AGRICULTURAL UNIVERSITY OF ATHENS
Department of Food Science and Human Nutrition

FACTORS AFFECTING PHYSICAL ACTIVITY AND SLEEPING HABITS IN A REPRESENTATIVE SAMPLE OF GREEK ADULTS: THE HELLENIC NATIONAL NUTRITION AND HEALTH SURVEY

Thesis submitted for the degree of

Doctor of Philosophy

at the Agricultural University of Athens

by

Ioanna A. Bakogianni

Supervisor: Professor Antonis Zampelas

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PhD thesis

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Περίληψη

Εισαγωγή: Η σωματική δραστηριότητα θεωρείται εξαιρετικά σημαντική για τη δημόσια υγεία παγκοσμίως. Η μελέτη και κατανόηση των παραμέτρων που σχετίζονται με τη σωματική δραστηριότητα μπορεί να βοηθήσει σημαντικά στην προώθηση της δημόσιας υγείας. Κοινωνικοί και δημογραφικοί δείκτες όπως η ηλικία, το φύλο, η απασχόληση, το μορφωτικό επίπεδο καθώς και προσωπικά χαρακτηριστικά και συνήθειες τρόπου ζωής όπως το σωματικό βάρος, οι συνήθειες ύπνου και η διατροφική πρόσληψη έχουν συσχετισθεί με την σωματική δραστηριότητα. Η συσχέτιση αυτή φαίνεται να επηρεάζει τη συχνότητα εμφάνισης χρόνιων νοσημάτων και σχετικών παραγόντων κινδύνου.

Σκοπός: Σκοπός της παρούσας μελέτης είναι να περιγράψει τη συσχέτιση της σωματικής δραστηριότητας με τη διάρκεια του ύπνου, τα κοινωνικά και δημογραφικά χαρακτηριστικά και τα χαρακτηριστικά του τρόπου ζωής σε ένα αντιπροσωπευτικό δείγμα του ενήλικου ελληνικού πληθυσμού.

Μέθοδοι: Η Πανελλαδική Μελέτη Διατροφής και Υγείας είναι μία μελέτη επιπολασμού που πραγματοποιήθηκε σε αντιπροσωπευτικό δείγμα του ελληνικού πληθυσμού από το 2013 έως το 2015. Στην παρούσα μελέτη συμπεριλαμβάνεται υποδείγμα του πληθυσμού της μελέτης ηλικίας 19-64 ετών.

Αποτελέσματα: Δημογραφικά, κοινωνικά και προσωπικά χαρακτηριστικά όπως το φύλο, το μορφωτικό επίπεδο, η επαγγελματική κατάσταση και το σωματικό βάρος σχετίζονται με τη συμμετοχή σε μέτριας έντασης και έντονη σωματική δραστηριότητα. Οι παράμετροι αυτές φαίνεται να έχουν μεγαλύτερη επίδραση από περιβαλλοντικές παραμέτρους όπως η διαθεσιμότητα ανοιχτών χώρων και χώρων άθλησης καθώς και το αίσθημα ασφάλειας στη γειτονιά. Η ενασχόληση με μέτριας ένταση σωματική δραστηριότητα σχετίζεται με τη διάρκεια

του ύπνου στους άνδρες αλλά όχι στις γυναίκες. Οι υπέρβαρες και παχύσαρκες γυναίκες είναι λιγότερο πιθανό να αναφέρουν ότι συμμετέχουν σε έντονη σωματική δραστηριότητα. Η πρόσληψη λίπους φάνηκε να είναι υψηλότερη στους συμμετέχοντες που καλύπτουν τις συστάσεις για επαρκή διάρκεια ύπνου.

Συμπεράσματα: Η σωματική δραστηριότητα και η διατροφική πρόσληψη επηρεάζονται από μια σειρά κοινωνικών και προσωπικών χαρακτηριστικών. Οι παράμετροι αυτές θα πρέπει να λαμβάνονται υπόψη κατά το σχεδιασμό πολιτικών δημόσιας υγείας για την προώθηση της σωματικής δραστηριότητας. Ο σχεδιασμός της παρούσας μελέτης δεν επιτρέπει την εξαγωγή συμπερασμάτων αναφορικά με την αιτιολογική σχέση των παραμέτρων αυτών και χρειάζεται περεταίρω έρευνα για να εντοπιστούν οι μηχανισμοί που οδηγούν σε αυτές τις συσχετίσεις.

Λέξεις κλειδιά: σωματική δραστηριότητα, ύπνος, διατροφή

Επιστημονικό πεδίο: Επιστήμες υγείας

Abstract

Background: Physical inactivity is considered a major public health issue worldwide. Understanding the factors that are associated with participation in physical activity is considered a significant facilitator of health promotion. Sociodemographic indicators, personal and lifestyle characteristics such as body weight, sleep duration and dietary intake have been associated with physical activity and their association has significant impact on the prevalence of chronic diseases and their risk factors.

Aim: The aim of this study is to describe the association of physical activity with sleep, socio-demographic and lifestyle characteristics

Methods: A cross-sectional survey was conducted from 2013 to 2015 in a representative sample of the Greek population. A subsample of healthy adults 19-64 years of age of this survey, were included in the current study.

Results: Social and personal characteristics such as gender, education level, employment status and weight status are associated with engagement to moderate and vigorous physical activity. Such parameters seem to outweigh the influence of environmental characteristics such as availability of sports facilities and neighborhood safety. Engagement to moderate physical activity is associated with sleep duration in men but not in women. Obese or overweight women are less likely to participate in vigorous physical activity. Fat intake has been shown to be higher in participants who meet sleep recommendations while they have reported lower carbohydrate intake. Energy and macronutrient intake has not been shown to have any significant association with weight status in our sample. Engagement to moderate physical activity is associated with sleep duration in men but not in women. Obese or overweight women are less likely to

participate in vigorous physical activity. Fat intake has been shown to be higher in participants who meet sleep recommendations while they have reported lower carbohydrate intake.

Conclusions: Physical activity and dietary intake are influenced by an array of social, individual and lifestyle characteristics and should be taken into account when designing interventions aiming in increasing physical activity. Further research is required to identify the underlying mechanisms for these associations and their causal relationships.

Keywords: Physical activity, nutrition, sleep duration, lifestyle habits

Discipline: Health sciences

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1. Introduction

1.1 Physical activity

Physical Activity (PA) can be defined as 'any bodily movement produced by skeletal muscles, that requires energy expenditure – including activities undertaken while working, playing, carrying out household chores, travelling, and engaging in recreational pursuits.' Physical activity can also include exercise which is a subcategory of physical activity that is planned, structured, repetitive, and aims to improve or maintain one or more components of physical fitness [1].

1.1.1 Definition and core terms

The main concepts involved in defining physical activity and its health effects are: type, duration, frequency and intensity.

- The type of physical activity is the mode of participation in physical activity. The type of physical activity (or exercise) can take various forms, e.g. aerobic, strength, flexibility, balance, which may have distinct health benefits [1], [2].
    - Aerobic physical activity (endurance activity): Activity in which the body's large muscles move in a rhythmic manner for a sustained period of time such as walking, running, swimming, and bicycling.
    - Muscle-strengthening activity: Physical activity and exercise, that increases skeletal muscle strength, power, endurance, and mass is designed to improve

muscular fitness by exercising a muscle or a muscle group against external resistance/force.

- Balance training includes static and dynamic exercises that are designed to improve the ability to withstand challenges from postural sway or destabilizing stimuli caused by self-motion, the environment, or other objects. Examples of balance training are walking backward, standing on one leg, or using a wobble board.
- Flexibility training is a health and performance related component of physical fitness that is the range of motion possible at a joint. Flexibility is specific to each joint and depends on a number of specific variables including, but not limited to, the tightness of specific ligaments and tendons. Flexibility exercises enhance the ability of a joint to move through its full range of motion.

- Duration is generally expressed in minutes and refers to the length of time in which an activity or exercise is performed.
- Frequency is expressed in sessions, episodes or bouts per week and refers to the number of times an exercise or activity is performed.
- Intensity refers to the rate at which the activity is being performed or the magnitude of the effort required to perform an activity or exercise. Intensity can be expressed in absolute or relative terms:
  - Absolute intensity is the amount of energy expended per minute of activity, assessed by oxygen uptake per unit of time (mL/min or L/min) or by metabolic equivalent (MET). One MET is the rate of energy expenditure while sitting at rest, which by convention corresponds to 3.5 mL of oxygen consumed per

kilogram of body mass per minute. Absolute intensity does not take into account the physiological capacity of the individual. METs are often used to define categories of physical activity such as light (up to 3 MET), moderate (3–6 METs) or vigorous (>6 METs), according to the quantity of energy consumed, compared to the rest level. Examples of moderate-intensity PA are brisk walking, gardening, dancing and of vigorous-intensity PA are running, up-hill walking, fast cycling/swimming, aerobics, competitive sports (e.g. football, basketball, and volleyball). Table 1 shows examples of activities and their corresponding METs. However, energy expenditure for any physical activity depends on body size, which means that a person that weighs more will expend more energy performing a given task compared to a person of lower body weight.

- Relative intensity is the level of effort required to perform an activity. It takes into account or adjusts to an individual's exercise capacity. For aerobic exercise it is expressed as a percentage of an individual's aerobic capacity (VO_2 max) or VO_2 reserve, or as a percentage of an individual's maximum heart rate which is 220 – age.

Table 1: Intensity level and Metabolic Equivalents for various activities

Activity	Intensity	METs
Sleeping	Light	0.9
Television watching	Light	1.0
Desk work	Light	1.8
Cleaning – dusting	Light	2.5
Walking – strolling (4.8 km/h)	Moderate	3.3
Vacuum cleaning	Moderate	3.5
Tennis – doubles	Moderate	5.0
Walking – brisk	Moderate	5.0
Aerobic dancing	Vigorous	6.5
Tennis – singles	Vigorous	8.0
Running (9.7 km/h)	Vigorous	10.0

1.1.1.1 Summary measures of physical activity

There is a variety of measures that has been used to express the amount of physical activity that is performed. Such measures can include combinations of duration, frequency and intensity of physical activity. For example, the total duration of a physical activity of specified intensity (minutes of moderate-intensity physical activity per week) or the estimation of energy expenditure per week are often used.

A summary measure that is widely used is Physical Activity Level (PAL). PAL is the ratio of overall daily energy expenditure to BMR and is used to characterize an individual's lifestyle.

1.1.1.2 Physical fitness

Physical activity stimulates the body's musculoskeletal, cardiorespiratory and metabolic systems and causes adaptations which make them more efficient. In other words the body gets fitter [3]. Physical fitness includes cardiorespiratory fitness, strength, flexibility, speed, power and body fat levels. Health-related fitness goes beyond pure physical function and encompasses sufficient functional capacity to carry out daily tasks with vigor and alertness, without under fatigue, and with ample energy to enjoy leisure-time pursuits and respond to emergencies [4]. Figure 1 shows the association of physical fitness with behavior and health outcomes.

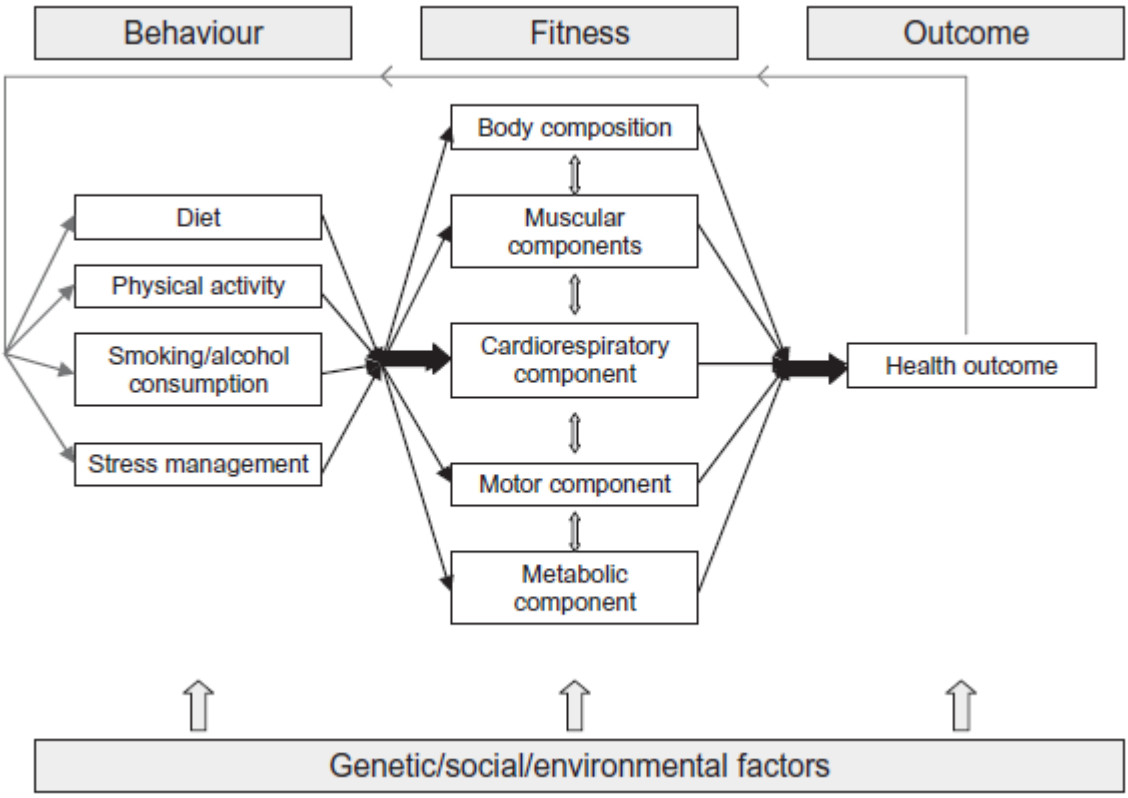


Figure 1: Association of physical fitness with behavior and health outcomes. Source L. Miles 2007 [3]

1.1.2 Domains of physical activity

Physical activity can be undertaken in different contexts throughout the day. The initial epidemiologic interest regarding the health effect of physical activity was initiated after the observation of differences in the incidence of cardiovascular disease in different occupational fields [5]. Over the past decades there has been a substantial increase in the prevalence of service occupations, accompanied with a decrease in goods producing and agricultural occupations, which is associated with a decrease in the levels of physical activity at work. This change resulted in a shift of the epidemiologic interest towards the effect of leisure time physical activity on health.

Regardless, physical activity still occurs in throughout the day, and its effect is greatly independent of its purpose. The most widely used categorization of physical activity uses four categories/ domains [4]:

- Occupational physical activity which takes place while working.
- Household physical activity includes household tasks such as cleaning or gardening.
- Transportation physical activity is performed in order to get from a place to another. Bicycling or walking to and from work or school, are examples of transportation physical activity.
- Leisure-time physical activity is performed when one is not working, doing household chores or during transportation from one place to another. Playing games, sports or exercise, and going for a walk are some examples of leisure time physical activity.

1.1.3 Physical activity assessment

Reasonably accurate measurement of physical activity is of great significance for better identifying the association between physical activity and health. Researchers often face the challenge of using a reliable and valid measure for physical activity. Doubly labelled water is still the gold standard for measuring total energy expenditure, however it is not often used due to high subject burden, cost and limited effectiveness in capturing qualitative data. Various other methods, both objective and subjective, have been developed for assessing physical activity, each of which has advantages and limitations [6].

1.1.3.1 Objective methods of physical activity assessment

1.1.3.1.1 Accelerometers

Accelerometry is an objective method for measuring physical activity which can be used both in laboratory and field settings. The main output of accelerometers is "counts" per unit time. Predictive equations have been developed in order to convert these "counts" in energy expenditure units, namely METs or kcal/min [7], [8]. The main advantage of this method is that it is non-invasive and results in a relatively low subject burden, and that it is inexpensive. However, it does not allow for accurate prediction of energy expenditure, especially when it is used for various activities.

1.1.3.1.2 Pedometers

Pedometry is mainly used to assess walking and the basic output is in form of step count. It is inexpensive and non-invasive. The main limitation of pedometry is that it is limited in

measuring walking activity and does not offer accurate measurement of distance covered and energy expended [9][10].

1.1.3.1.3 Heart rate monitors

Heart rate monitor is an objective tool, which is used to measure physical activity levels and energy expenditure. It is noninvasive and relatively inexpensive method which can be used both in controlled and free living settings. Its main limitations are that it has limited accuracy in measuring sedentary and light activities while it can be affected by electrical devices.

1.1.3.2 Subjective methods of physical activity assessment

Various subjective approaches have been developed for the assessment of physical activity and most of the times they involve the individuals recording their activity. Subjective methods include direct observation, physical activity diaries and physical activity questionnaires. The most significant shortcoming of subjective methods of physical activity assessment is that it is based on respondents' memory and recollection of PA. At the individual level, the validity of data regarding the level of physical activity and the energy expenditure from physical activity is much lower compared to objective methods [11], [12]. Subjective data tend to be more valid at a group level which allows for assessment of more people [13], [14].

1.1.3.2.1 Physical activity diaries/ logs

Self-administered physical activity diaries require participants to keep a log of physical activity in real time, providing details regarding the type, domain, duration and intensity of physical activity. This method provides detailed data and overcomes some limitations of physical activity questionnaires [15]. One of the most widely used diaries is Bouchard's Physical Activity

Record 34 in which participants report PA for each 15 minute interval over three days [16]. There is an intensity scale to rate physical activities in order to calculate total physical activity and total energy expenditure score. Use of physical activity diaries increases respondents' burden and if it is not completed in real time it is subject to memory bias.

1.1.3.2.2 Physical activity questionnaires

Physical activity questionnaires are the most common tool to assess physical activity levels. Physical activity questionnaires rely on participants' recall ability. There are different types of physical activity questionnaires which vary by the reference period, what they measure (type, duration, intensity of physical activity), how data are reported, whether they are domain specific etc. The main advantages of using questionnaires to estimate physical activity are that they are inexpensive, easy to administer, with minimum burden for the respondent [17]. As mentioned above, self-reported questionnaires are more reliable at the group than the individual level [11], [12], [18]. Moreover, its reliability can be increased when the questionnaire has a discrete reference period and is structured chronologically [17].

One of the most widely used physical activity questionnaires is the International physical activity questionnaire (IPAQ), which has been translated in many languages including Greek. The Greek version of IPAQ has also been tested for validity. IPAQ assesses three activity levels, vigorous, moderate and walking. There are two forms of the IPAQ questionnaire, the short and long form. Their difference is that in the IPAQ long form the questions are formed to provide separate domain specific information about the aforementioned types of physical activity. The reference period of IPAQ is the previous 7 days before the questionnaire is administered or typical 7 days. The output of IPAQ is the duration of walking, moderate physical activity and

vigorous physical activity during the past week which also allows for calculation of MET. In order to minimize misreporting of physical activity, both IPAQ forms include examples of different types of physical activity [19], [20].

1.1.4 Physical activity and health

Physical inactivity has been identified as the fourth leading risk factor for global mortality [21] and is considered one of the main modifiable risk factors for total mortality and risk for various chronic diseases including cardiovascular disease, diabetes, obesity, some types of cancer (breast, colon), hypertension, and depression [21].

According to the Global Burden of Disease study of 2017, 3.8% of total mortality and 8.3% of cardiovascular mortality in Europe is attributed to low physical activity (low physical activity here is defined as less than 8,000 MET-minutes per week) [22]. In Greece, the contribution of physical inactivity in total mortality is 3.3% and 7.4% for cardiovascular mortality (Figure 2) [22].

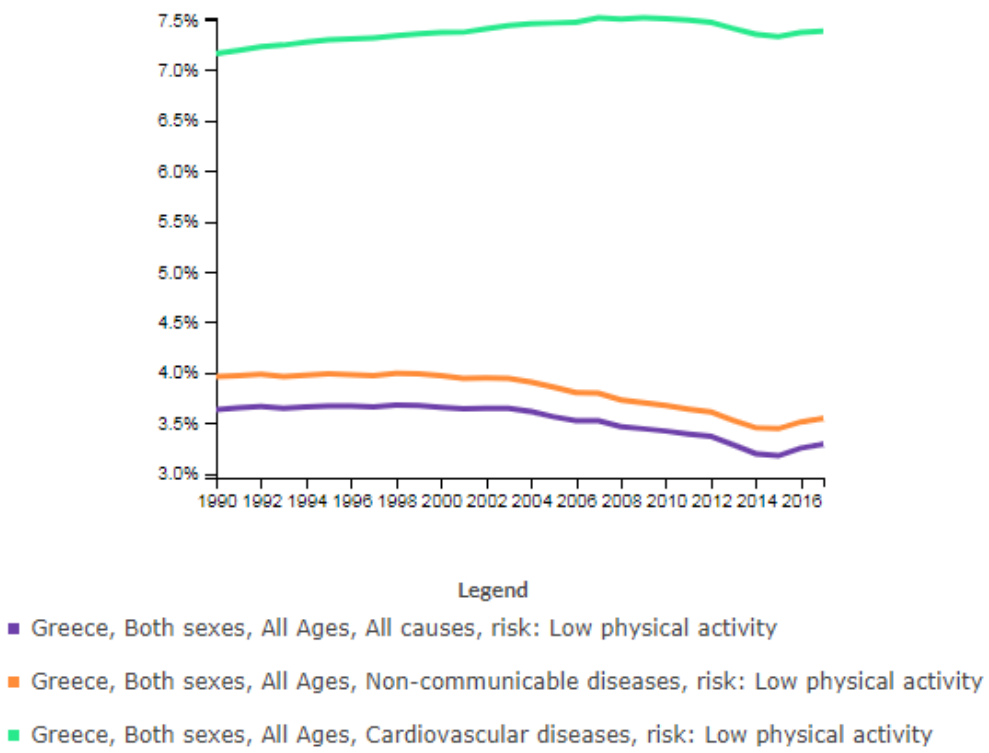


Figure 2: Percentage contribution of low physical activity in total mortality, mortality due to non-communicable diseases and mortality due to cardiovascular diseases based on Global Burden of Disease 2017 data.

A significant body of evidence demonstrates that engagement in regular physical activity is associated with various health benefits [4], [23], [24].

More specifically, there is strong meta-analyses and systematic review evidence demonstrating that there is a clear relationship between engagement to moderate-to-vigorous physical activity and all-cause mortality which does not vary by sex, age, race and weight status [25]–[27]. This has been shown to be a dose-response relationship (Figure 3).

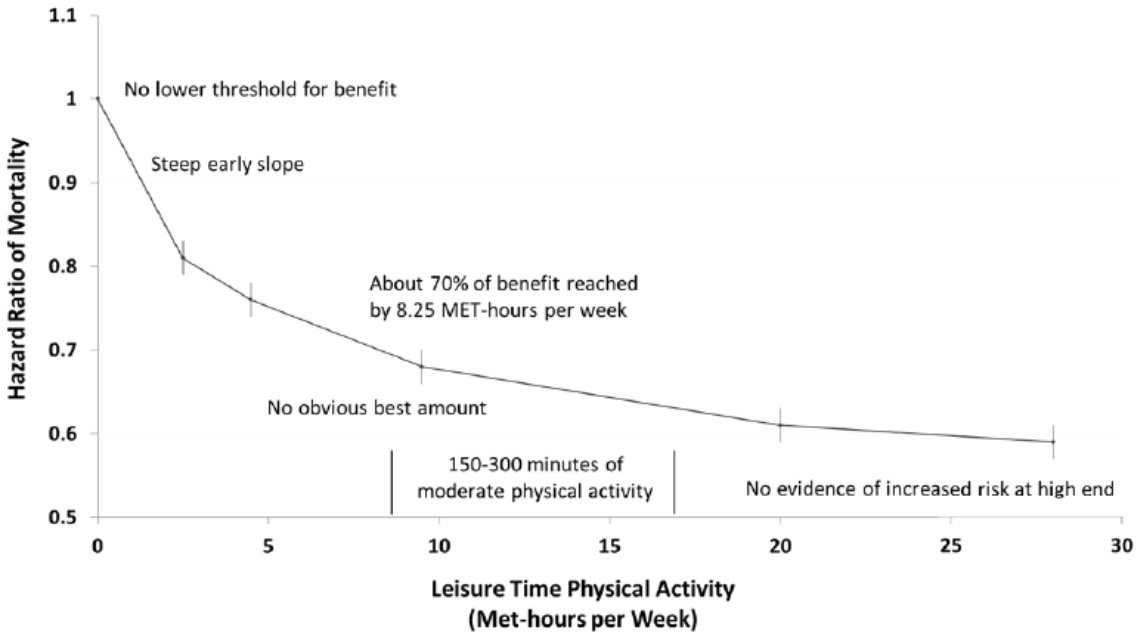


Figure 3: Relationship of moderate-to-vigorous physical activity to all-cause mortality. Source 2018 Physical Activity Guidelines Advisory Committee Scientific Report [4]

Figure 3, graphically demonstrates several important points that result from the pooled analysis of several studies examining the association of physical activity with all-cause mortality. More specifically, it has been shown that there is no lowest threshold for the beneficial effect, and at

the same time there is no apparent upper threshold. At least 70% of the potential benefit is reached at 150 minutes of moderate-to-vigorous activity per week.

Physical activity has also been shown to have a significant effect on the incidence of cardiovascular disease and cardiovascular mortality risk [4], [12]. In a meta-analysis of 36 studies, investigating the effect of low physical activity, moderate physical activity and vigorous physical activity on CVD incidence and mortality, it has been shown that CVD mortality had a strong dose-response relationship across the different categories of physical activity [28].

Physical activity participation is associated with weight gain. More specifically there is strong evidence that increased amounts of physical activity are associated with reduced weight gain in adults. Evidence shows that this relationship is more pronounced when physical activity participation is above 150 minutes per week [4]. This relationship is observed mainly with moderate-to-vigorous physical activity. The evidence regarding the association of physical activity with weight loss is not always significant. However it has been proposed that physical activity is of great importance for the maintenance of weight loss. This can be explained by the fact that weight loss results in a reduction in total energy expenditure and so any increase in physical activity serves in counteracting this decrease. The fact that those who maintain a high level of physical activity may also be better at maintaining their target of energy intake has been proposed as an additional explanation [29]. Prevention of weight regain in formerly obese individuals requires at least 60-90 minutes of moderate-to-vigorous physical activity per day [29].

There is increasing evidence supporting the significance of physical activity in primary and secondary prevention of type 2 diabetes. Given the fact that obesity is a major risk factor for

type 2 diabetes, it becomes clear that physical activity can play a significant role through the prevention of obesity. At the same time there is evidence that physical activity has an independent positive effect in the prevention of type 2 diabetes [30], [31]. Results from prospective studies support that physically active people have a 35-50% lower risk of developing type 2 diabetes compared to their physically inactive peers [32]. The benefit can be even greater for people who are at high risk of developing type 2 diabetes, as it has been shown that the risk can be reduced by 64%. Participation in physical activity can improve glucose tolerance and insulin sensitivity in people with impaired glucose tolerance. However, it is not clear yet whether there is a dose response relationship between physical activity and the risk of type 2 diabetes and which is the most beneficial type and intensity of physical activity to maximize the positive effect [30], [31].

Participation in regular physical activity has been shown to improve mental health indicators, such as reduced stress and anxiety levels and depression. This could also be involved in the prevention and management of other chronic diseases [24], [33]. More specifically, there is evidence that physical activity may result in reduced risk of clinical depression. At the same time, inactivity is associated with higher risk of subsequent depression [34]. Additionally there is evidence that physical activity has an important effect on both state anxiety (immediate anxiety feelings) and trait anxiety (stable anxiety characteristics). Longer term exercise training is associated with beneficial effects on trait anxiety [3].

Engagement to regular physical activity has been associated with the prevention of various types of cancer. Many international organizations include physical activity in their guidelines for cancer prevention. Physical activity may act in various ways to reduce cancer risk. There is a clear association of overweight and obesity with increased risk of developing various

cancers, including cancer of the breast, colon, kidney, and pancreas. Regular physical activity helps maintain a healthy body weight and may assist the prevention of certain cancers [35]. There are Greater amounts of physical activity have a strong relationship with lower risk of breast cancer. A meta-analysis of 38 cohort studies demonstrates that across all types of physical activity regardless of the domain, the highest versus the lowest physical activity engagement category, was associated with decreased risk of breast cancer [36]. In another study, it was also shown that physical activity is associated with reduced risk in both pre- and post- menopausal women [37]. Colorectal cancer and colorectal cancer mortality has also been shown to have an inverse association with participation to regular physical activity in both men and women [38].

1.1.4 Physical activity recommendations

Numerous national and international organizations have issued recommendations for physical activity. According to the World Health Organizations, adults aged 18-64 years old should do at least 150 minutes of moderate intensity aerobic physical activity per week or at least 75 minutes of vigorous intensity aerobic physical activity per week or an equivalent combination of moderate- and vigorous- intensity activity [1].

It is also recommended that aerobic activity should be performed in bouts of at least 10 minutes duration. Muscle-strengthening activities involving major muscle groups should be done on two or more days per week.

Additional health benefits could be gained by increasing moderate-intensity aerobic physical activity to 300 minutes per week, or 150 minutes of vigorous-intensity aerobic physical activity per week, or an equivalent combination of moderate- and vigorous-intensity activity [1].

1.3 Socio-demographic characteristics

Socioeconomic disparity in physical activity and nutrition is well documented and can explain observed social inequalities in health.

1.3.1 Association of Socio-demographic characteristics with physical activity, diet and health

Morbidity and mortality rates in industrialized societies have been shown to follow a socioeconomic gradient [39], [40]. There is significant amount of evidence supporting the fact that socioeconomic status and its derivatives (income, education, occupation) have a significant influence on health [41]. The main sociodemographic indicators that have been shown to affect health status are educational level and employment status. Highly educated individuals present with significantly lower cardiovascular disease mortality rate compared to individuals of primary or secondary education. `These differences are more prominent in gender male compared to female. Unemployment is also associated with poorer health [42].

Additionally it has been observed that individuals living in low-income and middle-income countries are 1:5 times more likely to die prematurely from non-communicable diseases compared to individuals that live in high-income countries [43].

Socioeconomic parameters influence several health risk factors such as poor diet and physical inactivity and smoking [44]. Diet quality is affected not only by age and sex but also by

occupation, education and income levels. There is epidemiological evidence suggesting that consumption of different food groups and nutrient is associated with socioeconomic indicators. More specifically, individuals of higher socioeconomic status (SES) are more likely to report higher consumption of fresh fruits, fresh vegetables and whole grain foods [45], [46]. At the same time, higher consumption of refined cereals and pasta is associated with lower SES. Fish, seafood and lean meat consumption is higher in higher SES groups [42], [47]. Diets of lower SES groups were characterized by fatty meats, more added fats, fried and canned fish and generally fried foods [48].

Previous study data, demonstrated that PA levels are varying across different population subgroups. In detail, it has been indicated that men are in general more physically active than women, especially when assessing leisure time PA [49]–[54]. Education and income also play a key role in the physical activity levels [50], [52], [55]–[57]

In summary, the available evidence suggests that the consumption of whole grains, lean meats, fish, low-fat dairy products, and fresh vegetables and fruit was consistently associated with higher SES groups, whereas the consumption of fatty meats, refined grains, and added fats was associated with lower SES groups.

Previous study data, demonstrated that PA levels are varying across different population subgroups. In detail, it has been indicated that men are in general more physically active than women, especially when assessing leisure time PA [49]–[54]. Furthermore, in some studies it has been demonstrated that unmarried people are the most active; however in other studies I has been shown that marital status is not related with PA behavior. Education and income also play a key role in the PA levels [50], [52], [55]–[57]. These differences observed among demographic- and/

or social separate subgroups, are key factors that should be well understood, as they could better define strategies that could be more efficient in increasing of PA.

1.4 Environmental determinants of physical activity

Given the importance of physical activity for health, research has been also focusing on the environmental factors that may tackle or promote physical activity participation. Growing literature from public health, transportation, urban planning, and leisure studies has examined the association of the built environment and physical activity. Studies examining the association of neighborhood characteristics with physical activity participation mainly focus on the presence of parks and recreation facilities, the walkability, the residential density and the vegetation of the area. Study results still remain mixed but there is evidence that proximity to parks and green areas is associated with increase moderate-to-vigorous physical activity [58]. In addition, it has been shown that an increase in the availability of physical activity facilities is associated with increased odds of achieving five or more bouts of moderate-to-vigorous intensity physical activity per week [59].

1.5 Sleep duration

It is well established that sleep is of great importance for health, cognitive performance and quality of life. There is evidence supporting that sleep influences both physical and mental health.

1.5.1 Sleep duration recommendations

The National Sleep Foundation has issued recommendations for the optimal sleep duration which is then associated with better physical and mental health outcomes. For adults 26-64 years the recommendation is for 7-9 hours of sleep.

1.5.2 Sleep duration and health

Short habitual sleep duration has been associated with increased body mass index in various population groups. Sleep deprivation has also been associated with increased energy intake and preference for high fat foods. Moreover, research has shown that sleep deprived men tend to consume more energy dense foods higher in carbohydrate content. The mechanism by which short sleep duration might affect weight status is not clear yet. Results from experimental studies suggest that sleep restriction is associated with altered levels of appetite-regulating hormones such as leptin and ghrelin which lead to increased appetite and increased food intake [60], [61].

Experimental studies have also shown that disturbed sleep duration is associated with decreased insulin sensitivity and glucose tolerance [62]. Moreover it has been associated with reduced ability to resist infection [63]. Epidemiologic studies have shown that short and long sleepers are at higher risk of coronary heart disease, type 2 diabetes, stroke and death [62], [64]–

[68]. Sleeping 7-9 hours has been systematically associated with lower risks of morbidity and mortality.

Sleep duration has been shown to interact with physical activity. The underlying mechanisms for this association are not clear. Results from NHANES have shown that individuals meeting physical activity guidelines do not report sleeping problems or short sleep duration [69]. Additionally, in other studies participants who reported exercising more than once per week were less likely to report bad sleep quality [70]. Experimental studies have also shown that physical activity is associated with improved sleep quality for people with sleeping disorders [71].

2. Survey Methodology Aims, Design and Preliminary Findings of the Hellenic National Nutrition and Health Survey (HNNHS)

Study design

This is a cross-sectional observational survey. Responders' selection was performed with a random stratified design based on the 2011 census data. Stratification was made according to (a) geographical density criteria by Greek region (7 regions), as provided by the Hellenic Statistical Authority, (b) age group of the reference population (<19, 20-65 and >65 years) and (c) gender distribution. A random selection of more than one individual per household was possible but no more than one individual from the same age group could be enrolled in the study. If households had children <6 years of age, one (if more were present) was randomly selected to be included in the study, upon consent. The sample required to accurately evaluate measures of effect for common risk factors and prevalence of chronic diseases (a priori estimated to equal to 1.2), at 0.05 level (alpha) was 3634 individuals, to achieve a statistical power equal to 85%. To maintain 85% power in the estimation of prevalence rates of chronic diseases or morbidities equal to 15%, with 1 standard deviation (SD) of the referent population (N=11,000,000), at 0.05 significance, a sample size of 4,658 was needed.

Sample

Invitations were sent to approximately 6,000 individuals (anticipating a 70-75% response rate) in to achieve the required sample size, based on a feasibility and volunteer basis in all Greek regions, by the study's investigators from 01.09.2013 to 31.05.2015. A total 4574 (42,5% men and 57.5% women) finally agreed to participate. The sample was distributed throughout Greece, with 47.2% of it residing in the Athens Metropolitan area, 18.5% in the region of Central

Macedonia, whereas the rest was almost equally scattered throughout the country (**Table 1**; p for the comparisons with Official statistics by region, age group and sex >0.7). Post-hoc assessment, accounting for large population (N>10,000) resulted in a 92% study power, for an effect size of 1.2 (OR=1.2). When the 15% probability of chronic disease was accounted for, the power was reduced to 84%.

Age standardization was performed using the 2011 Census as the reference population's data to check a-posteriori that the sampled population was representative of the Greek population, as per the aim of the study. The population was stratified by 10 years and statistical analyses were performed. The sampled population was representative for the age groups 0-19, 20-65 and 65+, and, hence were used in the analysis. Furthermore, the prevalence of chronic diseases (surveyed) of the actual Greek population (as per census), through direct standardization, was compared to the prevalence found in the study population. The crude and adjusted odds ratios (OR) calculated by age group in total and by gender did not significantly differ, hence allowing increasing generalizability of the results (all supplementary tables placed in **Appendix**).

Inclusion – exclusion criteria

Total HNNHS sample population included volunteers ≥6 months old that reside in Greece. Exclusion criteria included individuals (i), that did not speak Greek, (ii) women who were at that time breastfeeding or pregnant, (iii) members of the armed forces (including those that are currently undergoing their compulsory military service), (iv) individuals that reside in institutions (e.g. nursing homes, rehabilitation centers, hospice centers, psychiatric institutions, prisons, monasteries), (v) those that were unable to provide informed consent due to any cause

(e.g., mental impairment, psychiatric condition, drug abuse, vision or hearing loss) unless a first degree relative was able to assist in the process.

Data collection

Information was collected via a series of questionnaires, from the entire population sampled. Clinical examinations were performed on a subsample. More specifically, an initial interview took place at the volunteer's house, with the use of a specially designed computer software (i.e. Computer Assisted Personal Interview (CAPI)), to minimize response biases and misclassification (minimize volunteer burden and maximize reliability of collected data). The list of questionnaires applied can be seen in the Appendix (Supplementary Tables 1-2). In summary, the interviewing process included data on (i) demographics, (ii) quality of life (QoL), (iii) medical history (i.e. chronic & autoimmune diseases, depression, anxiety), (iv) breastfeeding, (v) vitamin and subscribed drug intake, (vi) memory impairment, (vii) eating habits, (viii) alcohol intake, (ix) smoking habits, (x) physical activity, (xi) sleeping habits, (xii) overall patient health, and (xiii) effects of economic crisis. The questionnaires were chosen according to the volunteer's age, as designated by the study's protocol (Supplementary Tables 1-3).

A detailed 24-hour dietary recall was obtained during this process. The volunteers were also interviewed for a second 24-hour dietary recall via telephone 8-20 days after the first interview and on specific days as specified by HNNHS study-protocol. Specific questionnaire structure and validated food atlases for food quantification were used depending on volunteer's age (≥1.5-4 years old, ≥4-<10 years old, ≥10-<12 years old and ≥12 years old) in order to maximize response accuracy. More specifically, dietary intake data were collected using two automated multiple-pass 24-hour dietary recalls and a Food Propensity Questionnaire (FPQ). To harmonize data collection, we based our food classification and description system on FOOdEx2

developed by EFSA [8], based on volunteers age (<2 years old and ≥2 years old). Main differences between the two versions was the food list, (was shorter for the <2 year old's), as well as the frequency response section. The latter referred to the frequency of food intake over the last 30 days for volunteers <2 years old, or to the past year for those ≥2 years old. Both FPQs were developed based on the Hellenic, European and International guidelines. Overall, the methods of dietary assessment were chosen as per EFSA recommendations for the harmonization of data across countries member states of the European Union [72]. Data on eating patterns and behaviors were also collected (timing of food intake, number of meals, activities performed during food consumption, place of consumption, and others) to account for their effects on individuals weight status as studies support [73][74][75]. The Nutrition Data System for Research (NDSR) (developed by the University of Minnesota) was used for nutrient analysis.

At the end of the interview, volunteers were provided with a list of questionnaires (hard copy) with specific instructions, to self-complete, based on the volunteer's age and their primary response to disease state during the interviewing process (Supplementary Table 2). These were to be fulfilled within a specific time period, to further reduce volunteer burden (time related) and to decrease interviewer and response bias because of the nature of the nature of the questionnaires (sensitive personal information). These questionnaires included (i) qualitative FPQ (asked to be completed by all volunteers, as explained above), (ii) perceived stress scale, (iii) perception of health control, (iii) eating behavior (iv) chronic disease specific information (onset, treatment, medical follow ups, and others), (v) pregnancy and infantile information (i.e., smoking during pregnancy, number of children, weight gain per pregnancy, infant's birth weight/length, breastfeeding (type & duration), and others), (vi) environmental exposure, (vii) social readjustment factors due to the economic crisis, (viii) asthma related information, and (vi)

gastrointestinal disorders (the Greek version of Rome III FGID questionnaires for both children and adults was completed).

Interview based questionnaires and those to be self-completed were addressed to volunteers ≥12 years old. Questionnaires related to volunteers, less than 12 years old, were addressed to his/her parent or primary guardian.

In the case of volunteers being unable to self-respond (i.e., with inhibiting health complications, adolescents with lack of knowledge in specific questions) a parent/guardian was asked to assist in the interview. The economic crisis questionnaire was answered only by one adult member per household. Information on primary respondent, or on potential help received during the process was recorded ("interviewee assistant"). A small list of questionnaires where exempt from this procedure (where the main respondent has to be the volunteer himself), due to the nature of the related questions. These included questions on (i) memory impairment, (ii) screen time and alcohol use, (≥12 years - <18 years), (iv) smoking habits (≥12 years - <18 years) and (v) patient health questionnaire.

Completed questionnaires were handed to the participants nearest mobile unit or were given to the experienced field investigator (who performed their initial interview), when completed. To achieve a maximum response rate, the study's trained personnel performed kind reminders via phone calls. A total of 3180 volunteers (2682 adults and 498 children and adolescents) completed all questionnaires (67% in total; 71% for adults and 62.6% for children & adolescents). Field investigators completed a quality control check-list upon checking the completed questionnaires.

Blood samples were taken from a sub-sample of the population. More specifically, all participants were invited to provide blood samples for biochemical – hematological evaluation.

Of them, 1197 (26.2% of total population; 28.7% of adult population) agreed; no age distribution differences were found between the total population and those who provided blood sample (p= 0.677). Each of these individuals visited one of the 5 mobile units where medical and anthropometrics were completed (please see Supplementary Table 3).

Experienced field investigators were from various scientific fields (dietitians, physicians, sociologists as well as dietetic and medical students), and received specialized training on the HNNHS fieldwork protocol. These specialists were involved in the development, methodology and application of study questionnaires and protocol procedure attainment was assessed with quality control testing, during field-investigation.

Ethical approval and consent form

The study was approved by the Ethics Committee of the Department of Food Science and Human Nutrition of the Agricultural University of Athens. It was also approved by Hellenic Data Protection Authority (HDPA). All members of the staff signed confidentiality agreements. Adult volunteers were asked to sign the consent form. For minors <13 years of age the parent or primary guardian signed the form and for volunteers between 13 and 18 years of age the consent form was asked to be signed by both (parent/ guardian and volunteer).

Questionnaires in brief

All questionnaires used in HNNHS, were derived based on a priori knowledge and from components of previously validated questionnaires. For this process. the outcome of interest and previous work performed in the Greek population were also considered

For demographic characteristics (marital status, education, health insurance, employment, income and changes in employment and/or income during the economic crisis) components from NHANES [76], Behavioral Risk Factor Surveillance System (BRFSS) study [77] and NDNS [78], questionnaires were used.

The Quality of Life (QoL) questionnaire included components of (i) QoL and chronic pain components of the Healthy Days Module developed by the Center for Disease Control (CDC) [79], (ii) questions with regards to self-reported height, weight and oral health, from the Health Survey for England and the Activity Limitations Module (also CDC developed) [80].

Two questionnaires were developed for alcohol consumption; one for minors and the second for adults. For minors (≥12 years old and <18 years old) the questionnaire was developed based on questions from the Youth Risk Behavior Survey [81], the European School Survey Project and other Drugs [82] and the Global School-based Student Health Survey (GSHS) [83]. For the adult questionnaire data from NHANES study [76], BRFSS [77], Arkansas Cardiovascular Health Examination Survey (ARCHES) [84] and Recommended Alcohol Questions by the National Institute on Alcohol Abuse and Alcoholism (NIAAA) [85] were used. Volunteers were classified as alcohol or non-alcohol consumers, based on their intake over the past 30 days. Frequency of alcohol intake among "consumers" was categorized as daily, weekly or monthly, based on their response on (i) total drinks per month consumed, (ii) drinks per week and/or (iii) drinks per month. For minors, the total number of individuals that reported having consumed an alcoholic drink at some point in life (and not just few sips) was reported.

As in the case of alcohol consumption, smoking habits questionnaire(s) were also based on volunteer's age. In particular, for adults questionnaires used were from the NHANES [76] and BRFSS [77] studies; for minors from the Youth Behavior Survey [81], NHANES [76] and the

European School Survey Project on Alcohol and other Drugs [83]. Volunteers were grouped into (i) current smokers, if they responded that they had smoked the past month, (ii) ever smokers, if they had smoked at any point in their life, and (iii) non-smokers, if they had never smoked. Frequency of smoking, among current smokers, was also recorded as "daily" or "sometimes". Among minors, the question referred as to whether they had ever tried to smoke (aged up to 19 years).

Physical activity has a well-known role as a health determinant hence the aim was to assess physical activity levels in all ages. Questionnaires on physical activity were modified based on age groups as per a priori knowledge, including (i) ≥2-<12 years old of the questionnaire was based on questions from the NHANES survey [86] and Preschool-aged Children Physical Activity Questionnaire (Pre-PAQ Home Version) [87] (ii) ≥12-<18 years old, the International Physical Questionnaire – Adolescents (IPAQ-A) [88], (iii) ≥18 years-<65 years old the IPAQ short form was used [19] and (iv) for ≥65 years of age a modified version of the IPAQ has been suggested [89]. Preliminary results reported in this study include level of physical activity as perceived by the adult volunteers (sedentary, low, moderate and active) or by the primary care giver if the volunteer was <12 years old.

Information about medical history for disease prevalence among the Greek population, related medical treatment and insurance coverage were collected. The synthesis of this questionnaire was based on the National Health Survey, NHANES [76], ARCHES [84], and the Million Women Study [90]. The definition of clinical investigated outcomes was based on the International Classification of Diseases (ICD)-10th version, recorded by experienced study investigators. Diabetes was defined as fasting blood glucose>125mg/dl or if on diabetic medication; dyslipidemia if total triglycerides> 150 mg/dl and/or total cholesterol>200 mg/dl or

on lipid-lowering medication; hypertension as average blood pressure greater or equal to 140/90 mmHg, or on antihypertensive treatment.

Further details on specific disease states (hypertension, dyslipidemia, diabetes) with specific questionnaires [84], were collected once the volunteer declared as having such a condition. In particular, data on prevalence of Chronic Obstructive Pulmonary Disease (COPD) was obtained using the COPD Population Screener [91] and Asthma using the questionnaire from the Hellenic Thoracic Society (for adults), and the Greek version of the questionnaire International Study of Asthma and Allergies in Childhood (ISAAC) [92] (minors 6 - 18 years old). Following a literature review the Rose Questionnaire for Angina [93] and the Edinburgh Claudication Questionnaire were used in HNNHS [94].

Additional the types of questionnaires used in the study can be viewed in the Appendix and they included information on breastfeeding, drug and supplement use, memory impairment (≥45 years old), eating habits and behavior (as previously reiterated), sleeping habits, data on depression, stress (acute and chronic) & health locus of control, gestational & child- birth related questions, environmental exposure, functional gastrointestinal disorders, vitamin D intake status & sun exposure, and economic crisis, to acquire adequate and substantial information on the population's exposures and risks. Details for each of these questionnaires will be provided upon analysis.

Clinical/ Physical evaluation and Biochemical variables

HNNHS also included physical examination (temperature, spirometry, blood pressure, etc.), anthropometry (weight, height, waist and hip circumference, body composition, and grip strength), and several blood tests (glucose, HbA1c (diabetics), insulin, total lipid profile, thyroid hormones, thyroglobulin, PTH, complete blood count, folic acid, iron, ferritin, B_{12}, 25OH-

vitamin D, creatine, urea, albumin, total protein, ALT, AST, bilirubin, uric acid, calcium, magnesium, manganese, selenium, hs-CRP, cortisol, and heavy metals, namely As, Cd, Co, Hg, Mo, Pb, Pt, Sb, W, Zn, Ce, La, Th, U) in a subsample of the population, to examine correlations with various health indices in later analyses (Supplementary Table 3).

Statistics

Prior to analysis, data were cross checked for missing values and outliers. Missing information was corrected if the information was derived from other questionnaires and/or measurements (non-reported values of weight and height were completed if the individual was measured at the CAPI). Also, individuals responding as non-diseased but reported taking a disease related medication, were classified as with disease outcome. Baseline socio-demographic are presented as frequencies and percentage (N, %) per gender. Variables of interest are presented in total and per gender and age-group (i.e., population's weight status, smoking, alcohol, physical activity, prevalence of chronic disease), while physical activity is presented by specific age groups (as per questionnaires). Chi-square test was used to assess gender differences by age group for weight status, smoking and alcohol intake, and for total prevalence of chronic disease by gender. Tukey's paired means test was used to detect differences between age groups (for each chronic diseases). All reported p-values were based on two-sided hypothesis tests, with significance level at 5%. The statistical models were computed using STATA 12.0 (STATA corp. Texas).

Results

Demographic data

The sample was distributed in all different regions of Greece (**Table 1**). 47.2% was in the region of Attica, 18.5% Central Macedonia, and the rest of the sample being scattered through various regions of Greece (1.3% Epirus, 4.2 % Eastern Macedonia and Thrace, 3.1% Peloponnese, 2.2% Western Macedonia, 5.2% Thessaly, 2.3% Central Greece, 4.8% Western Greece, 5.7% Crete, 1.1% Ionian islands, 2% North Aegean and 1.9% South Aegean).

The total number of participants is 4574 volunteers of which 1943 were males and 2629 females. **Table 2** shows distribution per gender, age and socioeconomic parameters. Age distribution was representative of the 2011 Census, with 19% (N=869) of the sampled population being 0-19 years old, 67% (N=3064), 20-64 years old, and 14% (N=639) were ≥65 years old. Marital status was as follows: 40.6% of the population was unmarried (43.3% males and 38.5% females), 48.4% married (51.4% males and 46.4% females) and 0.1% having a cohabitation agreement 6.2% were widowers (2.2% males and 9.2% females), 3.8% divorced and 0.7% separated.

Educational level greatly varied with approximately 32% having a University degree or greater, 7.1% had completed secondary education. Approximately 17% of the population had limited to low education, 27.1% completed lyceum (12 years of schooling), 5% technical secondary school and 8.3% private post-lyceum college. A large percentage of the population (78.3%; 77.8% males and 78.8% females) reported having public health insurance whereas only 4.3% had private insurance and 8.9% both types. A total of 8% males and 6.2% females were not insured (Table 2).

In terms of net monthly income (Table 2), 13,5% had low income (<€300-850), 11.4% had €851-1050, approximately 18% had moderate high income (€1051-1500), 10.6% had €1501-1900, 9.1% had €1901-2400, and 10.7% had high income (€2401-3800 and >€3801).

Weight status and behavioral data

Sample's self-reported weight status in total by age group (>20 years old) and gender based on Body Mass Index (BMI) can be found in **Table 3**. A total prevalence of 47.5% of the adult population was overweight (32%) and obese (15.5%), with the prevalence increasing with age in both genders. A significant body weight status difference was found in each age group, with males having a higher prevalence of overweight compared to females ($p<0.001$) in all age groups.

Frequency of alcohol consumption among adults was 72.4% (**Table 4**), with approximately 7% reporting daily consumption, 33% weekly and 60% on a monthly basis. A significant greater percentage of males reported of being alcohol consumers than females (81.1% compared to 67%, respectively; $p<0.001$) and being more frequent alcohol consumers as well ($p<0.001$). Among minors (12 to 19 years of age, inclusive), 111 out of 340 individuals (32.6%) reported as having consumed an alcoholic drink at some point before, and not only a few sips (Table 4). No significant differences were found between genders among minors in alcohol consumption ($p=0.121$).

Smoking frequency in the total population among adults and minors, per gender, is being shown in **Table 5**. Approximately 34% of the population were current smokers, whereas 50.9% reported on having smoked at some point in their life. Significant gender differences were found in both cases with a higher proportion of males reporting to have smoked (59% compared to 44%) or of being current smokers (38.3% compared to 30.8; $p<0.001$ for all). Among current smokers 87.3% reported to smoke daily with a borderline difference found between genders ($p=0.046$). A total of 22% of minors (up to 19 years of age, inclusive) reported of having tried to smoke at some point. No significant gender differences were found ($p=0.229$).

Preliminary results of physical activity level were self-reported as sedentary, low activity, moderately and very active (**Table 6**). The highest proportion of the population being very active was in young children (2-12 years old, 68.6%) and among adolescents (48.5%). Twenty – five percent (25%) of adults aged 18-65 and >65 years old reported being very active whereas 20% of the elderly (>65) reported of having a completely sedentary lifestyle.

Prevalence of chronic disease

In Table 7, the prevalence of various chronic diseases is presented in total and per age group (20-39, 40-64, and 65+) in adults. In each category, gender specific rates can also be viewed. The highest prevalence (16.7%) was reported for hyperlipidemia (increased cholesterol or triglycerides), with prevalence increasing in both genders with age (Tukey's test $p<0.001$ between groups). The same pattern was found for hypertension with the prevalence mounting to 56% (51.2% in males, 61% in females; $p<0.05$) in the elderly compared to 1.7% in adults aged 20-39 and 17.3% in the 40-65 age group (Tukey's test not significant). Accordingly, age patterns were seen in all CVD (CHD, angina, MI, heart failure, arrhythmia and stroke), with significant age group differences found only in heart failure (Tukey's test $p=0.014$ for 65+ compared to 20-39 years). Diabetes prevalence and osteoporosis was also considerably higher in the older age group (16,8%) compared to 3.8% in total population and 16.2% compared to 5.4%, respectively. Only osteoporosis was significantly different between age groups ($p<0.001$ for 65+ and 20-39 and 40-64). The prevalence of thyroid disease was high in all age groups, especially in females and significantly different between the 65+ and 20-39-year-old age groups (Tukey's test $p=0.026$). A significant difference was also found in cancer prevalence between the older and younger adult age groups (Tukey's test, $p=0.033$)

Gender differences and chronic disease

Significant gender differences were found in hyperlipidemia, arrhythmia, cancer, thyroid disease, osteoporosis, arthritis/rheumatoid arthritis, irritable bowel syndrome, depression, and chronic stress, with females having a significantly higher proportion in each one of them. Prevalence of asthma and cancer was also higher in females, more specifically in the 40-64 age group (4.8% vs. 1.7%; $p<0.05$ and 3.7% vs. 0.6%; $p<0.01$, respectively). Gender difference was also found in CHD with males having a higher prevalence in the total adult sample and in the older group ($p<0.001$, for all). The prevalence of MI did not differ in the total sample but was significantly higher in males over 65 years old than females in the same age group (9.1% vs. 1.9%; $p<0.001$). Diabetes mellitus was significantly higher in males aged 40-64 years old than females of the same age group (5.9% vs. 2.7%; $p<0.01$).

Discussion

The HNNHS was set up in 2013 with the aim to provide comprehensive, nutrition and health information, on a representative sample of the Greek population. Preliminary results of the HNNHS study showed an elevated prevalence of overweight and obesity in adults as well as dyslipidemia and hypertension. Among the adult population prevalence of overweight & obesity was almost 47%, significantly varying by gender, 17% of the total population had dyslipidemia, 13% hypertension and about 4% had diabetes and 14% were affected by a form of thyroidism. All outcomes significantly increased with age with prevalence of dyslipidemia and hypertension reaching 45% and 57% in the elderly, respectively. Furthermore, the prevalence of osteoporosis in Greek women over 65 year of age was 25.8%, a disease that is highly preventable.

In more detail, prevalence of overweight and obesity as well as chronic diseases increased with age with males having overall a higher weight status than females. This is in accordance with data from NHANES showing increased levels of obesity in adults, by sex, age and ethnicity. Hyperlipidemia prevalence in 2011 in Greece was 15% [95], and results from the ATTICA study reported that 1 in 2 adults (45±15) years old was dyslipidemic [96].This is in accordance with current results from HNNHS (44,8% in total; 39.9% in males and 48.3% in females). High levels of hypertension and hyperlipidemia were also found in other studies [97][98] and policies targeting the reduction of these public health outcomes are warranted as were developed by other countries upon findings [97][98]. Participation rate was higher in females than males, as has been reported in most European countries [99].

The proportion of alcohol consumption and current smoking status was high, although the latter, prevalence of smoking, was lower compared to previous findings in the Hellenic population[100]. An alarming proportion of minors had tried alcohol or had smoked at some point. Smoking is a known risk factor for many chronic diseases, including cardiovascular disease, many forms of cancer, asthma and COPD. Alcohol, although has been found to have protective effects on CVD, when consumed in moderation [101], it is forbidden in minors.

Regarding arterial hypertension, the present study's preliminary results are comparable with other studies where hypertension was self-reported (13.1% vs. 13.3%, respectively, n=5,003) [102]. As hypertension is a common risk factor of cardiovascular disease, data on level of awareness is warranted. Efstratopoulos et al., found an awareness level of 60.2% among Greek hypertensive individuals [103], therefore, further investigation is warranted. The prevalence of hypertension in the NHANES study, for those ≥20 years old was also close to the EPIC and HYPERTENSHELL studies (33.5%) [104]. A 4% prevalence of diabetes mellitus was

found in this study, reaching 6.3% for adults over 30 years of age, compared to 7% - 11% prevalence reported in Greece among adults [96][105] [106]. HNNHS included information on thyroid and renal function, for which there are no data available in the Greek population. Respective prevalence levels of 13.7% and 0.6% of those ≥20 years old were reported. The increased prevalence in all types of thyroid conditions (hypothyroidism, hyperthyroidism, Hashimoto thyroiditis), especially among women, underlies the value of HNNHS and stresses the need to further investigate risk factors linked to this outcome, such as iodine and vitamin D status, as well as nutritional intake and search for deficiencies. The prevalence of cardiovascular disease, the leading cause of mortality worldwide, found in the study population was 13.9%, in total. This included 7.7% of the total sample that reported having arrhythmia, 1.8% coronary heart disease, 1.3% myocardial infarction, 0.9% angina, 1.1 heart failure, and 1.1% had suffered a stroke.

Furthermore, an increased level of stress-associated disorders including chronic perceived stress (11.6%), depression (4.2%), Crohn's disease (0.4%) or ulcerative colitis (0,4%), and irritable bowel syndrome (6.9%) were found. These outcomes may be associated with the economic crisis seen in Greece over the past years but can also be linked to various nutritional and behavioral factors, that need to be examined. Interestingly, data with regards to perceived change in household budget show that most volunteers perceived change being more severe in 2012 (23.2%) than 2011 (18.3%) and 2013 (12.6%). Details that may have affected these stress-associated disorders, remain to be investigated.

Limitations

Due to the cross-sectional nature of the study, no causal relationships can be formulated. Also, the data presented and analyzed in this first report are from reported data. However,

experienced field investigators checked the data and recorded clinical outcomes based on ICD-10^{th} version codes. Furthermore, sensitive personal questions, were self-completed to decrease reporting bias. All clinical outcome data were further cross-checked with other related questions, ie, medications, in order to accurately code the participants and decrease misclassification. Reporting of data in more depth and comparison with other past small, non-nationally representative surveys in Greece are beyond the scope of this first methodological publication and will be described elsewhere.

Strengths

Health surveys as HNNHS can reveal target groups in need for prevention strategies according to educational level, employment and marital status, area of residence in a subnational level, and health behavior [40]. HNNHS, is the first national representative study performed in Greece to assess nutrition and health status of the population including all age groups. Questionnaires used were constructed after performing an extensive literature review and based on other validated questionnaires that have been used in other large national studies and in the Greek population. Another strength is the synergistic action of multiple health care specialists in study design, filed work and data analysis. Furthermore, the use of the especially designed computer software, CAPI, increases reliability of collected data, since it reduces response bias, misclassification and volunteer burden. Measurements, clinical assessment and blood tests performed in a subsample of the population will be used to further validate the preliminary results presented here.

Conclusions

The HNNHS study aims to evaluate the health of the Greek population. The data presented provide a preliminary overview of demographic and lifestyle data of the population. We envision

that this study will provide valuable information regarding the health of the Greek population and that it will become a rolling program that will facilitate the development and evaluation of public health policies addressing key risk factors that impact on the health of the Greek population.

Abbreviations

ARCHES: Arkansas Cardiovascular Health Examination Survey; BRFSS: Behavioral Risk Factor Surveillance System; CAPI: Computer Assisted Personal Interview; CDC: Centre for Disease Control; CHD: Coronary Heart Disease; CVD: Cardiovascular disease; COPD: Chronic Obstructive Pulmonary Disease; DM: Diabetes Mellitus; EFSA: European Food Safety Authority; EPIC: European Prospective Investigation into Cancer and Nutrition; FGID: Functional Gastrointestinal Disorders; FPQ: Food Propensity Questionnaire; GSHS: Global School-based Student Health Survey; HDPA: Hellenic Data Protection Authority; HNNHS: Hellenic National Nutrition and Health Survey; IPAQ: International Physical Activity Questionnaire; ISAAC: International Study of Asthma and Allergies in Childhood; MI: Myocardial Infarction; MRC: Medical Research Council; NatCen: NatCen Social Research; NDNS: National Diet and Nutrition Survey; NDSR: Nutrition Data System for Research; NHANES: National Health and Nutrition Examination Survey; NIAAA: National Institute on Alcohol Abuse and Alcoholism; OR: Odds ratio; QoL: Quality of Life; USA: United States of America.

Table 1: Distribution of the sample within Greece.

Prefecture	N	%
Attica	2160	47.2
Central Macedonia	844	18.5
Epirus	59	1.3
Eastern Macedonia, Thrace	193	4.2
Peloponnese	144	3.1
Western Macedonia	99	2.2
Thessaly	238	5.2
Central Greece	104	2.3
Western Greece	219	4.8
Crete	262	5.7
Ionian islands	51	1.1
North Aegean islands	92	2
South Aegean islands	87	1.9

Table 2: Volunteer baseline socio-demographic characteristics by gender.

	Males		**Females**	
	N	%	N	%
	1943	42.5	2629	57.5
Age				
0-19	426	21.9	443	16.9
20-64*	1259	64.8	1805	68.7
20-39	*797*	*41.0*	*1040*	*39.6*
40-65	*462*	*23.8*	*765*	*29.1*
65+	258	13.3	381	14.5
Marital status				
Unmarried	841	43.3	1012	38.5
Married	998	51.4	1217	46.3
Cohabitation agreement	2	0.1	2	0.1
Widower	43	2.2	241	9.2
Divorced	47	2.4	127	4.8
Separated	10	0.5	23	0.9
Don't know	-	-	1	0
Refused	-	-	4	0.2
Educational level				
No or little education	25	1.6	90	4
Primary school	128	8.2	224	9.9
Gymnasium	81	5.2	99	4.4
Lyceum	418	26.7	621	27.3
Technical school	133	8.5	57	2.5
Private college (Post Lyceum)	114	7.3	204	9
University degree (AEI)	336	21.5	517	22.7
University degree (TEI)	144	9.2	219	9.6
Master's degree	109	7	188	8.3
PhD	31	2	22	1
Refused	4	0.3	3	0.1
Net monthly income (€)				

≤300	76	3.9	106	4
301-650	148	7.6	285	10.8
651-850	171	8.8	264	10
851-1050	237	12.2	283	10.8
1051-1250	172	8.9	236	9
1251-1500	178	9.2	237	9
1501-1900	222	11.4	264	10
1901-2400	183	9.4	231	8.8
2401-3800	177	9.1	202	7.7
>3801	51	2.6	59	2.2
Don't know	122	6.3	214	8.1
Refused	204	10.5	246	9.4
Health insurance				
Uninsured	156	8	162	6.2
Insured, private	91	4.7	105	4
Insured, public	1511	77.8	2071	78.8
Insured, both private and public	157	8.1	252	9.6
Don't know	10	0.5	20	0.8
Refused	4	0.2	3	0.1

*the sampled population (N%) in the age group 20-64, was further categorized to 20-39 years and 40-65 to cross-reference with further analysis performed in these sub-categories.

Table 3: Population's weight status in total by age group and gender based on Body Mass Index (BMI) categorization.

Weight Status Categorization[±]	Total		By age group* and gender					
	Total Adult Population*		20-39[a]		40-64[b]		65+[c]	
			N (%)		N (%)		N (%)	
	N	%	M	F	M	F	M	F
Underweight	175	4.7	12 (1.5)	88 (8.5)	5 (1.1)	25 (3.3)	8 (3.1)	37 (9.8)
Normal weight	1772	47.9	420 (52.7)	722 (69.5)	139(30.2)	335 (43.8)	60 (23.3)	94 (24.8)
Overweight	1183	32.0	285 (35.8)	160(15.4)	212 (46.0)	244 (31.9)	127 (49.2)	154 (40.6)
Obese total	572	15.5	80 (10.0)	69 (6.6)	105 (22.8)	161 (21.1)	63 (24.4)	94 (24.8)

N (%), Frequency (percentage); M, males; F, Females

By gender: % of males or females in question compared to total number of males or females, respectively

[±] based on BMI (kg/m^2) categorization: <18.5 = underweight; 20-25=normal weight; >25-30=overweight; >30=obese

*Study population ≥20 years of age; Chi square test for difference in weight status between age groups in total ($p<.001$) and per gender ($p<.001$)

[a] Chi square test for difference in weight status between genders in 20-39-year-old group ($p<0.001$)

[b] Chi square test for difference in weight status between genders in 40-65-year-old group ($p<0.001$)

[c] Chi square test for difference in weight status between genders in 65+ year-old group ($p<0.006$)

Table 4: Frequency of alcohol consumption habits in minors and adults in total and by gender.

	Alcohol consumption*						
Adults (20+ years)	Total		Males		Females		Level of significance [a]
	N	%	N	%	N	%	
The past 30 days*							
No	998	26.9	285	18.8	713	32.8	p<0.001
Yes	2685	72.4	1229	81.1	1454	67.0	
Frequency							
Everyday	183	6.8	128	10.4	55	3.8	p<0.001
Weekly	874	32.6	456	37.1	418	28.8	
Monthly	1628	60.6	645	52.5	981	67.5	
Minors (12-19 years) ****							
Ever consumed							
No	229	67.4	142	89.3	153	84.5	p=0.121
Yes	111	32.6	17	10.7	28	15.5	
Don't know	1	0.5					
Refused	-	-					

**for adults (20 + years of age: N= 3705 in total, 7 missing): any alcohol consumption the past 30 days and frequency of consumption; ** for minors (12-20 years of age, N=340, 159 males and 181 females): whole alcoholic drink consumed at some point in life (and not just few sips). 66 minors were <18 years and 45 18 &19 years old*

[a] tested via chi square test for gender differences in adult population (20 years +) and in minors (up to 19 years); *p<0.05; **p<0.01; ***p<0.001;

Table 5: Frequency of smoking habits in total population among adults and minors by gender.

	Smoking**						
Adults (20+ years)	Total		Males		Females		Level of significance [b]
	N	%	N	%	N	%	
Ever smoked							
No	1935	52.4	620	41.0	1215	56.0	p<0.001
Yes	1878	50.9	893	59.0	955	44.0	
The past 30 days*							
No	2433	65.7	934	61.5	1497	68.5	p<0.001
Yes	1252	33.8	580	38.2	672	30.8	
Frequency							
Every day[a]	1093	87.3	519	89.5	574	85.4	P=0.046
Some days [a]	158	12.6	60	10.3	98	14.6	
Don't know	1	0.1					
Refused	-	-					
Minors (10-19 years)							
Ever smoked							
No	100	76.3	33	70.2	67	79.8	p=0.229
Yes	29	22.1	12	25.5	17	20.2	
Don't know	1	0.8					
Refused	1	0.8					

**for adults (>19 years of age: 3705 in total): ever smoking; for minors specified if they even tried it (then response yes)[a] for adults smoking the past 30 days (frequency (%) of smoking for smokers N=1252)[b]*
tested via chi square test for gender differences in adult population (20 years +) and in minors (up to 19 years); *p<0.05; **p<0.01; ***p<0.001;

Table 6: Physical activity levels among different age groups based on self-reported data.

Physical activity	**≥2 - <12 years**		**≥12 - <18 years**		**≥18 - <65 years**		**≥65 years old**	
	N	%	N	%	N	%	N	%
Sedentary way of life	-	-	-	-	-	-	128	20
Low activity	15	3.2	24	11.7	584	18.3	117	18.3
Moderate active, average	126	26.7	74	35.9	1357	42.4	205	32.1
Very active	324	68.6	100	48.5	812	25.4	160	25
Don't know	-	-	1	0.5	2	0.1	1	0.2
Refuse to respond	-	-	-	-	2	0.1	-	-

* Individuals were asked to report their perceived physical activity status or to state their child's if they responded on their behalf.

Table 7: Prevalence of chronic disease in adult population sampled, in total, by gender and by gender and age group.

Presence of disease/ condition	Total		By gender and age group[a]							
	Total Sample		By Gender [b] N (%)		20-39 N (%)		40-64 N (%)		65+ N (%)	
	N	%	M	F	M	F	M	F	M	F
Increased cholesterol or triglycerides[1]	765	16.7	297*** (15.2)	468 (17.8)	62** (7.8)	48 (4.6)	127 (27.6)	226 (29.5)	103* (39.9)	183 (48.3)
Don't know	175	3.8								
Hypertension	608	13.3	241 (12.4)	367 (14.0)	21* (2.6)	11 (1.1)	88 (19.1)	124 (16.2)	132* (51.2)	231 (61.0)
	47	1.0								
Coronary Heart Disease	69	1.8	53*** (3.4)	16 (0.7)	0 (0)	1 (0.1)	17 (3.7)	1 (0.1)	36*** (14.0)	14 (3.7)
Don't know	32	0.8								
Angina	36	0.9	19 (1.2)	17 (0.8)	6 (0.8)	4 (0.4)	6 (1.3)	2 (0.3)	7 (2.7)	10 (2.6)
Don't know	31	0.8								
Myocardial Infarction (Heart attack)	49	1.3	37 (2.4)	12 (0.5)	0	0	16** (3.3)	5 (0.7)	21*** (8.1)	7 (1.9)
Don't know	13	0.3								
Heart failure	42	1.1	16 (1.0)	26 (1.1)	0	3 (0.3)	2 (0.4)	8 (1.1)	14 (5.0)	15 (4.0)
Don't know	27	0.7								
Arrhythmia	295	7.7	91** (5.8)	204 (9.0)	21 (2.6)	48 (4.6)	25 (5.4)	71 (9.3)	45 (17.4)	78 (20.6)
Don't know	42	1.1								
Stroke	41	1.1	18 (1.1)	23 (1.0)	1 (0.1)	2 (0.2)	3 (0.7)	4 (0.5)	14 (5.4)	17 (4.5)
Don't know	11	0.3								
Cancer	53	1.2	14** (0.7)	39 (1.5)	3 (0.4)	1 (0.1)	3** (0.6)	28 (3.7)	8 (3.1)	10 (2.6)
Don't know	8	0.2								
Diabetes (Type I & II)[2]	162	3.6	73 (3.8)	89 (3.4)	3 (0.4)	4 (0.4)	27** (5.9)	21 (2.7)	42 (16.3)	64 (16.9)
Don't know	24	0.5								
Thyroid (any type of condition) [3]	629	13.8	93*** (4.8)	536 (20.4)	36*** (4.5)	160 (15.4)	26*** (5.6)	248 (32.4)	24*** (9.3)	113 (29.8)
Don't know	102	2.2								
Asthma	184	4.0	69 (3.6)	115 (4.4)	40 (5.0)	48 (4.6)	8* (1.7)	37 (4.8)	6 (2.3)	20 (5.3)
Don't know	16	0.4								
Chronic Obstructive Pulmonary Disease	63	1.6	25 (1.6)	38 (1.7)	5 (0.6)	8 (0.8)	9 (2.0)	15 (2.0)	11 (4.3)	15 (4.0)

(COPD)										
Don't know	77	0.6								
Chronic kidney disease	27	0.6	13 (0.7)	14 (0.5)	3 (0.4)	1 (0.1)	2 (0.4)	4 (0.5)	8 (3.1)	9 (2.4)
Don't know	3	0.1								
Osteoporosis[4]	206	5.4	13*** (0.8)	193 (8.3)	1 (0.1)	3 (0.3)	4*** (0.9)	95 (12.3)	8*** (3.1)	95 (25.8)
Don't know	79	2.1								
Arthritis/ Rheumatoid disease	324	7.1	65*** (3.3)	259 (9.9)	9* (1.1)	23 (2.2)	28*** (6.1)	106 (13.9)	28*** (10.8)	128 (33.8)
Don't know	83	1.8								
Crohn's disease or Ulcerative colitis	16	0.4	6 (0.3)	10 (0.4)	2 (0.2)	3 (0.3)	1 (0.2)	6 (0.8)	3 (1.2)	1 (0.3)
Don't know	6	0.1								
Irritable Bowel Syndrome (IBS)	317	6.9	53*** (2.7)	264 (10.1)	25*** (3.1)	105 (10.1)	18*** (3.9)	121 (15.8)	9* (3.5)	35 (9.2)
Don't know	46	1.0								
Depression	180	4.2	42*** (2.3)	138 (5.6)	15 (1.9)	33 (3.2)	12*** (2.6)	62 (8.1)	15 (5.8)	42 (11.1)
Don't know	63	1.5								
Chronic Stress	495	11.6	128*** (7.1)	367 (14.9)	56*** (7.0)	143 (13.8)	42*** (9.1)	134 (17.5)	25** (9.7)	78 (20.6)
Don't know	39	0.9								

[a] tested via chi square test for gender differences by age group; [b] tested via chi square test for gender differences in total sample; *p<0.05; **p<0.01; ***p<0.001;

By gender: % of males or females who reported as having the outcome in question compared to total number of males or females, respectively

By age-group: Number of outcomes reported per gender in each age-group (%)

[1]3.5 % of the sample replied that they do not know for cholesterol; <1% for hypertension, coronary heart disease, angina, myocardial infarction (0.3), stroke (0.3), heart failure, ; arrhythmia (1.1%), diabetes (0.53), 2.2% for any thyroid disease, asthma (0.35%), chronic obstructive pulmonary disorder (0.63%). Kidney failure (0.1%), 2.1% for osteoporosis, 1.8% for arthritis, 0.1% for Crohn's disease, 1.0% for irritable bowel syndrome, 1.5% for depression, 0.91% for chronic stress

[2] prevalence for type I diabetes: 3/4754

[3] 0-19 age group: for thyroid disease: Males (1.6%) and females (3.4%); For asthma: Males (3.5%), Females (2.3%); For chronic stress: Males 1.55%, females 4.3%

[4] out of which 13 osteopenia

3. Main socio-demographic, personal and neighborhood determinants of physical activity in adult Greek population

Introduction

The first hypotheses, regarding the beneficial effect of physical activity (PA) on health, came from observations of differences in the incidence of cardiovascular disease, depending on occupation [107]. However, PA levels are descending worldwide and are linked to health problems such as obesity, hypertension, glucose intolerance and diabetes, coronary artery disease and other [108].

Physical inactivity has been identified as the fourth leading risk factor for global mortality [21]. Specifically, it has been demonstrated that physically inactive individuals have 20% higher mortality risk, when compared to physically active peers [109], [110]. Beyond the effects of PA on reducing the risk of non-communicable diseases and on delaying the development of chronic disease [111], it has also beneficial effects on reducing stress and depression, improving emotional well-being and satisfaction [112]–[114]. Despite the well-reported and widely known beneficial effects of regular PA, the increasing prevalence of physical inactivity worldwide has major implications for the general health of the population and the prevalence of non-communicable diseases [1].

Previous study data, demonstrated that PA levels are varying across different population subgroups. In detail, it has been indicated that men are in general more physically active than women, especially when assessing leisure time PA [49]–[54]. Furthermore, in some studies it has been demonstrated that unmarried people are the most active; however in other studies it has been shown that marital status is not related with PA behavior. Education and income also play a key role in PA levels [50], [52], [55]–[57].

Environmental and neighborhood characteristics have also been correlated with PA behavior. It has been observed that availability of recreational facilities may influence participation in PA [115]–[119]. There are many factors that can affect participation in PA, such as availability of- and accessibility to open areas and sports facilities, safety [120] and the general characteristics of the area of residence [121].

The aim of this study is to identify the levels of PA in the Greek adult population using reported PA data of the Hellenic National Nutrition and Health Survey (HNNHS), the first nationally representative survey in Greece, and to describe the association of social, demographic, personal and neighborhood characteristics with participation in PA.

2. Methods

2.1 Study design

This study uses part of the sample collected in the terms of the Hellenic National Nutrition and Health Survey. HNNHS has been conducted by the Department of Food Science and Human Nutrition of the Agricultural University of Athens. It is a cross-sectional observational survey that included a nationally representative sample of the Greek population.

2.2 Participants and Sample

HNNHS participants are individuals over 6 months of age that reside in Greece. Pregnant and breastfeeding women, non-Greek-speaking residents, individuals undergoing compulsory military service, institutionalized individuals and people unable to provide informed consent of participation were excluded from the survey. The selection of participants was performed with a random stratified design based on 2011 census data of the Hellenic Statistical Authority, and resulted in 4574 participants over 6 months of age (42.5%

male and 57.5% female). Sample was collected in several areas of Greece, 47.2% were residents of Athens Metropolitan area, 18.5% were residents of the region of Central Macedonia and the rest was scattered throughout the country.

The sample of this analysis includes HNNHS participants 19-64 years of age who have no disability or chronic physical or mental disease. In detail, volunteers that reported that have been diagnosed with cancer, heart failure, chronic obstructive pulmonary disease, chronic kidney disease, autoimmune rheumatic diseases, arthritis, and autoimmune digestive disorders (Crohn's disease, ulcerative colitis) and depression or have a permanent moving disability were excluded from the analysis. Moreover individuals that had missing demographic data or missing or misreported physical activity data were excluded from the analysis. A sample of 2,296 participants was included in the analysis.

2.3 Data collection

Data collection of the HNNHS was performed between September 2013 and May 2015 and included an in-person interview using Computer Assisted Personal Interview which was designed for the aims of the HNNHS as well as a series of self-reported questionnaires.

Physical activity assessment and neighborhood characteristics

The International Physical Activity Questionnaire (IPAQ) was used to obtain information on PA. IPAQ is widely used worldwide to assess adults' physical activity levels. It has been translated in 22 languages and has been used in more than 150 studies. The short IPAQ form has also been translated in Greek, and test of validity has been performed in the translated form. It assesses physical activity based on its intensity. Participants were asked about the number of days and hours/minutes per day over the last 7 days related to walking, moderate-intensity, and vigorous-intensity activity. All questions include definitions and examples of the type of PA in order to minimize misreporting. IPAQ short form does not allow domain

(work, domestic, transport-related, leisure time physical activity) specific estimates of PA. Metabolic equivalent tasks (METs) from the formal guidelines of IPAQ were used. The number of minutes spent per week participating in each activity was multiplied by the MET score for that activity. The assigned MET levels used in the IPAQ scoring protocol are 8.0 for vigorous activity, 4.0 for moderate-intensity activity and 3.3 for walking. Total MET score is calculated by summing the MET scores of each activity type. According to the IPAQ scoring protocol, participants who achieved at least 3000 MET-minutes/week were assigned to the vigorous PA level category. Participants in moderate PA level category reported at least 600 MET-minutes/ week. Participants were categorized as participating in low PA level either when no activity was reported or when the activity reported was not enough to meet moderate or vigorous PA level category. Information on the availability of open areas and physical activity facilities such as parks, gyms, pools, as well as on the individual's frequency of perceived safety in the neighborhood where also assessed in the terms of the physical activity questionnaire of the HNNHS.

Socio-demographic data

Socio-demographic data were collected using valid questions that have been used by the Hellenic Statistical Authority but also from other national health surveys such as the National Health and Nutrition Examination Survey in the U.S. and the National Diet and Nutrition Survey in the UK. Data on participants' gender, age, education level, occupation and marital status was collected. Information on obtained educational qualifications was collected in response to the question: 'What is the highest educational qualification that you have obtained?'. Education level was categorized in primary (up to 6 years of formal education), secondary (6-12 years of formal education) and tertiary education level (more than 12 years of formal education). Information on employment status was self-reported in

response to the question "What is your current employment status?', and participants where then categorized in employed, unemployed, and retired.

Anthropometric and lifestyle characteristics

Data on self-reported standing height in meters and weight in kilograms were collected. Body Mass Index (BMI) was calculated by dividing self-reported body weight in kilograms (kg) by the squared self-reported height in meters (kg/m^2). Moreover, information was collected on participants' smoking habits.

2.4 Statistical analysis

Descriptive statistics, including proportions, frequencies, means and standard deviations were used for all variables. The large sample size, allows assuming that age, as a continuous variable, follows a normal distribution.

Physical activity levels were measured and categorized using the IPAQ scoring protocol; hence the participants were divided in three categories according to the levels of PA they engage in. Demographic and lifestyle characteristics are presented as mean (± standard deviation, SD) for continuous variables and as proportions for categorical variables.

Differences between categorical variables were calculated using the chi-square test for heterogeneity and trend. Differences between means were calculated using the t-test and analysis of variance. Multinomial logistic regression models assessing determinants of moderate and vigorous physical activity levels (compared to low) were fitted. The statistical significance level was set to 5 %. All analyses were performed using STATA statistical software (STATA 14.0, StataCorp LP, Texas, U.S.A.).

3. Results

3.1 Study participants

Table 1 describes the sample in terms of socio-demographic variables, weight status and smoking habits overall and stratified by gender. The mean age of the sample is 35.3 years and does not differ significantly between men and women. The vast majority of the sample (97.2%) was of secondary (39.2%) and tertiary (58.0%) education level. More women than men had completed more than 12 years of education (60.9% vs 54.3%). There was a significant difference in the employment status among two sexes, as 40.3% of women were unemployed compared to 26.3% of men. The prevalence of smoking was 8.1% higher in men than in women, while more men reported to be former smokers than women (23.2% vs 16.8%). As far as weight status is concerned, the average BMI of the total sample was 24.7 kg/m^2. Prevalence of overweight and obesity was higher for men (53.5%) than for women (46.5%).

Table 2 describes the sample in terms of the PA indicators that are assessed with IPAQ. Days of walking for the last 7 days before the interview, were similarly reported across genders, while the practice of moderate and vigorous-intensity physical activities differed significantly among men and women. The prevalence of zero days of vigorous activity was almost 20% higher in women than in men. Days of moderate activity was more frequent among women. There is a statistically significant difference between the total PA levels, as calculated using IPAQ score. Women seem to engage more in moderate physical activity than men (44.1% vs 37.6%), while men are more likely to report vigorous activity compared to women (40.3 vs 36.3%).

Crude analysis (Pearson's chi square test) of sample characteristics with PA level is presented in table 3. Women 40-64 years of age report higher levels of PA compared to those

of 19-39 years. For men there is no significant difference in PA levels among the different age groups.

Education level was associated with PA levels for both men and women. Most of the participants of secondary and tertiary education level engaged to moderate and high PA.

Employed women are less physically active than unemployed and retired women. There is no statistically significant difference between employment status and PA for men.

Marital status is not related to PA levels for men, but married women are more likely to lead a sedentary lifestyle compared to single women, while single women are more likely to engage to vigorous PA.

Male smokers are less physically active than male nonsmokers. 42.5% of male non-smokers report vigorous PA levels compared to 37.3% for smokers, while 27.2% of smokers report that they lead a sedentary life-style compared to 18% for non-smokers. Weight status, availability of open areas and perceived safety in the neighborhood do not seem to be associated with the levels of PA for both men and women.

Results of the multinomial logistic regression model assessing the determinants of physical activity levels are presented in Table 4. Availability of open areas and marital status are not significantly associated with PA levels in both genders. In both men and women, there is a marginally significant association between tertiary education level and engagement to vigorous physical activity. Retired and unemployed men are more likely to do moderate and vigorous physical activity respectively compared to employed men. Women who are overweight or obese appear to be significantly less likely to engage to moderate and vigorous PA compared to their under-/ normal-weight peers.

4. Discussion

This study is the first to assess PA participation determinants in a representative sample of the Greek population, using a valid questionnaire. Based on the frequency and duration of PA reported during the interview with the participants and the IPAQ scoring protocol, the sample was divided in three major categories, low PA, moderate PA and vigorous PA.

Previous study data, demonstrated that PA levels are varying across different population subgroups. In detail, it has been indicated that men are in general more physically active than women, especially when assessing leisure time PA [49]–[54]. Furthermore, in some studies it has been demonstrated that unmarried people are the most active; however in other studies it has been shown that marital status is not related with PA behavior. Education and income also play a key role in the PA levels [50], [52], [55]–[57]. These differences observed among demographic- and/ or social separate subgroups, are key factors that should be well understood, as they could better define strategies that could be more efficient in increasing of PA.

In our study, men are generally more active than women as they report higher frequency of vigorous PA. Women report higher participation in moderate PA. There is no statistically significant difference in the frequency of walking among the two sexes. This finding is in accordance with significant amount of literature where it seems that men report higher levels of PA. Men, generally, seem to participate more in leisure time PA, which is mainly associated with vigorous PA.

Age does not seem to be a significant determinant of PA participation or PA levels. Generally, age produces mixed results as far as participation in PA is concerned, especially in

the case of the current study that does not include older adults that generally tend to show low participation in PA.

As far as marital status is concerned, consistently with literature, there is no clear and significant association of marital status with the levels of PA for both sexes.

From our study it has been shown that people that are more physically active have higher educational level (Figures 1a and 1b). The number of participants that have completed up to 6 years of formal education is very small, thus they are not included in these analyses. This finding is in accordance with existing literature where it has been shown that higher education level is associated with higher levels of PA as a whole but it is also related with increase participation in leisure PA [57], [122]–[124].

There is a significant amount of literature assessing the effect of availability and accessibility of PA facilities and open spaces on PA levels and PA participation [125]. At the same time many interventions aiming in creating a more PA enhancing environment have been designed and implemented. In our study PA participation is not significantly associated with access to PA facilities. Finally, the participants' perceived feeling of neighborhood does not seem to be a significant factor affecting participation in PA.

Based or our findings, demographic and personal characteristics outweigh the influence of environmental characteristics.

To conclude, from our study it has been shown that PA participation could be affected by various factors varying from socio-demographic to personal and environmental factors.

The findings of this study can be of great significance for public health. Physical activity is of great importance for public health. HNNHS gives the opportunity to have a clear picture of the parameters that could facilitate and tackle participation in PA, hence it could provide a significant source of information for policy-makers to create policies and education

campaigns, custom to the needs of the Greek population, in order to achieve higher levels of PA and in the long-term result in lower incidence of non-communicable disease.

Strengths and limitations

The main strength of this study is that it includes a nationally representative sample of the Greek population. At the same time valid questionnaires and valid methods have been used in order to collect the information. Another very important strength is that there is a full set of data for each individual including demographic and social characteristics, medical history, PA assessment and other lifestyle characteristics.

The main limitation of the current study is that a subjective method is used for assessment of PA, which involves a high degree of subjectivity and reporting bias. Moreover, despite the fact that, in order to minimize the participants' burden, we decided to use the short form of IPAQ could increase the possibility of misreporting of PA as it does not allow domain specific reporting of PA participation.

Table 1. Study sample characteristics

	n	Overall	Women	Men	
Sex, n (%)	2,296		1,282 (55.8)	1,014 (44.2)	
Age, years*	2,296	35.3 (SD:12.2)	35.0 (SD:12.4)	35.5 (12.1)	0.194
Education, %	2,293				0.000
Pre-primary & Primary	64	2.8	3.4	2.1	
Secondary	898	39.2	35.7	43.6	
Tertiary	1,331	58.0	60.9	54.3	
Employment status, %	2,290				0.000
Employed	1,377	60.1	53.8	68.1	
Unemployed	782	34.2	40.3	26.3	
Retired	131	5.7	5.9	5.6	
Marital status, %	2,294				0.087
Married	1,380	60.2	58.7	62.0	
Single/Never married	883	38.5	39.6	37.1	
Separated/ divorced/ widowed	31	1.3	1.7	0.9	
Smoking habits, %	2,287				0.000
Smoker	789	34.5	30.9	39.2	
Non smoker	1,494	65.5	69.1	60.8	
Former smoker	291	19.4	16.8	23.2	0.005
Weight, kg	2,251	72.7 (SD:15.7)	64.9 (SD:0.3)	82.9 (SD:0.4)	0.000
Height, m	2,272	1.7 (SD:0.09)	1.65 (SD:0.002)	1.79 (SD:0.002)	0.000
BMI, kg/m^2	2,236	24.7 (SD: 4.3)	23.8 (SD:0.1)	26.0 (SD:0.1)	0.000
Under-normal weight, %	1,322	59.1	69.2	46.5	
Overweight/ Obese, %	914	40.9	30.8	53.5	

Table 2. Description of the sample in terms of leisure-time physical activity variables

	Women %	Men %	p-value
Days of vigorous activity in the last 7 days			0.000
0	70.7	51.3	
1-2	13.2	17.1	
3-4	11.1	16.8	
>5	5.0	14.8	
Days of moderate activity (other than walking) in the last 7 days			0.015
0	26.2	31.6	
1-2	24.0	24.8	
3-4	20.5	18.2	
>5	29.3	25.4	
Days of walking in the last 7 days			0.060
0	16.1	18.3	
1-2	16.1	15.9	
3-4	16.1	12.4	
>5	51.7	53.4	
Physical Activity levels			0.007
Low	19.6	22.1	
Moderate	44.1	37.6	
High	36.3	40.3	

Tab le 3: Association of sample characteristics with physical activity levels, stratified by gender. (*Pearson chi-square test)

	Women				Men			
	Physical activity level (based on total MET/week)				**Physical activity level (based on total MET/week)**			
	Low	**Moderate**	**High**	**p-value***	**Low**	**Medium**	**High**	**p-value***
Age, %				0.003				0.072
19-39	21.6	44.8	33.6		20.1	38.2	41.7	
40-64	15.5	42.6	41.9		26.4	36.2	37.4	
Education, %				0.001				0.000
Pre-primary & primary	9.3	30.2	60.5		19.0	28.6	52.4	
Secondary	19.0	40.5	40.5		20.4	30.4	49.2	
Tertiary	20.5	46.9	32.6		23.6	43.6	32.7	
Employment status, %				0.016				0.531
Employed	21.3	18.8	8.0		23.1	36.1	40.8	
Unemployed	45.1	43.0	42.7		21.0	40.6	38.4	
Retired	33.5	38.2	49.3		16.1	42.9	41.1	
Marital status, %				0.000				0.091
Married	21.7	47.3	31.0		19.4	38.5	42.1	
Single/ never married	16.6	39.0	44.4		26.3	35.9	37.8	
Separated/ Divorced/ Widowed	9.1	54.5	36.4		33.3	44.4	22.2	
Smoking habits, %				0.688				0.006
Smoker	19.6	42.9	37.5		27.2	35.5	37.3	
Non-smoker	18.7	45.0	36.3		18.4	39.1	42.5	
Former-smoker	18.2	50.7	31.1	0.276	11.9	47.6	40.5	0.011
BMI category, %				0.335				0.331
Under-normal weight, %	17.7	45.3	37.0		20.9	36.4	42.7	
Overweight/ Obese, %	21.3	43.0	35.7		23.1	38.8	38.1	
Available open areas				0.059				0.955
0-1	19.2	42.4	38.4		22.9	35.7	41.4	
2-3	15.4	49.1	35.5		21.3	37.2	41.5	
4-6	22.0	41.7	36.3		22.3	38.3	39.4	
Frequency of perceived neighborhood safety				0.683				0.643
Never	28.6	33.3	38.1		28.6	28.6	42.9	
Rarely	25.0	43.2	31.8		29.4	23.5	47.1	
Sometimes	21.2	45.5	33.3		21.5	39.2	39.2	
Most of the time	19.8	44.3	35.9		18.7	40.3	41.0	
Always	16.4	44.5	39.1		24.2	35.9	39.9	

Table 4: Association of Physical Activity levels and socio-demographic, lifestyle and neighborhood characteristics

	Moderate PA			**Vigorous PA**		
	Coefficient	Standard Error	p-value	Coefficient	Standard Error	p-value
Men						
Open areas						
2	0.168	0.273	0.537	0.104	0.269	0.700
3	0.136	0.249	0.585	0.075	0.246	0.760
Education						
Secondary	-0.176	0.692	0.799	-0.495	0.635	0.436
Tertiary	0.033	0.690	0.961	-1.225	0.637	0.054
BMI						
Overweight/Obese	0.067	0.181	0.712	-0.144	0.180	0.425
Marital Status						
Married	0.369	0.252	0.143	0.452	0.251	0.072
Divorced/Widowed	0.002	0.800	0.998	-0.776	0.952	0.415
Employment status						
Unemployed	0.101	0.221	0.646	-0.510	0.224	0.023
Retired	0.898	0.449	0.046	0.612	0.459	0.182
Women						
Open areas						
2	0.270	0.261	0.300	0.043	0.272	0.874
3	-0.240	0.235	0.308	-0.217	0.244	0.372
Education						
Secondary	-0.280	0.690	0.685	-0.995	0.653	0.128
Tertiary	-0.244	0.689	0.724	-1.285	0.654	0.049
BMI						
Overweight/Obese	-0.440	0.181	0.015	-0.691	0.192	0.000
Marital Status						
Married	0.098	0.228	0.668	-0.426	0.235	0.070
Divorced/Widowed	1.207	1.069	0.259	0.608	1.091	0.577
Employment status						
Unemployed	0.089	0.181	0.621	0.171	0.188	0.363
Retired	0.480	0.502	0.338	0.777	0.499	0.120

Figure 1a: Physical activity level in women stratified by education level

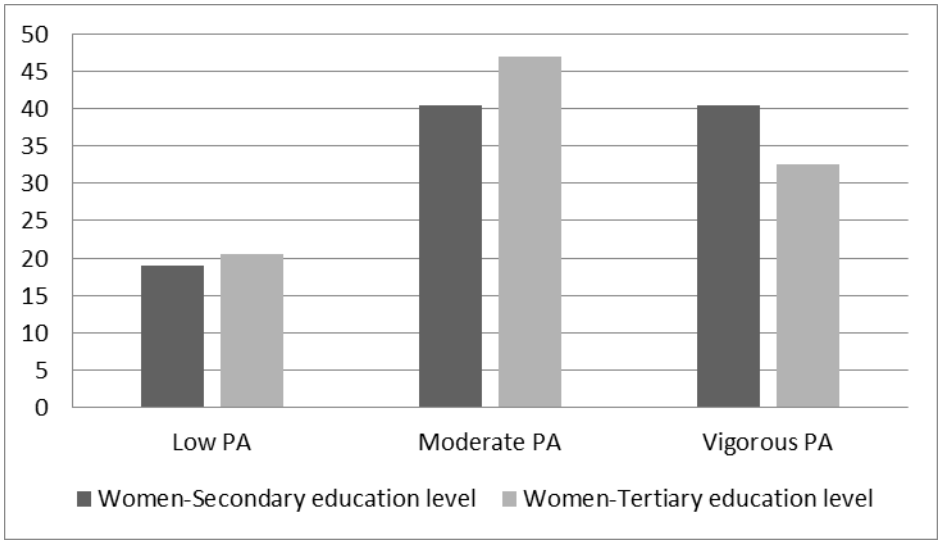
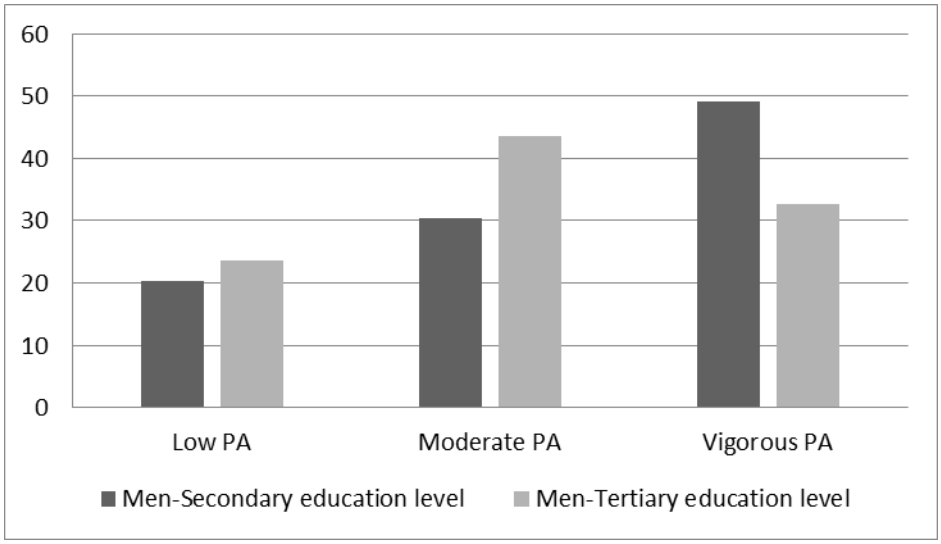


Figure 1b: Physical actvity level in men stratified by education level



4. Physical activity and dietary intake in association with sleep duration and weight status in a representative sample of the Greek adult population. Results from the Hellenic National Health and Nutrition Examination Survey (HNNHS)

Overweight and obesity are significant health burdens worldwide. There is a well-established relationship between dietary intake and health. The consumption of specific food groups or nutrients has been associated with prevalence of non-communicable diseases including cardiovascular disease and related risk factors, obesity, and cancer [126]. At the same time, physical activity has been shown to have an effect in many health aspects, especially those related with obesity and its consequences. Many public health organizations worldwide have issued recommendations for Health enhancing physical activity, suggesting engagement to minimum 150 minutes of moderate physical activity or 75 minutes of vigorous activity per week which corresponds to about 600 MET per week [4]. Meeting the recommendations for physical activity has been associated with reduced risk for cardiovascular disease, diabetes, and some types of cancer such as breast and colon cancer [127]. Dietary intake and physical activity are considered important modifiable risk factors for total mortality and development of non-communicable disease. However, it is widely known that individuals in western societies are following unhealthy diet habits and are physically inactive. For this reason, there is a growing scientific interest in identifying the parameters that might influence dietary intake and participation in physical activity. There is evidence that sleep duration is significantly associated with increased mortality and risk of obesity and weight gain [66], [128]–[130] and has also been associated with lower levels of engagement to physical activity [130]. Current recommendations for adequate sleep suggest that adults should sleep 7-9 hours per night [131]. The mechanism by which short sleep

duration might affect weight status is not clear yet. Results from experimental studies suggest that sleep restriction is associated with altered levels of appetite-regulating hormones such as leptin and ghrelin which lead to increased appetite, thus increased food intake [60], [61]. Additionally, sociodemographic and lifestyle characteristics have been associated with diet and physical activity. More specifically diet quality is affected by occupation and educational levels which are main indexes of socioeconomic status [42], [132], [133]. PA levels vary across different population subgroups as well. In detail, men are in general more physically active than women, especially when assessing leisure time PA [49], [52]. Education and income also play a key role in the physical activity levels [56], [57], [134].

The aim of this study is to explore the association of physical activity and dietary intake with lifestyle characteristics such as sleep duration and weight status.

Methods

Study design

This study uses part of the sample collected in the terms of the Hellenic National Nutrition and Health Survey (HNNHS). HNNHS has been conducted by the Department of Food Science and Human Nutrition of the Agricultural University of Athens. It is a cross-sectional observational survey that included a nationally representative sample of the Greek population.

Participants and Sample

HNNHS participants are individuals over 6 months of age that reside in Greece. Pregnant and breastfeeding women, non-Greek-speaking residents, individuals undergoing compulsory military service, institutionalized individuals and people unable to provide informed consent of participation were excluded from the survey. The selection of participants was performed with a random stratified design based on 2011 census data of the Hellenic Statistical Authority, and resulted in 4574 participants over 6 months of age (42.5% male and 57.5% female). Sample was collected in several areas of Greece, 47.2% were residents of Athens Metropolitan area, 18.5% were residents of the region of Central Macedonia and the rest was scattered throughout the country.

The sample of this analysis includes HNNHS participants 19-64 years of age who have no disability or chronic physical or mental disease. In detail, volunteers that reported that have been diagnosed with cancer, heart failure, chronic obstructive pulmonary disease, chronic kidney disease, autoimmune rheumatic diseases, arthritis, and autoimmune digestive disorders and depression or have a permanent moving disability were excluded from the analysis. Moreover, individuals that had missing demographic data, missing or misreported physical activity data or sleep duration data were excluded from the analysis. Additionally, extreme energy intakes (<600 or >6,000 kcal/d) were excluded from the dietary intake analysis. A sample of 2,217 participants was included in the main analysis.

Data collection

Data collection of the HNNHS was performed between September 2013 and May 2015 and included an in-person interview using Computer Assisted Personal Interview which was designed for the aims of the HNNHS as well as a series of self-reported questionnaires.

Physical activity assessment

The International Physical Activity Questionnaire (IPAQ) was used to obtain information on PA. IPAQ is widely used worldwide to assess adults' physical activity levels. It has been translated in 22 languages and been used in more than 150 studies. The short IPAQ form has also been translated in Greek, and test of validity has been performed in the translated form. It assesses physical activity based on its intensity. Participants were asked about the number of days and hours/minutes per day over the last 7 days related to walking, moderate-intensity, and vigorous-intensity activity. All questions include definitions and examples of the type of PA in order to minimize misreporting. IPAQ short form does not allow domain (work, domestic, transport-related, leisure time physical activity) specific estimates of PA. Metabolic equivalent tasks (METs) from the formal guidelines of IPAQ were used. The number of minutes spent per week participating in each activity was multiplied by the MET score for that activity. The assigned MET levels used in the IPAQ scoring protocol are 8.0 for vigorous activity, 4.0 for moderate-intensity activity and 3.3 for walking. Total MET score is calculated by summing the MET scores of each activity type. According to the IPAQ scoring protocol, participants who achieved at least 3000 MET-minutes/week were assigned to the vigorous PA level category. Participants in moderate PA level category reported at least 600 MET-minutes/ week. Participants were categorized as participating in low PA level either when no activity was reported or when the activity reported was not enough to meet moderate or vigorous PA level category.

Dietary assessment

Assessment of dietary intake in the HNNHS was performed using interviewer-administered 24 hour recall which was based on the USDA Automated Multiple-Pass Method (AMPM) [135]. The FoodEx2 food classification and description system developed by EFSA was used for the standardized description of the reported food items [136]. Age appropriate

food atlases and standardized household measures (e.g. glasses, plates) were used to assist participant in accurately estimating the portion size of the food consumed. Two 24 hour recalls were performed for each participant. The first 24 hour recall was collected in-person during the interview and the second by telephone (15.5% of the survey's participants did not complete the second 24 hour recall). In order to analyze data collected in the 24 hour recall, the Nutrition Data System for Research (NDSR; Nutrition Coordinating Center, University of Minnesota) was used as the main food composition database. This database was further enriched for traditional dishes using data derived from Greek food composition tables. Intake of energy was expressed in kcal/day. Macronutrient (protein, total fat, carbohydrates) was expressed in g/day and for the purpose of this study their contribution to total energy intake was also calculated.

Demographic, lifestyle & sleep data

Socio-demographic data were collected using valid questions that have been used by the Hellenic Statistical Authority but also from other national health surveys such as the National Health and Nutrition Examination Survey in the U.S. and the National Diet and Nutrition Survey in the UK. Data on participants' gender, age, education level, occupation and marital status was collected. Information on obtained educational qualifications was collected in response to the question: 'What is the highest educational qualification that you have obtained?'. Education level was categorized in primary (up to 6 years of formal education), secondary (6-12 years of formal education) and tertiary education level (more than 12 years of formal education). Information on employment status was self-reported in response to the question "What is your current employment status?'; and participants where then categorized in employed, unemployed, and retired.

Data on self-reported standing height in meters and weight in kilograms were collected. Body Mass Index (BMI) was calculated by dividing self-reported body weight in

kilograms (kg) by the squared self-reported height in meters (kg/m^2). Moreover, information was collected on participants' smoking habits.

Data on sleep habits was collected using questions from valid questionnaire, namely the NHANES SQL [137] and The Pittsburgh Sleep Quality Index [138].

3. Results

3.1 Study participants

Table 1 describes the sample in terms of socio-demographic variables, weight status, smoking habits, sleep duration, physical activity levels and dietary intake overall and stratified by gender. The mean age of the sample is 35.2 years and does not differ significantly between men and women. The vast majority of the sample (97.1%) were of secondary (38.9%) and tertiary (58.2%) education level. More women than men reported having completed tertiary education level (61.5% vs 54.1%). There was a significant difference in the employment status among two sexes, as 40.1% of women were unemployed compared to 26.3% for men. The prevalence of smoking was significantly higher in men than in women (by 8.1%), while more men reported to be former smokers than women (23.4% vs 16.7%). As far as weight status is concerned, the average BMI of the total sample was 24.7 kg/m2. The prevalence of overweight and obesity was higher for men (53.1%) than for women (30.7%). Physical activity levels differed significantly between men and women. Women engage more in moderate physical activity than men (45.3% vs 38.2%), while men are more likely to report vigorous activity (40.7 vs 36.8%). At the same time, women were more likely to follow the recommendation for health enhancing physical activity compared to men. Total energy, total fat and total carbohydrates intake did not differ between men and women but protein intake was higher for women than men (17.2% vs 16.3%). There was no

significant difference in sleep duration between males and females. Due to small sample number for participants who reported long sleeping hours (more than 9), participants who slept more or less than recommended duration were grouped together. Analysis was also performed when excluding those participants, and the results or the tendency of the results did not differ.

Physical activity, sleep duration and weight status

Crude analysis (Pearson's chi square test) of sample characteristics and sleep duration with PA level is presented in table 2. Women 40-64 years of age report higher levels of PA compared to those of 19-39 years. For men there is no significant difference in PA levels in the different age groups. Education level was associated with PA levels for both men and women. Most of the participants of secondary and tertiary education level engaged to moderate and high PA. Employed women are less physically active than unemployed and retired women. There is no statistically significant difference between employment status and PA for men. Male smokers are less physically active than male nonsmokers. 42.4% of male non-smokers report vigorous Weight status is not significantly associated with PA levels. As far as sleep duration is concerned, there is a significant association of physical activity level with sleep duration in men. In detail, men that follow recommendations for adequate sleep are more likely to engage to moderate physical activity compared to those that do not.

This analysis was repeated using Multinomial Logistic Regression adjusted for age, smoking, education and employment; it has been shown that men that follow recommendations for adequate sleep (7-9 hours) are more likely to engage to moderate physical activity. This association is not significant in vigorous physical activity levels. In addition, weight status is not associated with physical activity in male participants. In female participants there was no

significant association between sleep duration and PA levels. However, it has been shown that overweight and obese women are 40% less likely to engage to vigorous PA compared to their under- and normal-weight peers.

Dietary intake, sleep duration and weight status

Crude analysis exploring the association of energy and macronutrient intake with sleep duration, engagement to physical activity and sample characteristics using Student's ttest is presented in Table 3. There is as significant association between energy intake and meeting PA recommendations. More specifically, male participants that meet PA recommendations have been shown to consume less kcal per day compared to the ones that do not meet PA recommendations (2016 kcal vs 2172 kcal). This relationship is still significant by inverse for female participants where women that engage to health enhancing physical activity consume more calories compared to the ones that do not. There is also significant relationship between total fat and total carbohydrates intake and sleep duration in men. More specifically, men that sleep 7-9 hours report higher fat intake (38.5% vs 36.8%) and lower carbohydrate intake (46.7% vs 48.6%) compared to short and long sleepers. Female participants that follow sleep recommendations consume more total fat (38.1% vs 36.5%) and less protein (17.0% vs 17.7%) compared to the ones that do not.

The adjusted multiple regression model used is shown in Table 5 with sleep duration and weight status as predictors and energy and macronutrient intake as the outcome, adjusted for sex, age, education, smoking and physical activity level. Weight status is not significantly associated with dietary intake. There is a significant association between sleep duration and total fat and carbohydrate intake (adjusted for energy). As indicated, participants that sleep 7-9 hours report more total fat intake (1.72%) per day. Analysis was also performed for

saturated fat (results not shown) but no significant association was indicated. Furthermore, participants who reported sleeping 7-9 hours reported less total carbohydrate intake (1.9%) compared to participants who sleep less or more than recommended.

Discussion

To our knowledge this is the first study to investigate the association of physical activity participation and dietary intake of energy and macronutrients with sleep duration, weight status and other sociodemographic and lifestyle characteristics in a nationally representative sample of the Greek adult population.

According to our analysis, physical activity is associated with sleep duration in men but not in women. More specifically, men that sleep 7-9 hours are more likely to engage to moderate physical activity compared to men than sleep less or more than that. This association is not present in vigorous levels of physical activity. This finding is accordance with other epidemiologic studies which have shown that better self-reported sleep is positively associated with better self-reported physical activity [139]–[141]. There are many parameters that have been explored to explain this relationship. More specifically, there is evidence that better sleep is related with greater ability and willingness to exercise [142]. Moreover, individuals who engage to health enhancing physical activity also tend to follow healthier lifestyle habits which are related to sleep such as tobacco use, excessive caffeine intake, and alcohol intake. In our sample, we have shown that male non-smokers are more likely to be more physically active compared to smokers. There is also epidemiologic evidence that physical activity results in better sleep. This is a cross-sectional study hence our findings do not infer causality between sleep duration and physical activity. Further research, needs to take place in order to have a clear understanding of the mechanisms associated with the effect of sleep duration on physical activity levels.

Female participants who are obese or overweight are less likely to report engagement to vigorous physical activity. This relationship was not statistically significant for men but the tendency was present in vigorous levels of physical activity. Literature also supports that

overweight and obesity is consistently inversely associated with physical activity [143], [144].

Multiple regression results show that weight status is not associated with energy and macronutrient intake in our sample. Moreover, there was no interaction between energy intake and sleeping hours. This has also been shown in other epidemiological studies [145]. Participants who meet sleep recommendations have been shown to report higher fat intake. This is not in accordance with existing evidence where it has been found that inadequate sleep is associated with higher consumption of fat and lower intake [146]–[148]. Moreover participants meeting sleep recommendations reported lower carbohydrate intake. Experimental studies have also indicated higher intake of carbohydrates in sleep restriction conditions [64], [149]. At the same time, there is also evidence that sleep duration was independent from fat and carbohydrate intake [145]. It seems that there is mixed evidence regarding the association of sleep duration and dietary intake. At the same time the mechanisms underlying this association is not clear yet.

To sum up, our evidence suggests that physical activity and dietary intake are associated with sociodemographic, personal and lifestyle parameters. The cross-sectional study design does not allow for causal inferences but it provides a great background for further research on lifestyle determinants of dietary intake and physical activity.

Strengths and limitations

The main strength of this study is that it includes a nationally representative sample of the Greek population. At the same time valid questionnaires and valid methods have been used in order to collect the information. Another very important strength is that there is a full set of data for each individual including demographic and social characteristics, medical history, PA assessment and other lifestyle characteristics. Additionally the dietary assessment method used was multiple 24 hour recall, administered by the AMPM method, which standardizes the description of the reported food items and, therefore, maximizes the accuracy of the estimated food consumption.

Some limitation should also be considered. This study uses data from a cross-sectional study, which does not allow for drawing conclusions regarding causality between physical activity or dietary intake and sleep duration, weight status and other parameters. Another significant limitation is that a subjective method is used for the assessment of PA, which involves a high degree of subjectivity and reporting bias. Similarly, duration of sleep is also self-reported. Moreover, the fact that, in order to minimize the participants' burden, we decided to use the short form of IPAQ could increase the possibility of misreporting of PA as it does not allow domain specific reporting of PA participation.

Table 1. Study sample characteristics

	Overall	Male	Female	p-value
Sex, n (%)		984 (44.4)	1,233 (55.6)	
Age, years*	35.2 (SD:12.2)	35.4	35.1	0.572
Education, %				0.000
Pre-primary & Primary	2.9	2.1	3.5	
Secondary	38.9	43.8	35.0	
Tertiary	58.2	54.1	61.5	
Employment status, %				0.000
Employed	60.3	68.2	54.1	
Unemployed	34.0	26.3	40.1	
Retired	5.7	5.5	5.8	
Marital status, %				0.057
Married	60.2	62.3	58.6	
Single/Never married	38.5	36.9	39.7	
Separated/ divorced/ widowed	1.3	0.8	1.7	
Smoking habits, %				
Smoker	34.7	39.2	31.1	0.000
Non smoker	65.3	60.8	68.9	
Former smoker	19.5	23.4	16.7	
Weight, kg	72.7 (SD:15.6)	82.8	64.6	0.000
Height, m	1.71 (SD: 0.09)	1.79	1.65	0.000
BMI, kg/m^2	24.7(SD:4.4)	26.0	23.7	0.000
Under-normal weight, %	59.2	46.9	69.3	
Overweight/ Obese, %	40.8	53.1	30.7	
Physical Activity levels (%)				0.003
Low	19.4	21.1	17.9	
Moderate	42.1	38.2	45.3	
High	38.5	40.7	36.8	
Recommended physical activity level				0.015
Yes	80.6	78.3	82.5	
No	19.4	21.7	17.5	
Energy intake (kcal)	2028 (SD:881.8)	2050 (SD: 883)	2011 (SD: 880)	0.301
Total fat intake (%)	37.8 (SD:10.4)	38.1 (SD:10.2)	37.5 (SD:10.5)	0.198
Total protein intake (%)	16.8 (SD:5.5)	16.3 (SD:5.3)	17.2 (SD:5.6)	0.000
Total carbohydrate intake (%)	47.6 (SD:14.2)	47.1 (SD:13.3)	48.0 (SD:14.9)	0.161
Sleep duration (hours)	7.6	7.7	7.6	0.293
Short sleep (%)	28.8	23.4	26.0	0.348
Recommended sleep duration (%)	63.0	67.3	65.7	
Long sleep (%)	8.2	9.3	8.3	

Table 2: Association of physical activity sleep duration and sample characteristics, stratified by gender.

	Male				Female			
	Physical activity level (based on total MET/week)				**Physical activity level (based on total MET/week)**			
	Low	**Moderate**	**High**	**p-value***	**Low**	**Moderate**	**High**	**p-value***
Age, %				0.090				0.028
19-39	19.2	39.0	41.8		19.4	46.1	34.5	
40-64	25.3	36.5	38.1		14.9	43.7	41.5	
Education, %				0.000				0.000
Pre-primary & primary	19.0	28.6	52.4		9.3	30.2	60.5	
Secondary	19.3	30.7	50.0		16.0	42.0	42.0	
Tertiary	22.8	44.6	32.6		19.5	47.9	32.6	
Employment status,%								
Employed								
Unemployed								
Retired								
Smoking habits, %				0.022				0.735
Smoker	25.4	36.4	38.2		18.5	43.6	37.9	
Non-smoker	18.1	39.5	42.4		17.6	46.0	36.4	
Former-smoker	12.1	47.9	40.0	0.030	16.2	52.8	31.0	0.194
BMI category, %				0.207				0.433
Under-normal weight, %	19.6	37.1	43.3		16.3	46.4	37.2	
Overweight/ Obese, %	22.5	39.6	37.9		19.4	44.1	36.5	
Recommended Sleep duration, %				0.008				0.079
Yes	20.2	41.8	38.0		16.1	45.8	38.0	
No	22.3	31.3	46.3		20.7	46.5	11.3	

*Pearson chi-square test

Table 3: Association of macro-nutrient intake with sleep duration and sample characteristics

	Males				Females			
		Dietary intake (%E)				Dietary intake (%E)		
	Energy (kcal)	**Total fat (%E)**	**Total carbohydrates (%E)**	**Total protein (%E)**	**Energy (kcal)**	**Total fat (%E)**	**Total carbohydrates (%E)**	**Total protein (%E)**
Age								
19-39	2044	38.1	47.1	16.3	2005	37.5	48.0	17.1
40-64	2064	38.1	47.3	16.4	2024	37.6	48.1	17.3
Smoking habits								
Smoker	2052	38.2	46.8	16.9	2039	37.9	47.3	17.2
Non-smoker	2044	38.0	47.4	16.0	1998	37.4	48.3	17.2
Former-smoker	2003	37.4	48.1	16.2	2013	37.7	47.6	17.2
BMI category								
Under-normal weight	2079	38.4	46.7	16.2	2020	37.4	48.1	17.2
Overweight/ Obese	2021	37.8	47.6	16.4	2001	37.6	48.0	17.1
Recommended PA levels								
Yes	2016*	38.0	47.0	16.0	2038*	37.4	48.1	17.3
No	2172*	38.3	47.6	16.4	1880*	37.8	47.5	16.7
Recommended Sleep duration								
Yes	2040	38.5*	46.7*	16.2	1982	38.1*	47.5	17.0*
No	2049	36.8*	48.6*	16.3	2080	36.5*	49.2	17.7*

*ttest

Table 4: Association between physical activity sleep duration and weight status

	Moderate PA			Vigorous PA		
	Risk Ratio	Standard Error	p-value	Risk ratio	Standard Error	p-value
Males						
Age category						
40-64	0.68	0.14-	0.068-	0.53	0.11	0.004
Recommended sleep duration						
Yes	1.49	0.29	**0.045**	0.90	0.17	0.571
BMI						
Overweight/Obese	1.02	0.19	0.918	0.76	0.14	0.159
Smoking habits						
Smoker	0.65	0.12	**0.019**	0.59	0.11	**0.006**
Education						
Secondary	0.93	0.63	0.916	0.70	0.43	0.561
Tertiary	1.15	0.21	0.837	0.30	0.19	0.058
Employment status						
Unemployed	1.33	0.31	0.208	0.66	0.15	0.077
Retired	2.07	0.93	0.107	1.52	0.70	0.369
Females						
Age category						
40-64	1.33	0.15	0.184	1.46	0.33	0.093
Recommended sleep duration						
Yes	1.26	0.22	0.192	1.42	0.26	0.059
BMI						
Overweight/Obese	0.76	0.15	0.161	0.61	0.12	**0.016**
Smoking habits						
Smoker	0.94	0.17	0.750	1.10	0.21	0.628
Education						
Secondary	0.87	0.59	0.840	0.34	0.22	0.099
Tertiary	0.4	0.58	0.810	0.24	0.15	**0.028**
Employment status						
Unemployed	1.12	0.21	0.543	1.17	0.23	0.425
Retired	1.98	1.02	0.189	2.88	1.49	**0.041**

Table 5: Association between macro-nutrient with sleep duration and weight status

	Total energy (kcal)			**Total fat (%E)**			**Total carbohydrates (%E)**			**Total protein (%E)**		
	Coeff.	SE	p-value	Coeff.	SE	p-value	Coeff.	SE	p-value	Coeff.	SE	p-value
Sex												
Females	-28.4	41.6	0.494	-0.39	0.49	0.420	0.68	0.67	0.305	0.91	0.26	0.001
Age												
40-64	-1.3	45.7	0.977	0.33	0.53	0.536	-0.53	0.73	0.468	0.42	0.29	0.146
Education level												
Secondary	16.8	126.5	0.894	2.80	1.48	0.059	-4.55	2.03	**0.026**	0.24	0.79	0.763
Tertiary	2.38	126.2	0.985	2.77	1.48	0.061	-4.38	2.03	**0.031**	0.34	0.79	0.668
Smoking habits												
Smoker	44.3	41.9	0.290	0.20	0.49	0.681	-0.78	0.67	0.244	0.42	0.26	0.108
Weight status												
Overweight/ Obese	-45.0	43.7	0.303	0.15	0.51	0.760	0.15	0.70	0.835	-0.12	0.27	0.651
Physical activity level												
Moderate	4.7	55.13	0.932	-0.05	0.65	0.935	-0.13	0.88	0.882	-0.02	0.34	0.943
Vigorous	-108.1	56.5	0.056	-0.04	0.66	0.950	-0.70	0.90	0.436	-0.10	0.35	0.769
Recommended sleep duration												
Yes	-68.2	42.3	0.108	1.72	0.50	**0.001**	-1.90	0.68	**0.005**	-0.47	0.26	0.077

5. Conclusions

To our knowledge this is the first study to assess the association of sociodemographic determinants with physical activity and the association of physical activity with sleep duration in a representative sample of the Greek adult population, using valid questionnaires. Based on the frequency and duration of PA reported during the participants' interview and the IPAQ scoring protocol, the sample was divided in three major categories, low PA, moderate PA and vigorous PA.

In our study, men are generally more active than women as they report higher frequency of vigorous PA. Women report higher participation in moderate PA.

There is a significant amount of literature assessing the effect of availability and accessibility of PA facilities and open spaces on PA levels and PA participation. At the same time many interventions aiming in creating a more PA enhancing environment have been designed and implemented. In our study, PA participation is not significantly associated with access to PA facilities. Finally, the participants' perceived feeling of neighborhood does not seem to be affecting participation in PA.

According to our analysis, physical activity is associated with sleep duration in men but not in women. More specifically, men that sleep 7-9 hours are more likely to engage to moderate physical activity compared to men than sleep less or more than that. This association is not present in vigorous levels of physical activity. A lot of research has been performed to explain this association but is still not clear. Some parameters that are thought to be involved in the association of physical activity and sleep are that better sleep results in greater ability and willingness to exercise, the fact that physically active individuals also tend to engage to healthier lifestyle habits which are related to sleep such as tobacco use, excessive caffeine intake, and alcohol intake. In our sample, non-smokers are more likely to be more physically active compared to smokers. Female participants who are obese or

overweight are less likely to report engagement to vigorous physical activity. This relationship was not statistically significant for men but the tendency was present in vigorous levels of physical activity.

Presence of overweight and obesity is not associated with energy and macronutrient intake in our sample. Moreover, there was no interaction between energy intake and sleeping hours. Participants who meet sleep recommendations have been shown to report higher fat intake. Moreover participants meeting sleep recommendations reported lower carbohydrate intake. Experimental studies have also indicated higher intake of carbohydrates in sleep restriction conditions. At the same time, there is also evidence that sleep duration was independent from fat and carbohydrate intake. The evidence regarding the association of sleep duration with dietary intake, and the underlying mechanisms are not clear yet.

Our results add to existing literature regarding the significance of sleep duration on health indicators. The evidence still remains unclear mainly due to the presence of major confounders and the fact that all sleep duration, physical activity and dietary intake are self-reported. Further analysis and research is required in order to better understand the mechanisms which result in the effect of sleep duration in health. Our results could serve as an important theoretical base for the design of experimental studies and trials in order to measure the effect of sleep duration on dietary intake of specific nutrients, on diet quality, on willingness to perform physical activity and on the levels of physical activity.

Furthermore, our analysis suggests that physical activity is associated with sociodemographic, personal and lifestyle parameters which seem to outweigh the impact of environmental and neighborhood characteristics. There is evidence that interventions at the city or neighborhood level have improved community physical activity levels. Our data on the availability of open areas is relatively limited and quite subjective. In order, to reach safe

conclusions regarding the importance of availability of physical activity premises in the neighborhood more focused research on the topic should be done.

Physical activity is of great importance for public health and there is a global interest in designing interventions and implementing health policies that will result in increasing physical activity. HNNHS gives the opportunity to have a clear picture of the parameters that could facilitate and tackle participation in PA hence it could provide a significant source of information for policy-makers. It is quite clear groups of lower socioeconomic status as indicated by educational level and employment status require more focused approaches. It is of great importance that national health initiative and policies promote physical activity provide the opportunity of PA participation in all settings. At the school level physical education classes should become obligatory at a daily basis, an initiative that has already been implemented in some EU member states. In addition, free access to local gyms and sports facilities should be provided to residents who face financial difficulties. Information campaigns should be organized at a local level in order to promote physical activity and inform the public about the great significance of physical activity on their health. Such initiative will result in a better informed population who will take care of their health, avoid behaviors that are associated with ill health and effectively to a healthier, more productive population. Such a result will lead to a significant reduction of both heath care and non-health care costs allowing for a healthier, more content and well-being oriented society

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