Universidad de Navarra

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Europeo en Alimentación, Nutrición y Metabolismo
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Directora del Proyecto:

Maijaliisa Erkkola
Dept: Food and Nutrition
Faculty of Agriculture and Forestry
University of Helsinki

Co-Director del Proyecto:

Santiago Navas Carretero
Dpto: Ciencias de la Alimentación y Fisiología
Facultad de Farmacia y Nutrición
Universidad de Navarra

Graduada en Nutrición Humana y Dietética
CELIA BURGAZ ANDRES
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El Director del Máster Universitario Europeo en Alimentación, Nutrición y Metabolismo, Prof. J. Alfredo Martínez Hernández hace constar que el presente trabajo ha sido realizado por el Graduado en Nutrición Humana y Dietética CELIA BURGAZ ANDRES en el Departamento de Alimentación y Nutrición de la Universidad de Helsinki.

Dr. J. Alfredo Martínez Hernández

Pamplona a 4 de septiembre de 2018

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Celia Burgaz Andrés

Pamplona, August 2018

ABBREVIATIONS AND DEFINITIONS

CI	Confidence Interval
DAGIS	(Swedish: *pre-school*) Increased Health and Well-being in Preschools (Study)
DP	Dietary Pattern
EBRB	Energy Balance-Related Behaviours
FFQ	Food Frequency Questionnaire
HRS	Hours
IDEFICS	Identification and Prevention of Dietary- and Lufestyle-Induced Health Effects in Children and Infants (Study)
MIN	Minutes
(MV)PA	(Moderate-to-Vigorous) Physical Activity
NCD	Non-Communicable Disease
NDNS-RP	National Diet and Nutrition Survey – Rolling Programme
NHANES	National Health and Nutrition Examination Survey
PEL	Parental Educational Level
REM	Rapid-Eye Movement
SD	Standard Deviation
SES	Socio-Economic Status
ST	Screen Time
UK	United Kingdom
US(A)	United States (of America)
VEGMEAT	Vegetables-And-Processed-Meats
WHO	World Health Organization

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1. INTRODUCTION

In all industrialized countries around the world, overweight and obesity rates have increased[1]. Between 1998 and 2001, Finland had one of the highest rates of adulthood obesity among Europe, and experienced one of the greater increases, preceded only by Spain[1]. Based on self-report data from the World Health Organization (WHO), overweight and obesity estimates from 2012 show that more than 66% of adult men and 46% of adult women in Finland were overweight[2]. The proportion of men and women with obesity was 20.4% and 19%, respectively[2]. Adulthood obesity prevalence forecasts predicts that by 2030, 29% of men and 27% of women will be obese[2].

At the present time, the expanding prevalence of overweight and obesity among children is also of special concern, as such rates have increased globally reaching epidemic proportions. Sadly, over the past 30 years, the prevalence has nearly tripled[3]. It is a widespread and growing obstacle relevant in different sectors, as it inevitably leads to medical, social, economic and political challenges. Obesity rates among early ages are directly associated with a wealth of negative health outcomes and with a higher probability of developing diseases during adulthood[4]. Health disorders such as cardiovascular disease, atherosclerosis, hypertension, type 2 diabetes, metabolic syndrome, and fatty liver disease, among others[4].

Energy balance-related behaviours (EBRBs) established during the childhood period, track into adulthood[5]. These EBRBs consist mainly on physical activity, sedentary behaviours and food consumption. In infancy, diet is considered an important and modifiable exposure with both short- and long-term implications for development and health[6]. If these dietary behaviours are not taught during early stages of life, the consequences have an impact on the health status of the future adult population. Therefore, it can be said that nutrition in early childhood is a cornerstone in the development of life-long health[7]. And as Professor Lawrence T. Weaver claimed, "Paediatricians should be more interested in adult disease because the child is the father of the man"[8]. Following his thoughts, health professionals should focus on the diseases that are now present to avoid them in future generations, and therefore to prevent before the cure becomes a global necessity. However, the reason for the epidemic rates of obesity cannot just be explained by the variations in the traditional lifestyle factors such as diet (increased food intake, large food portions, and snacking) and reduction of physical activity. Thus, it has been proposed recently that the shortening of the habitual sleeping times might play a substantial role in the causal pathways of childhood overweight[1].

Sleeping patterns are learned during childhood and by repeating them over the years, they become habits. With increased literature on the detrimental effects of poor sleep on physical and mental health outcomes in children[9,10,11,12], emphasizing on the importance of the amount and quality of sleep is becoming a public health priority worldwide. Yet, it is less well known the impact that sleep plays on energy-balance and diet since early life. At present there is more evidence that supports the impact that sleep has on diet, and diet on sleep[13]. However, further research is needed to investigate how sleep may potentially be used as a modifiable factor in the treatment of non-communicable diseases (NCDs).

The present study seeks to investigate the associations existing between sleep duration and dietary patterns (DPs) in early ages, to determine if there are differences among genders, and to detect how these associations differ among dissimilar socio-economic status (SES). From the results obtained, future research on this topic could be targeted and better health promotion plans could be created in order to diminish the observed differences. Both sleep and diet quality play an important role in health along the lifespan, since early stages of life. Additionally, sleeping habits are less susceptible to wealth factors when compared to dietary patterns, as they should not depend directly on economic determinants to be achieved. Sleep and diet have separately been studied, as both sleep quality and healthy eating patterns have a direct impact in the health of the population. However, to our knowledge, until the date there are no published studies that have investigated these associations together and in pre-school subjects.

This study was conducted within a research survey carried out by the Folkhälsan Research Center together with the University of Helsinki. The main goal of the larger research project '*DAGIS*' (from Swedish, meaning '*pre-school'*) - Increased Health and Wellbeing in Preschools - is to diminish the impact of socio-economic differences in energy balance-related behaviours among pre-school children. The main interests are to study the association between EBRBs and stress regulation among three- to six-year-old pre-schoolers, to establish the factors related to these EBRSs and long-term stress both at home and at pre-school, and to identify the existing socio-economic status differences[14].

2. LITERATURE REVIEW

2.1. Sleeping habits

2.1.1. Definition, recommendations and measurement

Sleep is primarily a behaviour[15]. At the epidemiological level, normal adult sleep duration is from 7 to 8 hours per night[16], but according to the National Sleep Foundation, in children and adolescents more sleeping time is needed, from 10 to 13 hours per night[17]. However, there is a lack of consensus on the optimal sleep duration for children[18].

Curiously, sleep quality and how an individual feels after waking up are as important as the amount of sleep itself. Optimal sleep duration is decisive to live a long life, as recent studies have shown that people with either shorter or longer sleep durations than recommended, live shorter lives[16]. Beyond sleep duration and quality, sleep timing is gaining recognition as an important additional factor to consider for the promotion of good health outcomes and behaviours[19].

Over the past years, to assess sleep duration objectively, it has been widespread to measure sleep using actigraphy or polysomnography[20,21,22], as it allows to determine the total sleep minutes and exclude the wake periods. However, to assess sleeping habits among pre-school-aged children, the most common technique is the parent-reported survey assessing child sleep duration, quality and sleep hygiene practices[23,24] based on the respective National Sleep Foundations. Either parents report what time their child typically goes to bed and wakes up[23], or they report the time their child spends sleeping in a 24-hour period, recorded to the nearest half hour[24,25].

Thus, what do we mean when we talk about healthy sleeping habits? Sleep can be assessed both as sleep duration as well as sleep quality, which also considers minor aspects as sleep efficiency, rapid-eye movement (REM) phase, difficulties to wake up in the morning and tiredness during the day[18]. Sleep health and hygiene refers to the various habits, environmental factors and practices that may influence both quality and length of sleep. Sleep timing refers to the hour in which an individual goes to bed and the time in which the individual wakes up. The present study will focus mainly in the sleep duration, considered as hours of sleep per night during the week.

2.1.2. Time trends in sleep duration and the impact of society

In 1971, Omran[26] illustrated how health and disease patterns suffer transformations over time in societies, depending among other factors, on the extent of demographic transition and rate of economic development, to result in an epidemiological transition[27]. At present times, sleep's importance is increasingly perceived. Indeed, sleep curtailment is one novel behaviour that has been developing along the past decades and has become remarkably prevalent[1]. Diverse studies have suggested that over the past decades the sleep duration has declined[28,29,30,31], which parallels with other public health trends, including the rise in overweight rates.

Yet, secular trends in sleep duration are poorly reported[1]. It was only in the 1960s and 1970s that the sleep recording became a routinely procedure[32]. A comparison of surveys conducted in the 1960s and 1970s to those conducted in the 21st century suggest a concealed decrease in sleep length among adults[1]. Data from the 2008 "Sleep in America" shows a noticeable shortening of sleep duration, and sleep times in European countries seem to follow an analogous trend[1].

Inappropriate or insufficient sleep caused by brief sleep duration and/or poor sleep quality are problems that are becoming more and more prevalent in a society with a 24-hours access to diverse commodities[18,19]. As a matter of fact, the main causes of this lack of sleep are primarily due to contemporary styles of living, which include an excessive artificial light through the use of screens until late hours at night, combined with the absence of defined bedtime routines in households[33]. In modern times, having a sufficient sleep duration in order to maintain health and well-being is becoming a luxury[34] in a society defined each time more by the necessity of fast and easy solutions and the use of technology. But these claims are not just exhausting, they are also harmful. In fact, as it is widespread known, using electronic devices before going to bed suppresses the release of melatonin, making it more difficult to fall asleep[35]. Poorly rested children who wake up feeling tired have metabolic alterations even after eight hours of shuteye[35]. Therefore, lifestyle behaviours such as diet, physical activity, sleep and screen usage are established contributors to health[35]. Knowing this, it is not surprising that a growing area of concern is the use of screen devices before bed-time and its detrimental effects on sleep hygiene[36].

Many different factors combine to facilitate later bedtimes, causing a delay in the timing of the circadian system[34]. It is mainly because the urban environment has changed vastly over the past decades, impacting our sleep, dietary patterns and possibly even health incomes. Children's sleep duration and quality has decreased over the past years, meanwhile in parallel, lifestyle and dietary behaviours have also changed. Chrono-nutrition focuses on the impact of the timing of eating on health outcomes, and it could mediate the effects between sleep, diet and urbanization[37]. As the prevalence of non-communicable diseases has increased globally, so has the amount of population who adopts unhealthy lifestyle behaviours[38]. Inevitably, changes in social, physical and economic environments are key drivers of risk factors for NCDs[38,39].

Even if there is still narrow evidence supporting a clear decline in sleep trends[13], and the limited evidence can be conflicting, in children secular trends seem to show a bright picture: a systematic review by Matricciani et al. (2012)[18], from twenty countries from 1905 to 2008 shows a consistent decrease in sleep duration, both in children and adolescents. The sample's median rate of change was -0.76 min nightly per year over the last century, illustrating a decrease of more than 1 hour/night over the study period. Specifically, the median rate of change was higher on non-school days compared to school days, for older children (16- to 18-years old) compared to younger ones (5- to 8-years old), and for boys compared to girls. Nonetheless, drop rates varied per region – Europe, United States of America (USA), Canada and Asia – and in some particular regions – Australia, the United Kingdom (UK) and Scandinavia – a small increase was observed. These changes may be partly explained by the fact that the samples were not homogeneous and only 14 of the studies included explicit information about the distribution of the days of the week in which children had attended school, as it varies among countries. Even if this meta-analysis does not determine possible causes for the identified trends, it has been speculated that this declined secular rates may occur as a result of delays in children's bedtimes, but unchanged wake up times[18].

So, even though children should sleep at least from 9 to 11 hours each night according to health behaviour recommendations to prevent NCDs[36], the adherence to health behaviour recommendations of sleep is decreasing. For instance, in a study conducted in 2015 it was witnessed that only 56% of a sample of Australian children and adolescents followed the mentioned recommendations[36]. Results from a study among Spanish children aged 2-14 years showed that overall, short sleep duration increased from 30% in 1987 to almost 45% in 2011, in all demographic groups, without significant differences between boys and girls. The sleep duration was associated with year of survey, age, parental educational level (PEL), obesity and physical activity[40]. However, the situation in Finland seems slightly different. In 2010, the proportion of Finnish pre-schoolers sleeping on average 9-11h was 99.1%[41], according to a parent-reported survey. Interestingly, in 2005 Pääkkönen[42] found that Finnish children were getting more sleep on weekends and less sleep on weekdays in 2000 compared with 1987. According to the book *Time Use Changes in Finland through the 2000s*[43], children aged 10-14 sleep on average 9 hours and 47 minutes. Yet, there is no information about sleep duration in younger children. Nonetheless, to our knowledge, the information about sleep duration in preschool-aged children is scarce.

According to a cohort study carried out in children and adolescents in US, inadequate sleep increased from 23 to 36% among 6-9-years old. Those levels increased among the three survey periods, meaning that along the ten years of the cohort, 6-9-year-olds had the lowest levels of inadequate sleep, followed by the 10 to 13-year-olds, and the 14 to 17-year-olds, who had the highest ones (49%)[44]. These results reveal that scarce sleep seems to develop as young as age six, and increments with age, becoming frequent and socially patterned.

It can be concluded that in general children and adolescents sleep less now compared to decades ago[19]. However, the way of measuring sleep length has changed. Currently the methods used are surveys, actigraphy and polysomnography. Therefore, it could be possible that this measurement changes partly explain the differences between sleep duration along the past century until present times. Changes in social behaviours could be promoted by policies which aware the population about the important role that sleep plays on overweight and obesity[4]. Yet, there is disagreement about whether there is enough evidence of declining sleep duration[34]. Especially in pre-school children there is limited empirical evidence.

2.1.3. Sleeping habits and health outcomes in children

Sleep is important for both the well-being and the proper development of children. Particularly, small children are vulnerable to the effects of inadequate sleep[41]. The fact that sleep restriction has a spectrum of detrimental effects on both our health and well-being is now evident. The research on this area started recently, and yet the view of sleep and its prominence for health has already changed. Current data from the WHO shows that heart diseases and strokes are the two leading causes of death worldwide[45]. As it is now considered an epidemic disease, poor sleep should be a modifiable risk factor prevented since childhood for this chronic condition, as so are smoking, unhealthy diets and lack of physical activity[46]. Insufficient sleep has been directly linked to detrimental health effects[47] and has consistently been shown to exert a wide range of adverse effects on body systems. Epidemiological evidence show that poor sleep is associated with a higher risk of chronic diseases, including obesity as one of the main ones[48,49]. In children, inadequate or poor sleep has been linked with health and behavioural disorders, poor sociability, learning disabilities and obesity[36]. Longer sleep length is generally associated with better body composition, emotional regulation and growth in children aged 0 to 4 years[50]. On the other hand, shorter sleep is associated with longer screen time (ST)[50].

Inverse association between sleep length and overweight have been found in children[25]. According to results from a recent study carried out in Shanghai, less than 10 hours of sleep per night is associated with overweight and obesity rates in children[4]. These conclusions support the results from other study conducted in Malaysia that evaluated the influencing factors of obesity in children from 6 to 12 years old, which found that children with shorter sleeping time had a 4.5 times higher chance of being overweight or obese when compared to a standard sleep duration group[51]. Notwithstanding these associations, not all studies have found direct connection between sleep limitation and either overweight or obesity[52,53].

In addition to the already mentioned repercussions on health, non-adequate sleeping habits have direct impact on stress levels too. Like a vicious circle, the unhealthy compensation mechanisms to control stress levels may rebound in obesity, which together with anxiety, could lead to additional unhealthy future compensations such as smoking or drinking alcohol during adolescence or adulthood[54]. Stress levels and the cortisol secretion may cause sleep disruptions in children[55,56]. Therefore, the regulation of stress in children is one of the most important factors associated with both EBRB and SES.

Sleep health and hygiene is every time more and more important as in 2007 the International Agency for Research on Cancer classified the circadian disruption as a probable human carcinogen[34]. The circadian disruption refers to the external changes that occur within the 24-hour rhythms which optimize the metabolic functions of the body. Such disturbances can lead to diverse health issues such as fatigue, insomnia and lack of appetite (among others), causing changes in factors that directly alter health, leading to higher levels of obesity, stress and more sleep alterations[34]. Some studies highlight the importance of adequate sleep, as its insufficiency has been linked with problems as impaired ability to concentrate, retain information and additional mood disorders, including anxiety, depression or hyperactivity[57].

The results of a cross-sectional study among Australian children showed that a combination of late bedtimes and late wake-up times was associated with a higher risk of obesity and poorer diet quality, independently of sleep duration, physical activity level and sociodemographic characteristics[58]. Children with late bedtimes/wake-up times have been reported to engage in less moderate-to-vigorous physical activity (MVPA) and more ST compared with a group of children with early bedtimes/wake-up times, despite having similar sleep durations[19]. Such results seem to suggest that sleep timing plays an important role in health outcomes and should be analysed together with sleep duration.

2.1.4. Sociodemographic determinants of sleeping habits

Sleeping patterns differ from country to country, modulated by a wealth of diverse variations in demographic structures of the population, economic development, access and use of technology, working hours, light/obscurity times and cultural traditions. In addition to all these factors, a strong correlation exists between SES and sleep, resulting in shorter sleep duration among individuals within lower household incomes[59]. However, a study published in 2015 reports that US adolescents from lower SES were more likely to self-report adequate sleep when compared to subjects with higher SES[60]. Besides, it has been reported that there is a wide gap between gender differences, with girls less likely to report getting more than 7 hours of sleep compared with boys[60]. Lower SES during childhood may be associated with shorter sleep in adulthood[61].

Despite well-established differences in many of the health outcomes related to sleep (such as obesity) the vast majority of sleeping research has been conducted on small homogeneous samples[44]. Only a few researches have studied the social determinants of sleep in children. From 1991 to 2011, Knutson (2013)[9], identified five publications that examined socio-economic differences in sleep among children. The global patterns indicate that children who come from more disadvantaged backgrounds have worse sleep quality and shorter duration compared to those who live in more advantaged circumstances[9]. A recent study illustrates that SES significantly mediated associations with sleep duration and sleep timing variability[20]. To support this information, there is evidence among Australian children and adolescents of social disparity regarding the rates of adherence. Children from lower SES meet fewer recommendations to prevent NCDs when compared to their higher SES coequals[36]. Moreover, children from rural areas meet more recommendations than children from urban areas.

On the other hand, contrarily to the information presented above, according to a cohort study in the US[44], those children who came from households with more than a high school degree where prone to have inadequate sleep, meaning that children with more educated parents slept less overall. To support this information, data from a recent report that used prospectively measured SES in childhood in relation to adult sleep[61], concluded that short sleep duration is less likely to be consistently associated with low SES. These results may indicate that sleep length may not be a key sleep characteristic for understanding health disparities associated with SES.

2.2. Diet and dietary patterns

2.2.1. Definitions and recommendations

Early childhood is an important nutritional period as the incidence and outcome of different metabolic diseases have been found to be associated with dietary patterns in this stage of life[7]. While a wealth of nutrition literature and research focuses on the role of specific nutrients or foods, summarizing dietary data into an overall pattern offers a wider possibility to study the relationship between whole diets and health[6]. This approach examines foods that are frequently consumed together, to achieve a DP score and to organize participants in groups of subjects consuming similar types of foods. If a pattern is associated to the nutrients intake or nutritional biomarkers of children, it indicates that the score is a trustful measure to quantify the quality of the diet[6].

In previous studies among children, the identified patterns were commonly divided into two or three groups. The studies that focused on two groups, presented high variability. Some tended to differentiate the patterns commonly into Healthy and Unhealthy/Processed[6,62,63,64,65]. However, other studies separated the dietary patterns into Fruits and Vegetables, and Energy-dense and Meat-based[66], or into Core foods and Poor-quality-Fats and Added-Sugars[67]. Furthermore, those studies that distinguished dietary patterns into three groups, separated them into Processed, Healthy and Sweet[68], into Highly Unhealthy, Healthier or Moderately Unhealthy[62] or into Diverse, High Fat and High Sugar[69]. Therefore, it could be said that there is a high variability when defining dietary patterns among children, as they can vary among different countries and cultures or even between ranges of ages.

Dietary patterns established in the earlier ages of life track into mid-childhood[67]. Follow-ups of DPs from age three to nine years[70] and from age six years into adulthood[71] suggest that the habits and preferences established during preschool ages may influence longer-term food choices. Yet, there are few systematic reviews of studies involving pre-school children.

Dietary recommendations are based on evidence that a healthy diet is a protective factor against malnutrition and prevention of NCDs[72]. From the six health behaviour recommendations to prevent or reduce the risk of NCD in children, two consist on dietary advice. More specifically, on vegetables and fruits consumption, as they are a fundamental source of nutrients, phytochemicals, dietary fibre and high daily intakes directly related to good health[36]. These recommendations are two serves per day of fruit and five portions per day of vegetables. Regarding sleeping habits, the already mentioned recommendation is to have from 9 to 11 hours of sleep per night. Two other recommendations centre in habits regarding both PA and screen usage, supporting the practice of at least 60 minutes of daily PA, and less than two hours per day of ST. The sixth recommendation involves teeth-brushing habits[36]. Yet, the proportion of children from 5- to 16-years old meeting all the above-mentioned recommendations together is sub-optimal (< 0.5%), according to a study conducted in 2017[36]. Overall, the adherence rates for the recommendations on diet were 79% for fruits, but only 7% for vegetables[36].

However, there are few systematics reviews of studies involving preschool children. The associations between DPs and health has been mainly reviewed for adults. Understanding whether and how early DPs could shape future health, wellbeing and development is an important area of research[6].

2.2.2. Diet and socioeconomic status

Both diet and health have variations among social status all the way from childhood to adulthood[73,74]. Socio-economic status inequalities during childhood can affect dietary patterns, and therefore future health[68]. Recent data suggest that SES is closely associated to the quality of the diet[75], for instance reporting that higher SES consume larger amounts of fruits and fresh vegetables compared to middle and lower SES groups, together with other dietary differences. Existing evidence on the impacts of PEL on the nutrition of children is plagued by internal and external validity concerns[76], meaning that there is a causal relationship between both variables, and at the same time, such association can be generalized to other settings or population. Diverse studies confirm that early socio-economic deprivations are associated with poorer dietary choices[34,77,78]. In Finland, several studies have found associations between SES and diet among adolescents[14,79,80]. A study of among Finnish children[81] found that the healthy eating index varied between sociodemographic groups. The results suggested that further public health programs should improve dietary behaviours in pre-school children, especially among families with a history of lower PEL[81]. However, there is limited literature that reports these associations in younger children.

To analyse the impact of socio-economic factors on diet, the IDEFICS study[68] identified three DPs from a total baseline of 9.301 children aged 2-9 years from eight European countries. These patterns were labelled: (1) "processed" (frequent consumption of snacks and fast food), (2) "sweet" (high consumption of sweet foods and drinks), and (3) "healthy" (rich in fruits and vegetables). At the same time, in order to study the existing vulnerabilities associated to their DPs, children were divided into two groups according to their socio-economic and parental situation. In this regard, the vulnerable groups were subdivided in: (1) children whose parents lacked a social network, (2) children from single-parent families, (3) children of migrant origin and (4) children with either one or both parents unemployed. According to the results obtained, children whose parents lacked a social network or migrants more likely followed the processed pattern, both at baseline and follow-up. Whereas children whose parents were homemakers, were at baseline less likely to follow a processed DP. The study[68] revealed that a greater number of vulnerabilities seemed to be associated to higher probabilities of children being at risk of having unhealthy diet behaviours.

A study conducted from 2008 to 2015 among Australian children aged 4 months at baseline, compared the intakes of vegetables, fruits and discretionary foods with the Australian Dietary Guidelines. The results showed that the majority of children (>90%) met vegetable and fruit guidelines at 9 months, however thereafter (1.5 years, 3.5 years and 5 years) rates of correct intakes had a substantial reduction. Those children from higher SES followed DPs closed to the guidelines for most food groups and at most ages[82]. Other findings in Chinese school children significantly associate age, male gender, low level of PEL, lack of outdoor activity during weekends, short sleep duration, poor consumption of vegetables and high of snacks and sugar-sweetened drinks, with overweight or obesity rates in children[4].

The cross-sectional LATE study conducted in Finland from 2007 to 2009, among 2.864 children from 0.5 years onwards, showed that a sufficient perceived income seemed important in the meal patterns in childhood. Children from families with income insufficiency had a greater risk of skipping breakfast and not following the 4 to 6 meals per day recommendations. The study described that there are socio-economic differences in meal patterns and that these are more evidenced during childhood compared to adolescence[83].

When considering DPs, the results from a recent study among Mexican children aged 5-15 years show that subjects from lower SES and home environmental factors were more likely to follow an unhealthier dietary pattern, such as high fat and high sugar patterns[69]. Furthermore, according to a systematic review[6], among studies centred in the analysis of the association between dietary patterns and sociodemographic characteristics, high PEL was positively associated with healthier DPs during pre-school years. Meanwhile, the relationship between higher household income and healthier DPs was inconsistent. Such results[6] suggest that PEL may not go always in line with the SES. Some studies associated financial difficulties in households positively related to processed food patterns, whereas other studies did not report similar results[6]. As a matter of fact, Shin et al suggested that a higher income was associated with higher scores on all DPs, including the healthy and the unhealthy ones[65].

Lifestyle behaviours seem also to be associated with academic achievement, and poor academic achievement can further conduce to poorer health over lifespan. A recent study carried out in Canadian adolescents[35] showed that a frequent consumption of vegetables and fruits, breakfast and dinner with family and regular PA were positively associated with higher levels of academic results, while frequent consumption of junk food, not meeting sleep recommendations, and overweight and obesity were negatively associated with a higher academic achievement. Considering this, it could be concluded that healthy lifestyle behaviours may be associated with higher academic achievement in early ages[35], which would probably end up translated in higher socio-economic positions. Socio-economic factors have an impact on the dietary habits of children[69,82,83]. Interestingly, the just mentioned results suggest that the association may exist also the other way around: diet and other lifestyle behaviours may play a role in the future SES of a subject.

2.2.3. Association between sleeping habits and diet

Over the last years, research on sleep duration's effects and dietary intake has increased, as sleep is a pivotal regulator of metabolic activity and functioning, including energetic metabolism, glucose and appetite regulation[34]. Especially, in view of its possible link as a modifiable risk factor for chronic NCDs such as obesity[34]. Inverse association between sleep length and overweight have been found in children[25].

Lack of sleep affects dietary intake, and the mechanism behind the effects is simple: short sleeping hours lead to hormonal changes. It increases the hunger perceived and alters the appetite[33]. Experiments have demonstrated that appetite and hunger perceptions are higher after sleep deprivation, having a major tendency to eat high fat and carbohydrate foods[85]. This appetite increment may contribute to food intake variations, increasing the amount of energy intake from high fat and sweet foods, consequently inducing overweight. As food preferences and consumption are directly related to caloric intake, it is of great importance to study the processes that influence these behavioural patterns.

Inevitably, sleep timing affects dietary choices[34], so sleep may play a major role in the increased rates of obesity. It is likely that shorter sleep might have an influence in skipping breakfast on week days or eating fast food and savoury snacks. Indeed, short sleep has been associated with intakes rich in energy but low in nutrients[85]. Independently of sleep length, later sleep hours have also been associated with poorer food choices in children, characterized by higher energy intake[58] and high snacks, and lower vegetables consumption[86].

A recent systematic review in five databases[87] studied in adults the effect that partial sleep deprivation had on energy balance. Energy balance was defined as energy intake and energy expenditure, whereas deprivation of partial sleep was defined as <6h per night. According to the results from eleven studies of the review, energy intake significantly increased by 1611 kJ/d (95% CI 1054, 2163) after partial sleep deprivation compared to the control subjects. Furthermore, no effect was found on total energy expenditure or resting metabolic rate, deriving in a net positive energy balance which, if kept during time, may lead to weight gain. Interestingly, the changes observed in energy intake were accompanied by a significantly higher fat consumption, lower protein intakes but with no effect on carbohydrate rates.

In a study[88] conducted in adults in the US using data from the National Health and Nutrition Examination Survey (NHANES) 2007-2008 it was seen that there were variations in energy intake across very short sleepers (<5h/night; 2.036 kcal/day), short sleepers (5-6h/night; 2.201 kcal/day) and long sleepers (>9h/night; 1.926 kcal/day) in relation to normal sleepers (7-8h/night; 2.151 kcal/day) (P=0.001)[88]. Another analysis from NHANES 2005-2006 in adults saw an inverse association between serum levels of vitamin B12 and sleep duration, 25-hydroxy vitamin D and sleepiness, and vitamin B9 and sleep quality. In addition, serum total carotenoids concentrations were associated with higher odds of short sleep duration compared to the normal hours (7-8h/night)[89].

Furthermore, data from the first 4 years of the National Diet and Nutrition Survey Rolling Programme (NDNS-RP) of the UK indicates that, among adults, the normal sleepers (8h/night) consume higher amounts of vitamin C, fibre and iron, and had higher serum concentrations of carotenoids, selenium and urinary nitrogen compared with both short (<6h/night) and long (>9h/night) sleep durations[90].

This accumulative literature above mentioned evidences how sleep directly impacts dietary intake. However, diet, specific foods or even dietary patterns could also affect sleep, and by now this question has been less explored. At the moment, some observational studies in adults provide information about this link, concluding that higher fat intakes have been associated with sleeping disorders[91], and a Mediterranean pattern has been related to less insomnia problems in women aged sixty-five years and older[92].

As observed, the information described above was mainly related to adult population, meanwhile by the moment there is scarce information among children. Previous research in adolescents claimed that sleep duration during the week is briefer than during weekend nights, and sleep duration during week nights has a stronger association with weight when compared to weekend nights[25,93,94]. Therefore, among previous ages, sleep duration during week nights and weekend nights may similarly present differences in the relationship with diet.

A study comparing two groups of children, one with reduced and the other with increased sleep, found that children of the second group had inferior weight, reduced levels of fasting leptin and lower reported food intake (g/day)[86]. Additionally, above-mentioned studies support that the amount of sleep and food intake levels are inversely proportional to the amount of soft drinks consumption, meanwhile longer sleep duration and healthier patterns directly relate to major levels of physical activity[63,64].

To support these findings, the results of a recent study in Chinese school children[4] suggest that, despite diet plays an important role on the health status of children, it may not be the main cause of overweight and obesity. Instead, PA and reduced sleep time could be related to such weight increase. However, in Finland inappropriate sleeping habits during childhood seems to have an association with unhealthy eating habits in children. According to a previous study among Finnish children from 10 to 11 years old, poor sleep during school nights was associated with a more frequent consumption of energy-rich foods, mainly fast foods and sweets, and lower consumption of nutrient dense food[25]. To our concern, there are no studies at the moment that give information about this same situation in pre-school children.

2.3. Conclusion of the literature review

Globally, the adherence of children to health behaviour recommendations is low[36]. A proportion of children seem to follow a transition to a less healthy pattern of dietary intake over time[62]. Whereas in adults it is known that SES and demographic factors are directly linked to health recommendations[39], little is known about the factors that contribute to this low adherence during pre-school ages, with only some studies regarding the topic. The risk of developing NCD during lifespan is increasing due to the actual society variations.

Special attention should be paid to children from lower socio-economic groups as they tend to follow unhealthier dietary patterns[68]. Effective strategies to avoid the inequalities regarding SES are needed in order to avoid these inequalities in health, as the steadfastness and growth of socio-economic health differences keeps attracting not just researchers, but clinicians and politicians as well[68]. Recently, there has been extensive research on the associations between adult education and the health status of next generations[76]. Obesity disproportionally affects children from low-income households, contributing to socio-economic disparities in NCD throughout the lifespan[94]. Sleep duration and other factors such as screen usage, have an impact on child's weight status[94]. At present, it can be concluded that in countries at all levels of income, health follows a social gradient: the lower the socio-economic position, the worse the health[45].

Despite identified divergence in child health outcomes associated with sleep, an overarching gap in the literature remains, as the existing publications on this subject in pre-school aged children are scarce, and the existing literature is mainly carried out in small, homogeneous samples. Evidence is reflecting the importance of a good sleep routine and its importance is coming under scrutiny[40] regarding adequate DPs and general global health behaviours among the population. However, the majority of the existing research has mainly been conducted in high-income and developed countries with limited socio-cultural variability, in adult population or children in ages from 6 to 14. There is a lack of information about the sleep routines of younger children, without national data or even the same measurement of sleep. Thus, little is known about the age in which the sleep modulations and changes may begin and whether its prevalence might change over time. However, one thing is sure: pre-school children are a key target for valuable interventions since the EBRBs are mainly established in this stage of life and tend to persist in life.

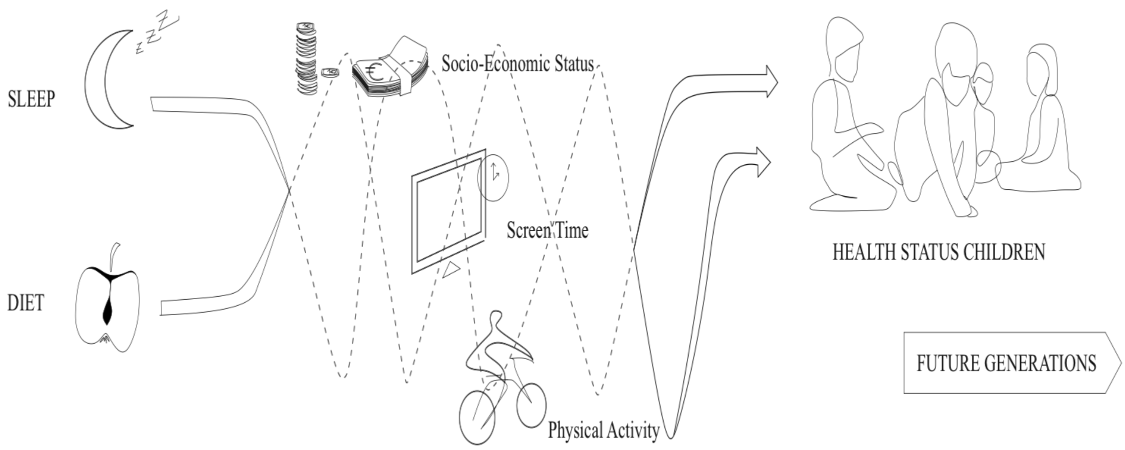

Figure 1. Associations between sleep and diet, modulated by socio-economic status, screen time and physical activity, and its effects on children's health that can track on future generations.

3. HYPOTHESIS AND AIMS OF THE STUDY

The hypothesis of this study is that shorter sleep duration will be associated with unhealthier dietary patterns.

In order to extend the present findings and literature, the objective of this study was to examine the associations between sleep duration and dietary patterns in Finnish children from 3 to 6 years old. The secondary aims were to evaluate whether these results differed between gender and sociodemographic characteristics.

Specific research questions:

1. Is there an association between sleep length during the whole week, during week nights and weekend nights, and dietary patterns in pre-school aged children?

2. Are these associations different for boys and girls?

3. Does these associations differ among different socio-economic status?

4. METHODOLOGY

4.1. Study Design

The present study was a part of the health promotion research project 'DAGIS' (Increased Health and Wellbeing in Preschools) conducted by the Folkhälsan Research Center together with the University of Helsinki, focusing on the health behaviours of pre-school children in Southern and Western Finland. For comprehensive information about the DAGIS project (http://www.dagis.fi), a detailed description is given by Lehto et al. (2018)[14].

The study was conducted according the Declaration of Helsinki and good scientific practices. All procedures involving the Ethics approval for the study were approved by the University of Helsinki Ethical Review Board in the Humanities and Social and Behavioral Sciences on February 24th, 2015 (#6/2015). Parents were able to withdraw their children from the study or no give their consent to participate. Participants had also the right to withdraw from the study at any time without consequences.

About 74% of three-to-five-years old in Finland attend pre-school[95], making it an ideal environment for interventions as all children under school-age have a subjective right to a place in pre-school of 20h/week[96]. Municipalities in Finland are responsible of offering pre-school services based on national guidelines[96]. In addition, families pay fees vary depending on the size and income of the family.

4.2. Study Population

Between autumn 2015 and spring 2016 a cross-sectional survey was conducted in municipalities situated in Southern and Western Finland, and where selected according to their location and their socioeconomically diverse population, covering both urban and rural environments. The municipalities were: *Porvoo, Loviisa, Vantaa, Hyvinkää, Lohja, Seinäjoki, Kauhajoki,* and *Kurikka*[14]. Participating municipalities provided a list of all municipal pre-schools and private pre-schools from which the municipalities purchase early education services. The eligibility criteria for the pre-school were (1) having at least one group consisting of 3- to 6-year-old children, (2) providing early education only during the daytime, (3) being Finnish or Swedish speaking (official languages of Finland), and (4) charging income-dependent fees[14]. Using a list randomization program (https://www.random.org/lists) the 169 pre-schools were contacted using the randomized order given. Sixteen pre-schools were excluded based on the eligibility criteria. Thusly, 153 pre-schools were invited to participate in the survey[14]. The final number of participating pre-schools was 66 (43% of the invited) and the number of children with parental consent was 892 (25% of the invited). No data from twenty-eight consented children was received. The final data available for the DAGIS study was of 864 participating children[14]. The participation rate of the pre-schools under study was 29%[97].

4.3. Measures and methods of estimation

Outcomes measured were demographics, food consumption, sleep duration, screen usage and physical activity. The food consumption information was later used to calculate dietary pattern scores[97]. Only children with sufficient data were included in each of the analyses.

Sleep length

Part of the DAGIS questionnaire to be filled by parents or guardians focused on sleeping habits of children, including bedtime and wake-up time. Sleeping patterns can be estimated either subjectively via questionnaires or objectively via actigraphy[98,99]. The parents were asked to report bed times and wake-up times of the child in a 7-day sleep diary. At least 6 nights of measurements were required for a reliable measure of self-reported sleep[98].

Dietary pattern scores

The DAGIS questionnaire also contained a developed and short food frequency questionnaire (FFQ) to be filled by parents. Food consumption during the last week (7 days) was measured using a forty-seven-item FFQ that included sixteen groups of food items developed for the DAGIS study[97]. Parents or legal guardians were asked to report how many times during the past week their children had consumed different foods at home or in places other than pre-school[97]. The FFQ included three answer columns: 'not at all', 'times per week' and 'times per day'. Instructions were to either tick the 'not at all' box or to write a number in one of the other columns. The FFQ was intentionally restricted not to cover municipality-provided foods and drinks consumed during the pre-school hours[97].

The dietary patterns used in this study has been previously analysed and described in detail by Vepsäläinen et al. (2018)[97]. With the information given, dietary pattern scores based on the FFQ food groups were created for each participant. Three components were identified (see Table 1). The first component was labelled '*Sweets-and-treats pattern*' (Sweet DP) based on its high loading of e.g. sweet biscuits and cereal bars, chocolate, ice cream, sweets and soft drinks. The second component was characterized by high loading of e.g. nuts, natural yoghurt, berries, eggs, wholegrain porridge, non-sweetened breakfast cereals and muesli, therefore named '*Health-conscious pattern'* (Healthy DP). Finally, the third component was named '*Vegetables-and-processed meats pattern*' (VegMeat DP) as it contained high loadings of e.g. fresh vegetables, cold cuts, fresh fruits, flavoured yoghurt and wholemeal bread. When the dietary pattern scores were created, they did not differ between genders.

Confounding variables: Socioeconomic status, screen time and physical activity

Covariates in the analyses comprised child's age and gender, parental level education, screen time usage and moderate to vigorous physical activity. The present study used the highest education level in the family as an indicator of the socioeconomic status in children's household[100], as previous studies[100,101] used the parental education as an estimator of the familiar socioeconomic status. Parents or legal guardians were asked to complete a questionnaire which reported their highest education level. The educational level options were categorized from a ready-made seven-item list which covered the most common educational degrees in Finland. PEL (parental educational level) was divided in three groups: Low = secondary/high school or lower, or vocational school graduate or below; Middle = Bachelor's degree or equivalent; High = Master's degree or higher.

Two more potential confounders were analysed: moderate to vigorous physical activity and screen time. To measure the levels of physical activity and sedentary time, children wore an *accelerometer* (Actigraph wGT3X-BT, ActiGraph, Pensacola, FL) for one week, 24 hours per day, as previous studies indicate that one week is enough to determine the habitual PA levels and sedentary time in children[103]. An actigraphy is a both valid and reliable measure of PA and is extensively used for the objective measurement among children[103,104,105]. The accelerometer data were distinguished into sedentary time, light activity and moderate to vigorous physical activity (MVPA) in preschool-hours, home-hours in pre-school days (later weekday) and on weekend. A child needed to have accelerometer data from at least four days, with at least one weekend day and at least 600 minutes per day, to be included in the analyses. The cut-points used were Evenson's as it is reported that this cut-points are reliable when measuring physical activity levels among children[103]. Cut points for MVPA is 2.296 counts per minute.

For the screen time measurements, each parent had to complete a 7-day diary reporting the children's ST at home[100]. The translated-version of a previously validated diary was used[100]. The original version was modified so that it could be asked separately the television watching and DVD/video watching, and the use of tablet computers and smartphones as an option was added[100]. Screen time is therefore a composite variable of the usage of television, computer, DVD/video, and tablet/smartphone. The total time reported was transformed into minutes (divided by the hours and multiplied by 60 min) and the daily minutes were summed together. The total average of weekday (5/7) and weekend (2/7) ST in minutes was calculated to form the daily average screen-time measure.

Table 1. Variables used in the analyses.

Role in the analyses	Variable name	Variable description	Type of variable
Outcome: Dietary pattern scores[1]	Sweets-and-treats pattern (Sweet DP)	Higher loadings of: sweet biscuits and cereal bars; chocolate; ice cream; sweets; soft and sugar-sweetened drinks; sweet pastries; crisps and popcorns; sugar-sweetened cereal breakfast cereals and muesli; flavoured nuts, almonds and seeds; sausages, frankfurters and luncheon meats.	Continuous
	Health-conscious pattern (Healthy DP)	Higher loadings of: plain nuts, almonds and seeds; natural yoghurt and quark; berries; eggs; wholegrain porridge, non-sweetened cereal breakfast and muesli; dried fruit and berries; wholegrain rice and pasta; peas, beans, lentils and soya; cooked and canned vegetables; commercial baby foods and smoothies.	Continuous
	Vegetables-and-processed-meats pattern (VegMeat DP)	Higher loadings of: cooked and canned vegetables; fresh vegetables; cold cuts; fresh fruit; flavoured yoghurt and quark; wholemeal bread; high-fat cheese; fruit juice; sausages, frankfurters and luncheon meats.	Continuous
Exposure: Sleep length[2]	Week nights	Sleep length sum from Sunday/Monday night to Thursday/Friday night.	Continuous
	Weekend nights	Sleep length sum: Friday/Saturday night + Saturday/Sunday night.	Continuous
	7-day average sleep	(5 x sleep length on Week nights + 2 x sleep length on Weekend nights)/7	Continuous
Confounding factors:			
Screen time[3]	ST	Minutes per day that the children spent using screens (TV, DVD, Computer, electronic devices)	Continuous
Moderate to vigorous physical activity[4]	MVPA	Minutes per hour (at least 2.296 counts per minute)	Continuous
Parental educational level[5]	PEL	Highest education in the family in three classes: (1) Secondary school or lower (*Low*); (2) Polytechnic degree (*Middle*); (3) Master's degree or higher (*High*).	Classified

DP: Dietary Pattern; MVPA: Moderate-to-vigorous physical activity; PEL: Parental educational level; ST: Screen time. [(1)]Reported in the FFQ (Analysis detailed elsewhere[97]). [(2)]Reported in the sleep diary. [(3)]Reported in the screen time diary. [(4)]Measured with the accelerometer, Evenson's cut-points. [(5)]Reported in the initial parental questionnaire.

4.4. Data analysis

All analyses were performed using The Statistical Package for Social Sciences (SPSS) version 22, 2013 (IMB Inc., Chicago, IL, USA).

Prior to the statistical analysis, it was agreed by our team that the sleep-length data considered for the week nights should be of at least three or more nights, and for the weekend nights both nights should be reported to be considered as well. Therefore, only pre-school children with complete FFQ and with the considered enough sleep-length data (three or more nights during the week and/or both nights during the weekend) were included in the principal component analysis. The final data analysed for this study varied from 602 to 736 pre-school children.

For this study, sleeping time was calculated on the basis of the bed time and wake-up time reported by parents, on week nights and weekend nights separately. An average daily sleeping time was also calculated, for a 7-day period using the sleeping time during week nights and weekend nights according to the formula: (5 x sleep length on week nights + 2 x sleep length on weekend nights)/7.

The normal distribution of all the variables was assessed using *Shapiro-Wilk test,* and visual graphics (*Histogram and Box-Plot*). By the diagrams it could be appreciated that all the variables followed an almost normal distribution. All variables were analysed as normally distributed during all the proceeding of the analyses. The variable "Health-conscious Dietary Pattern" presented an extreme outlier that was included in all the analyses. Differences in sleep length and dietary patterns between genders were analysed for continuous variables with *Student's T test*, categorical variables (parental level education) were analysed with χ^2 *test*. Correlations were checked using both the *Pearson and Spearman correlation* analyses, to check if there were possible differences in the results. Dietary pattern scores were used as dependent variables, while sleep duration, parental educational level, screen usage, and physical activity were used as independent variables. Gender was controlled in all models with total data. Interactions between gender and the independent variables were computed for each dependent-independent variable analysis. Linear regression models were used to test the associations between the sleep duration and dietary patterns.

The analyses were conducted in two stages. First, we sought to determine which dietary patterns were associated with the sleep variables and the other variables considered in the study (age, parental education, screen time, and physical activity). The associations were tested separately using linear regression analysis. Differences between genders were also studied, using stratified analysis. Secondly, multiple regression analyses were used to determine whether the dietary patterns were associated with either week nights or weekend nights' sleep length. Lastly, another multiple regression analysis was conducted to see if the associations between sleep duration and dietary patterns stratified by SES.

β-coefficients, p-values and 95% confidence intervals (CI) are reported to facilitate the interpretation of the associations. Two different models were used. The first model shows the associations between sleep duration and dietary pattern scores adjusted by gender, whereas the second model shows the associations between sleep duration and dietary patterns adjusted by gender and parental educational level.

5. RESULTS

5.1. Participants characteristics

Descriptive characteristics of the sample are shown in Table 2. The population (n=736) was evenly divided between boys and girls (52% for boys and 48% for girls). Regarding dietary patterns, there were no significant differences between genders. On average, the participants slept 10.4 hours (hrs) per night (range 8.35 - 12.27 hrs). There were no differences between genders. The levels of physical activity among boys were higher compared to the girl's levels.

Table 2. Demographic characteristics, dietary patterns, sleep length, screen usage and physical activity of all participants in DAGIS, by sex (N=736).

	Total sample		***Boys***		***Girls***		
	Mean	*SD*	*Mean*	*SD*	*Mean*	*SD*	*P-value**
Sleep duration, *hrs/ night*							
Week nights	10.3	.58	10.2	.57	10.3	.60	0.16
Weekend nights	10.5	.67	10.5	.64	10.5	.70	0.24
7-d Average	10.4	.52	10.3	.51	10.4	.54	0.10
Dietary variables							
Sweet DP	-.006	1.00	-.045	.94	.047	1.05	0.26
Healthy DP	-.007	.99	-.057	.95	.045	1.03	0.16
VegMeat DP	.004	1.00	.032	1.04	-.026	.94	0.48
Age, *years*	4.7	.89	4.7	.88	4.7	.91	0.22
ST, *min/day*	107.2	51.0	114.3	47.8	108.5	48.4	0.13
MVPA, *min/hour*	5.5	1.9	6.08	1.7	5.12	1.5	**<0.001**
	N	*%*	*N*	*%*	*N*	*%*	*P-value**
PEL							
Low	150	20.4%	76	20.8%	74	20.7%	
Middle	311	42.3%	150	39.7%	161	45%	
High	272	37%	152	40.2%	120	33.5%	
Total	733	99.6%	378	100%	355	99.2%	0.11

DP: Dietary pattern; Hrs: hours; Min: minutes; MVPA: Moderate-to-vigorous physical activity; PEL: Parental education level; ST: Screen time; SD: Standard deviation.
Missing values: PEL (3).
*Statistical tests compared demographic characteristics by gender.
Significant values are in bold.

5.2. Associations between sleep and diet

The Pearson correlations between the studied variables are presented in Table 3. Age was positively associated with the Sweet DT, ST and PA, and inversely associated with the Healthy DP. Regarding the PEL, the strongest direct association was with the Healthy DP. PEL was inversely associated with the two other DPs, and it was negatively associated with sleep during weekend nights. Sleep length during week nights was inversely associated with the Sweet DP, whereas it was positively associated with the Healthy DP. Children's ST was significantly associated with all of the other variables, the strongest association being with the Sweet DP. MVPA was inversely associated with sleep length both during the week and the weekend nights, however it was not significant when the 7-days average sleep length was considered.

Table 3. The Pearson Correlation coefficients between the studied factors (N varies between 602 and 736).

	1.	2.	3.	4.	5.	6.	7.	8.	9.
Sleep Duration									
1. Week nights	--								
2. Weekend nights	**0.462****	--							
3. 7-d Average	**0.946****	**0.0726****	--						
Dietary Patterns									
4. Sweet DP	**-0.079***	**-0.082***	**-0.102***	--					
5. Healthy DP	**0.124***	0.015	**0.084***	0.012	--				
6. VegMeat DP	-0.022	0.008	-0.004	0.005	-0.013	--			
Potential confounders									
7. Age	-0.070	-0.050	-0.050	**0.014****	**-0.103****	0.033	--		
8. ST	**-0.143****	**-0.82***	**-0.134***	**0.313****	**-0.112****	**0.100****	**0.205****	--	
9. MVPA	**-0.081***	**-0.072****	-0.074	-0.038	-0.077	0.033	**0.204****	0.010	--
10. PEL	0.015	**-0.078***	-0.026	**-0.109****	**0.153****	**-0.092***	0.016	**-0.109****	0.005

DP: Dietary pattern; MVPA: Moderate-to-vigorous physical activity; PEL: Parental educational level; ST: Screen time. Significant values are in bold.

**: correlation is significant at the 0.01 level (2-tailed)

*: correlation is significant at the 0.05 level (2-tailed).

5.3. Differences among genders

In the first stage of the univariate analysis (Table 4), sleep duration in all the studied forms was negatively associated with the Sweet-and-treats DP. In the gender-stratified analyses, these associations were only significant among girls, being the value of the 7-day average sleep the most significant one (β = -0.168, P = 0.003). Sleep duration during week nights and the 7-day average sleep was positively associated with the Health-conscious DP. These associations were again only significant among girls, being the week length strongly positively correlated (β = 0.163, P = 0.002). No associations between sleep length and vegetables-and-processed meats DP were found.

In the second stage of the analysis (Tables 5, 6 and 7), the associations of the multivariate analysis somewhat weakened for girls and only some associations remained statistically significant. For girls, the only association that reminded statistically significant was the sleep length during week nights with the health-conscious dietary pattern (β = 0.128, P = 0.022), however no associations were found for the sleep length during weekend nights (Table 6). Girls getting a longer sleep during the week were more likely to consume food items included in the Health-conscious DP compared with girls sleeping shorter. A strong significant association (P < 0.001) was found between the sweet-and-treats dietary pattern and screen usage. The interaction was also significant between the vegetables-and-processed-meat DP and ST.

When the associations where studied along the whole week with a multivariate analysis (Table 7), the association between the Sweet DP and the sleep duration in girls were negatively correlated (β = -0.121, P = 0.030). The ST was strongly positively significant in both genders when associated with the Sweet DP, meanwhile the association between screen usage and Vegetables-and-processed-meats DP was significant just among girls (β = 0.132, P = 0.028). In this analysis, MVPA in girls was inversely associated with the Vegetables-and-processed-meats DP (β = -0.128, P = 0.033).

Table 4. Associations between dietary patterns parameters and age, sleep length, screen usage and physical activity. (β-coefficient values and 95% CI). Univariate analysis.

	Total (N=736)			Girls (N=358)			Boys (N=378)		
	β-coefficient	95% CI	P	β-coefficient	95% CI	P	β-coefficient	95% CI	P
Sweet DP									
Sleep length									
Week nights	**-0.079**	**-0.259, -0.009**	**0.035**	**-0.131**	**-0.414, -0.048**	**0.014**	-0.025	-0.210, 0.128	0.634
Weekend nights	**-0.082**	**-0.229, -0.008**	**0.035**	**-0.118**	**-0.338, -0.013**	**0.035**	-0.043	-0.210, 0.089	0.428
7-d Average	**-0.102**	**-0.332, -0.045**	**0.010**	**-0.168**	**-0.542, -0.115**	**0.003**	-0.031	-0.246, 0.138	0.579
Age	**0.104**	**0.035, 0.196**	**0.005**	**0.133**	**0.035, 0.273**	**0.012**	0.075	-0.028, 0.188	0.144
ST	**0.313**	**0.005, 0.008**	**0.000**	**0.344**	**0.005, 0.010**	**0.000**	**0.285**	**0.004, 0.008**	**0.000**
MVPA	-0.038	-0.067, 0.022	0.319	-0.052	-0.113, 0.040	0.345	-0.004	-0.060, 0.056	0.940

CI: Confidence interval; DP: Dietary pattern; MVPA: Moderate-to-vigorous physical activity; ST: Screen time.
Significant values are in bold.

Table 4 (Continued). Associations between dietary patterns parameters and age, sleep length, screen usage and physical activity. (β-coefficient values and 95% CI). Univariate analysis.

	Total (N=736)			Girls (N=358)			Boys (N=378)		
	β-coefficient	95% CI	P	β-coefficient	95% CI	P	β-coefficient	95% CI	P
Healthy DP									
Sleep length									
Week nights	**0.124**	**0.088, 0.336**	**0.001**	**0.163**	**0.104, 0.461**	**0.002**	-0.077	-0.043, 0.303	0.141
Weekend nights	0.015	-0.090, 0.135	0.696	0.087	-0.033, 0.291	0.119	-0.070	-0.260, 0.054	0.198
7-d Average	**0.084**	**0.014, 0.308**	**0.032**	**0.138**	**0.055, 0.482**	**0.014**	0.020	-0.166, 0.241	0.715
Age	**-0.103**	**-0.195, -0.035**	**0.005**	**-0.132**	**-0.267, -0.032**	**0.013**	-0.070	-0.185, 0.033	0.173
ST	**-0.112**	**-0.004, -0.001**	**0.003**	**-0.109**	**-0.005, 0.000**	**0.044**	**-0.110**	**-0.004, 0.000**	**0.040**
MVPA	**-0.077**	**-0.091, -0.002**	**0.043**	-0.027	-0.095, 0.058	0.626	-0.103	-0.117, 0.000	0.051

CI: Confidence interval; DP: Dietary pattern; MVPA: Moderate-to-vigorous physical activity; ST: Screen time.
Significant values are in bold.

Table 4 (Continued). Associations between dietary patterns parameters and age, sleep length, screen usage and physical activity. (β-coefficient values and 95% CI). Univariate analysis.

	Total (N=736)			Girls (N=358)			Boys (N=378)		
	β-coefficient	95% CI	P	β-coefficient	95% CI	P	β-coefficient	95% CI	P
VegMeat DP									
Sleep length									
Week nights	-0.022	-0.162, 0.086	0.552	-0.027	-0.207, 0.123	0.615	-0.016	-0.216, 0.158	0.762
Weekend nights	0.008	-0.101, 0.123	0.842	0.017	-0.126, 0.171	0.769	-0.001	-0.170, 0.168	0.992
7-d Average	-0.004	-0.152, 0.137	0.915	-0.020	-0.231, 0.161	0.726	-0.009	-0.196, 0.233	0.867
Age	0.033	-0.044, 0.117	0.378	0.034	-0.072, 0.144	0.518	0.029	-0.085, 0.155	0.569
ST	**0.100**	**0.001, 0.004**	**0.008**	**0.159**	**0.001, 0.005**	**0.003**	0.043	-0.001, 0.003	0.431
MVPA	0.033	-0.025, 0.065	0.388	-0.077	-0.119, 0.020	0.159	0.097	-0.004, 0.125	0.067

CI: Confidence interval; DP: Dietary pattern; MVPA: Moderate-to-vigorous physical activity; ST: Screen time.
Significant values are in bold.

Table 5. Associations between dietary patterns parameters and age, sleep length during the weekdays, screen usage and physical activity. (β-coefficient values and 95% CI). Multivariate analysis.

	Total (N=636)			**Girls (N=322)**			**Boys (N=314)**		
	β-coefficient	95% CI	P	β-coefficient	95% CI	P	β-coefficient	95% CI	P
Sweet DP									
Week nights	-0.049	-0.212, 0.044	0.200	-0.083	-0.333, 0.038	0.119	-0.005	-0.185, 0.169	0.931
Age	0.050	-0.030, 0.140	0.207	0.091	-0.017, 0.226	0.091	-0.004	-0.124, 0.117	0.951
ST	**0.292**	**0.005, 0.008**	**0.000**	**0.313**	**0.005, 0.009**	**0.000**	**0.279**	**0.003, 0.008**	**0.000**
MVPA	-0.054	-0.080, 0.013	0.061	-0.090	-0.142, 0.011	0.091	-0.014	-0.054, 0.070	0.803
Healthy DP									
Week nights	**0.103**	**-0.043, 0.312**	**0.010**	**0.128**	**0.032, 0.419**	**0.022**	0.072	-0.067, 0.312	0.204
Age	-0.077	-0.175, 0.004	0.060	**-0.116**	**-0.258, -0.005**	**0.041**	-0.025	-0.156, 0.100	0.669
ST	-0.072	-0.003, 0.000	0.074	-0.058	-0.004, 0.001	0.302	-0.095	-0.004, 0.000	0.101
MVPA	-0.067	-0.090, 0.007	0.096	-0.009	-0.085, 0.073	0.879	**-0.126**	**-0.140, -0.007**	**0.031**

CI: Confidence interval; DP: Dietary pattern; MVPA: Moderate-to-vigorous physical activity; ST: Screen time.
Significant values are in bold.

Table 5 (Continued). Associations between dietary patterns parameters and age, sleep length during the weekdays, screen usage and physical activity. (β-coefficient values and 95% CI). Multivariate analysis.

	Total (N=363)			**Girls (N=322)**			**Boys (N=314)**		
	β-coefficient	95% CI	P	β-coefficient	95% CI	P	β-coefficient	95% CI	P
VegMeat DP									
Week nights	0.002	-0.127, 0.133	0.965	-0.014	-0.198, 0.155	0.809	0.024	-0.152, 0.236	0.673
Age	0.009	-0.077, 0.096	0.831	0.032	-0.083, 0.148	0.579	-0.012	-0.145, 0.119	0.845
ST	**0.101**	**0.000, 0.004**	**0.013**	**0.136**	**0.000, 0.005**	**0.017**	0.071	-0.001, 0.004	0.227
MVPA	-0.005	-0.051, 0.044	0.896	-0.104	-0.140, 0.005	0.066	0.073	-0.025, 0.112	0.211

CI: Confidence interval; DP: Dietary pattern; MVPA: Moderate-to-vigorous physical activity; ST: Screen time.
Significant values are in bold.

Table 6. Associations between dietary patterns parameters and age, sleep length during the weekends, screen usage and physical activity. (β-coefficient values and 95% CI). Multivariate analysis.

	Total (N=586)			**Girls (N=296)**			**Boys (N=290)**		
	β-coefficient	95% CI	P	β-coefficient	95% CI	P	β-coefficient	95% CI	P
Sweet DP									
Weekend nights	-0.059	-0.201, 0.028	0.138	-0.088	-0.299, 0.032	0.113	-0.029	-0.199, 0.118	0.614
Age	0.047	-0.035, 0.137	0.247	0.071	-0.045, 0.205	0.208	0.027	-0.092, 0.147	0.650
ST	**0.291**	**0.004, 0.008**	**0.000**	**0.348**	**0.005, 0.010**	**0.000**	**0.234**	**0.002, 0.007**	**0.000**
MVPA	-0.071	-0.088, 0.005	0.077	-0.101	-0.150, 0.006	0.072	-0.025	-0.073, 0.047	0.667
Healthy DP									
Weekend nights	-0.010	-0.140, 0.108	0.804	0.053	-0.098, 0.261	0.372	-0.086	-0.302, 0.043	0.141
Age	-0.079	-0.182, 0.005	0.063	-0.104	-0.255, 0.016	0.085	-0.043	-0.177, 0.083	0.477
ST	-0.081	-0.004, 0.000	0.052	-0.057	-0.004, 0.001	0.333	**-0.119**	**-0.005, 0.000**	**0.048**
MVPA	-0.059	-0.086, 0.014	0.163	-0.003	-0.087, 0.083	0.958	-0.104	-0.123, 0.007	0.079

CI: Confidence interval; DP: Dietary pattern; MVPA: Moderate-to-vigorous physical activity; ST: Screen time.
Significant values are in bold.

Table 6 (Continued). Associations between dietary patterns parameters and age, sleep length during the weekends, screen usage and physical activity. (β-coefficient values and 95% CI). Multivariate analysis.

	Total (N=586)			**Girls (N=296)**			**Boys (N=290)**		
	β-coefficient	95% CI	P	β-coefficient	95% CI	P	β-coefficient	95% CI	P
VegMeat DP									
Weekend nights	0.029	-0.077, 0.162	0.484	0.010	-0.147, 0.175	0.861	0.045	-0.109, 0.247	0.446
Age	-0.001	-0.091, 0.089	0.982	0.029	-0.092, 0.152	0.631	-0.027	-0.165, 0.104	0.658
ST	**0.101**	**0.000, 0.004**	**0.017**	**0.131**	**0.000, 0.005**	**0.027**	0.084	-0.001, 0.004	0.166
MVPA	0.008	-0.043, 0.053	0.842	**-0.118**	**-0.153, -0.001**	**0.048**	0.112	-0.003, 0.131	0.061

CI: Confidence interval; DP: Dietary pattern; MVPA: Moderate-to-vigorous physical activity; ST: Screen time.
Significant values are in bold.

Table 7. Associations between dietary patterns parameters and age, sleep length during the whole week (7-day average), screen usage and physical activity.) (β-coefficient values and 95% CI). Multivariate analysis.

	Total (N=572)			Girls (N=288)			Boys (N=284)		
	β-coefficient	95% CI	P	β-coefficient	95% CI	P	β-coefficient	95% CI	P
Sweet DP									
7-d Average	-0.075	-0.289, 0.007	0.063	**-0.121**	**-0.454, -0.023**	**0.030**	-0.015	-0.231, 0.177	0.796
Age	0.051	-0.032, 0.142	0.213	0.068	-0.048, 0.202	0.228	0.030	-0.092, 0.152	0.626
ST	**0.296**	**0.004, 0.008**	**0.000**	**0.334**	**0.005, 0.010**	**0.000**	**0.251**	**0.003, 0.007**	**0.000**
MVPA	-0.077	-0.093, 0.002	0.060	-0.104	-0.153, 0.004	0.063	-0.026	-0.076, 0.049	0.669
Healthy DP									
7-d Average	0.063	-0.038, 0.286	0.132	0.106	-0.024, 0.444	0.078	-0.015	-0.197, 0.256	0.798
Age	-0.079	-0.183, 0.006	0.068	-0.103	-0.254, 0.017	0.086	-0.040	-0.179, 0.091	0.519
ST	-0.070	-0.003, 0.000	0.101	-0.041	-0.003, 0.002	0.490	-0.106	-0.005, 0.000	0.085
MVPA	-0.059	-0.088, 0.015	0.167	-0.008	-0.091, 0.079	0.889	-0.109	-0.132, 0.006	0.075

CI: Confidence interval; DP: Dietary pattern; MVPA: Moderate-to-vigorous physical activity; ST: Screen time.
Significant values are in bold.

Table 7 (Continued). Associations between dietary patterns parameters and age, sleep length during the whole week (7-day average), screen usage and physical activity. (β-coefficient values and 95% CI). Multivariate analysis.

	Total (N=572)			**Girls (N=288)**			**Boys (N=284)**		
	β-coefficient	95% CI	P	β-coefficient	95% CI	P	β-coefficient	95% CI	P
VegMeat DP									
7-d Average	0.026	-0.105, 0.203	0.534	-0.006	-0.221, 0.201	0.926	0.060	-0.112, 0.344	0.318
Age	0.002	-0.088, 0.093	0.962	0.026	-0.095, 0.149	0.662	-0.026	-0.165, 0.108	0.681
ST	**0.106**	**0.000, 0.004**	**0.014**	**0.132**	**0.000, 0.005**	**0.028**	0.085	-0.001, 0.004	0.168
MVPA	-0.022	-0.062, 0.036	0.603	**-0.128**	**-0.160, -0.007**	**0.033**	0.075	-0.027, 0.113	0.226

CI: Confidence interval; DP: Dietary pattern; MVPA: Moderate-to-vigorous physical activity; ST: Screen time.
Significant values are in bold.

5.4. Differences among socioeconomic status

The final analyses focused on describing the associations between sleep length and dietary patterns variations among socio-economic status (Tables 8 and 9). The associations between sleep duration and DPs were not statistically significant. The only association that showed statistical significance was the association between screen usage and sweet-and-treats DP, among the three socioeconomic levels. A further multivariate analysis for the weekend nights was conducted (Table 9), as the previous analysis of Pearson's correlation test showed an inverse association between PEL and sleep length during the weekend. However, in this analysis no significant associations were found.

Table 8. Parental education and the associations between dietary patterns parameters and age, gender, sleep length, screen usage and physical activity. (β-coefficient values and 95% CI). Multivariate analysis.

	Highest education in the family								
	Low (N=107)			**Middle (N=247)**			**High (N=215)**		
	β-coefficient	95% CI	P	β-coefficient	95% CI	P	β-coefficient	95% CI	P
Sweet DP									
Sleep length									
Week nights	-0.077	-0.496, 0.213	0.431	-0.063	-0.324, 0.121	0.370	-0.100	-0.210, 0.128	0.198
Weekend nights	-0.078	-0.443, 0.197	0.447	-0.059	-0.269, 0.107	0.397	0.019	-0.261, 0.091	0.807
Age	0.135	-0.072, 0.402	0.170	0.084	-0.042, 0.220	0.183	0.011	-0.035, 0.203	0.870
Gender	0.065	-0.285, 0.578	0.502	**-0.153**	**-0.518, -0.054**	**0.016**	0.035	-0.194, 0.323	0.624
ST	**0.251**	**0.001, 0.010**	**0.012**	**0.301**	**0.004, 0.008**	**0.000**	**0.291**	**0.004, 0.008**	**0.000**
MVPA	-0.149	-0.226, 0.029	0.129	-0.022	-0.081, 0.057	0.730	-0.057	-0.080, 0.058	0.435

CI: Confidence interval; DP: Dietary pattern; MVPA: Moderate-to-vigorous physical activity; ST: Screen time.
Significant values are in bold.

Table 8 (Continued). Parental education and the associations between dietary patterns parameters and age, gender, sleep length, screen usage and physical activity. (β-coefficient values and 95% CI). Multivariate analysis.

	Highest education in the family								
	Low (N=107)			**Middle (N=247)**			**High (N=215)**		
	β-coefficient	95% CI	P	β-coefficient	95% CI	P	β-coefficient	95% CI	P
Healthy DP									
Sleep length									
Week nights	0.103	-0.168, 0.521	0.312	0.136	-0.016, 0.438	0.068	0.066	-0.147, 0.362	0.405
Weekend nights	-0.061	-0.400, 0.222	0.571	-0.077	-0.295, 0.089	0.292	0.006	-0.206, 0.222	0.939
Age	-0.148	-0.398, 0.063	0.152	-0.053	-0.188, 0.079	0.424	-0.101	-0.223, 0.036	0.157
Gender	0.077	-0.259, 0.580	0.449	-0.004	-0.244, 0.231	0.956	-0.033	-306, 0.194	0.659
ST	0.067	-0.003, 0.006	0.521	-0.043	-0.003, 0.002	0.516	-0.105	-0.005, 0.001	0.132
MVPA	0.114	-0.054, 0.194	0.267	-0.070	-0.109, 0.033	0.295	-0.113	-0.141, 0.019	0.131

CI: Confidence interval; DP: Dietary pattern; MVPA: Moderate-to-vigorous physical activity; ST: Screen time.
Significant values are in bold.

Table 8 (Continued). Parental education and the associations between dietary patterns parameters and age, gender, sleep length, screen usage and physical activity. (β-coefficient values and 95% CI). Multivariate analysis.

	Highest education in the family								
	Low (N=107)			**Middle (N=247)**			**High (N=215)**		
	β-coefficient	95% CI	P	β-coefficient	95% CI	P	β-coefficient	95% CI	P
VegMeat DP									
Sleep length									
Week nights	0.000	-0.326, 0.327	0.999	-0.010	-0.268, 0.234	0.893	0.051	-0.179, 0.351	0.525
Weekend nights	-0.023	-0.326, 0.264	0.833	0.123	-0.029, 0.394	0.091	-0.100	-0.364, 0.081	0.212
Age	-0.014	-0.233, 0.204	0.896	0.068	-0.070, 0.226	0.300	-0.083	-0.214, 0.056	0.249
Gender	0.026	-0.347, 0.448	0.801	0.043	-0.175, 0.349	0.513	-0.113	-0.459, 0.061	0.132
ST	0.086	-0.002, 0.006	0.417	**0.174**	**0.001, 0.006**	**0.008**	0.022	-0.002, 0.003	0.749
MVPA	0.021	-0.106, 0.129	0.843	-0.033	-0.098, 0.059	0.622	0.008	-0.070, 0.088	0.912

CI: Confidence interval; DP: Dietary pattern; MVPA: Moderate-to-vigorous physical activity; ST: Screen time.
Significant values are in bold.

Table 9. Parental level education and the associations between dietary patterns parameters and age, gender, sleep length during the weekend, screen usage and physical activity. (β-coefficient values and 95% CI). Multivariate analysis.

	Low (N=109)			**Middle (N=254)**			**High (N=220)**		
	β-coefficient	95% CI	P	β-coefficient	95% CI	P	β-coefficient	95% CI	P
Sweet DP									
Weekend nights	-0.097	-0.456, 0.150	0.318	-0.092	-0.295, 0.037	0.126	-0.033	-0.234, 0.138	0.613
Age	0.134	-0.070, 0.398	0.167	0.079	-0.047, 0.217	0.205	0.010	-0.121, 0.140	0.889
Gender	0.059	-0.288, 0.549	0.538	-0.152	-0.517, -0.055	0.015	0.042	-0.174, 0.328	0.547
ST	**0.251**	**0.001, 0.010**	**0.011**	**0.289**	**0.003, 0.008**	**0.000**	**0.302**	**0.003, 0.009**	**0.000**
MVPA	-0.146	-0.221, 0.029	0.132	-0.020	-0.079, 0.057	0.745	-0.049	-0.106, 0.051	0.493

CI: Confidence interval; DP: Dietary pattern; MVPA: Moderate-to-vigorous physical activity; ST: Screen time.
Significant values are in bold.

Table 9 (Continued). Parental level education and the associations between dietary patterns parameters and age, gender, sleep length during the weekend, screen usage and physical activity. (β-coefficient values and 95% CI). Multivariate analysis.

	Low (N=109)			**Middle (N=254)**			**High (N=220)**		
	β-coefficient	95% CI	P	β-coefficient	95% CI	P	β-coefficient	95% CI	P
Healthy DP									
Weekend nights	-0.041	-0.356, 0.235	0.686	-0.011	-0.181, 0.151	0.860	0.039	-0.127, 0.232	0.565
Age	-0.148	-0.397, 0.060	0.147	-0.058	-0.191, 0.073	0.382	-0.101	-0.219, 0.033	0.148
Gender	0.079	-0.246, 0.572	0.431	-0.026	-0.279, 0.185	0.691	-0.045	-0.320, 0.164	0.527
ST	0.064	-0.003, 0.005	0.537	-0.059	-0.004, 0.001	0.362	-0.120	-0.005, 0.000	0.078
MVPA	0.104	-0.059, 0.186	0.308	-0.058	-0.098, 0.038	0.381	-0.099	-0.129, 0.023	0.174

CI: Confidence interval; DP: Dietary pattern; MVPA: Moderate-to-vigorous physical activity; ST: Screen time.
Significant values are in bold.

Table 9 (Continued). Parental level education and the associations between dietary patterns parameters and age, gender, sleep length during the weekend, screen usage and physical activity. (β-coefficient values and 95% CI). Multivariate analysis.

	Low (N=109)			**Middle (N=254)**			**High (N=220)**		
	β-coefficient	95% CI	P	β-coefficient	95% CI	P	β-coefficient	95% CI	P
VegMeat DP									
Weekend nights	-0.033	-0.325, 0.234	0.748	0.116	-0.010, 0.365	0.064	-0.073	-0.289, 0.085	0.285
Age	-0.017	-0.234, 0.197	0.866	0.053	-0.087, 0.212	0.411	-0.072	-0.199, 0.064	0.312
Gender	0.014	-0.360, 0.412	0.893	0.051	-0.158, 0.365	0.435	-0.114	-0.453, 0.052	0.119
ST	0.084	-0.002, 0.006	0.423	**0.171**	**0.001, 0.007**	**0.007**	0.012	-0.002, 0.003	0.857
MVPA	0.016	-0.107, 0.125	0.880	0.024	-0.062, 0.091	0.714	0.015	-0.071, 0.088	0.838

CI: Confidence interval; DP: Dietary pattern; MVPA: Moderate-to-vigorous physical activity; ST: Screen time.
Significant values are in bold.

6. DISCUSSION

6.1. Key results

The present study aimed to investigate the association between the three dietary patterns previously identified in the sample *(Sweet-and-treats, Health-conscious* and *Vegetables-and-processed-meats*) and sleep duration in children aged 3-6 years participating in the DAGIS project. This study found that sleeping more during week nights was associated with a healthier dietary pattern and with a lower consumption of foods high in sugar. Sleeping habits seem to have more implications for girls' dietary patterns than for boys', who did not show any association throughout the analyses.

Girls who slept less during the week scored higher on the Sweet-and-treats DP score than did boys with similar sleeping habits. On the other hand, girls who slept longer, scored higher on the Health-conscious DP, whereas no such association was found for boys. When adjusting for parental level education, screen usage and physical activity, the associations between sleeping habits and dietary patterns weakened.

According to the obtained results, it could be said that sleep duration could be associated with dietary patterns. There seem to be gender difference that should be analysed in further studies, as the obtained results where significant just among girls. On the other hand, when the same associations were studied for the three groups of parental educational level to see the differences between socioeconomic statuses, no significant results were found.

6.2. Interpretation and generalizability of the results

In the results obtained from the correlation analysis separately, SES was positively associated with the Healthy DP, whereas there was a negative association with the Sweet DP. These results can easily be explained, as families from higher socio-economic levels in developed countries tend to spend more money on healthy foods, when compared to families from lower backgrounds[34,68,75,77,78,82]. Foods from the Sweet DP usually have lower prices than the ones integrated in the Healthy DP.

Another interesting result from the same correlation test showed that the higher the PEL was, the less children slept during the weekend. One hypothesis derived from these results could be that children from more advantaged households do more activities during the weekend compared to the ones from lower backgrounds, who may have the same routines as they have during the week and therefore their bedtimes and routines do not suffer a significant impact[44].

In both univariate and multivariate models, sleep duration in all the analysed forms was negatively associated with Sweet DP and positively associated with the Healthy DP. However, these associations were significant just among girls. In an earlier study by Erkkola et al. (2011)[106], it was observed that there was a slightly higher dietary variability among girls compared to boys, and such variance increased with increasing age. This could suggest that the associations among girls are more easily detected because of that. Another study by Keyes et al. (2015)[60], reported a wide gap between gender differences, claiming that boys were more likely to report getting more than 7 hours of sleep, compared to girls. Yet, those results only considered sleep trends, but the study did not focus on dietary patterns. Therefore, the plausible mechanism behind these results are hard to interpret, as at such early ages there are no hormonal or physiological changes that could explain such differences between genders. It could be hypothesised that girls' sleeping habits are more susceptible to dietary nutrients intake compared to boys'. The mechanisms behind the associations between longer sleep and Healthy DP just among girls could be explained by upbringing and personal values. It could be possible that parents follow recommendations regarding a generally accepted lifestyle for girls, both when it comes to sleep and to diet. However, to our knowledge there are not studies that support such hypothesis. In addition, these hypotheses would go in contrast when explaining why shorter sleep is associated with higher loadings of sugary foods, again just among girls. Additionally, the ages of the participants are so low that these hypotheses are hard to determine, as girls from 3- to 6-years-old are not that aware of the general lifestyle recommendations. Another plausible explanation for the obtained results could be the fact that, even if the sleep duration was practically the same between boys and girls, the variation in girls was a higher compared to boys. And not just in the sleep length, but also in the SweetDP and in the HealthyDP, the SD among boys was lower. Such high standard deviation (SD) among girls provides us with more statistical power to observe differences in the results.

During the analyses, it could be noticed that when adjusting for PEL, MVPA and ST, the association between shorter sleep and the Sweet DP was attenuated. In the analyses, MVPA was not independently associated with the food consumption patterns, just with the sleep duration, but ST and PEL were. It may be that both ST and PEL influence both sleep duration and dietary intake and act as confounders.

In multivariate models, the ST usage was strongly positively associated with the Sweet DP. The results were significant among both genders and also among all three socio-economic levels. Such results are also worth of further research and could be studied as a research question on its own. The association between ST and the 'processed' DP was also positive, yet the results were significant just among girls. The reasons that lay behind these results may be explained by the trends followed of snack consumption while watching TV or during the screen usage in general[107], however to our knowledge such differences between genders do not seem to follow an already studied mechanism. For the specific case of ST, which was significantly associated through all the analyses with both the sweet and the VegMeat DP, it could also be possible that larger amount of screen usage decreases sleep duration[94]. And consequently, a major ST may have a further impact on dietary intake, by increasing the opportunities to eat sugary and processed foods[94]. It also could be thought that ST and diet, as well as MVPA, are associated because they may manifest a certain lifestyle allowed or encouraged by parents' rules[107]. It could be said that in families with less strict rules about ST, their diet could be less healthily.

The most unpredictable outcome obtained from the multivariate model was the fact that, when stratifying for PEL, results did not differ between the three groups. However, such results are plausible in a country like Finland, as every child has the right to attend preschool[96], and the majority of them are public ones with fees depending on the parental salary. Such equalities make the access to healthy habits easier and should be considered as an example for other countries that are trying to reach the same results among the population. Nonetheless, the sample size was not homogeneous, and results could not be reliable as children from households with lower parental educational level were less (109), whereas those from the middle and the higher education were 254 and

220, respectively. And, in addition, parents in the middle group were considerably highly educated as well.

6.3. Comparison with previous studies

The aim of this study was to explore for the first time the effect-role that sleep duration may play in the dietary patterns of pre-school children in Finland, considering separately the gender and the socio-economic status differences.

The fact that PEL resulted positively associated with the Healthy DP and showed a negative association with the Sweet DP is mainly in line with previous studies on adults, older children and adolescents[34,68,75,76,77,78,79,80], even if the sample of our size was composed of younger-aged children. In a previous Finnish study, high parental education level was most commonly associated with a "health conscious pattern" when compared to children from lower parental education households, who were more prone to follow a "traditional dietary pattern"[71]. Higher PEL was also related to shorter sleep during the weekend. These results match with the ones from a previous study among American children and adolescents[44,60,61]. However, diverse researches regarding these same associations obtained different results[9,36], reporting that children from lower SES tend to have shorter sleep durations compared to those from more advantaged status. Therefore, researched evidence until the date about this association seems to be confusing and further studies are needed in order to understand the causality of the association.

The fact that longer sleep duration is associated with higher consumption of healthy foods and lower intake of sugary products agrees with previous results[25,34,58,64,84,85,86,91]. The present results suggest that girls sleeping less during the week score higher on the sweet-and-treats DP score than did boys with similar sleeping habits. These results do not match with a previous study among Finnish adolescents[25] as the same associations were more prevalent among boys. On the other hand, girls who slept longer, scored higher on the health-conscious DP. These results are mainly in line with the ones reported by Westerlund et al. (2009)[25], which showed similar associations among girls regarding sleep length and healthy eating patterns. However, to our knowledge, it was the first time that such associations were found just among girls. As a matter of fact, in the previous study on Finnish 10-11-year-old children[25] the same associations studied seemed to have more implications for boys, contrarily to our results.

To our knowledge, no studies had previously investigated the associations between sleep duration and dietary patterns in pre-school children. The majority of the results from the present study are mainly in line with results from former studies, showing that poor sleep is associated with unhealthier DP. However, as far as we are concern, this is the first time that such associations are significant just among girls.

6.3. Considerations and future prospects

The study has revealed useful information about possible modifiable mediators in the association between sleep and pre-school's children diet. When aiming to reduce socio-economic status differences in children's sleep length, the focus should be mainly on diminishing ST, and improving both diet and sleep quality. Further studies are needed in order to confirm the associations found. However, a possibility exists that there are no causal associations between sleep duration and dietary patterns, as it is not possible to predict the causality of the results since it is a cross-sectional study. Future studies with a cohort design and intervention plans are needed to confirm a causal association.

In addition, it would be interesting if further studies about sleep to analyse not just the sleep length but also the regularity of the sleeping habits, as previous studies suggested that sleep requirements vary among individuals and therefore sleep time is not the only way to measure adequate sleep[108]. Previous studies[109] have shown that adequate sleeping habits are associated with a wealth of healthy behaviours. Therefore, it has been suggested that short sleep may be a screening indicator of unhealthy lifestyle. Further studies regarding sleep times, duration and its adequateness are needed to prevent future unhealthy outcomes among the population.

Future researches should also focus on the epidemiological aspects and on the mechanisms behind the gender differences observed in the present study regarding the associations between sleep and dietary pattern. It would be useful to understand how and why the association between sleep duration and sweet and healthy dietary patterns differ that much among different genders during the early childhood. More research is needed on why the associations obtained were not found among boys.

We found a stronger association with dietary patterns for sleep duration on week nights compared to weekend nights. Other studies looking at the association between sleep duration and overweight found stronger results for sleep during the week than for sleep during the weekend[25,93]. This could be explained by the fact that during the week, children have to wake up early even after inadequate sleep, meanwhile during the weekends they can sleep longer, as they can wake up later in the morning. Week nights, however, dominate the sleep length of children. Daily routines during the week are therefore of special concern when promoting healthy lifestyle habits.

The fact that the screen time usage was so strongly associated with the sweet dietary pattern since early ages is also worth of further research as most studies focus on older children[94,107,110]. Moreover, in further studies, along with the screen usage and dietary patterns, it would be also interesting to study the differences between genders in the physical activity levels and the dietary variables, with special attention to its associations with processed foods or DPs.

Wide health promotion strategies, as well as better and more efficient communication, are needed in order to improve both parents' and children's awareness of the importance of a healthy lifestyle adherence. As health recommendations is one public health strategy to assist populations to reduce their risk of NCD and improve both their health and wellbeing, monitoring the population compliance with healthy patterns is an important aspect of this field planning. In order to prevent poor or inadequate sleeping habits along the life course, care and control are needed across all age groups to establish critical periods for intervention. A compelling and well-designed school health program is one of the most cost-effective expenses a nation can do to improve education and health simultaneously. By doing so, important health risks can be prevented. Meanwhile, it can also lead to changes in educational, social, economic and political conditions that have a repercussion in the well-being of the population[72]. Therefore, there is a necessity to provide information to determine whether the relationships between sleeping habits and lifestyle behaviors affect pre-school children and how they differ across diverse environmental and sociocultural settings. Such information is key for the plan and development of interventions that can be adapted as public health programs and, particularly in this case, as ways to inform the Finnish population about health and cost-less active habits to improve their present and future well-being. Ironically, the wide use of social media among children, adolescents and parents may be a useful strategy in the years ahead to promote the recommendations by embedding them in related advertisements or interactions[19].

It can be anticipated that, in future prospect, health education programs aimed to the general public will not only include recommendations about a healthy diet and physical activity, but also about how to achieve adequate and good-quality sleep. Interventions may benefit from including gender-specific strategies.

6.4. Strengths and limitations

The young age of the children participating in the study is one aspect that calls for attention. Only few studies exist on how sleep and diet are related, especially among such young ages. Another strength of the study is that since the majority of children in Finland spend much of their time during the week in standardized pre-schools, the environment of them has a high potential to promote healthy habits. Ways of promoting them could be through physical and social environments[111], as the results obtained from the study could be applied to create action plans to modify the actual situation. A further strong point of this study is the fact that sleep length was calculated following exact hours of bed in time and wake-up time reported by parents, considering that previous studies on the similar topic[25] used data from bedtime and wake-up times from questionnaires having half-hour intervals alternatives. These sleep fluctuations of 30 minutes can affect the validity of the sleep durations. Additionally, in most studies about sleep, participants report their “usual” sleeping times, which can be overestimated[112,113]. The fact that the present study used a diary makes this measure more precise. An additional strength of the study, regarding sleeping habits, is the fact that the analyses were carried out separately during week nights, weekend nights and for the whole week. The use of the actigraphy was also a strength of the study, as it provided with reliable and more importantly specific objective measurements. However, the accelerometer was used only to measure MVPA, therefore for the sleep duration the results are obtained from the parent-reported data.

Participance in the present study was voluntary, and a written compulsory consent from the parents was asked. This might have selected the children participating in the study towards more health-conscious individuals, whereas parents with a less healthy lifestyle might have chosen their offspring not to participate. A less selective data could have shown stronger associations than the ones found in the present study. Another limitation of this study is that the parent-reported diary may lead to bias, as parents might be unable to constantly monitor their children's times and behaviours, especially regarding to sleep bedtime and wake-up times. Parental-reported diaries of child sleep appear to produce discrepant estimates among children and adolescents[114,115]. More limitations of this study are that the nap hours of children were not analysed, as there was not data available of the naps they took during the pre-school hours.

7. CONCLUSION

According to the results obtained in the present study, it could be concluded that:

1. Sleep length during the whole week, during the weekdays and weekend is inversely associated with a sweet dietary pattern consumption. On the other hand, sleep length both during the whole week and the weekdays is positively associated with a higher intake of healthy foods.
2. Girls tend to have a higher consumption of sweet foods the less they sleep, during the weekdays and the whole week. Whereas in general they are more likely to follow a healthy dietary pattern the longer the sleeping hours. Such associations do not seem to be present among boys.
3. There do not seem to exist differences between sleep length and dietary patterns when considering different socio-economic backgrounds among children from pre-schools in Finland.

However, the literature research and the obtained results highlight the fact that, when talking together about sleep and diet, we are still on a narrow piece of *terra ferma* in a wide sea of the unknown.

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