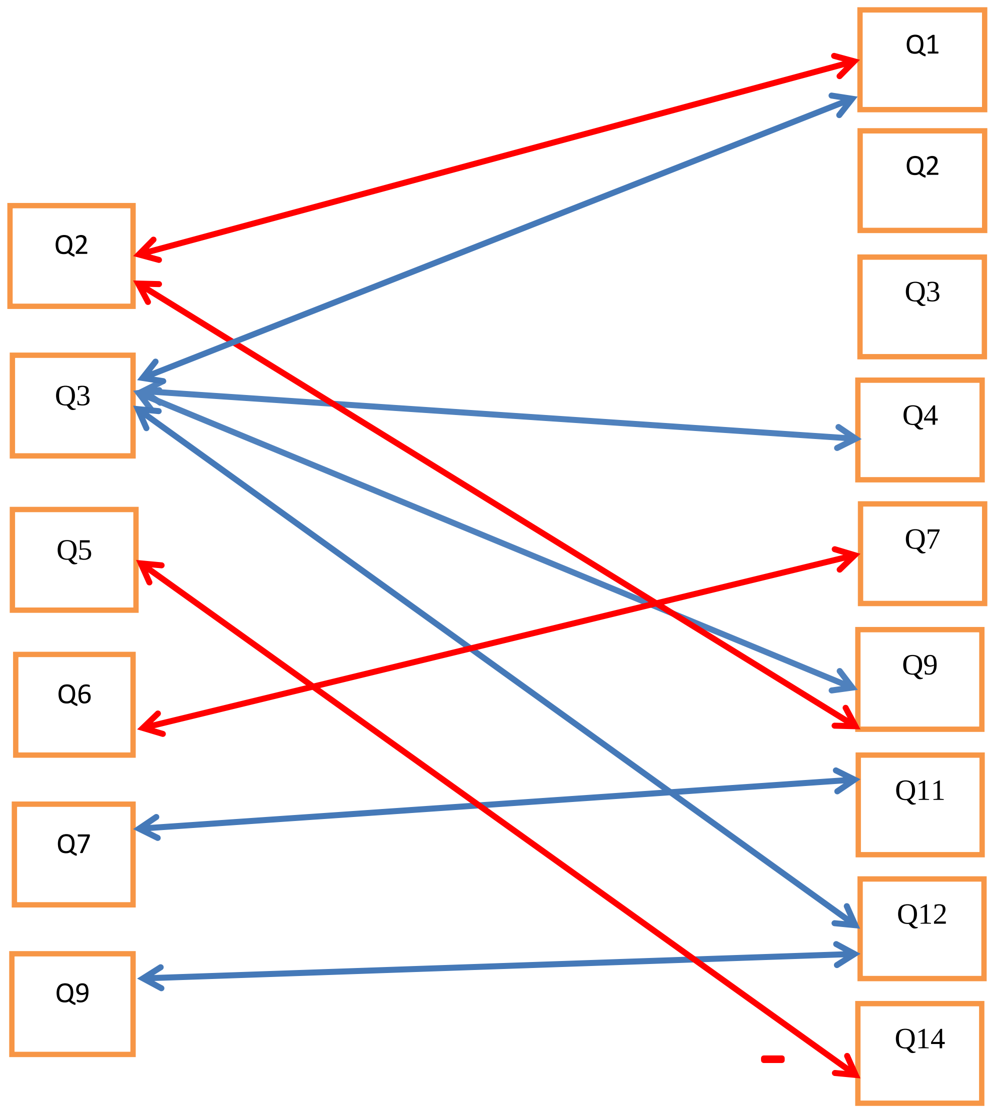

Figure 1: Correlation among the questions of the adherence to Mediterranean diet, arrows indicates strong correlation (significant at the level of 0.05). Red arrows are for correlation in the sample of older adults, blue arrows are for the correlation in the sample of younger adults.

-Manuscript VII-

Communications

COMMUNICATIONS

18th ISANH Middle East World Congress, Beirut Antioxidants 2017, Saint Joseph University of Beirut, Lebanon, May 3-4, 2017.

Intake estimation and dietary sources of polyphenols in adults living in a Mediterranean region.

KARAM, Joanne; BIBILONI, Maria del Mar; SERHAN, Mireille; TUR, Josep A.

The NUTRedOx COST Action CA16112 &the 6th NutriOx Atelier 2017, Strasbourg, ECPM, University of Strasbourg 27-29 September 2017

Estimation of dietary fatty acid intake in Mediterranean old adults

M.M. Bibiloni, J. Karam, A. Julibert, E. Argelich, J.M. Gámez, I. Llompart, A. Sureda, A. Pons, J.A. Tur

18th ISANH Middle East World Congress
Beirut Antioxidants 2017
May 3-4, 2017 , Saint Joseph University of Beirut, Lebanon

INTAKE ESTIMATION AND DIETARY SOURCES OF POLYPHENOLS IN ADULTS LIVING IN A MEDITERRANEAN REGION.

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Introduction: Polyphenols are found abundantly in our diets and are shown to have great impact on health. The Phenol Explorer database release 3.6 holds data on polyphenol content in food.
Methods: The study was carried out in 211 participants dwelling women (*n*=112) and men (*n*=99) in Mallorca. Polyphenol intake was calculated from foods collected through recall diets using the Polyphenol Explorer.
Results: The mean daily intake of polyphenol was 332.7 mg/d (SD: 237.9; median: 299 mg/d). Women had a higher consumption than men. Higher income and educational level were related to a higher intake of polyphenols. Polyphenol intake was highest by people aged 64-67 years. Lifestyle factors also affected polyphenol intake: alcohol drinkers' consumed more than nondrinkers and physically active people consumed more than inactive ones. The major class of polyphenols in the total food intake was flavonoids, and among them the major subclass was flavanols. Alcoholic beverages were the major contributors in the polyphenol intake (118.3 mg/d, SD: 127.5), and 17.7% of total polyphenol was from wine.
Conclusion: The intake of flavonoids was highest among other classes. Red wine was the major contributor in the polyphenol intake.

Keywords: Polyphenol, food groups, dietary source, polyphenol classes, polyphenol subclasses.

Table 1. Total polyphenol intake and energy adjusted polyphenol intake according to sociodemographic and physical characteristics (n=211)

		Polyphenol intake			Energy adjusted Polyphenol intake		
	N	mean (SD)	median (IQR)	P value	mean (SD)	median (IQR)	P value
Total Population	211	332.7 (197.4)	299.5 (250.4)		187.5 (100.5)	172.9 (140.3)	
Sex							
Men	99	375.8 (217.6)	343.2 (317.8)	0.006	187.1 (103.1)	161.8 (155.9)	0.889
Women	112	294.7 (169.8)	276.6 (188.5)		187.8 (98.7)	173.2 (134.9)	
Educational Level							
Primary School	95	284.3 (156.3)	258.4 (207.6)	0.014	168.8 (85.7)	163.2 (108.8)	0.085
Secondary School	75	365.9 (200.1)	334.1 (312.2)		198.6 (108.1)	184.3 (116.1)	
University Graduate	41	384.4 (250.5)	343.2 (294.2)		210.3 (112.2)	191.2 (142.1)	
Income							
Low (<600 euros/month)	60	272.48 (167.3)	242.6 (221.6)	0.006	179.9 (101.2)	163.93 (134.8)	0.464
Medium (600-900 euros/month)	23	305.15 (167.3)	307.0 (265.3)		169.2 (86.7)	158.92 (141.8)	
High (>900 euros/month)	128	332.7 (208.9)	332.2 (282.9)		194.3 (102.5)	178.19 (141.3)	
Age Class							
50-63	74	284.4 (159.4)	260.2 (196.9)	0.045	149.8 (75.6)	129.9 (98.3)	<0.001
64-67	67	364.3 (212.8)	347.6 (265.6)		205.5 (105.5)	189.4 (122.9)	
≥68	70	353.5 (211.0)	304.0 (211.0)		209.9 (108.2)	201.0 (159.6)	
Smoking Status							
No	194	335.2 (188.3)	308.1 (248.8)	0.147	189.1 (98.0)	175.1 (149.3)	0.188
Yes	17	305.0 (287.8)	263.0 (162.0)		169.3 (128.4)	149.1 (121.5)	
Alcohol Drinking							
No	95	261.5 (162.7)	223.1 (209.4)	<0.001	160.6 (97.5)	137.0 (127.0)	<0.001
Yes	116	391.1 (204.7)	353.0 (279.0)		209.5 (98.0)	201.8 (130.7)	
Physical Activity							
Inactive	105	293.4 (190.7)	263.03 (195.2)	0.001	169.9 (98.3)	150.5 (117.9)	0.005
Active	106	371.7 (197.2)	348.02 (291.7)		204.9 (100.1)	100.1 (153.1)	
BMI Range							
Normal	82	350.1 (196.5)	317.7 (258.4)	0.518	202.7 (99.6)	190.2 (140.7)	0.100
Overweight	86	324.8 (204.8)	290.7 (239.3)		182.1 (101.5)	163.3 (131.7)	
Obese	43	315.4 (185.7)	299.5 (267.4)		169.3 (98.4)	150.5 (155.6)	

Table 2. Distribution (mg/recall: mean and SD) of total polyphenol classes and subclasses in food groups.

	Food group										
Polyphenol class	Total Foods	Oils and seeds	Nonalcoholic beverages	Alcoholic beverages	Cereals	Sweets	Fruits	Nuts	Legumes	Others	Vegetables
Total Polyphenols	332.7 (237.9)	26.2 (46.5)	32.1 (71.8)	118.3 (127.5)	25.2 (39.9)	17.3 (37.8)	98.6 (126.3)	28.1 (178.3)	8.0 (10.6)	11.1 (31.0)	68.5 (99.0)
Flavonoids	170.3 (144.4)	0.7 (5.5)	24.1 (71.5)	86.4 (97.9)	0.1 (0.6)	15.1 (34.3)	71.2 (88.5)	0.1 (0.3)	7.2 (10.6)	7.6 (28.0)	16.3 (28.2)
Flavanols	46.0 (57.7)	0	2.1 (5.3)	49.5 (55.7)	0	12.5 (32.0)	9.3 (19.6)	0.1 (0.3)	2.5 (5.2)	0.03 (0.1)	1.0 (4.0)
Flavonols	22.7 (29.9)	0.2 (1.7)	0.1 (0.4)	7.2 (8.1)	0	1.0 (2.5)	4.7 (7.0)	<0.01	1.9 (5.7)	2.3 (18.0)	11.4 (20.6)
Flavanones	30.7 (50.6)	0	3.1 (14.8)	1.0 (1.0)	0	0.1 (0.4)	29.2 (50.4)	0	0	0.1 (0.5)	0.1 (0.1)
Flavones	10.7 (20.3)	0.2 (0.9)	0.5 (2.2)	0	0.14(0.6)	1.5 (2.1)	2.0 (5.0)	0	0.2 (0.3)	2.2 (3.9)	5.1 (19.5)
Anthocyanin	36.7 (61.9)	0.3 (2.8)	0	23.0 (26.7)	0	0	25.7 (60.1)	0	1.9 (6.9)	0	0
Dihydrochalcones	0.3 (1.8)	0	0	0	0	0	0.3 (1.9)	0	0	0	0
Isoflavonoids	19.3 (71.1)	0	18.4 (70.3)	0	0	0	0	0	0.6 (2.0)	0.7 (11.5)	0
Phenolic Acids	100.0 (130.0)	5.0 (17.0)	7.7 (7.4)	21.9 (20.0)	0.4 (2.1)	2.0 (3.5)	21.7 (57.8)	27.3 (178.4)	0.8 (1.0)	1.1 (2.3)	47.4 (74.5)
Benzoic Acid	17.5 (90.6)	0.5 (1.8)	3.0 (5.0)	9.5 (8.6)	0.1 (0.1)	0.01 (0.1)	1.4 (4.5)	19.3 (176.9)	0.1 (0.2)	0.1 (0.2)	2.6 (11.1)
Cinnamic Acid	82.2 (92.9)	4.5 (15.9)	4.7 (7.0)	12.1 (11.5)	0.4 (2.0)	2.0 (3.5)	20.3 (55.9)	8.0 (29.2)	0.7 (0.9)	1.0 (2.2)	44.8 (73.2)
Alkylphenols	25.3 (39.2)	0	0.02 (0.03)	<0.01	25.3 (39.6)	0.1 (0.2)	0	0	0	0	0
Alkylmethoxyphenols	0.1 (0.2)	0	0.02 (0.03)	0.1 (0.3)	0	<0.01	0	0	0	<0.0	0
Lignans	7.2 (15.6)	2.3 (14.4)	<0.01	0	0.04 (0.1)	<0.01	4.8 (7.1)	<0.01	0	0.1 (0.4)	0.4 (1.4)
Stillbenes	2.6 (4.4)	0	0	4.7 (5.1)	0	<0.01	0.1 (0.2)	<0.01	0.02 (0.03)	0	0
Tyrosol	20.6 (21.9)	17.5 (21.1)	0.04 (0.3)	4.5 (4.4)	0	0.0 (0.1)	0	0	0	1.9 (2.6)	0
Other polyphenols	2.4 (3.8)	0.5 (1.6)	0.2 (0.9)	1.0 (0.9)	0	0.0 (0.0)	0.8 (2.2)	0.7 (1.0)	0	0.3 (2.4)	<0.01

Table 3. Main food contributors in the different polyphenol classes and subclasses.

	Main food contributors: percentage of contribution to polyphenol class		
Total Polyphenols	soy milk 5.4%	artichoke 6.2%	red wine 17.7%
Flavonoids	orange 9.5%	soy milk 10.8%	red wine 26.8%
Flavanols	plum 4.9%	pure chocolate 8.7%	red wine 56.5%
Flavonols	apple 11.9%	spinach 13.0%	red wine16.6%
Flavanones	commercial orange juice10.0%	orange juice31.3%	orange 52.6%
Flavones	oli d'inca whole wheat cookies 5.2%	orange juice 13.7%	artichoke 43.8%
Anthocyanin	cherry 17.5%	black grapes 22.1%	red wine 33.7%
Dihydrochalcones	apple juice 9.7%	peach and grapes juice 10.3%	peach juice 80.0%
Isoflavonoids	soy sprouts 0.5%	soy yogurt 3.9%	soy milk 95.59%
Phenolic Acids	red wine 9.0%	artichoke 15.5%	potato 16.5%
Benzoic Acid	red wine 17.4%	chestnuts19.4%	walnuts 23.5%
Cinnamic Acid	red wine 6.7%	artichoke 19.7%	potato 21.0%
Alkylphenols	corn cereals breakfast bar 7.3%	rice cereals breakfast bars 19.2%	whole wheat bread 44.5%
Alkylmethoxyphenols	powder coffee 1.0%	coffee beans 24.0%	beer 74.4%
Lignans	orange 19.5%	mandarine 20.0%	cantaloupe20.7%
Stillbenes	black grapes 1.5%	white wine 3.8%	red wine 91.9%
Tyrosol	olive oil 19.2%	green olives 24.3%	virgin olive oil 31.4%
Other polyphenols	green olives 11.7%	orange juice 14.4%	walnuts 42.1%

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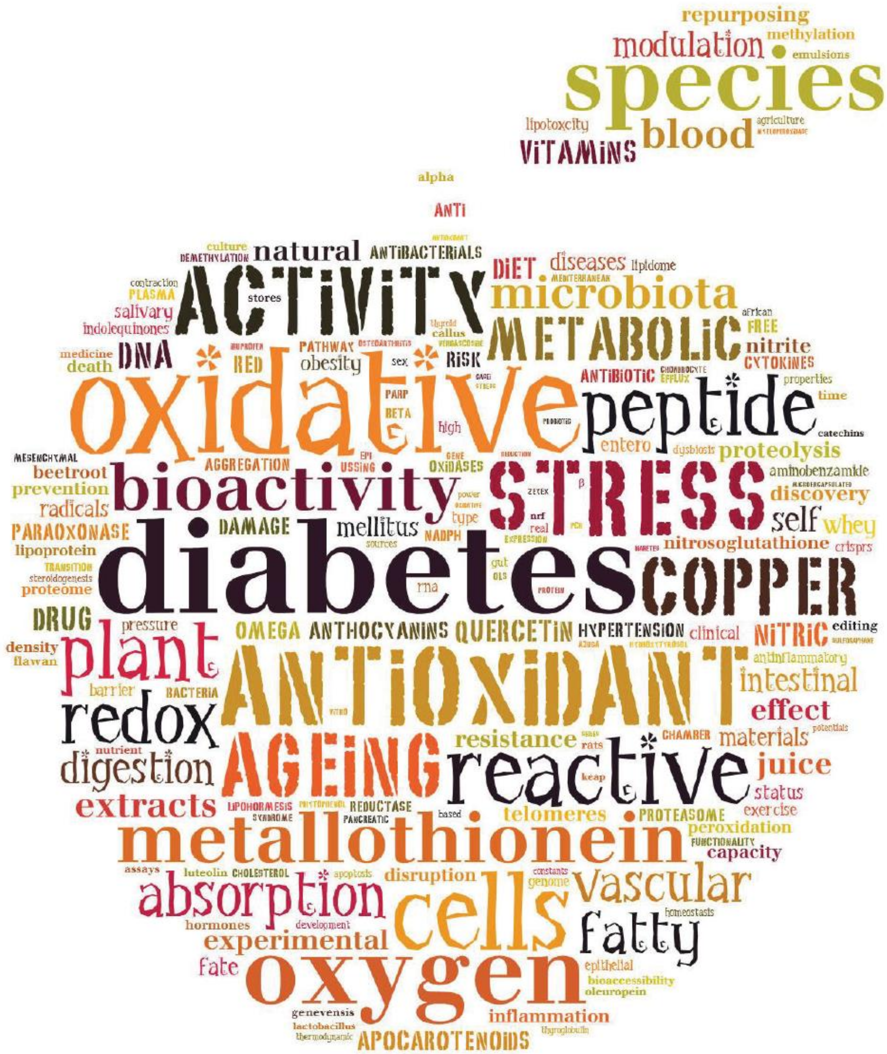

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P3

Estimation of Dietary Fatty Acid Intake in Mediterranean Old Adults

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Introduction: Fats provide food a unique flavor and texture, they are as well a major source of energy, help absorbing and transporting carotenoids and fat-soluble vitamins, are precursors of signaling molecules and are an essential component of cell membranes.

Objective: Assessment of the lipid dietary intake, fatty acids intake and food sources in a sample of Mediterranean old adults.

Methods: The study was conducted in 211 participants dwelling women (*n*= 112) and men (*n*= 99). Lipid and fatty acid intake were assessed using a Spanish database.

Results: The mean intake of lipids was 68.6 g/day (standard deviation, SD: 24.6; 34.4%, SD: 7.0 of total energy consumed). Men consumed more lipids than women. Younger participants and those with a higher education consumed more lipids than the other ones. The main sources of fat were MUFA (16.7%, SD: 4.1), followed by SFA (9.6%, SD: 2.6) and PUFA (5.0%, SD: 1.7). Oils & seeds were the major contributors in the lipid intake (38.8%, SD: 16.0), MUFA (53.9%, SD: 18.7) and PUFA (33.0%, SD: 16.4). The intake of the main classes of fatty acids did not abide by the International (PUFA) and Spanish recommendations (SFA, MUFA). The intake of ALA, EPA and DHA were lower than recommendations. The cholesterol intake (243.9 mg, SD: 140.4) was within the range of the Spanish recommendations.

Conclusions: Fat intake was assessed according to sex, age class and education level and results were shown to be statistically significant. The main dietary fat source was MUFA, abundantly found in the Mediterranean diet, and the most contributing food to lipid intake was oils & seeds. However, the fatty acids intake did not abide by the recommendations for all the observed ones.

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Recapitulation

My work is founded on two studies; one based in Spain, the other one is based in Lebanon. The first study is based on data collected between 2013-2014 in Mallorca and the target population is older adults aged between 55 and 80 (men) and 60 and 80 (women). The second study is based on a survey conducted among older adults and younger ones in Beirut the capital of Lebanon. Statistical analysis provided information about the polyphenols intake, fatty acid intake, minerals intake and the physical condition in older adults in Mallorca; it also provided preliminary information about the adherence to Mediterranean diet in Lebanon among younger adults and older ones.

1. Nutritional intake in Mallorca:

The calculated mean polyphenol intake (332.8 mg/d) was relatively low compared to other studies in Sicily (663.7 mg/d) (84), Spain (820 mg/d) (85), and France (1193 mg/d) (86), but higher than the intake estimated in Denmark (1–100 mg/d) (87), and similar to that observed in Brazil (377.5 mg/d) (88). Alcohol drinkers in this study had higher intake than non-drinkers. Unlike the results obtained in Poland (89), no differences in polyphenol intake were registered between smokers and non-smokers. Flavonoids were the main ingested polyphenol class in this study, similarly to previous Polish and Spanish studies (85, 89) whereas phenolic acids were the main polyphenol class among French adults (86). Nonalcoholic beverages were the main source of polyphenols among the French and Polish adults (86, 89); nuts and fruits among Sicilian and Spanish adults, respectively (84, 85); and coffee was the main contributor to the intake of other populations (85, 86). However, in the present study alcoholic beverages were the main source of polyphenols, with wine being the highest food contributor. The polyphenol intake may differ according to the usual food intake in a region, but also according to the age, educational level, and lifestyle factors that impact on the eating habits; hence it is difficult to compare between populations.

The calculated mean fat intake in the total sample (68.6 g/day), in men (78.6 g/day) and women (59.9 g/day) were lower than the ones obtained in the Irish study (71.9 g/day), in men (84.5 g/day) and women (65.5 g/day) older than 65 years old (90) but higher than those obtained in the United States in the total sample (66 g/day), in men (77 g/day) and women (57 g/day) above 60years (91). Similarly to the Irish study, men were shown to consume more lipids than women (90). Participants younger than 65 years old had the highest lipid intake, just as the Irish study showed (90), this might be due to a decrease in nutrient consumption including fat for one third of people over 65 have reduced saliva production, causing difficulties in eating that may impair appetite (92). Oils and seeds were the highest contributors in the lipid intake; it contributed by 38.8% of total lipid intake whereas in Ireland it only contributed by 8.4% of lipid intake and the highest contributors were meat products (fresh meat, meat products and meat dishes) (90). The main fat source in Ireland (90) was SFA, followed by MUFA and PUFA in elderlies. In this study, MUFA were shown to be the main source of fat, followed by SFA and PUFA. This may be due to high adherence to the Mediterranean diet, which is high in MUFA (93). The intake of total lipids, cholesterol and PUFA abided by the Spanish recommendations, the intake of ALA, DHA and MUFA was lower than those recommendations and the SFA intake was higher than recommended for both sexes. The intake of total lipids, cholesterol, MUFA and SFA abided by recommendations set by EFSA and WHO. MUFA intake in this study was adequate, similarly to the one registered in Ireland in 2011 (90). EPA and DHA intake in Ireland fit the recommendations for elderlies, whereas in this study the consumption was only adequate by women. ALA and PUFA intake were lower than recommendations unlike the study in Ireland for both men and women (90).

The daily consumption of calcium expressed as median (748.6 mg/d) is lower than the recommendations set by IOM (94) and the intake in Netherlands (944 mg/d) (95) for both men and women. The intake of copper is higher than the IOM recommendations by both men and women; however it is very similar to the intake in Ireland (96). The median intake of iodine is lower by 45% in men 52.2% in women than the IOM recommendations, the intake of Selenium is higher than those recommendations (77.8% by men and 29.5% by women) (94). The intake of iron (13.5 mg/d M 11.9 mg/d F) is higher than the recommendations (8 mg/d) but similar to the intake in Germany (97). The intake of magnesium by men (360 mg/d) is lower than the recommendations (94), Phosphorus consumption is 52.8% and 82.8% higher than recommendation for women and men respectively but lower than the intake in Netherlands for both sexes (1480 mg/d) (95). The intake of zinc is 21.8% and 13.8% lower than recommendations by men and women respectively; it is lower than the intake in the UK for both sexes as well (98).

2. Physical condition in Mallorca:

Maximum HGS was lower among older participants, non-overweight women, inactive men, and men with abdominal obesity. Moreover, 24.5% of the participants had low maximum HGS and this risk increased in women, adults older than 65 and 67 for men and women respectively; and decreased in overweight and overfat older adults. Maximum 8-f TUG score was higher among older participants, those with lower education, lower income, and inactive participants, those with abdominal obesity and overfat, and women with a BMI $\geq$27 kg/m^2.

Additionally, 36.8% of participants had high 8-f TUG score and this risk increased in women, and overweight, overfat and abdominal obese participants; and decreased in high educated participants, those with an income of 900 euros or higher per month, and those who were slightly active and active participants. Presarcopenia, sarcopenia and severe sarcopenia prevalence were 2.6%, 0.3% and 0.5% respectively among the studied population; however, 4.5% of men and 19.1% of women registered low physical condition (assessed by high scores in 8-f TUG and low scores in HGS tests) but not low ASMI. The frequency of sarcopenia (0.3%) in this study was lower than the one in a northern Spanish city (2.4%), and unlike this northern Spanish city, women were more prone to be affected (19.1% of women registered low physical condition) (99). This is reflected positively on the population studied for a very low frequency of sarcopenia implies a decreased risk of adverse health outcomes, including falls, loss of independence, disability. As such, this decreases the socioeconomic burden in the studied population (100). Physical activity has a major effect on physical condition (101). Physical activity behavior is affected by two major components of socioeconomic status: educational level and income. Educational level plays a primary role in the level of physical activity; an age-related decline in physical activity was observed among low-education individuals (102).Our results showed higher prevalence of high 8-f TUG among participants with lower education. Income plays a major role in determining the physical activity; individuals with higher income were more engaged in physical activity according to several studies (103, 104). In our study, prevalence of low HGS and high 8-f TUG scores was higher among those with a lower income. Our findings showed as well that inactive participants had higher 8-f TUG score than active or slightly active participants. Finally, being single was also associated with higher prevalence of low HGS. An adequate nutritional intake is an important element of any strategy to preserve muscle mass and strength during aging. Muscle wasting is a multifactorial process. A loss of fast twitch fibers, insulin resistance and glycation of proteins may play an important role in the loss of muscle strength and development of sarcopenia. Protein intake plays an integral part in muscle health and an intake of 1.0–1.2 g/kg of body weight per day is optimal for older adults (105).

Older men are shown to have weaker grip muscular strength, lower body strength, lower body flexibility and aerobic ability but stronger agility/dynamic balance and are faster. In men, the higher the BMI, FMI and WHtR are the lower the aerobic ability is but the better the agility/dynamic balance is. Higher values of the body composition variables (BMI, FMI, WHtR) were associated as well with a faster speed. The grip muscular strength is decreased when the fat increases (Higher FMI and WHtR), lower body flexibility decreases with higher WHtR. The lower body is weaker when the TG and TG/HDL- chol ratio are higher. The walking speed is slower but the aerobic ability is stronger when the LDL- chol is higher. Aerobic ability decreases with higher TG/HDL-chol ratio. After adjusting for age + age^2 and the additional body composition covariates, higher values of TChol, LDL-chol and non-HDL-chol were correlated with weaker grip muscular strength, higher TG value was associated with weaker lower body strength. In women, the older age is correlated with weaker grip muscular strength and better agility/dynamic balance. Increased BMI and FMI are correlated with better agility/dynamic balance and walking speed, increased WHtR and FMI are correlated with decreased aerobic ability. A better aerobic ability is found in women with higher TChol. After adjusting for age + age^2 and the additional body composition covariates, higher values of TG, TChol, non-HDL-chol and TG/HDL-chol ratio were associated with better aerobic ability, higher TG values were associated with slower walking speed and higher TG/HDL-chol ratios were associated with weaker grip muscular strength. Many studies in the literature supported the findings; older people who have a low physical activity level had significantly higher cardiovascular risk factor as BMI, WC compared to those who have medium and high PA (106, 107), and higher HDL (107,108)and triglycerides in men (107). Increasing physical fitness hence lead to better cardiovascular disease predictors for specific physical fitness measurements, this leads to a better aging process and might be used in strategies implementation for the prevention of chronic diseases.

3. Adherence to Mediterranean diet in Lebanon

The 14 points adherence to the Mediterranean diet questionnaire (MEDAS) was adapted from Estruch et al. (109); this short questionnaire was used by the PREDIMED study for immediate feedback (110) in Spain. Mean score of adherence among younger adults (7.91); mean score of adherence among older adults (8.48) were higher than the one observed in the United Kingdom in a high risk of cardiovascular disease sample (5.47) (111) and in heart or lung transplant recipients aged 16 years or more, at least 6-months post-transplant and clinically stable patients in Manchester (6.6) (112), but it was lower than adequate adherence defined as ≥ 9 (113). Older adults had a higher score than younger ones due to better dietary habits with age similarly to a study conducted among Michigan adults; younger ones were found to have bad eating habits (114). 47.48% of the sample has an adequate adherence to the Mediterranean diet (Score ≥9) compared to 50.2% of participants having adequate score in a coronary artery disease study among older adults (115). However, 52% of older adults have an adequate score of adherence confirming healthier habits among this age group. More men have adequate score of adherence to Mediterranean diet than women due to the effect of gender on food choices influenced by the effect of the superior temporal sulcus stimulation (116). A higher percentage of adherence to Mediterranean diet was found for questions Q1, Q5, Q6, Q7, Q8, Q10, Q11 and

Q13 among coronary artery disease study than Lebanese participants (115); older adults in Beirut, Lebanon had higher percentage of adherence for questions Q2, Q3, Q4, Q9, Q12 and Q14. It should be noted that the consumption of butter and margarine is highest among Lebanese older adults (adherence 37.6% compared to 90% in the coronary artery disease study and 73.5% among older adults) who probably use it in the traditional foods (117). The low consumption of fish confirms the outcome of another study showing a low consumption of fish among the adult population living in Beirut, Lebanon (118). The correlation among the questions differs in the two age groups due to different eating habits.

Conclusions

1. **Mediterranean diet in Spain (Mallorca)**

1.1 Nutritional intake

I. The mean daily intake of polyphenol was 332.7 mg/d. Most polyphenols consumed were flavonoids, and among them the major subclass was flavanols. Alcoholic beverages were the major contributors to the total polyphenol intake (118.3 mg/d), and red wine contributed by 17.7% of total polyphenols consumed.

II. The mean daily intake of lipids was 68.6 g/day. MUFA was the main fatty acid ingested. Oils & seeds were the highest contributors in the intake of lipids. The intake of fatty acids did not abide by the International (PUFA) and Spanish recommendations (SFA, MUFA). ALA, EPA and DHA intake were lower than recommendations, but cholesterol intake was within the range of recommendations.

III. Calcium was the only mineral consumed in quantities lower than DRI, 2/3 DRI and 1/3 DRI, Magnesium was consumed is quantities lower than DRI and 2/3 DRI, Copper and iron were both consumed in quantities lower than DRI by both men and women.

1.2 Physical condition

I. Older men have decreased lower body strength and flexibility, weaker muscular grip and lower aerobic ability than younger ones. Lower aerobic ability, lower grip muscular strength and lower body flexibility is observed in higher body composition variables. In women, older age is correlated with weaker muscular grip strength; increased WHtR and FMI are correlated with decreased aerobic ability.

II. The highest maximum HGS score was found in younger participants, overweight women, active men, and men with no abdominal obesity. The highest maximum 8-f TUG score was found in older and inactive participants, low education, low income, abdominal obesity and overfat. 24.5% of participants had low maximum HGS and 36.8% had low 8-f TUG score. Sarcopenia was 0.3%, however 4.5% of men and 19.1% of women registered low physical condition (low scores in both 8-f TUG and HGS tests).

2. Mediterranean diet in Lebanon (Beirut)

I. Among university students, the mean Mediterranean score estimated was 7.96. Men had a slightly higher adherence to the Mediterranean diet than women. Nonsmokers had higher score than those who smoke. Stratification of the questionnaire revealed a relatively high spread of usage of olive oil in cooking (86.3%) though only 50.3% consumed more than 4 teaspoons per day. The percentage of participants consuming food according to the Mediterranean diet standards was higher than 50% except for wine and fish. Positive correlations were found between the different components of MEDAS, in addition the percentage of participants who had an adequate score (≥9) is higher in non-smokers.

II. Among older adults, the mean Mediterranean score estimated was 8.48. Men (9) had a slightly higher adherence to the Mediterranean diet than women (8.3). The percentage of participants consuming food according to the Mediterranean diet standards was higher than 50% except for wine and fish. Positive correlations were found between the different components of MEDAS.

Future steps are to be taken in Lebanon including validating a food frequency questionnaire for older adults, starting an interventional study on older adults to establish the correlation between abiding by the Mediterranean diet and better prognosis of diseases, general wellbeing, physical fitness and healthy aging. Do research in parallel between Spain and Lebanon the two Mediterranean countries. The polyphenol content, fatty acid content and mineral content of the food consumed in Lebanon will be investigated in older adults and compared with the results obtained in Mallorca (Eastern vs Western sides of Mediterranean area). The association between cardiovascular risk predictors and physical fitness measurements and the sociodemographic, health and lifestyle determinants of physical condition will be investigated as well in the same age group to compare it to the sample from Mallorca.

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