HAROKOPIO UNIVERSITY

SCHOOL OF HEALTH SCIENCE AND EDUCATION

DEPARTMENT OF NUTRITION & DIETETICS

POSTGADUATE PROGRAM IN APPLIED NUTRITION & DIETETICS

NUTRITION & EXERCISE

Nutrition & exercise indicators in relation to blood pressure levels in high risk families for type 2 Diabetes Mellitus in Europe

Master's Thesis

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Η Ειρήνη Μπασδέκη δηλώνω υπεύθυνα ότι:

1) Είμαι ο κάτοχος των πνευματικών δικαιωμάτων της πρωτότυπης αυτής εργασίας και από όσο γνωρίζω η εργασία μου δε συκοφαντεί πρόσωπα, ούτε προσβάλει τα πνευματικά δικαιώματα τρίτων.

2) Αποδέχομαι ότι η ΒΚΠ μπορεί, χωρίς να αλλάξει το περιεχόμενο της εργασίας μου, να τη διαθέσει σε ηλεκτρονική μορφή μέσα από τη ψηφιακή Βιβλιοθήκη της, να την αντιγράψει σε οποιοδήποτε μέσο ή/και σε οποιοδήποτε μορφότυπο καθώς και να κρατά περισσότερα από ένα αντίγραφα για λόγους συντήρησης και ασφάλειας.

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Περίληψη

Εισαγωγή: Η υπέρταση και ο σακχαρώδης διαβήτης τύπου 2 (ΣΔ2) αποτελούν δύο από τα κυριότερα προβλήματα υγείας παγκοσμίως, τα οποία είναι αλληλένδετα, καθώς οι υπερτασικοί ενήλικες έχουν υψηλότερο κίνδυνο ανάπτυξης ΣΔ2. Πολλές συμπεριφορές διατροφής και φυσικής δραστηριότητας συνδέονται ξεχωριστά με την υπέρταση ή το διαβήτη. Ωστόσο, η υπάρχουσα γνώση για αυτές τις συμπεριφορές σε σχέση με την υπέρταση σε ενήλικες υψηλού κινδύνου για ΣΔ2 είναι ελάχιστη.

Σκοπός: Η διερεύνηση της ύπαρξης πιθανών συσχετίσεων μεταξύ των διατροφικών συνηθειών και των δεικτών φυσικής δραστηριότητας με τα επίπεδα αρτηριακής πίεσης και την ύπαρξη υπέρτασης, σε ένα μεγάλο δείγμα ενηλίκων υψηλού κινδύνου για ΣΔ2, από 6 ευρωπαϊκές χώρες.

Μεθοδολογία: Στην παρούσα μελέτη χρησιμοποιήθηκαν τα συγχρονικά δεδομένα της μελέτης Feel4Diabetes. Συμμετείχαν 2500 άτομα από 6 ευρωπαϊκές χώρες. Η συστολική (ΣΠ), η διαστολική (ΔΠ) καθώς και η ύπαρξη υπέρτασης μετρήθηκαν και αξιολογήθηκαν σύμφωνα με τις τελευταίες Ευρωπαϊκές οδηγίες. Επιπλέον, έγιναν ανθρωπομετρικές μετρήσεις, αξιολόγηση συμπεριφορών διατροφής και άσκησης και εξετάσεις αίματος, μέσω τυποποιημένων διαδικασιών, σταθμισμένου εξοπλισμού και επικυρωμένων ερωτηματολογίων. Η στατιστική ανάλυση διεξήχθη σε ομάδες υψηλού και χαμηλού κινδύνου, καθώς επίσης έγινε διαχωρισμός ανάλογα με την ηλικία, την περιοχή και την κοινωνικοοικονομική κατάσταση.

Αποτελέσματα: Από τους 2500 συμμετέχοντες, οι 1550 χαρακτηρίστηκαν ως χαμηλού κινδύνου (FINDRISC<12) και οι 890 ως υψηλού κινδύνου (FINDRISC>12). Ο ΔΜΣ ήταν ο κύριος παράγοντας που συνδέθηκε ανεξάρτητα με την ύπαρξη αυξημένης ΣΠ, ΔΠ και υπέρτασης, σε ομάδες υψηλού, αλλά και χαμηλού κινδύνου. Στην ομάδα χαμηλού κινδύνου, η υψηλή πρόσληψη μπύρας, μηλίτη, οινοπνευματωδών ποτών και χαμηλής κατανάλωσης οσπρίων συνδέθηκε θετικά με τη ΣΠ, τη ΔΠ και την ύπαρξη υπέρτασης. Στην ομάδα υψηλού κινδύνου, η χαμηλή κατανάλωση οσπρίων και η υψηλή πρόσληψη οινοπνευματωδών ποτών συνδέθηκαν θετικά με τη ΣΠ και τη ΔΠ, ενώ η υψηλή πρόσληψη οινοπνευματωδών συνδέθηκε επίσης θετικά με την ύπαρξη υπέρτασης. Η σωματική δραστηριότητα δεν συσχετίστηκε σημαντικά με καμία από τις παραμέτρους που μελετήθηκαν στο παρόν δείγμα.

Συμπέρασμα: Η αυξημένη κατανάλωση οινοπνευματωδών ποτών, η χαμηλή κατανάλωση οσπρίων και ο ΔΜΣ αποτελούν τους κυριότερους παράγοντες που συνδέονται θετικά με τη ΣΠ, τη ΔΠ και την ύπαρξη υπέρτασης σε ενήλικες υψηλού κινδύνου για ΣΔ2. Τα μελλοντικά προγράμματα πρόληψης θα πρέπει να εντοπίζουν και να αντιμετωπίζουν έγκαιρα αυτές τις συμπεριφορές ώστε να υπάρχει πιο αποτελεσματική αντιμετώπιση του κινδύνου για ΣΔ2.

Λέξεις κλειδιά: υπέρταση, σακχαρώδης διαβήτης, διατροφικές συμπεριφορές, φυσική δραστηριότητα

Abstract

Background: Hypertension and Type 2 Diabetes Mellitus (T2DM) are two of the main health problems worldwide, which are widely interrelated, as hypertensive adults have a higher risk for developing T2DM. Many dietary and physical activity behaviors are separately associated with hypertension or diabetes. However, knowledge regarding these behaviors in relation to hypertension in adults at high risk for T2DM is scarce.

Aim: To examine the possible associations of dietary habits and physical activity indices with blood pressure levels and existence of hypertension in adults at high risk for T2DM in a large sample from six European countries.

Methods: Feel4Diabetes baseline data are used in this study. 2500 participants from six European countries participated in this study. Systolic (SBP), Diastolic (DBP) blood pressure and existence of hypertension were measured and assessed following the latest European Guidelines. Anthropometric measurements, dietary & physical activity behaviors and blood tests were also evaluated through standard procedures, equipment and validated questionnaires. Statistical analyses were conducted in high and low risk groups, and also separated according to age, region and socioeconomic status (SES).

Results: Out of 2500 participants, 1550 were defined as low risk (FINDRISC<12) and 890 as high risk (FINDRISC>12). BMI was the main factor independently associated with SBP, DBP and hypertension existence in both high and low risk groups. In the low risk participants, high intake of beer, cider, spirits and low legume consumption were positively associated with SBP, DBP and existence of hypertension. In the high risk group, low legumes consumption and high intake of spirits were positively associated with SBP and DBP, while high intake of spirits was also positive associated with existence of hypertension. Physical activity was not significantly associated with any of the studied parameters in the present sample.

Conclusions: Increased intake of spirits, low legume consumption and BMI are the main factors positively associated with SBP, DBP and existence of hypertension in adults at high risk of hypertension. Future prevention programs should early identify and tackle these behaviors in order to more efficiently reduce risk for T2DM.

Key words: hypertension, diabetes mellitus, dietary behaviors, physical activity

List of tables

Abbreviations

T1DM	Type 1 Diabetes Mellitus
T2DM	Type 2 Diabetes Mellitus
SBP	Systolic Blood Pressure
DBP	Diastolic Blood Pressure
BMI	Body Mass Index
AHA	American Heart Association
WHO	World Health Organization
EPA	Eicosapentaenoic Acid
DHA	Docosahexaenoic Acid
DASH	Dietary Approach to Stop Hypertension
HDL	High Density Lipoprotein
LDL	Low Density Lipoprotein
TAG	Triacylglycerol
PA	Physical Activity
MPA	Moderate Physical Activity
VPA	Vigorous Physical Activity
SES	Socioeconomic Status

1. Introduction

Diabetes mellitus and hypertension are two of the most important health problems worldwide. In recent years, the prevalence of these two conditions has a remarkable increase, which in turn has led to an increased scientific interest. [1]

1.1 Hypertension

According to the latest European guidelines, hypertension is defined as the repeated measurements of blood pressure over 140/90 mm Hg (systolic and diastolic, respectively). [2] Whereas, the revised American Heart Association guidelines (AHA), sets the borderline value for hypertension diagnosis above 130/80 mm Hg. [3]

The prevalence of hypertension is highly dependent on the thresholds used. Based on the revised US guidelines about 40% of world's population is affected, with a higher incidence in older ages. [2] Hypertension is responsible for 7.5 million deaths worldwide, which equals to 12.8% of all deaths per year. [4] In 2025, prevalence of hypertension is estimated to be at 29% globally, which is about 1.5 billion people. [5]

Taking into account the latest AHA hypertension guidelines, about 103 million people have been diagnosed with hypertension in USA, which accounts for 46% of the adult population. [6] Based on World Health Organization (WHO) data, prevalence of hypertension in Africa and Europe exceeds 40%. [4] In Greece, 20.9% of the population aged over 15 has hypertension, according to Hellenic Statistical Authority. For older people the prevalence is greater. More specific, 30.5% of people aged 55 – 64 and 51.1% of people aged 65 – 74 are hypertensive. [7]

Hypertension is the major risk factor for the development of various cardiovascular diseases, such as heart failure, stroke, atherosclerosis, atrial fibrillation and peripheral vascular disease. [8] It is remarkable that over 50% of deaths from stroke or myocardial infarction occur in hypertensive individuals. [9] In addition, hypertension is responsible for a variety of diseases. It is the major risk factor for kidney disease, leading to chronic renal failure. [5] Also, hypertension is attributable to adverse conditions, such as blindness, gangrene of the lower limbs and preeclampsia. [10]

Non-modifiable risk factors of hypertension are genetic predisposition, age (especially people over 55 years old), sex (males are in greater risk, especially in younger ages), nationality (African race), high socio – economic status and chronic diseases (diabetes mellitus, chronic kidney disease,

coronary heart disease). [11] [12] [13] Among the most important modifiable risk factors are diet (increased sodium consumption, reduced consumption of potassium, magnesium, calcium and increased alcohol consumption), obesity, smoking, physical inactivity (which may lead to excess body weight) and stress. [11] [12] [14]

1.2 Diabetes mellitus

Diabetes mellitus is a chronic disease characterized by hyperglycemia. Inability of the pancreas to produce insulin or inadequate amounts of the hormone, or inefficient use of the hormone by the body are the main causes of hyperglycemia. [15] The 3 main types of diabetes are type 1 diabetes mellitus (T1DM), type 2 diabetes mellitus (T2DM) and gestational diabetes.

T2DM is the most common type of diabetes worldwide, caused by [11] insufficient insulin response, a condition defined as insulin resistance. T2DM is common in adults, but is increasingly observed in children, adolescents and young people due to rising levels of obesity and sedentary lifestyle. [15] Hyperglycemia, increases thirst and hunger, frequent urination and weight loss. However, T2DM might also be asymptomatic for a long time. [11]

T2DM is a global issue and its prevalence has risen dramatically over the last few years. [15] [16] In 1980 prevalence of T2DM was 108 million adults or 4.7 % of the population, worldwide. Nowadays, it has almost quadrupled and reaches 425 million adults, 20 – 79 years old, which is 8.8 % of global population. [15] [17] In 2045, it is estimated that about 629 million people aged 20 – 79 will have T2DM. [15]

In 2014, 64 million people in Europe, almost 7.3 % of European population, had been diagnosed with T2DM. By 2017, prevalence had increased to 8.8 % of the European population. [15] [17] In Greece, 7.2 % of adults aged 20 – 79 years old have T2DM. [15] However, the prevalence of T2DM for the elderly (>75 years old) is 30.3 %. [18] It should be mentioned that about 212.4 million, almost 50 % of diabetics, have undiagnosed T2DM. [15] .

Inappropriate management of T2DM leads to a variety of acute or chronic complications. [15] [19] Hyperglycemia and hypoglycemia are short term complications. Hyperglycemia might lead to diabetic ketoacidosis or to hyperglycemic diabetic coma. On the other hand, hypoglycemia might cause loss of consciousness. [19]

Chronic complications of T2DM can be either microvascular or macrovascular. Neuropathy, nephropathy and retinopathy (blindness resulting gradually from damage in retinal vessels) are microvascular complications. Macrovascular complications include coronary heart disease, peripheral vascular disease, diabetic encephalopathy and diabetic foot. [11] [15] Moreover, T2DM is associated with increased risk of cancer, mental disability tuberculosis and depression. [15]

Pathogenesis of T2DM is characterized by a set of risk factors, some of which are non – modifiable and some are modifiable. [11] Genetic predisposition, age, nationality (African race) and gestational diabetes are non – modifiable risk factors. [11] [15] [19] [20] Modifiable risk factors consist of obesity, unhealthy diet and type of diet in childhood, physical inactivity and smoking. [15] [19] [21]

1.3 Hypertension & diet

Diet is one of the most important modifiable risk factors for hypertension. Various components of the diet, that have either a protective or an aggravating role in the onset of hypertension, are listed below.

1.3.1 Nutrients

Sodium

Sodium is an electrolyte and it is a component of almost every food. Its consumption is strongly associated with the occurrence of a variety of diseases, such as hypertension. [11] Sodium ions activate the brain renin – angiotensin – aldosterone system, causing sympathetic system activation which leads to vasoconstriction and increase of blood pressure. [22] AHA guidelines for prevention and treatment of hypertension recommend that sodium consumption should not exceed 1500 mg/ day, which is equal to 3.8 g of salt. [1] European guidelines are similar, recommending consumption of 5 – 6 g of salt per day, which is about 2000 – 2400 mg of sodium. [3] However, daily sodium intake exceeds recommendations, since most people consume 9 – 12 g salt per day. [23] A large number of interventional studies, reviews and meta – analyses confirms the beneficial effect of reducing salt consumption in arterial blood pressure. Salt reduction, even when the intake is above recommendations, is strongly associated with reduced blood pressure both in hypertensive and healthy subjects. [24] [25]

Potassium

Potassium is also an electrolyte. Potassium intake is associated with reduction of blood pressure, not only in hypertensives but also in healthy subjects. [26] Reduction of blood pressure levels is attributed to increased sodium excretion in the urine, inhibition of renin secretion, antagonism of angiotensin and increase of endothelium – dependent vasodilation. [11] There are many epidemiological studies and meta – analyses which support the inverse association of adequate potassium intake and arterial pressure. [27] [28]

Calcium & Magnesium

Calcium and magnesium are micronutrients that appear to have beneficial effects on blood pressure. Calcium can lower blood pressure levels by increasing excretion of sodium in urine, by regulating the activation of the sympathetic nervous system and by decreasing calcium excretion in vascular smooth muscle cells which leads to lower vasoconstriction. Magnesium contributes to vasodilation, since it decreases cells' calcium intake and activates prostaglandin 12 production, which causes vasodilation. [11] Data from reviews and meta – analyses suggest that adequate intake of these micronutrients also are favorable for arterial pressure. [29] [30] [31]

Dietary fiber

Adequate intake of dietary fiber provides protection against cardiovascular diseases through a variety of mechanisms, one of which is blood pressure reduction. [11] Meta – analyses data also support the protective effect of dietary fiber on arterial pressure. [32]

ω – 3 polyunsaturated fatty acids

Eicosapentaenoic (EPA) and docosahexaenoic (DHA) are ω – 3 polyunsaturated fatty acids with beneficial effects on hypertension. [33] Many studies and meta – analyses confirm the positive effect of EPA and DHA on blood pressure. [34]

1.3.2 Food groups

Dairy

Dairy consumption is often associated with unfavorable effects on blood pressure levels. However, daily consumption of low fat dairy, seems to have beneficial effects on arterial blood pressure. A large number of prospective and interventional clinical trials and data from meta – analyses suggest

that daily consumption of low fat dairy, could contribute to the prevention or reduction of elevated blood pressure, in healthy or hypertensive subjects respectively. [35] [36] [37] [38] [39]

Fruits & Vegetables

Fruits and vegetables are important components of a healthy diet. Guidelines of numerous health organizations, as well as health professionals' recommendations suggest their daily adequate consumption for the preservation of health and the prevention of many diseases, like hypertension. [1] [15] Data from meta – analyses also suggest that there might be an inverse association of adequate fruit and vegetable consumption with risk of developing hypertension. [40] [41]

Nuts

This food group is well known for its increased content of polyunsaturated fatty acids. Frequent consumption of nuts, but not over – consumption, has been associated with reduced risk of hypertension by a large number of meta –analyses. [42] [43] [44]

Fish

The main source of ω – 3 polyunsaturated fatty acids is fish. Fish consumption is an important component of a healthy diet. Its beneficial effect on hypertension is confirmed by many reviews and meta – analyses. [45]

Alcohol & alcoholic drinks

Excess alcohol consumption is related to several diseases, including hypertension. [15] A large number of studies suggest that high alcohol consumption, more than 2 drinks per day, is strongly associated with hypertension. However, moderate alcohol consumption, 1 to 2 drinks daily, might reduce the risk of hypertension, only in women. It is also found that consumption of alcohol, especially red wine, accompanied by a meal, may have a protective role in relation to hypertension. [46] [47]

1.3.3 Dietary patterns

There is a large number of nutrients and food groups that may affect blood pressure. However, nutrients and food items are not consumed in isolation and investigation of their combined effects in meals throughout a day related to health conditions is more meaningful. The most important dietary patterns investigated in relation to hypertension, are the Mediterranean diet and the DASH diet

(Dietary Approach to Stop Hypertension) diet. Recent meta – analyses suggest that adhesion to the Mediterranean or the DASH dietary pattern could decrease blood pressure in hypertensive subjects or lower the risk for hypertension development. [48] [49] [50] [51]

1.4 Hypertension & physical activity

Physical activity (PA) and sedentary lifestyle are two of the most important lifestyle factors that both affect arterial pressure. [1]

1.4.1. Physical activity

Both organized and non-organized PA are very important non – pharmacological intervention for hypertension prevention and risk reduction. [1] A large number of studies and meta – analyses demonstrate an inverse relationship between PA and blood pressure levels. [52] [53] [54] In 2017, a large meta – analysis found that subjects who met the PA guidelines had a 6 % reduction in hypertension risk compared with inactive individuals. [55]

Aerobic exercise is the most widely form known for its effectiveness in blood pressure reduction. [56] [57] [58] However, resistance training and isometric exercise training are also beneficial and could decrease both systolic and diastolic blood pressure, with greater effects observed in pre – hypertensive and hypertensive subjects. [59] [60] Additionally, PA is a very important lifestyle factor, since it affects blood pressure acutely. A meta – analysis investigating the acute effect of exercise on blood pressure demonstrates that a few hours after an exercise session there was a significant reduction in blood pressure levels. The beneficial effects were more distinct with jogging, when the PA was performed as a preventive strategy or for people not taking antihypertensive medication. [61]

1.4.1. Sedentary lifestyle

Sedentary behavior is associated with a variety of adverse health outcomes, including hypertension. In 2008, it has been estimated that physical inactivity was the main cause of 9.4 % of deaths worldwide, which was more than 5 million deaths. [62] Sedentary behavior is an independent risk factor for cardiovascular mortality and hypertension, since it is associated with these outcomes, even when subjects are physically active. [63] Therefore, increased PA and avoidance of prolonged sitting are recommended for health improvement. [64]

1.5 Hypertension, risk factors for diabetes mellitus & diet

There is a large number of studies investigating the separate associations of diet with hypertension and with T2DM. However, there is little evidence regarding the possible effects of diet on hypertension in people with risk factors or diagnosis for T2DM.

Among the few relevant studies, one conducted in overweight and obese adults with primary hypertension investigated the effects of DASH diet in arterial pressure, body weight and glucose metabolism. It was a 3 – month prospective randomized study with 131 participants that were separated in the DASH group and the control group. Participants in the intervention group were given an individualized diet plan, whereas the control group received only standard recommendations. In the DASH group there was a significant decrease in body mass, blood pressure and fasting glucose, for both sexes, indicating the beneficial effects of DASH diet. [65]

In another randomized, controlled trial, researchers examined if 1 year of Mediterranean diet administration and lifestyle intervention had any effects on insulin resistance. In this study, 315 subjects participated, 156 of which were overweight and hypertensives, the rest were overweight with normal blood pressure. They were given a personalized diet plan in order to reach a target body weight; physical activity and smoking cessation were also encouraged. Hypertensive patients decreased their BMI and HOMA – IR. However, HOMA – IR was still abnormal and significantly higher in comparison to control group, after 1 year of diet and lifestyle intervention. [66]

1.6 Hypertension, risk factors for diabetes mellitus & exercise

As with diet there are many studies in the literature investigating the effects of exercise or sedentary behavior separately on hypertension and T2DM. However there is little knowledge regarding the possible effects of physical activity and sedentary behavior on people with hypertension and risk factors or diagnosis for T2DM.

1.6.1. Hypertension, risk factors for diabetes mellitus & physical activity

There are not many studies available in the literature. In 2016, a randomized, controlled trial compared the effect of low – volume high intensity against high – volume low intensity exercise on insulin sensitivity and glucose control in 62 overweight, mild hypertensive and inactive women. Participants under medication were excluded. They were randomized in 3 groups, low – volume high intensity group, high – volume low intensity group and the control group. The training groups

followed three training sessions per week for 15 weeks, while control group had no lifestyle changes during the same period of time. It was found that plasma glucose and insulin levels significantly decreased after low – volume high intensity exercise compared to control group, indicating that this type of physical activity is favorable for insulin sensitivity in hypertensive women. [67]

1.6.2. Hypertension, risk factors for diabetes mellitus & sedentary lifestyle

Sedentary lifestyle is an important risk factor for many diseases like hypertension and T2DM. There is little evidence available in the literature about the results in blood glucose and insulin levels after replacing sedentary time with exercise in hypertensive subjects. In one available study, Suboc et al. conducted a randomized control trial in 96 pre – hypertensive and hypertensive sedentary adults. The aim of the study was to investigate possible associations of reduction in sedentary time with cardiovascular function and insulin sensitivity. Intervention's lasted 12 weeks and participants were divided in 3 groups, two groups had different levels of reduction in sedentary time and one group had an increase. No statistically significant reductions were observed in insulin sensitivity and blood glucose levels in the first two groups following sedentary time reduction. However more studies are needed in order to thoroughly investigate this issue. [68]

1.7 Purpose

The data available in the literature regarding diet, physical activity and their relation with blood pressure levels in adults at high risk for T2DM are inadequate and unclear. The purpose of this study is to examine the possible association of dietary habits and physical activity indices with blood pressure levels in families at high risk for T2DM in a large sample in Europe.

2. Methods

2.1 The study

Feel4Diabetes was a large school– and community– based intervention among families from vulnerable groups in six European countries, organization and planning of which started in January 2015. As "vulnerable" groups were defined families from low/middle income countries (Bulgaria, Hungary), from low socioeconomic areas in high income countries (Belgium, Finland) and from countries with economic crisis (austerity measures) (Greece, Spain). The aim of the study was to promote healthy lifestyle and come up against obesity and obesity – related metabolic risk factors for the prevention of T2DM among these families. In this large intervention study 11.511 families participated.

2.2 Recruitment

Sample collection started in January 2016. Recruitment was conducted within the provinces of Oost-Vlaanderen and West-Vlaanderen (Belgium), Varna and Sofia (Bulgaria), Satakunta (Finland), Attica (Greece), Debrecen and its county (Hungary) and Zaragoza (Spain). Children attending the first three grades of compulsory education and their families were recruited to the study. Feel4Diabetes final sample consisted of a total of 11.511 families ("all families") of whom 2.230 were "high – risk families". The identification of the high-risk families was based on type 2 diabetes risk estimation using the Finnish Diabetes Risk Score (FINDRISC). To be regarded as a "high-risk family", at least one parent in the family had to fulfil the country-specific cut-off point.

2.3 Feel4Diabetes Protocol

After the end of the initial recruitment and assessment of the study population the intervention of the study was initiated. Intervention of the Feel4Diabetes study was divided in 2 groups. The first is the "all families" group whose intervention was applied in the school environment and the other one is the "high risk families" group. For this group intervention took place out of school focusing only in families at high risk for developing T2DM. The initial measurements were carried out between April and June, whereas for Finland, Hungary and Bulgaria between August and September of 2016.

Adults of "high risk families" were asked to attend the local community center of the municipality participating in the study, in order to undergo a more analytic assessment. Intervention in "high risk

families" group included 7 counseling sessions about participants' lifestyle during the 1st year of the study, (academic year 2016 – 2017). The first 6 sessions were completed by March 2017, whereas the 7th was held in September 2017. In the 7th session, the results from the 1st follow – up and the 1st check – up were presented to each family. In the last session the objectives of the second year of intervention were set. The counseling sessions included behavioral techniques in order to increase motivation and self – efficacy of participants in "high risk families" group, to improve self – regulation and establish measurable, feasible, realistic and time – specific goals. In every session, "high risk families" group was provided with relevant material and carried out specific activities, either during the session or at home. During the 2nd year of intervention, (academic year 2017 – 2018), participants received incentive feedback and mobile message guidance.

2.4 Ethical approval and consent forms

The Feel4Diabetes study adhered to the Declaration of Helsinki and the conventions of the Council of Europe on human rights and biomedicine. Prior to initiating the intervention, all participating countries obtained ethical clearance from the relevant ethical committees and local authorities. In Greece the study was approved by the Bioethics Committee of Harokopio University and the Greek Ministry of Education. All parents/caregivers provided a signed consent form before being enrolled in the study.

2.5 Measurements

Participants from both groups were asked to undergo anthropometric measurements, physical activity assessment, arterial pressure measurement and blood tests. In "high risk families" group, parents/guardians were asked to fill in a specific questionnaire for themselves and another one for their children.

2.5.1 Anthropometric measurements

Body weight

Body weight was measured twice in every session for each participant by the same examiner. Measurements were conducted by using weight scales SECA 813 and SECA 877. Participants were asked to remove their shoes, any heavy object (e.g. belt, keys) and clothes that could be removed. Then, participants were asked to stand in the center of the scale with their weight evenly distributed on both legs. They had to remain stable until the indication was stabilized in the scale. The

indication was recorded at the nearest ten kilogram (0,1 Kg). A third measurement was performed only if the previous two varied by 100 g.

Study participants were categorized for their body weight by using Body Mass Index (BMI), as defined by WHO. [69] Individuals unable to stand or in a wheelchair, pregnant women or participants who refused were excluded.

Height

Height was measured twice for each participant by the same examiner. For height measurements SECA 213, SECA 214, SECA 217 and SECA 225 were the stadiometers used. Researchers asked every participant to remove the shoes or any other garment or object that caused difficulties to the measurement (e.g. heavy clothing, hair accessories). Then, they hat to stand in a natural position with the back turned to the stadiometer, focus on a point straight across and remain stable. The researcher had to confirm that the participant's position was correct and then the measurement was conducted at the end of a deep breath. There was a third measurement only if the previous two varied more than 1 cm.

Participants with difficulties in standing, unable to move or in a wheelchair, those being higher than the maximum height of the stadiometer, pregnant women or people that refused to get measured were excluded from the measurement.

Waist circumference

Waist circumference measurement was carried out twice. A non-elastic band (SECA 201) calibrated in millimeters (mm), was used to measure waist circumference. The measurement was carried out in a private place. The researcher asked the participants to remove objects which tend to change body shape (e.g. belt). They were also asked to remove clothes in order to reveal the waist; in cases that the participant did not consent to remove its clothes the measurement was carried out in light clothing, which was recorded. The participant was asked to breathe normally while the researcher had to record the mark of the tape at the end of the expiration. The value in the band was recorded at the nearest tenth of a centimeter (0,1 cm). A third measurement was carried out only if the previous two varied more than 1 cm.

Categorization of the study participants according to their waist circumference was performed in accordance with specific classification limits defined by WHO. [69] Difficulties in standing,

stationary individuals or in a wheelchair, colostomy, ileostomy, recent abdominal surgery or other problems/devices that made it difficult to the researcher to carry out the measurement appropriately, individuals with greater waist circumference that the tape could measure, pregnancy or refusal to get measured were the main reasons for not participating in this measurement. For each case the reason was recorded.

2.5.2 Arterial pressure

The automated Omron M6 AC and Omron M6 were used to measure systolic and diastolic blood pressure and pulses/minute. The measurement was conducted in a private, quiet place with the proper temperature. The participant was asked to sit down and relax for 5 minutes before the measurement. Then, the researcher had to start the measurement and the indication of the device was recorded. With the participant remaining in the same position, two other measurements were conducted, with one minute interval. The average of the three measurements was calculated. The total existence of hypertension was evaluated by separation of the participants 2 groups; the first consisted of participants with normal blood pressure and the second of hypertensive participants. As hypertensive were considered the participants with increased SBP and DBP, or even when only one was out of normal range. Hypertension was defined according to the latest European guidelines. [2]

Participants that were mutilated, with open sores, wounds or rashes in both arms, participants with malformations in both arms that made it impossible to place the cuff, participants with malfunction in their lymph nodes that caused difficulty in fitting the cuffs, pregnancy or refusal were the main reasons for not participating in this measurement. For each case the reason was recorded.

2.5.3 Blood tests

Blood samples were collected from the participants in order to determine levels of total cholesterol, HDL cholesterol, LDL cholesterol, triglycerides and fasting glucose in their bloods. Samples' collection was conducted early in the morning, around 8.30 to 10.30. The examination required an overnight fasting (twelve hours). The process was quick and simple. A specialized researcher collected up to 16mL of blood from the participant by venipuncture. Some of the collected blood was held and left for 30 to 120 minutes without using an anticoagulant, in order to separate the serum. The blood after sneezing was centrifuged at 3000 rpm for 10 minutes, until the serum was divided into fractions and then stored at -80 ° C. All the serum samples of the participants were stored at -80 ° C.

In order to determine total cholesterol, HDL cholesterol, LDL cholesterol and triglycerides, the enzymatic chromatogram (Roche Diagnostics SA, Vasilia, Switzerland) was used with the assistance of an automatic analyzer (Roche / Hitachi Modular). The potential existence of dyslipidemia in participants was determined based on the limits of the National Cholesterol (NCEP), National Cholesterol Education Program. [70] For glucose determination, the method of the hexokinase (enzymatic reaction GOD-PAP) was used. The probable existence of diabetes, pre-diabetes and / or dysglycemia among participants was determined based on the WHO limits. [71]

2.5.4 Demographics – Dietary habits

Demographic characteristics were collected using questionnaires. More specific, the questions for the adult participants concerned their identity, questionnaire completion area, date of birth, level of education, race, marital status, their main occupation for the last six months, smoking habits, usual hours of sleep, whether or not the person was aware of the possible existence of T2DM, medication for T2DM if it was already diagnosed and possible medication for raised blood pressure or cholesterol, which was prescribed by a doctor.

In addition, there were questions about the individual's dietary habits regarding the frequency of meals and snacks, the frequency and quality of consumption certain types of food at breakfast and the reasons for skipping breakfast. Moreover, participants were asked to record the frequency of eating meals with others, the quantity, quality and frequency of consumption of particular types of food (dairy products, bread, fats, fruits, vegetables, pulses, red meat, processed meat, white meat, fish, seafood, salty snacks, pastries, nuts, seeds, water, tea, coffee, alcoholic beverages, soft drinks with or without sugar). Participants were also asked to express their opinion about their current body weight and about the minimum consumption of fruits and vegetables per day recommended for adults.

2.5.5 Physical activity

Physical activity levels were assessed by using pacemakers and accelerometers. OMRON Walkman Style Pro Pedometer and Omron HJ-322UE Walking Style Pro 2.0 3D USB Accelerator Sensor Step Counter were the types of devices used. Also the accelerometer model GT1M ActiGraph, GT3X ActiGraph , GT3X + ActiGraph, Traxmeet was used.

Pacemakers and accelerometers were given to the participants and instructions were also given for proper use. They were also provided with a calendar of activities in order to keep a record. Every

time the device had to be deactivated, they had to write down the reason and the time that the device was not in use. Every device was secured to the trouser/ skirt zone of each participant and specifically to the right hip side in alignment with the middle of the right knee. As soon as the participant stood up the device was activated. Participants with movement difficulties or restricted movement (e.g. leg break) were excluded from this measurement.

Physical activity for both participants' groups was also assessed by using a relevant questionnaire. Questions were related to the frequency, intensity, type of physical activity that the participant had the previous 7 days and contribution of other people to the decision for physical activity. There were also questions about the time and the reason for possible adoption of sedentary behavior. Moreover, participants were asked to write down their opinion on the minimum recommended time for physical activity.

2.6 Statistical analysis

Statistical analyses were performed using statistical package 21.0 (SPSS: Statistical Package for Social Sciences, SPSS Inc., Chicago, IL, USA). Normality of distribution of variables was checked using the Kolmogorov – Smirnov test. Categorical variables are presented as relative frequencies (%) and continuous as mean ± standard deviation (SD). Multivariate linear regression analysis was performed (including all dietary and physical activity variables, as well as smoking and gender) in order to assess the possible independent associations of the above mentioned behaviors with either SBP or DBP. Similarly multiple logistic regression analysis was used to investigate the independent associations of the above mentioned behaviors with existence of hypertension. All analyses were performed in the total sample divided in high and low risk groups separated by score 12 of the FINDRISC score, as well as according to region, age and SES categories also for high and low risk for T2DM groups. BMI was entered in both linear and logistic multivariate models in order to highlight those behaviors independently associated with SBP, DBP or existence of hypertension from all other behaviors tested, as well as from BMI. Level of statistical significance was set at $p \leq 0.05$ for all analyses.

3. Results

Study population

In the present study 2500 non-diabetic people participated, 1550 of which were identified as low risk (FINDRISC<12) and 890 as high risk (FINDRISC>12). 35.5% of the participants were overweight and 36.5% were obese. Mean SBP was 117.77 (±16.66) and mean DBP was 78.29 (±11.42) in total group while 44.8% of low risk and 58.6% of high risk participants were hypertensive. Baseline characteristics of the study population are presented in Table 1.

Table 1. Characteristics of the study population (Mean±SD or %)

Variables	**Total** (n=2500)	**FINDRISC<12** (n=1550)	**FINDRISC≥12** (n= 890)
Gender			
Female	66.3%	66.7%	66.9%
Male	33.7%	33.3%	33.1%
Age by 2 groups			
<45	76.1%	81.7%	66.4%
>45	23.9%	18.3%	33.6%
Education			
0-14	40.6%	38.7%	42.5%
>15	59.4%	61.3%	57.5%
Region			
Central - North Europe	28.5%	28.1%	29.2%
Southeast Europe	71.5%	71.9%	70.8%
BMI* (Kg/m^2)	28.53 (±5.44)	27.11 (±4.90)	31.03 (±5.38)
Weight status			
<18.5 kg/m2	0.6%	0.8%	0.2%
18.5-25 kg/m2	27.4%	36.7%	11.1%
25-30 kg/m2	35.5%	37.1%	32.3%
>30 kg/m2	36.5%	25.4%	56.4%
Waist circumference (cm)	94.68 (±14.30)	91.20 (±13.49)	100.88 (±13.62)
Smoking status			
Never smoked	45.9%	48.2%	41.8%
Former smoker	28.3%	26.5%	31.8%
Current smoker	25.9%	25.3%	26.4%
SBP* (mean of 2nd and 3rd measurement) (mm Hg)	117.77 (±16.66)	116.06 (±16.36)	120.93 (±16.98)
DBP* (mean of 2nd and 3rd measurement) (mm Hg)	78.29 (±11.42)	77.08 (±11.13)	80.57 (±11.64)
Existence of Hypertension and Prehypertension			
No	50%	55.2%	41.4%

Yes	50%	44.8%	58,6%
Medication for high blood pressure			
No	92%	95.8%	85.9%
Yes	8%	4.2%	14.1%
Total cholesterol (mg/dL)	194.39 (±37.65)	192.33 (±36.79)	198.23 (±38.67)
LDL (mg/dL)	120.58 (±32.88)	118.21 (±32.36)	124.54 (±33.25)
HDL (mg/dL)	53.12 (±13.95)	54.56 (±14.46)	50.94 (±12.70)
TAG (mg/dL)	109.17 (±85.07)	101.71 (±72.12)	122.82 (±104.39)
Glucose (mmol/L)	5.26 (±0.78)	5.17 (±0.66)	5.43 (±0.94)
Insulin (mU/L or µIU/mL)	9.95 (±8.99)	8.77 (±6.49)	12.20 (±11.24)
Findrisc score	10.27 (±4.06)	7.98 (±2.96)	14.23 (±2.25)
Low fat dairy (240mL/day)	0.82 (±1.19)	0.79 (±1,17)	0.90 (±1.25)
Full fat dairy (240mL/day)	0.43 (±0.76)	0.45 (±0,78)	0.42 (±0.4)
Vegetables (cups/day)	0.58 (±0.55)	0.60 (±0.56)	0.56 (±0.54)
Fruits and berries (cups/day)	0.52 (±0.51)	0.53 (±0.50)	0.50 (±0.52)
Refined cereals (30g)	0.16 (±0.59)	0.16 (±0,54)	0.15 (±0.69)
Whole grain cereals	0.47 (±0.89)	0.48 (±0,89)	0.45 (±0.85)
Legumes (cups/day)	0.28 (±0.25)	0.29 (±0,26)	0.28 (±0.24)
Red meat (g/day)	73.43 (±55,70)	70.40 (±50,69)	78.26 (±62.71)
White meat (g/day)	55.95 (±42,87)	54.69 (±41,04)	59.50 (±45.65)
Fish (g/day)	33.92 (±28.10)	33.81 (±27,83)	35.00 (±28.67)
Salty snacks* (portions/day)	0.24 (±0.31)	0.23 (±0.28)	0.25 (±0.33)
Sweet snacks* (40g/day)	0.57 (±0.73)	0.56 (±0.69)	0.58 (±0.74)
Nuts and seeds (30g/day)	0.31 (±0.49)	0.32 (±0.52)	0.28 (±0.42)
Tea (250mL/day)	0.35 (±0.72)	0.35 (±0.73)	0.34 (±0.68)
Coffee (250mL/day)	1.48 (±1.29)	1.47 (±1.22)	1.50 (±1.38)
Soft drinks with sugar (250mL/day)	0.20 (±0.48)	0.19 (±0.47)	0.21 (±0.49)
Soft drinks without sugar (250mL/day)	0.24 (±0.59)	0.22 (±0.58)	0.27 (±0.61)
Juice without sugar (250mL/day)	0.24 (±0.38)	0.25 (±0.36)	0.24 (±0.43)
Juice with sugar (250mL/day)	0.10 (±0.27)	0.09 (±0.27)	0.10 (±0.26)
Beer and cider (330mL/day)	0.26 (±0.58)	0.25 (±0.46)	0.26 (±0.52)
Wine (125mL/day)	0.18 (±0.35)	0.18 (±0,33)	0.17 (±0.39)
Spirits (40mL/day)	0.10 (±0.29)	0.09 (±0,25)	0.10 (±0.33)
MPA* (min/day)	40.52 (±62.16)	40.16 (±61.61)	39.99 (±62.32)
VPA* (min/day)	44.46 (±87.52)	44.27 (±86.31)	43.75 (±85.89)
Walking (min/day)	64.96 (±105.91)	66.22 (±105.55)	64.68 (±109.28)
Sitting (hours/day)	5.35 (±3.35)	5.26 (±3.34)	5.52 (±3.37)

*BMI: Body Mass Index

*SBP: Systolic Blood Pressure

*DBP: Diastolic Blood Pressure

*MPA: Moderate Physical Activity

*VPA: Vigorous Physical Activity

*Salty snacks: chips, pizza, cheese pie

*Sweet snacks: chocolate, biscuits, ice cream

Systolic Blood Pressure (SBP)

BMI was the main factor independently associated with SBP, in high and low risk groups both in the total sample as well as in subgroups according to age, region and socioeconomic status (SES). In low risk participants, high intake of low fat dairies, spirits and low legume consumption were positively associated with SBP, independently of sex and smoking. After adjustment for BMI, the above associations were still found, but also beer and cider consumption was positively associated with SBP. On the other hand, in high risk group, low legumes consumption and high intake of coffee and spirits were positively associated with SBP. After adjusting for BMI, all mentioned associations remained statistically significant. In low risk group, legume consumption was inversely associated with SBP independently of region, age and SES, but this was not found for high risk group. In high risk group, coffee consumption was positively associated with SBP only in people older than 45 years old and people from low SES group, independently from BMI. Associations of all variables with SBP are shown in Table 2, whereas associations of variables with SBP by age, region and SES are shown in Table 3.

Diastolic Blood Pressure (DBP)

BMI was again an independent factor positively associated with DBP in all the analyses performed. Similarly with SBP, high intake of low fat dairies, spirits and low legume consumption were positively associated with DBP, independently of sex and smoking. After adjustment for BMI, the above associations were still found, but also beer and cider consumption was positively associated with DBP. In high risk group, wine and reduced refined cereals and spirits consumption were inversely associated with DBP, independently of sex and smoking. The same associations were found after adjusting for BMI. Only in low risk group, legume consumption was inversely associated with DBP independently of region, age and SES. In high risk group, refined cereals were positively associated with DBP in Southeast Europeans, in high SES people and in participants >45years of age, before and after BMI adjustment. Associations of all variables with DBP are shown in Table 2, whereas associations of variables with DBP by age, region and SES are shown in Table 4.

Table 2. Associations of dietary and physical activity indices with SBP, DBP and Existence of Hypertension in high and low risk for T2DM groups

Variables	**Total** Beta (95% CI)					
	Findrisc<12 (n=582)			**Findrisc≥12 (n=268)**		
	SBP	**DBP**	**Existence of Hypertension**	**SBP**	**DBP**	**Existence of Hypertension**
Low fat dairy (cups)	**0.10 * (0.30 – 3.19)**	**0.10 * (0.20 – 2.28)**	1.18 (0.94 – 1.48)	0.09 (-0.43 – 3.47)	0.11 (-0.16 – 2.59)	**1.53 * (1.11 – 2.10)**
Full fat dairy (cups)	0.04 (-0.86 – 2.43)	0.06 (-0.29 – 2.08)	1.19 (0.92 – 1.55)	0.06 (-1.63 – 5.38)	0.07 (-1.01 – 3.94)	1.44 (0.86 – 2.42)
Vegetables (cups)	0.05 (-0.65 – 3.52)	0.07 (-0.18 – 2.81)	1.22 (0.87 – 1.70)	0.07 (-1.59 – 6.39)	0.11 (0.01 – 5.27)	1.35 (0.76 – 2.42)
Fruits (cups)	0.04 (-4.05 – 1.55)	-0.08 (-3.77 – 0.24)	0.66 (0.42 – 1.04)	-0.05 (-6.42 – 3.06)	-0.03 (-4.09 – 2.60)	0.58 (0.29 – 1.16)
Refined cereals (g)	-0.04 (-4.23 – 1.35)	-0.05 (-3.19 – 0.81)	0.78 (0.48 – 1.25)	0.08 (-1.20 – 7.09)	**0.14 * (0.59 – 6.44)**	0.94 (0.46 – 1.91)
Whole grain cereals (g)	-0.07 * (-2.68 – 0.10)	-0.01 (-1.10- 0.90)	0.90 (0.72 – 1.13)	-0.05 (-3.20 – 1.22)	-0.03 (-1.95 – 1.16)	0.83 (0.61 – 1.13)
Legumes (cups)	**-0.17 * (-15.98 – -6.09)**	**-0.18 * (-11.58 – -4.48)**	**0.24* (0.10 – 0.54)**	**-0.13 (-17.88 – -0.43)**	-0.07 (-9.73 – 2.58)	0.69 (0.20 – 2.40)
Red meat (g)	-0.07 * (-0.05 – 0.002)	-0.05 (-0.03 – 0.01)	1.00 (0.99 – 1.00)	-0.01 (-0.04 – 0.04)	0.04 (-0.02 – 0.04)	1.00 (1.00 – 1.01)
White meat (g)	0.07 (-0.003 – 0.07)	0.03 (-0.02 – 0.04)	1.00 (0.99 – 1.01)	0.08 (-0.02 – 0.10)	0.003 (-0.04 – 0.04)	1.00 (0.99 – 1.01)
Fish (g)	0.07 (-0.01 – 0.13)	0.08 (0.00 – 0.00)	1.01 (1.00 – 1.02)	0.09 (-0.03 – 0.18)	0.04 (-0.05 – 0.10)	1.01 (0.99 – 1.02)
Salty snacks (portions)	-0.02 (-4.33 – 2.56)	0.01 (-2.19 – 2.75)	0.89 (0.53 – 1.52)	0.06 (-3.49 – 9.19)	0.03 (-3.49 – 5.45)	1.82 (0.73 – 4.57)
Sweet snacks (g)	-0.02 (-2.29 – 1.21)	-0.001 (-1.28 – 1.24)	0.92 (0.69 – 1.21)	-0.09 (-6.58 – 1.23)	-0.14 (-5.56 –-0.05)	0.58 (0.29 – 1.13)
Nuts & seeds (g)	0.02 (-1.56 – 2.65)	-0.01 (-1.70 – 1.32)	1.13 (0.81 – 1.58)	-0.08 (-6.18 – 1.30)	-0.06 (-3.97 – 1.31)	0.89 (0.53 – 1.47)
Coffee (mL)	0.06 (-0.26 – 1.73)	0.03 (-0.44 – 0.99)	0.98 (0.84 – 1.15)	**0.13 * (0.07 – 3.24)**	0.12 (-0.06 – 2.18)	1.20 (0.92 – 1.57)
Soft drinks with sugar (mL)	-0.004 (-3.68 – 3.32)	0.01 (-2.13 – 2.89)	0.98 (0.55 – 1.73)	-0.05 (-9.34 – 4.36)	-0.02 (-5.71 – 3.96)	1.37 (0.49 – 3.80)
Soft drinks without sugar (mL)	0.06 (-0.36 – 4.02)	0.05 (-0.57 – 2.58)	1.18 (0.83 – 1.67)	0.03 (-2.37 – 4.13)	0.07 (-1.00 – 3.58)	1.30 (0.82 – 2.08)
Juice without sugar (mL)	-0.02 (-4.95 – 2.52)	-0.07 (-5.16 – 0.20)	0.92 (0.51 – 1.69)	0.05 (-3.88 – 10.14)	0.01 (-4.44 – 5.45)	0.55 (0.20 – 1.49)
Juice with sugar (mL)	0.07 (-0.10 – 8.60)	0.04 (-1.36 – 4.88)	1.04 (0.53 – 2.07)	-0.04 (-11.58 – 5.88)	-0.06 (-9.11 – 3.20)	0.86 (0.25 – 2.98)

Beer/cider (mL)	0.08 ***** (-0.12 – 5.29)	0.07 ***** (0.35 – 3.52)	1.37 ***** (0.85 – 2.21)	0.09 (-2.00 – 9.01)	0.08 (-1.57 – 6.20)	3.01 ***** (1.00 – 9.07)
Wine (mL)	-0.03 (-5.68 – 2.53)	-0.02 (-3.47 – 2.42)	0.82 (0.42 – 1.61)	-0.12 ***** (-16.02 – 0.20)	**-0.15 *** **(-12.55 – -1.11)**	0.70 (0.17 – 2.94)
Spirits (mL)	**0.10 *** **(1.45 – 12.20)**	**0.10 *** **(0.88 – 8.59)**	1.98 (0.73 – 5.37)	**0.16 *** **(2.04 – 14.62)**	**0.23 *** **(3.88 – 12.76)**	2.47 (0.70 – 8.73)
Moderate PA (min)	-0.01 (-0.02 – 0.02)	-0.01 (-0.02 – 0.01)	1.00 (1.00 – 1.00)	0.02 (-0.03 – 0.05)	0.02 (-0.02 – 0.03)	1.01 (1.00 – 1.01)
Vigorous PA (min)	-0.01 (-0.02 – 0.01)	-0.06 (-0.02 – 0.003)	1.00 (1.00 – 1.00)	0.01 (-0.03 – 0.03)	0.003 (-0.02 – 0.02)	1.00 (0.99 – 1.00)
Walking (min)	-0.32 (-0.01 – 0.01)	-0.01 (-0.01 – 0.01)	1.00 (1.00 – 1.00)	0.09 (-0.004 – 0.04)	0.07 (-0.01 – 0.02)	1.00 (1.00 – 1.01)
Sitting (min)	0.01 (-0.35 – 0.41)	-0.001 (-0.28 – 0.27)	1.02 (0.96 – 1.09)	0.04 (-0.42 – 0.82)	0.02 (-0.36 – 0.51)	0.96 (0.88 – 1.05)

Bold phase presents statistical significant associations before adjustment with BMI

*****: statistically significant association of the variable and also statistical significance of BMI after BMI adjustment

†: statistically significant association of the variable, after BMI adjustment

Table 3. Associations of dietary and physical activity indices with SBP, by region, age and SES, in high and low risk for T2DM groups

Variables	Systolic Blood Pressure Beta (95% CI)											
	Findrisc <12						**Findrisc ≥12**					
	Region		**Age group**		**Education level**		**Region**		**Age group**		**Education level**	
	Central-North Europe (n=187)	**Southeast Europe (n=395)**	**<45 (n=487)**	**>45 (n=95)**	**0 – 14 (n=242)**	**>14 (n=340)**	**Central-North Europe (n=98)**	**Southeast Europe (n=170)**	**<45 (n=188)**	**>45 (n=80)**	**0 – 14 (n=127)**	**>14 (n=141)**
Low fat dairy (cups)	**0.15 * (0.12 – 4.79)**	-0.02 (-2.22 – 1.61)	**0.10 * (0.21 – 3.19)**	0.16 * (-1.90 – 9.19)	**0.14 * (0.14 – 5.69)**	0.09 (-0.21 – 3.29)	0.07 (-1.55 – 3.25)	-0.10 (-7.56 – 2.04)	0.12 (-0.46 – 3.90)	0.02 (-5.98 – 7.01)	0.09 (-1.55 – 4.89)	0.09 (-1.31 – 4.11)
Full fat dairy (cups)	0.11 (-0.75 – 5.55)	0.000 (-1.94 – 1.93)	0.06 (-0.41 – 3.25)	0.003 * (-4.52 – 4.65)	0.07 (-1.13 – 4.05)	-0.01 (-2.43 – 1.94)	0.05 (-4.08 – 6.84)	0.05 (-3.20 – 5.94)	0.09 (-1.49 – 6.97)	-0.10 (-10.79 –4.76)	0.09 (-3.19 – 8.86)	0.11 (-1.85 – 7.78)
Vegetables (cups)	0.12 (-0.79 – 7.64)	-0.01 (-2.60 – 2.11)	0.06 (-0.52 – 3.73)	0.08 (-5.70 –11.29)	-0.01 (-4.02 – 3.25)	0.09 (-0.28 – 4.98)	0.03 (-5.36 – 7.42)	0.07 (-2.85 – 7.52)	0.09 (-2.20 – 7.86)	0.02 (-7.51 – 8.96)	0.14 (-1.42 –10.24)	0.05 (-4.83 – 8.19)
Fruits (cups)	-0.13 (-10.23 –1.06)	0.03 (-2.20 – 4.06)	-0.02 (-3.52 – 2.18)	-0.14 (-19.02 –6.88)	-0.04 (-6.15 – 3.25)	-0.02 (-4.39 – 2.71)	-0.02 (-9.61 – 7.75)	-0.07 (-8.18 – 3.44)	-0.09 (-8.79 – 2.37)	0.05 (-7.69 –11.74)	0.11 (-12.01 –3.78)	-0.02 (-7.23 – 5.92)
Refined cereals (g)	-0.03 (-8.49 – 5.26)	-0.02 (-3.55 – 2.41)	-0.04 (-3.99 – 1.58)	0.10 (-11.92 –30.11)	0.03 (-3.31 – 6.00)	-0.05 (-5.39 – 1.85)	-0.06 (-13.53 –6.76)	**0.18 * (0.37 – 10.54)**	0.01 (-5.34 – 5.81)	**0.37 † (2.17 – 20.33)**	-0.01 (-8.01 – 7.37)	0.12 (-1.60 – 9.22)
Whole grain cereals (g)	-0.01 (-2.60 – 2.44)	-0.08 * (-3.13 – 0.29)	-0.06 (-2.77 – 0.36)	-0.13 (-5.51 – 1.78)	**-0.13 * (-4.74 – -0.20)**	-0.04 (-2.57 – 1.06)	-0.07 (-3.85 – 1.83)	0.02 (-3.29 – 4.30)	-0.16 (-4.59 – 0.48)	-0.08 (-7.03 – 3.60)	-0.06 (-5.01 – 2.59)	-0.09 (-4.73 – 1.53)
Legumes (cups)	-0.01 (-13.97 – 12.83)	**-0.10 * (-11.67 – -0.32)**	**-0.16 * (-15.74 – -5.34)**	**-0.30 (-40.29 – -1.35)**	**-0.17 * (-19.87 – -3.09)**	**-0.13 * (-14.24 – -1.72)**	-0.08 (-62.31 – 24.75)	-0.08 (-15.33 – 5.15)	-0.07 (-17.25 – 5.84)	-0.24 (-33.00 – 0.90)	-0.02 (-13.67 – 10.43)	**-0.20 (-30.13 – -0.55)**
Red meat (g)	**-0.23 * (-0.15 – -0.04)**	0.02 (-0.03 – 0.04)	-0.06 (-0.05 – 0.01)	-0.004 (-0.09 – 0.08)	-0.11 (-0.09 – 0.00)	-0.06 (-0.05 – 0.02)	0.05 (-0.10 – 0.15)	-0.001 (-0.05 – 0.05)	0.01 (-0.05 – 0.05)	-0.18 (-0.16 – 0.03)	-0.06 (-0.08 – 0.04)	0.01 (-0.06 – 0.07)
White meat (g)	-0.10 (-0.14 – 0.03)	0.09 (-0.01 – 0.08)	**0.11 (0.01 – 0.09)**	-0.10 (-0.18 – 0.08)	0.001 (-0.06 – 0.06)	**0.11 (0.004 – 0.10)**	-0.09 (-0.18 – 0.06)	0.17 (-0.01 – 0.14)	0.13 (-0.02 – 0.12)	-0.08 (-0.25 – 0.14)	-0.02 (-0.11 – 0.09)	0.13 (-0.03 – 0.15)
Fish (g)	0.23 (0.10 – 0.47)	-0.03 (-0.09 – 0.05)	0.07 (-0.02 – 0.13)	-0.02 (-0.21 – 0.19)	0.002 (-0.11 – 0.11)	0.12 (0.01 – 0.19)	0.20 (-0.01 – 0.35)	-0.06 (-0.19 – 0.09)	0.07 (-0.08 – 0.18)	0.15 (-0.09 – 0.37)	0.05 (-0.10 – 0.18)	0.16 (-0.02 – 0.35)
Salty snacks (portions)	-0.10 (-10.87 – 1.80)	0.04 (-2.17 – 5.72)	-0.06 (-7.78 – 1.39)	0.16 (-2.85 –11.28)	0.01 (-4.57 – 5.26)	-0.09 (-10.46 – 0.36)	-0.05 (-22.91 – 15.11)	0.15 (-1.42 – 12.97)	0.04 (-5.32 – 8.54)	0.02 (-20.24 – 24.50)	**-0.20 (-31.54 - - 0.18)**	0.16 (-1.83 –13.18)
Sweet snacks (g)	-0.05 (-3.40 – 1.69)	-0.06 (-4.21 – 0.94)	-0.08 * (-3.71 – 0.10)	**0.27 * (1.30 – 11.01)**	0.05 (-2.03 – 4.45)	-0.04 (-3.06 – 1.32)	-0.10 (-11.58 – 4.28)	-0.12 (-7.80 – 1.58)	-0.04 (-5.45 – 3.72)	-0.21 (-17.98 –1.00)	-0.003 (-7.92 – 7.67)	-0.16 (-8.78 – 0.90)
Nuts & seeds (g)	-0.07 (-4.64 – 1.93)	-0.01 (-3.19 – 2.80)	0.03 (-1.40 – 2.99)	0.09 * (-4.85 –10.84)	-0.01 (-3.35 – 3.06)	0.04 (-1.82 – 4.39)	0.04 (-6.94 – 10.15)	0.003 (-4.35 – 4.51)	-0.12 (-8.61 – 0.89)	0.03 (-6.39 – 8.50)	0.04 (-3.78 – 6.11)	-0.14 (-11.88 –0.86)
Coffee (mL)	0.02 (-1.29 – 1.58)	-0.08 * (-2.82 – 0.37)	0.06 (-0.29 – 1.82)	-0.06 (-3.94 – 2.48)	0.08 (-0.64 – 2.85)	0.01 (-1.11 – 1.36)	0.12 (-0.87 – 2.95)	0.07 (-1.69 – 4.24)	0.05 (-1.17 – 2.31)	**0.27 † (0.12 – 9.28)**	**0.21 † (0.13 – 4.89)**	0.12 (-0.61 – 4.17)

Soft drinks with sugar (mL)	0.04 (-3.81 – 6.23)	-0.05 (-7.91 – 2.48)	0.03 (-2.30 – 4.99)	-0.18 (-21.94 –3.12)	-0.01 (-6.54 – 5.35)	-0.01 (-4.68 – 4.17)	-0.12 (-14.58 –3.93)	-0.02 (-11.65 –9.50)	-0.06 (-11.14 –5.20)	0.10 (-11.87 – 23.91)	0.08 (-7.23 –15.48)	-0.07 (-14.60 –5.98)
Soft drinks without sugar (mL)	0.04 (-1.88 – 3.60)	0.01 (-4.72 – 5.33)	0.07 (-0.21 – 4.62)	0.10 (-3.31 – 8.41)	-0.02 (-5.25 – 3.77)	**0.12 (0.68 – 5.68)**	0.10 (-1.98 – 5.59)	-0.14 ***** (-14.29 –0.66)	0.04 (-2.54 – 4.42)	0.06 (-8.24 –13.78)	**0.18 † (0.23 – 8.13)**	-0.08 (-9.47 – 3.44)
Juice without sugar (mL)	0.06 (-3.82 – 10.97)	-0.01 (-4.80 – 3.72)	-0.01 (-4.47 – 3.28)	0.05 (-10.41 – 6.11)	0.02 (-5.28 – 6.91)	-0.05 (-7.53 – 2.25)	0.16 (-1.35 – 19.03)	-0.04 (-12.70 –7.13)	0.06 (-4.64 – 11.23)	0.01 (-15.99 – 16.79)	-0.01 (-10.66 – 10.08)	0.08 (-5.13 –14.78)
Juice with sugar (mL)	-0.03 (-9.89 – 6.66)	0.07 (-1.35 – 8.78)	**0.09 * (0.65 – 10.62)**	-0.04 (-12.47 –8.95)	0.11 (1.32 – 17.33)	0.05 (-2.43 – 7.42)	-0.01 (-13.54 – 12.38)	-0.08 (-18.76 –6.06)	-0.09 (-16.77 – 4.39)	-0.003 (-19.27 – 18.79)	0.03 (-10.77 – 15.22)	-0.11 (-21.66 –5.45)
Beer/cider (mL)	0.16 ***** (-0.32 –10.34)	0.07 ***** (-0.96 – 5.21)	**0.10 * (0.55 – 6.26)**	-0.02 (-9.03 – 7.47)	0.11 ***** (-0.94 – 9.21)	0.07 (-1.05 – 5.30)	0.04 (-6.78 – 9.18)	0.09 (-5.18 –13.10)	0.08 (-3.64 – 9.90)	0.15 (-5.05 –18.40)	-0.14 (-16.36 –4.91)	0.12 (-2.47 –11.71)
Wine (mL)	**-0.17 * (-18.61 – -0.70)**	0.02 (-3.77 – 5.40)	-0.05 (-6.89 – 1.77)	-0.02 (-15.52 – 13.21)	0.02 (-6.77 – 9.19)	-0.08 (-8.73 – 1.01)	**-0.27 * (-35.13 – -5.31)**	-0.09 (-16.01 –5.48)	-0.08 (-14.86 – 4.92)	-0.15 (-27.93 –5.83)	0.01 (-12.59 – 13.32)	-0.13 (-22.06 –3.68)
Spirits (mL)	0.002 (-14.82 – 15.31)	**0.16 * (3.45 – 14.94)**	0.07 (-0.68 –10.55)	**0.34 * (8.55 – 46.77)**	**0.13 * (0.34 – 24.00)**	0.10 (-0.15 –11.82)	0.17 (-1.56 –14.08)	0.08 (-7.29 –18.30)	0.08 (-4.55 – 13.54)	0.23 (-1.93 –23.14)	0.13 (-3.93 –16.93)	**0.18 * (0.16 – 18.40)**
Moderate PA (min)	-0.02 (-0.05 – 0.04)	0.04 (-0.02 – 0.04)	-0.02 (-0.03 – 0.02)	-0.09 (-0.10 – 0.05)	0.001 (-0.03 – 0.03)	-0.07 (-0.05 – 0.01)	0.11 (-0.03 – 0.10)	-0.02 (-0.05 – 0.04)	-0.002 (-0.05 – 0.05)	-0.01 (-0.09 – 0.08)	0.04 (-0.04 – 0.07)	-0.03 (-0.07 – 0.05)
Vigorous PA (min)	-0.11 (-0.08 – 0.01)	0.01 (-0.01 – 0.02)	-0.03 (-0.02 – 0.01)	0.24 (0.00 – 0.10)	-0.01 (-0.02 – 0.02)	0.04 (-0.02 – 0.04)	0.01 (-0.07 – 0.08)	-0.06 (-0.05 – 0.03)	-0.01 (-0.04 – 0.04)	0.05 (-0.07 – 0.10)	-0.05 (-0.05 – 0.03)	0.05 (-0.04 – 0.08)
Walking (min)	0.04 (-0.02 – 0.03)	0.03 (-0.01 – 0.02)	-0.06 (-0.03 –0.003)	0.27 (0.004 – 0.07)	0.06 (-0.01 – 0.02)	-0.06 (-0.04 – 0.01)	0.01 (-0.03 – 0.03)	0.19 (0.004 – 0.08)	0.18 (0.01 – 0.05)	-0.12 (-0.10 – 0.04)	0.17 (-0.001 –0.05)	0.07 (-0.03 – 0.06)
Sitting (min)	0.01 (-0.69 – 0.84)	-0.003 (-0.45 – 0.43)	0.02 (-0.31 – 0.50)	0.09 (-0.78 – 1.74)	0.08 (-0.18 – 1.08)	-0.04 (-0.72 – 0.31)	0.21 (0.01 – 1.91**)**	-0.09 (-1.23 – 0.35)	0.05 (-0.47 – 0.99)	0.06 (-1.35 – 2.04)	-0.03 (-1.20 – 0.83)	0.03 (-0.80 – 1.13)

Bold phase presents statistical significant associations before adjustment with BMI

*****: statistically significant association of the variable and also statistical significance of BMI after BMI adjustment

†: statistically significant association of the variable, after BMI adjustment

Table 4. Associations of dietary and physical activity indices with DBP, by region, age and SES, in high and low risk for T2DM groups

Variables	Diastolic Blood Pressure Beta (95% CI)											
	Findrisc <12						**Findrisc ≥12**					
	Region		**Age group**		**Education level**		**Region**		**Age group**		**Education level**	
	Central-North Europe (n=187)	**Southeast Europe (n=395)**	**<45 (n=487)**	**>45 (n=95)**	**0 – 14 (n=242)**	**>14 (n=340)**	**Central-North Europe (n=98)**	**Southeast Europe (n=170)**	**<45 (n=188)**	**>45 (n=80)**	**0 – 14 (n=127)**	**>14 (n=141)**
Low fat dairy (cups)	0.15 * (-0.10 – 3.19)	-0.01 (-1.45 – 1.33)	**0.10 * (0.05 – 2.28)**	0.15 * (-1.40 – 5.48)	**0.15 * (0.12 – 4.05)**	0.09 (-0.29 – 2.22)	0.09 (-1.03 – 2.56)	-0.07 (-4.83 – 2.07)	0.10 (-0.53 – 2.69)	0.11 (-2.68 – 5.94)	0.12 (-0.95 – 3.74)	0.08 (-1.10 – 2.76)
Full fat dairy (cups)	**0.19 (0.41 – 4.85)**	0.01 (-1.23 – 1.58)	0.06 (-0.45 – 2.29)	0.09 (-1.81 – 3.87)	0.10 * (-0.43 – 3.25)	0.03 (-1.18 – 1.95)	0.03 (-3.52 – 4.62)	0.08 (-1.59 – 4.98)	0.07 (-1.60 – 4.66)	-0.01 (-5.33 – 4.99)	0.08 (-2.61 – 6.15)	0.13 (-0.82 – 6.03)
Vegetables (cups)	0.08 (-1.60 – 4.34)	0.04 (-1.04 – 2.39)	0.07 (-0.31 – 2.87)	0.13 (-2.45 – 8.09)	0.04 (-1.77 – 3.38)	0.09 (-0.21 – 3.56)	0.10 (-2.54 – 6.98)	0.10 (-1.44 – 6.02)	0.08 (-1.83 – 5.61)	0.11 (-2.91 – 8.02)	0.15 (-1.07 – 7.40)	0.10 (-2.03 – 7.24)
Fruits (cups)	-0.14 (-7.04 – 0.92)	-0.03 (-2.95 – 1.60)	-0.08 (-3.91 – 0.40)	-0.09 (-10.30 – 5.77)	-0.08 (-4.96 – 1.71)	-0.07 (-4.30 – 0.79)	-0.07 (-8.51 – 4.42)	-0.04 (-5.17 – 3.18)	-0.04 (-5.08 – 3.17)	0.02 (-5.97 – 6.93)	-0.05 (-6.93 – 4.54)	-0.04 (-5.69 – 3.67)
Refined cereals (g)	-0.05 (-6.58 – 3.11)	-0.02 (-2.61 – 1.72)	-0.04 (-3.09 – 1.08)	0.03 (-11.55 – 14.52)	0.01 (-3.18 – 3.42)	-0.05 (-3.89 – 1.30)	-0.04 (-9.05 – 6.08)	**0.25 * (1.67 – 8.99)**	0.06 (-2.59 – 5.65)	**0.45 † (3.35 – 15.40)**	0.05 (-4.12 – 7.06)	**0.20 * (0.53 – 8.23)**
Whole grain cereals (g)	0.04 (-1.29 – 2.26)	-0.03 (-1.62 – 0.87)	-0.001 (-1.19 – 1.16)	-0.01 (-2.36 – 2.16)	-0.04 (-2.11 – 1.12)	-0.004 (-1.35 – 1.25)	-0.08 (-2.87 – 1.37)	0.01 (-2.59 – 2.87)	-0.12 (-3.35 – 0.39)	0.01 (-3.42 – 3.63)	0.02 (-2.45 – 3.07)	-0.11 (-3.50 – 0.95)
Legumes (cups)	-0.03 (-11.38 – 7.50)	**-0.10 * (-8.31 – -0.06)**	**-0.17 * (-11.28 – -3.49)**	**-0.39 * (-28.72 – -4.57)**	**-0.18 * (-13.88 – -1.99)**	**-0.13 * (-10.33 – -1.35)**	-0.04 (-38.75 – 26.14)	-0.01 (-7.94 – 6.80)	-0.06 (-11.58 – 5.49)	-0.16 (-18.28 – 4.20)	-0.04 (-10.42 –7.09)	-0.09 (-15.22 –5.83)
Red meat (g)	**-0.23 (-0.10 –-0.00)**	0.05 (-0.01 – 0.04)	-0.03 (-0.03 – 0.02)	-0.05 (-0.06 – 0.04)	-0.03 (-0.04 – 0.03)	-0.09 (-0.05 – 0.01)	0.04 (-0.08 – 0.11)	0.09 (-0.02 – 0.05)	0.06 (-0.02 – 0.05)	-0.17 (-0.11 – 0.02)	0.04 (-0.03 – 0.05)	0.01 (-0.05 – 0.05)
White meat (g)	-0.09 (-0.09 – 0.03)	0.02 (-0.03 – 0.04)	0.05 (-0.01 – 0.05)	-0.11 (-0.12 – 0.05)	0.01 (-0.04 – 0.05)	0.06 (-0.02 – 0.06)	-0.07 (-0.12 – 0.06)	0.06 (-0.03 – 0.07)	0.06 (-0.03 – 0.07)	-0.25 (-0.25 – 0.01)	-0.07 (-0.10 – 0.05)	0.03 (-0.05 – 0.07)
Fish (g)	**0.25 * (0.06 – 0.32)**	-0.01 (-0.06 – 0.05)	0.07 (-0.02 – 0.10)	0.04 (-0.11 – 0.14)	-0.07 (-0.11 – 0.04)	**0.20 * (0.05 – 0.18)**	0.09 (-0.08 – 0.18)	-0.10 (-0.16 – 0.04)	0.05 (-0.07 – 0.12)	0.06 (-0.11 – 0.19)	-0.01 (-0.11 – 0.09)	0.12 (-0.05 – 0.22)
Salty snacks (portions)	-0.09 (-7.31 – 1.61)	0.08 (-0.61 – 5.13)	-0.05 (-5.19 – 1.68)	0.24 (-0.54 – 8.22)	0.02 (-3.01 – 3.96)	-0.06 (-6.24 – 1.52)	-0.19 (-24.07 –4.27)	0.11 (-2.16 – 8.19)	-0.02 (-5.69 – 4.56)	0.07 (-10.68 – 19.00)	-0.04 (-13.77 –9.02)	0.03 (-4.59 – 6.10)
Sweet snacks (g)	-0.04 (-2.19 – 1.40)	-0.04 (-2.60 – 1.13)	-0.04 (-2.09 – 0.76)	**0.24 * (0.31 – 6.33)**	0.05 (-1.50 – 3.09)	-0.01 (-1.76 – 1.38)	-0.14 (-9.26 – 2.56)	-0.15 (-6.05 – 0.69)	-0.07 (-4.59 – 2.18)	-0.19 (-11.56 –1.03)	-0.09 (-8.03 – 3.30)	-0.16 (-6.20 – 0.69)
Nuts & seeds (g)	-0.10 (-3.60 – 1.03)	-0.04 (-3.05 – 1.30)	0.01 (-1.39 – 1.90)	-0.05 (-5.89 – 3.83)	-0.02 (-2.63- 1.91)	-0.003 (-2.28 – 2.17)	-0.04 (-7.42 – 5.33)	0.04 (-2.42 – 3.95)	-0.12 (-6.13 – 0.89)	0.03 (-4.29 – 5.59)	0.05 (-2.73 – 4.46)	-0.16 (-8.95 – 0.12)
Coffee (mL)	-0.04 (-1.24 – 0.78)	-0.08 * (-2.05 – 0.26)	0.02 (-0.59 – 1.00)	0.05 (-1.56 – 2.42)	0.05 (-0.77 – 1.71)	-0.01 (-0.97 – 0.80)	0.16 (-0.44 – 2.40)	0.02 (-1.87 – 2.40)	0.07 (-0.74 – 1.84)	0.24 (-0.20 – 5.87)	0.15 (-0.49 – 2.97)	0.13 (-0.41 – 3.00)
Soft drinks with sugar	0.05 (-2.50 – 4.58)	-0.03 (-4.72 – 2.83)	0.02 (-2.01 – 3.45)	-0.06 (-9.71 – 5.83)	0.05 (-2.67 – 5.75)	-0.003 (-3.27 – 3.08)	-0.09 (-9.53 – 4.27)	-0.01 (-8.16 – 7.05)	-0.04 (-7.52 – 4.56)	0.14 (-6.18 –17.55)	0.03 (-7.39 – 9.11)	-0.02 (-8.00 – 6.67)

(mL)												
Soft drinks without sugar (mL)	0.03 (-1.54 – 2.32)	-0.002 (-3.72 – 3.58)	0.06 (-0.47 – 3.14)	0.01 (-3.54 – 3.73)	-0.06 (-4.76 – 1.63)	**0.13 (0.52 – 4.10)**	0.17 (-0.64 – 5.00)	-0.09 (-8.64 – 2.11)	0.09 (-1.10 – 4.04)	0.05 (-5.83 – 8.78)	**0.18 † (0.01 – 5.75)**	-0.04 (-5.78 – 3.40)
Juice without sugar (mL)	0.02 (-4.58 – 5.84)	-0.06 ***** (-5.03 – 1.16)	-0.07 (-5.23 – 0.57)	-0.03 (-9.27 – 7.18)	-0.07 ***** (-6.67 – 1.97)	-0.08 (-6.20 – 0.82)	0.07 (-5.02 –10.17)	-0.03 (-8.25 – 6.01)	0.02 (-5.05 – 6.68)	-0.06 (-13.71 –8.04)	-0.02 (-8.15 – 6.92)	0.01 (-6.62 – 7.55)
Juice with sugar (mL)	0.004 (-5.67 – 6.00)	0.01 (-3.40 – 3.96)	0.06 (-1.01 – 6.47)	-0.03 (-7.56 – 5.72)	**0.17 * (1.72 – 14.94)**	-0.02 (-4.24 – 2.83)	0.03 (-8.39 – 10.93)	-0.12 (-15.21 –2.64)	-0.11 (-13.16 –2.47)	-0.01 (-13.23 – 12.02)	0.04 (-7.51 –11.38)	-0.13 (-16.42 –2.87)
Beer/cider (mL)	0.001 (-3.74 – 3.77)	**0.12 * (0.30 – 4.78)**	0.09 ***** (-0.10 – 4.19)	-0.05 (-6.09 – 4.15)	0.06 (-2.27 – 4.92)	0.09 ***** (-0.37 – 4.18)	0.12 (-3.43 – 8.46)	0.10 (-3.42 – 9.73)	0.04 (-4.02 – 5.99)	0.20 (-1.67 –13.89)	-0.11 (-10.69 –4.76)	0.16 (-0.76 – 9.33)
Wine (mL)	-0.07 (-8.88 – 3.75)	0.02 (-2.62 – 4.04)	-0.03 (-4.18 – 2.31)	-0.04 (-10.02 – 7.80)	0.09 (-2.27 – 9.04)	-0.09 (-6.53 – 0.46)	**-0.23 (-23.17 – -0.94)**	-0.14 (-13.29 –2.16)	-0.11 (-11.70 –2.92)	-0.16 (-19.27 –3.13)	-0.05 (-11.18 –7.64)	-0.15 (-16.96 –1.36)
Spirits (mL)	0.06 (-6.90 – 14.34)	**0.14 * (1.06 – 9.40)**	**0.10 (0.38 – 8.80)**	0.19 (-2.30 – 21.41)	0.06 (-4.60 –12.17)	**0.15 * (1.65 – 10.23)**	**0.39 * (3.56 – 15.22)**	0.11 (-3.80 –14.60)	0.16 (-0.58 –12.78)	0.21 (-1.66 –14.98)	0.19 (-1.04 –14.12)	**0.29 * (4.19 – 17.16)**
Moderate PA (min)	0.004 (-0.03 – 0.03)	0.02 (-0.02 – 0.02)	-0.01 (-0.02 – 0.02)	-0.12 (-0.07 – 0.03)	-0.003 (-0.02 – 0.02)	-0.09 ***** (-0.04 –0.003)	0.08 (-0.03 – 0.07)	-0.04 (-0.04 – 0.03)	-0.05 (-0.04 – 0.03)	-0.01 (-0.06 – 0.05)	0.03 (-0.03 – 0.05)	-0.06 (-0.06 – 0.03)
Vigorous PA (min)	-0.14 ***** (-0.06 – 0.003)	-0.07 (-0.02 – 0.004)	-0.01 (-0.02 – -0.001)	0.26 (0.00 – 0.07)	-0.07 (-0.02 – 0.01)	0.02 (-0.02 – 0.02)	0.07 (-0.04 – 0.07)	-0.04 (-0.04 – 0.02)	0.06 (-0.02 – 0.04)	-0.09 (-0.07 – 0.04)	-0.04 (-0.04 – 0.02)	0.05 (-0.03 – 0.05)
Walking (min)	0.03 (-0.01 – 0.02)	0.04 (-0.01 – 0.01)	-0.04 (-0.02 – 0.01)	0.22 (00.00 – 0.04)	0.05 (-0.01 – 0.02)	-0.04 (-0.02 – 0.01)	0.07 (-0.01 – 0.03)	0.11 (-0.01 – 0.05)	0.15 (0.00 –0.04)	-0.06 (-0.06 – 0.04)	0.14 (-0.01 – 0.03)	0.03 (-0.03 – 0.04)
Sitting (min)	0.01 (-0.51 – 0.57)	-0.01 (-0.35 – 0.29)	-0.01 (-0.34 – 0.27)	0.19 ***** (-0.20 – 1.36)	0.06 (-0.26 – 0.64)	-0.05 (-0.55 – 0.19)	0.13 (-0.29 – 1.13)	-0.06 (-0.81 – 0.37)	-0.01 (-0.56 – 0.52)	0.23 (-0.23 – 2.02)	-0.004 (-0.75 – 0.72)	-0.06 (-0.89 – 0.48)

Bold phase presents statistical significant associations before adjustment with BMI

*****: statistically significant association of the variable and also statistical significance of BMI after BMI adjustment

†: statistically significant association of the variable, after BMI adjustment

Existence of Hypertension

BMI was the main independent factor positively associated with existence of hypertension in both high and low risk group, as well as in all low risk and some of the high risk age, region and socioeconomic status (SES) subgroup analyses. In both low and high risk group, high beer/ cider consumption as well as BMI were the most dominant correlates of increased risk of hypertension. After analyzing by region, age or SES, low legumes and high beer consumption was positively associated with existence of hypertension in most of the low risk groups, but not in the high risk group. Also, in the low risk group high consumption of nuts and increased sitting time through the day (>45 years of age group) were also positively associated with existence of hypertension, which was not evident in the high risk group. Respectively, in high risk groups, reduced fruits (In low SES, low age) and white meat (in Central-north Europe), and increased beer (in >45 age), coffee (in Central-north Europe) and salty snacks (in Southeastern Europe) consumption were also positively associated with hypertension, after adjusting for BMI. Table 5 analytically presents associations of variables with hypertension existence by age, region and SES.

Table 5. Associations of dietary and physical activity indices with **E**xistence of Hypertension, by region, age and SES, in high and low risk for T2DM groups

Variables	**Existence of Hypertension** Beta (95% CI)											
	Findrisc <12						**Findrisc ≥12**					
	Region		**Age group**		**Education level**		**Region**		**Age group**		**Education level**	
	Central-North Europe (n=187)	**Southeast Europe (n= 395)**	**<45 (n=487)**	**>45 (n=95)**	**0 – 14 (n=242)**	**>14 (n=340)**	**Central-North Europe (n=98)**	**Southeast Europe (n = 170)**	**<45 (n=188)**	**>45 (n=80)**	**0 – 14 (n=127)**	**>14 (n=141)**
Low fat dairy (cups)	1.22 (0.81 – 1.84)	0.95 (0.66 – 1.38)	1.21 (0.94 – 1.56)	1.57 (0.54 – 4.63)	1.16 (0.75 – 1.79)	1.27 (0.93 – 1.75)	1.13 (0.47 – 2.72)	0.81 (0.39 – 1.67)	1.58 * (1.08 – 2.30)	1.83 (0.50 – 6.67)	1.32 (0.76 – 2.31)	1.56 (0.98 – 2.50)
Full fat dairy (cups)	1.23 (0.67 – 2.25)	1.17 (0.84 – 1.62)	1.09 (0.80 – 1.48)	2.05 (0.91 – 4.63)	1.12 (0.73 – 1.72)	1.24 (0.84 – 1.82)	**15.99 (1.07 – 238.46)**	1.16 (0.61 – 2.21)	1.50 (0.79 – 2.87)	1.13 (0.34 – 3.79)	2.18 (0.78 – 6.05)	1.43 (0.67 – 3.04)
Vegetables (cups)	1.16 (0.55 – 2.47)	1.18 (0.78 – 1.79)	1.15 (0.81 – 1.65)	**5.94 * (1.19 – 29.75)**	1.07 (0.59 – 1.95)	1.33 (0.82 – 2.17)	0.80 (0.12 – 5.25)	1.62 (0.75 – 3.50)	1.36 (0.62 – 2.99)	0.87 (0.23 – 3.30)	2.47 (0.90 – 6.79)	0.98 (0.37 – 2.61)
Fruits (cups)	**0.32 (0.11 – 0.93)**	0.89 (0.50 – 1.56)	0.64 (0.39 – 1.06)	1.22 (0.09 – 17.16)	0.56 (0.25 – 1.26)	0.75 (0.40 – 1.44)	0.07 (0.003 – 1.54)	0.65 (0.27 – 1.56)	**0.38 * (0.14 – 0.99)**	0.69 (0.15 – 3.23)	**0.21 † (0.05 – 0.95)**	0.55 (0.20 – 1.52)
Refined cereals (g)	0.47 (0.15 – 1.53)	0.87 (0.49 – 1.56)	0.80 (0.48 – 1.32)	0.67 (0.02 – 22.94)	0.75 (0.32 – 1.73)	0.88 (0.46 – 1.67)	0.01 (0.00 – 2.16)	2.24 (0.79 – 6.39)	1.04 (0.45 – 2.42)	41.08 (0.00 – 0.00)	0.69 (0.15 – 3.13)	1.35 (0.42 – 4.37)
Whole grain cereals (g)	0.89 (0.58 – 1.35)	0.94 (0.69 – 1.29)	0.95 (0.73 – 1.24)	0.74 (0.35 – 1.56)	0.93 (0.65 – 1.33)	0.76 (0.54 – 1.06)	0.60 (0.26 – 1.39)	0.88 (0.49 – 1.60)	0.72 (0.49 – 1.06)	0.77 (0.33 – 1.82)	0.84 (0.45 – 1.57)	0.81 (0.50 – 1.32)
Legumes (cups)	0.27 (0.02 – 3.49)	0.50 (0.19 – 1.36)	**0.28 * (0.11 – 0.69)**	**0.001 * (0.00 – 0.15)**	**0.22 (0.05 – 0.89**	0.33 * (0.11 – 1.03)	7.78 (0.14 - 3.76)	1.68 (0.38 – 7.35)	0.86 (0.14 – 5.12)	0.24 (0.02 – 2.99)	4.24 (0.50 – 36.14)	**0.09 (0.01 – 0.92)**
Red meat (g)	**0.98 (0.97 – 0.99)**	1.00 (1.00 – 1.01)	1.00 (0.99 – 1.01)	**0.98 (0.96 – 1.00)**	0.99 (0.99 – 1.00)	1.00 (0.99 – 1.01)	1.00 (0.95 – 1.05)	1.01 (0.99 – 1.01)	1.01 (0.99 – 1.02)	1.00 (0.98 – 1.01)	1.00 (0.98 – 1.01)	1.01 (0.99 – 1.02)
White meat (g)	1.00 (0.99 – 1.02)	1.00 (0.99 – 1.01)	1.01 (0.99 – 1.01)	0.98 (0.96 – 1.01)	0.99 (0.99 – 1.01)	1.01 (1.00 – 1.02)	**0.88 † (0.78 – 0.99)**	1.01 (0.99 – 1.02)	1.00 (0.99 – 1.01)	0.97 † (0.94 – 1.00)	1.00 (0.99 – 1.02)	0.99 (0.98 – 1.00)
Fish (g)	1.03 (0.99 – 1.06)	1.00 (0.99 – 1.01)	1.00 (0.99 – 1.02)	0.98 (0.94 – 1.03)	0.99 (0.97 – 1.01)	1.03 (1.01 -1.04)	1.06 (0.97 – 1.15)	0.98 (0.96 – 1.00)	1.01 (0.99 – 1.03)	1.02 (0.99 – 1.06)	1.01 (0.99 – 1.04)	1.01 (0.98 – 1.04)
Salty snacks (portions)	0.39 (0.11 – 1.44)	1.27 (0.58 – 2.79)	0.59 (0.26 – 1.36)	4.14 (0.85 – 20.24)	1.06 (0.44 – 2.54)	0.41 (0.13 – 1.28)	0.01 (0.01 – 0.94)	**3.82 * (1.02 – 14.29)**	1.84 (0.55 – 6.23)	2.01 (0.03 – 131.51)	**0.05 (0.003 – 0.76)**	2.67 (0.64 – 11.07)
Sweet snacks (g)	0.87 (0.57 – 1.34)	0.88 (0.55 – 1.40)	0.80 (0.56 – 1.12)	3.32 * (0.98 – 11.23)	0.99 (0.53 – 1.85)	1.01 (0.69 – 1.46)	**0.01 (0.00 – 0.88)**	0.43 (0.17 – 1.10)	0.69 (0.29 – 1.64)	0.08 (0.01 – 1.31)	1.10 (0.20 – 6.00)	0.48 (0.19 – 1.22)
Nuts & seeds (g)	0.90 (0.50 – 1.63)	1.20 (0.72 – 1.99)	1.18 (0.81 – 1.72)	**17.79 * (1.27 – 250.13)**	0.86 (0.48 – 1.53)	1.82 * (0.98 – 3.39)	2.52 (0.19 – 33.01)	1.42 (0.77 – 2.64)	0.46 (0.19 – 1.12)	15.86 † (1.96 – 263.16)	1.75 (0.71 – 4.32)	**0.30 (0.09 – 0.99)**
Coffee (mL)	0.92 (0.71 – 1.19)	**0.72 * (0.53 – 0.97)**	0.99 (0.83 – 1.18)	0.64 (0.34 – 1.22)	1.03 (0.78 – 1.36)	0.88 (0.71 – 1.10)	**3.12 † (1.11 – 8.78)**	0.88 (0.56 – 1.39)	1.13 (0.82 – 1.56)	1.27 (0.62 – 2.57)	1.43 (0.83 – 2.46)	1.32 (0.90 – 1.94)
Soft drinks with sugar	0.89 (0.33 – 2.43)	1.06 (0.43 – 2.64)	1.10 (0.57 – 2.13)	0.85 (0.07 – 10.47)	1.57 (0.64 – 3.85)	0.75 (0.36 – 1.60)	2.93 (0.22 – 38.86)	2.07 (0.39 – 11.01)	1.37 (0.38 – 4.97)	2.42 (0.08 – 69.42)	3.87 (0.48 – 31.09)	1.21 (0.25 – 5.86)

(mL)												
Soft drinks without sugar (mL)	1.24 (0.73 – 2.08)	0.75 (0.30 – 1.87)	1.13 (0.76 – 1.67)	**31.33 * (1.04 – 46.45)**	0.75 (0.37 – 1.51)	1.62 (0.98 – 2.70)	**6.52 (1.06 – 39.97)**	0.70 (0.23 – 2.12)	1.37 (0.78 – 2.40)	1.37 (0.14 – 13.13)	**2.26 † (1.10 – 4.65)**	1.23 (0.45 – 3.41)
Juice without sugar (mL)	2.06 (0.55 – 7.66)	1.07 (0.50 – 2.28)	0.81 (0.41 – 1.59)	7.87 (0.56 – 111.08)	1.48 (0.57 – 3.85)	0.64 (0.26 – 1.57)	5.20 (0.22 – 124.04)	0.36 (0.08 – 1.78)	0.47 (0.14 – 1.60)	1.55 (0.08 – 28.39)	0.24 (0.03 – 1.72)	0.55 (0.10 – 2.92)
Juice with sugar (mL)	2.30 (0.37 – 14.49)	0.64 (0.26 – 1.60)	1.40 (0.61 – 3.25)	**0.05 (0.00 – 0.59)**	1.13 (0.25 – 5.02)	1.15 (0.47 – 2.81)	5.45 (0.10 –9.49)	0.41 (0.06 – 2.80)	0.68 (0.13 – 3.63)	0.68 (0.01 – 38.24)	3.68 (0.31 – 44.48)	0.47 (0.05 – 4.16)
Beer/cider (mL)	1.50 (0.54 – 4.14)	1.54 * (0.85 – 2.78)	1.52 * (0.87 – 2.64)	0.63 (0.18 – 2.24)	**2.61 * (1.01 – 6.78)**	1.15 (0.65 – 2.06)	1.17 (0.23 – 4.23)	3.51 (0.71 – 17.34)	1.73 (0.50 – 6.01)	**4.04 † (2.44 – 7.46)**	0.73 (0.07 – 7.92)	5.64 (0.84 – 38.12)
Wine (mL)	0.28 (0.06 – 1.39)	1.24 (0.56 – 2.76)	0.66 (0.30 – 1.41)	1.64 (0.08 – 33.50)	1.59 (0.39 – 6.39)	0.47 (0.20 – 1.14)	0.003 (0.00 – 10.09)	0.88 (0.14 – 5.51)	1.71 (0.24 – 12.38)	0.17 (0.01 – 4.83)	35.42 (0.83-1510.45)	0.47 (0.07 – 3.28)
Spirits (mL)	0.62 (0.03 – 14.79)	2.42 (0.71 – 8.25)	1.43 (0.49 – 4.18)	**5.93 * (2.15 - 5.19)**	1.02 (0.15 – 6.89)	2.51 (0.66 – 9.58)	6.81 (0.10 – 1.07)	3.86 (0.40 – 37.03)	3.24 (0.53 – 20.04)	1.77 (0.10 – 31.25)	4.65 (0.49 – 43.95)	2.00 (0.42 – 9.46)
Moderate PA (min)	1.00 (0.99 – 1.01)	1.00 (1.00 – 1.01)	1.00 (0.99 – 1.00)	0.99 (0.97 – 1.01)	1.00 (0.99 – 1.01)	1.00 (0.99 – 1.00)	1.03 (0.99 – 1.07)	1.00 (0.99 – 1.01)	1.01 (0.99 – 1.01)	1.00 (0.98 – 1.01)	1.01 (0.99 – 1.02)	1.01 (0.99 – 1.02)
Vigorous PA (min)	1.00 (0.99 – 1.01)	1.00 (1.00 – 1.00)	1.00 (0.99 – 1.00)	1.02 (1.00 – 1.04)	1.00 (0.99 – 1.00)	1.01 (1.01 – 1.02)	1.01 (0.98 – 1.05)	1.00 (0.99 – 1.00)	1.00 (0.99 – 1.00)	1.00 (0.99 – 1.02)	1.00 (0.99 – 1.01)	1.00 (0.99 – 1.01)
Walking (min)	1.00 (0.99 – 1.00)	1.00 (1.00 – 1.00)	1.00 (0.99 – 1.00)	1.01 (0.99 – 1.01)	1.00 (0.99 – 1.00)	1.00 (0.99 – 1.00)	1.00 (0.99 – 1.01)	1.01 (0.99 – 1.01)	1.00 (0.99 – 1.01)	0.99 (0.98 – 1.01)	1.01 (1.00 – 1.01)	1.00 (0.99 – 1.01)
Sitting (min)	0.97 (0.84 – 1.12)	1.03 (0.95 – 1.11)	1.03 (0.96 – 1.10)	**1.46 * (1.09 – 1.96)**	1.06 (0.96 – 1.18)	0.99 (0.91 – 1.09)	1.18 (0.82 – 1.68)	0.88 (0.77 – 1.01)	0.93 (0.83 – 1.04)	1.17 (0.90 – 1.52)	1.01 (0.85 – 1.21)	0.85 (0.73- 1.00)

Bold phase presents statistical significant associations before adjustment with BMI

*****: statistically significant association of the variable and also statistical significance of BMI after BMI adjustment

†: statistically significant association of the variable, after BMI adjustment

4. Discussion

The present study was conducted in 2500 non diabetic adults, with risk factors for T2DM, in order to investigate the possible association of dietary habits and physical activity indices with blood pressure. The most dominant findings of the study was that consumption of low fat dairies, beer and spirits as well as BMI are positively associated with an increase in blood pressure (SBP, DBP and existence of hypertension) in both low and high risk groups. Positive associations were also found for coffee consumption with SBP only in the high risk group. On the other hand, legumes consumption was the only behavior inversely associated with SBP and DBP in the low risk group. The above findings were independent of sex, smoking and obesity.

BMI, low consumption of legumes and high consumption of beer, cider and spirits were the main factors positively associated with SBP, DBP and existence of hypertension in low and high risk population. To the best of our knowledge there are no studies in the literature investigating the associations of all these variables with SBP, DBP or total existence of hypertension, in high risk population for T2DM. However, a study conducted in a smaller sample, consisted of 131 hypertensive participants, overweight and obese with impaired blood glucose, found that a 3 – month adoption of DASH diet led to significant decrease in SBP, DBP, glucose and insulin. Dietary habits mentioned above could be a part of a healthy type of diet, such as the DASH diet. [65] Moreover, it has to be mentioned that legumes consumption is more studied as part of a healthy dietary pattern, specifically as part of the Mediterranean diet. Many studies and meta – analysis have investigated Mediterranean diet's beneficial effects on blood pressure. In a recent review, Shen et al. concluded that components of Mediterranean diet (high legume consumption, moderate alcohol consumption, mostly wine, vegetables, fruits, olive oil) are associated with reduction in blood pressure levels. [49] Additionally, in the present study an inverse association of wine consumption with SBP and DPB was detected, in the high risk group. As it was mentioned in the introduction, alcohol overconsumption (esp. beer, spirits) is a burden for blood pressure, especially for men. [46] However, red wine consumption, accompanied by a meal, might have a protective role for blood pressure, firstly by lowering central aortic blood pressure and secondly because the increase in blood pressure appears to be eliminated when combined with food . [47]

Analysis by region, age and education groups in both high and low risk adults might be subjected to statistical flaws due to fragmentation of the study sample in small groups; however there are some worth-mentioned outcomes. Legumes consumption was inversely associated with SBP and DBP in every low risk subgroup of the analysis, except for North Europeans. The same association was found for hypertension existence, which was independent of age and SES. Beneficial effect of legumes consumption was not found in high risk subgroups. Positive association of beer and cider consumption with SBP, DBP and existence of hypertension was observed in almost every low risk subgroup, but again in North Europeans the mentioned association was only found for SBP. On the other hand, beer and cider consumption was not associated with SBP, DBP or existence of hypertension in any of the high risk subgroups, except for existence of hypertension in participants in the older participants' subgroup. As it has already been mentioned above, studies investigating beer or legumes consumption, especially in such subgroups, are not available in the literature. However, it is known that increased alcohol consumption is positively associated with high blood pressure levels in general population, which might explain the reason why beer and cider consumption are positively associated with hypertension existence in some of the low risk groups. [46] As far as legumes consumption is concerned, their beneficial effect might be due to increased fiber content, consumption of which is known to be inversely associated with hypertension. [32]

One outcome expected to be found, was the inverse association of physical activity (moderate, vigorous, walking) in total sample, in both low and high risk group. Despite the expectation, none of the mentioned physical activity and sedentary behaviors had a significant result. However, in the subgroup of low risk participants, older than 45 years, a positive association of sitting time with DBP and hypertension existence was found. The present findings are in accordance with in a recent Suboc et al. which found no statistically significant reductions in blood pressure levels in the groups following sedentary time reduction, after a 12 – week intervention in 96 pre – hypertensive and hypertensive sedentary adults, older than 50 years. [68] Many more studies are needed in order to investigate this issue more analytically.

Strengths & Limitations

This study has certain strengths and limitations. First of all, it is the first study investigating associations of dietary and physical activity behaviors with hypertension in 6 different countries across Europe. Furthermore, the large study sample, the standardized protocols and procedures followed across all centers, and the objectively collected data (i.e. blood and anthropometric indices,

blood pressure and physical activity level recorded via pedometers/ accelerometers) safeguard the more objective and reliable assessment and increase the generalizability of findings. As far as the limitations are concerned, some of the collected data were self – reported and thus prone to recall bias and social desirability. Additionally, since the present study is cross – sectional, determination of cause and effect relationship is impossible.

5. Conclusion

In conclusion, beer, cider, spirits, reduced legume consumption and BMI are the main factors positively associated with SBP, DBP and hypertension existence in the low risk group. All the above dietary habits, except for reduced legume consumption, are also positively associated with SBP, DBP and hypertension existence in the high risk group. Future studies in in populations at high risk for T2DM are essential in order to more accurately define the main dietary and physical activity behaviors associated with SPB, DBP and hypertension existence and to more efficiently reduce diabetes risk.

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