ENDORSE

Environmental determinants of overweight in Rotterdam schoolchildren

Klazine van der Horst - Nachtegaal

Colofon

ISBN: 978-90-8559-569-4

Lay-out and Print: Optima Grafische Communicatie
Cover-illustration: Optima Grafische Communicatie

This thesis was printed with financial support of the Department of Public Health, Erasmus MC, Rotterdam.

ENDORSE
Environmental Determinants of Overweight in Rotterdam Schoolchildren

ENDORSE
Omgevingsdeterminanten van overgewicht bij Rotterdamse scholieren

Proefschrift

ter verkrijging van de graad van doctor aan de
Erasmus Universiteit Rotterdam
op gezag van de rector magnificus

Prof.dr. H.G. Schmidt

en volgens besluit van het College voor Promoties.

De openbare verdediging zal plaatsvinden op
woensdag 7 oktober 2009 om 11.30 uur
door

Klazine-Anja van der Horst - Nachtegaal

geboren te Zwolle

PROMOTIECOMMISSIE

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Part I Introduction to the ENDORSE project

1 General Introduction

1.1 INTRODUCTION

Overweight and obesity are a major threat to public health as the prevalence's of overweight and obesity are rising worldwide in all age groups. Obesity in children and adolescents is of particular interest since it persists into adulthood and is associated with severe health consequences. Therefore, the prevention of overweight and obesity is important for public health. To be able to develop theory and evidence-based interventions aimed at the prevention of excess weight gain, it is essential to identify which specific energy intake and energy expenditure behaviors contribute most to excess weight gain, and which determinants are associated with engagement in such behaviors.

This thesis reports on a number of studies on the identification of individual and environmental correlates of behaviors related to the energy balance (i.e. energy intake and expenditure behaviors). These studies were part of the ENDORSE project (ENvironmental Determinants of Obesity in Rotterdam SchoolchildrEn) which was initiated to contribute to systematic, evidence based research on individual and environmental determinants of overweight and obesity. The ENDORSE project was initially a cross-sectional study and after the first data collection a follow-up data collection was funded. Data were collected at baseline (2005/2006) and two years later (2007/2008) in a cohort of adolescents aged 12-15 years. The studies in this thesis were based on the baseline data collection, as the longitudinal data was not available in time to use in this thesis. This introductory chapter describes the background, aims and theoretical framework used in the ENDORSE project and presents an overview of the individual studies that are part of this thesis.

1.2 A MODEL FOR PLANNED HEALTH PROMOTION

Overweight and obesity prevention has to target the most important risk factors and the underlying determinants. Prevention of overweight and obesity through the promotion of healthy dietary habits and a physically active lifestyle by means of health education and health promotion should therefore be carefully planned. To increase the likelihood of intervention success, careful evidence-based planning of obesity prevention interventions should be a standard procedure. The use of health promotion planning models helps to improve the quality of interventions and in these models five important steps can be distinguished (Figure 1.1) [1]. The first two steps in this model for planned health education and promotion cover the epidemiological analysis. These first two steps should (I) identify important threats to public health and (II) the risk factors including risk behaviors for these public health threats. The result is a set of priorities for preventive interventions, health change goals and specific target groups for interventions. The third step identifies important and changeable determinants of risk behaviors. In step 4 of the model, intervention strate-

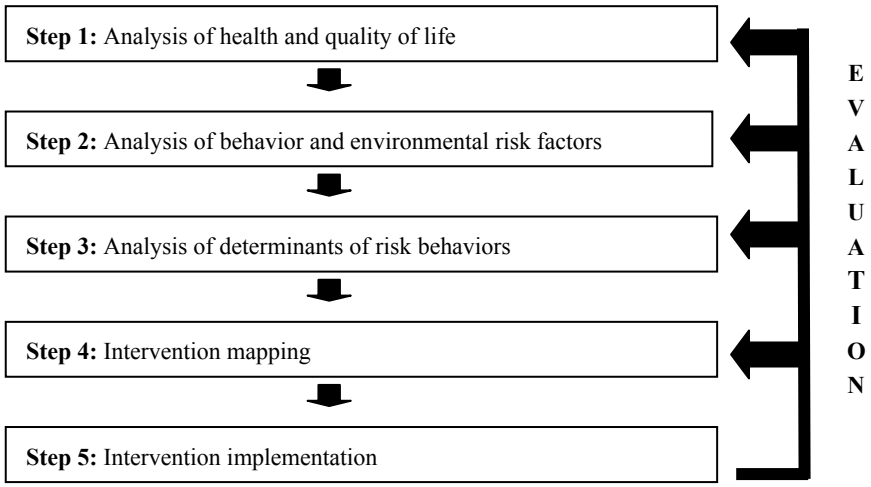

Figure 1.1 A model for planned health education and promotion [1]

gies, methods and materials need to be selected and/or developed that address the most important and changeable determinants identified in the third step. In the final step the interventions should be implemented and disseminated in such a way that the target population is reached and exposed to the intervention. Each step should be based on established theory and sufficient scientific evidence.

The ENDORSE project was initiated to contribute to systematic, evidence based research on individual and environmental determinants of overweight and obesity and focused mainly on step 2 and 3 of the model for planned health education and promotion (Figure 1.1).

1.3 ANALYSIS OF HEALTH AND QUALITY OF LIFE: OBESITY

Obesity is a vast and growing public health problem as the prevalence of overweight and obesity is rising worldwide in all age groups [2, 3]. Obesity may become the most important determinant of preventable diseases within the foreseeable future [4]. Overweight and obesity often manifest early in life [5, 6] and are associated with an increased risk of serious diseases during childhood and adolescence [7, 8]. Obesity during childhood causes a clustering of cardiovascular disease risk factors such as hypertension and dyslipidaemia. Other important complications of childhood obesity are type 2 diabetes, musculoskeletal and pulmonary disorders and obesity is further associated with psychosocial problems such as a low self esteem, depression and eating disorders (Table 1.1) [9, 10]. Furthermore, obese

children and adolescents are likely to become obese adults, who have an increased risk for various chronic diseases and premature death [9, 11].

In the Netherlands, an increasing proportion of adolescents are classified as overweight and obese (Table 1.2 & 1.3). Between 2002 and 2004, in 12 to 15 year old adolescents the prevalence of overweight ranged between 15.2% and 20.1% and between 2.7% and 4.7% for obesity [12-14]. Youth from Moroccan and Turkish backgrounds have the highest prevalence rates of overweight [12, 15]. In Rotterdam, overweight and obesity prevalence is higher compared to the general Dutch adolescent population. Especially youth in Rotterdam from a Turkish background show very high prevalence rates of overweight and obesity with percentages ranging between 38% and 45% [16]. The complications that obese adolescents may develop, the tracking of obesity into adulthood, and the vulnerability of obese adolescents make a strong case for the prevention and treatment of overweight and obesity in youth. However, treatment of overweight and obesity in adolescents is difficult as adolescents have less autonomy over food and physical activity behaviors compared to adults and they are more susceptible to peer pressure. The overall success of existing family and school-based interventions has been disappointing [17, 18]. Only few adolescents succeed to maintain their lower body weight and most of the weight loss is often regained within a few years [9]. Adolescents are therefore an important target group for intervention activities that prevent them from gaining excess weight and becoming overweight or obese.

Table 1.1 Complications of childhood obesity [9, 10]

Complications of childhood obesity	Examples
Psychosocial problems	Poor self esteem
	Depression
	Eating disorders
Pulmonary problems	Sleep apnoea
	Asthma
	Exercise intolerance
Gastrointestinal problems	Gall stones
Endocrine problems	Type 2 diabetes
Cardiovascular problems	Dyslipidaemia
	Hypertension
Neurological problems	Pseudo tumor cerebri: headache, vision abnormalities
Renal problems	Glomerulosclerosis
Musculoskeletal problems	Flat feet
	Low back pain

Table 1.2 Prevalence of overweight in the Netherlands (adolescents 12-15 years old) [13, 14, 19]

	Overweight (%)					
	Boys			Girls		
Age	1980	1997	2002-2004	1980	1997	2002-2004
12	3.4	7.1	16.2	6.1	9.0	17.1
13	3.6	7.1	15.3	6.0	9.1	15.2
14	3.9	7.3	15.6	6.1	9.1	16.2
15	4.2	7.7	16.8	6.2	9.4	20.1

Table 1.3 Prevalence of obesity in the Netherlands (adolescents 12-15 years old) [13, 14, 19]

	Obesity (%)					
	Boys			Girls		
Age	1980	1997	2002-2004	1980	1997	2002-2004
12	0.2	0.7	2.8	0.4	1.1	3.1
13	0.2	0.7	2.8	0.4	1.0	2.7
14	0.2	0.7	3.4	0.4	1.0	2.8
15	0.2	0.7	3.9	0.4	1.1	4.7

1.4 ANALYSIS OF BEHAVIORAL RISK FACTORS FOR OBESITY

A long-term positive energy balance in which energy input through food intake exceeds energy expenditure through physical activity eventually causes obesity. Therefore, high energy intake and low physical activity can be identified as important risk behaviors for overweight and obesity. Prevention of overweight and obesity can be achieved by lowering energy intake and/or increasing energy expenditure. The increase in overweight and obesity is therefore largely related to behavioral factors that can be referred to as energy balance-related behaviors. However, it is not yet very clear which specific risk behaviors are related to overweight and obesity in children and adolescents [20]. Recent overviews have suggested a range of energy balance-related behaviors that may contribute substantially to a higher risk for unnecessary weight gain, such as high intake of energy-dense, micronutrient poor foods and a sedentary lifestyle, and behaviors that may contribute to a lower risk for weight gain such as physical activity and high fiber intake [21-23]. However, studies and reviews have also reported inconsistent results on the role of specific dietary and physical activity sub-behaviors [22]. An overview of the available evidence is given in Table 1.4. Most evidence in this overview is based on systematic reviews of observational and intervention studies.

Table 1.4 Overview of the available evidence on risk behaviors for overweight and obesity

Behaviors	Evidence	References
Dietary behaviors		
Snacks / fast food intake	Probable / insufficient for children	[26, 27]
Sugar-sweetened beverage intake	Convincing	[23, 28]
Breakfast consumption	Possible	[29]
Fruit / vegetable	Insufficient	[30, 31]
Fiber intake / Non-starch polysaccharide	Convincing	[23, 32-34]
Intake of dairy products	Possible	[23, 35, 36]
Portion sizes	Possible	[23, 37]
Physical activity behaviors		
Overall physical activity	Probable	[38, 39]
Leisure time physical activity (sports, walking, cycling)	Insufficient	[38]
Physical education	Insufficient	[40-42]
Active transport to school	Insufficient / no relationship	[43-45]
Sedentary behaviors		
Television viewing	Convincing (small effect)	[21, 25]
Computer use	No relationship	[25]

With respect to food intake, convincing evidence for an association with overweight and obesity exists for sugar-sweetened beverage consumption and fiber intake. The evidence for associations with overweight and obesity are less clear for other behaviors such as breakfast consumption, portion sizes and consumption of dairy products and fast food or snack consumption (Table 1.4). Snacking, fast food intake and large portion sizes have been found to be associated with energy and fat intake, but none of these factors have been found to be consistently related to obesity [20].

Furthermore, the relative importance of different aspects of physical activity is poorly understood. It is unclear whether obesity is similarly related to a reduction in physical activity behaviors and/or an increase in sedentary behaviors [22, 24]. A small but significant association has been found between television viewing and body fatness among children and adolescents [21, 25], while evidence for specific physical activity sub-behaviors such as active transport and leisure time sports, such as walking and bicycling is lacking.

In summary, the available evidence on behavioral risk factors for overweight shows that for many of the dietary and physical activity sub-behaviors the evidence is insufficient. Therefore, more and stronger studies are needed to examine the specific risk behaviors for

overweight and obesity in the dietary and physical activity domain, such as leisure time walking and bicycling, sports and snack consumption. It has, however, been established that a combination of changes in both energy balance behaviors, i.e. diet and physical activity seems the most promising strategy for successful obesity prevention.

To curb the obesity epidemic, it is important to identify specific target groups of adolescents who are more at risk of becoming obese by engaging in more (or specific) energy balance-related behaviors. Being able to distinguish specific target groups provides the opportunity to better tailor interventions to the needs and perceptions of those most at risk [46]. Currently, there is insufficient insight into the occurrence of a number of overweight related risk behaviors among adolescents and also whether it is possible to distinguish specific subgroups that are more likely to engage in such specific risk behaviors.

1.5 ANALYSIS OF DETERMINANTS OF ENERGY BALANCE-RELATED BEHAVIORS

Individual determinants

In determinant research the emphasis has been primarily on individual (intrapersonal) cognitive determinants of behavior such as attitudes, perceived behavioral control, subjective norms and intentions, informed by social cognition models such as the Social Cognitive Theory [47] and the Theory of Planned Behavior (TPB) [48]. According to the TPB, if people evaluate the behavior as positive (attitude), if they think significant others want them to perform the behavior (subjective norm), and if people are convinced that they can successfully execute the behavior required to produce the desired outcomes (perceived behavioral control), they will be more likely to have a high intention (motivation) and a higher likelihood of engaging in the behavior (Figure 1.2). The TPB has been found to be useful for the identification of potential determinants of energy balance-related behaviors such as soft drink consumption [49-51], snack consumption [52] total physical activity and physical exercise [53, 54]. On average 30% of the variance in health behaviors can be explained with the TPB variables [53, 54]. The TPB is useful in examining intrapersonal determinants of obesity related behaviors. However, individuals interact with people in their environment such as parents and peers and the individual behavior takes place in environmental settings such as the home, the neighborhood or school. Therefore, next to intrapersonal factors, other factors might also be important for examining determinants of obesity related behaviors.

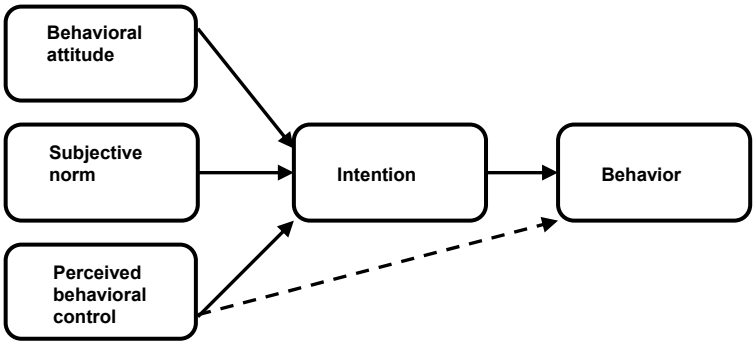

Figure 1.2 Theory of Planned Behavior [28]

Environmental determinants

An important development in overweight and obesity prevention research has been the recognition of the role of "the environment" in influencing health and health behavior and there has been a shift in focus from individual influences on health behaviors to environmental influences [55]. Socio-ecological models include environmental factors as an important element. The environment can be defined as everything and anything outside the person [56]. The environment is the context in which human beings act and interact. Socio-ecological models focus on how individual, intrapersonal and environmental factors interact and shape health behavior. Socio-ecological models have a complex and multidimensional nature as they describe the environment not only in terms of physical and social components, but also in terms of the objective (actual) or subjective (perceived) attributes of the environment [57].

A useful framework for the classification of environmental determinants is the Analysis Grid for Environments Linked to Obesity (ANGELO) (figure 1.3) [58]. This framework was specifically developed to conceptualize obesogenic environments, and enables the identification of potential intervention settings and strategies.

According to the ANGELO framework, environmental determinants can be classified according to two environmental levels (micro and macro) and four environmental types (physical, socio-cultural, economic, and political). Individuals interact with the environment in various micro or local environments such as schools, homes, workplaces and neighborhoods. Broader macro environments such as health and education systems, food industry, media and the government influence these micro environmental settings. Different types of the environment can be distinguished, such as the *physical* environment, which refers to

which foods and physical activity opportunities are available, the *economic* environment, which refers to the costs of food and activity, the *political* environment, which refers to the rules related to food and activity (e.g. laws and regulations), and the *socio-cultural* environment which refers to social interactions, norms, beliefs and values in a community related to food and activity [58]. These types of environments have representations at the micro-level and on the macro-level. An example of a physical environmental factor at a micro level is the availability of physical activity equipment at home, while an urban or suburban neighborhood setting and infrastructure is an example of a physical environmental factor at the macro level.

As more and more studies focus on environmental determinants of health behaviors it is important to get a clear overview of the evidence these studies have provided so far, the gaps that exist in the available literature and the possibilities to improve the research in this field.

Levels / Types	Micro-environment	Macro-environment
Physical environment		
Economic environment		
Political environment		
Socio-cultural environment		

Figure 1.3 Analysis Grid for Environments Linked to Obesity [38]

Other determinants of energy balance-related behaviors

Next to cognitive and environmental determinants there are also other possible determinants that may influence energy balance-related behaviors such as habit strength and demographic factors. Research is needed to explore the importance of these determinants for various energy balance-related behaviors and the working mechanisms of these possible determinants.

Most energy balance-related behaviors occur regularly in daily life, such as the consumption of breakfast and walking for transportation. Therefore, such behaviors might be more or less automatic behaviors not requiring much or any cognitive efforts. If a behavior is often repeated, it might become a habit, i.e. an automatic response to a certain environmental cue [59]. Recent studies indicated that habit strength seems to be a useful variable to incorporate in studies on correlates of energy balance-related behaviors [60-63].

Demographic factors such as gender, age, educational level and ethnicity are also associated with energy balance-related behaviors [21, 24, 64-66] and can be considered as more distal or upstream determinants. These variables can act also as moderators of the environment – behavior relationship as the determinants of energy balance-related behaviors

might vary by population sub-groups. Studies are needed that explore whether potential determinants have a different impact on energy balance-related behaviors with respect to gender, ethnicity, age and educational level or socio-economic status [67].

Mediating and moderating effects of individual and environmental determinants

Well-developed ecological models specify not only *that* different types of variables (individual and environmental) interact, but also the working mechanisms of these variables, thus *how* they interact. Kremers and colleagues proposed in their Environmental Research framework for weight Gain prevention (EnRG framework) that environmental factors can have a direct and an indirect influence on behavior [56, 67] (Figure 1.4).

The direct influence reflects an automatic, "mindless" process of the environment on behaviors. For instance, dietary behaviors and the amount of foods eaten are strongly influenced by factors such as portion size, food visibility and the ease of obtaining foods [68]. The indirect influence of environments on energy balance-related behaviors is through a more cognitive process in which the individual factors, such as attitudes, subjective norms and perceived behavior control play a role. For example, environments that offer appealing opportunities to eat unhealthy foods may result in positive attitudes regarding the consumption of these unhealthy foods, resulting in higher intakes of these foods. In the EnRG framework it is also proposed that the direct and indirect pathways can be influenced by moderating factors or effect modifiers; the level of cognitive mediation or direct environmental influence is expected to differ according to personal and behavioral attributes such as habit strength, demographic factors and personality [67, 69, 70].

Only few studies have examined the relative importance of environmental determinants and individual (cognitive) determinants and there is also lack of empirical evidence regarding the influence of environmental determinants on energy balance-related behaviors among adolescents [67, 70-72]. More research is needed on environmental determinants of energy balance-related behaviors in school, neighborhood and home settings with preferably stronger study designs in which mediating and moderating effects can also be examined.

In the ENDORSE study, the TPB and the ANGELO framework which are both incorporated in the EnRG framework were used as a theoretical framework. To inform obesity prevention interventions for adolescents, the ENDORSE study focused mainly on physical and socio-cultural environmental factors in micro settings such as the school, home and neighborhood.

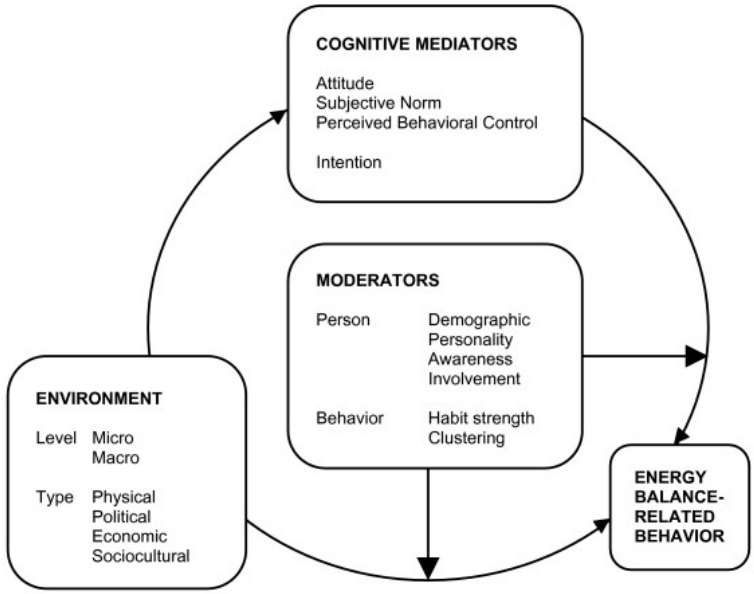

Figure 1.4 Environmental Research framework for weight Gain prevention [47]

1.6 OUTLINE OF THE THESIS

As stated before, the ENDORSE project was initiated to contribute to systematic, evidence based research on individual and environmental correlates of overweight and obesity. The ENDORSE project focused on the analysis of risk behaviors for overweight and the analysis of determinants of these risk behaviors, step 2 and 3 of the model for planned health education and promotion (Figure 1.1). This resulted in specific recommendations for obesity prevention interventions among adolescents. The specific aims of the ENDORSE project were:

1. to identify which presumed energy balance-related behaviors are associated with overweight and obesity;
2. to examine important individual and environmental correlates of presumed energy balance-related behaviors;
3. to investigate the associations with and the interactions between these correlates and energy balance-related behaviors;
4. to formulate objectives to be targeted in interventions aimed at the prevention of overweight in adolescents aged 12-15 years.

The studies presented in this thesis focus on aim 2 and 3 of the ENDORSE project, and the central research questions that will be addressed are:

I. What are important individual and environmental correlates of energy balance-related behaviors?
II. To what extent is the association between environmental factors and energy balance-related behaviors mediated by individual cognitions?

The thesis is divided in three parts. The first part of this thesis gives an introduction to the ENDORSE study, with this general introduction as the first chapter. Chapter 2 presents the study protocol of the ENDORSE study in which the design and methods are described, as well as the results of the pilot work on the identification of risk behaviors for overweight and obesity.

In the second part of this thesis environmental correlates of energy balance-related behaviors are identified by studying the existing literature. Two systematic reviews of the literature were conducted, one for dietary behaviors (Chapter 3) and one for physical activity (Chapter 4). The review for dietary behaviors is an original review, whereas the review for physical activity is an update of an existing review conducted by Sallis and colleagues [64].

In the third part of this thesis, demographic factors as correlates of energy balance-related behaviors are studied. Chapter 5 presents gender, ethnic and educational differences in overweight and energy balance-related behaviors. Chapter 6 describes the results of a study on socio-demographic correlates of active commuting to school. Although such socio-demographic factors are not easily modifiable and are therefore not easy access points for intervention development, these factors can be important to identify specific target groups for obesity prevention interventions.

In the fourth part of the thesis, the associations of individual and environmental correlates with energy balance-related behaviors, and possible mediation through individual correlates from the Theory of Planned Behavior are examined, with the EnRG framework as the theoretical framework. In Chapters 7-9 the potentially important mediation role of cognitions in the association between environmental factors and energy balance-related behaviors is investigated. The study in Chapter 9 is based on another dataset to examine the mediating role of cognitions in further detail with other variables. This study used data from the Dutch Obesity Intervention in Teenagers Study [73].

In the general discussion a summary of the main findings of this thesis and recommendations for further research and practice are provided.

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2 The ENDORSE study: research into environmental determinants of obesity related behaviors in Rotterdam schoolchildren

van der Horst K, Oenema A, van de Looij-Jansen P, Brug J. The ENDORSE study: research into environmental determinants of obesity related behaviors in Rotterdam schoolchildren.

BMC Public Health 2008, 8: 142.

ABSTRACT

Background: Children and adolescents are important target groups for prevention of overweight and obesity as overweight is often developed early in life and tracks into adulthood. Research into behaviors related to overweight (energy balance-related behaviors) and the personal and environmental determinants of these behaviors is fundamental to inform prevention interventions. In the Netherlands and in other countries systematic research into environmental determinants of energy balance related behaviors in younger adolescents is largely lacking. This protocol paper describes the design, the components and the methods of the ENDORSE study (Environmental Determinants of Obesity in Rotterdam SchoolchildrEn), that aims to identify important individual and environmental determinants of behaviors related to overweight and obesity and the interactions between these determinants among adolescents.

Methods: The ENDORSE study is a longitudinal study with a two-year follow-up of a cohort of adolescents aged 12-15 years. Data will be collected at baseline (2005/2006) and at two years follow-up (2007/2008). Outcome measures are body mass index (BMI), waist circumference, time spent in physical activity and sedentary behaviors, and soft drink, snack and breakfast consumption. The ENDORSE study consists of two phases, first employing qualitative research methods to inform the development of a theoretical framework to examine important energy balance related behaviors and their determinants, and to inform questionnaire development. Subsequently, the hypothetical relationships between behavioral determinants, energy balance related behaviors and BMI will be tested in a quantitative study combining school-based surveys and measurements of anthropometrical characteristics at baseline and two-year follow-up.

Discussion: The ENDORSE project is a comprehensive longitudinal study that enables investigation of specific environmental and individual determinants of overweight and obesity among younger adolescents. The project will result in specific recommendations for obesity prevention interventions among younger adolescents.

BACKGROUND

Adolescent overweight and obesity are important public health concerns in the Netherlands as well as in other western countries, due to the increasing proportion of adolescents classified as overweight or obese [1]. Children and adolescents are an important target group for intervention activities aimed at the prevention of overweight. Overweight and obesity often manifest early in life [2, 3] and is associated with an increased the risk of serious diseases during childhood and adolescence [4]. Furthermore, obese children and adolescents are likely to become obese adults, who have an increased risk for various chronic diseases and premature death [5]. Therefore, it is important to develop interventions that prevent children and adolescents from gaining excess weight. Prevention of weight gain can best be achieved by focusing on both sides of the energy balance equation; energy intake (diet) and energy expenditure (physical activity). To be able to develop theory and evidence-based interventions aimed at the prevention of excess weight gain, it is essential to identify which specific energy intake and energy expenditure behaviors contribute most to excess weight gain, and which determinants mediate or predict engagement in such behaviors.

An important development in overweight and obesity prevention research has been the recognition of the environment as a potentially important determining factor for energy balance related behaviors [6]. Currently, there is only limited scientific evidence regarding the influence of environmental determinants on energy balance related behaviors among adolescents [7, 8]. Few studies have examined the relative importance of environmental determinants and individual (cognitive) determinants that have been the more traditional focus of behavior change interventions, and there is also lack of empirical evidence regarding the interactions between these determinants [9-11]. Research into environmental determinants is now emerging and more rigorous and well-designed studies are needed to draw stronger inferences for relationships between environmental determinants, energy balance related behaviors and BMI. Such studies are also needed to identify the interactions between determinants of various energy balance related behaviors and the mechanisms underlying the associations between individual and environmental determinants of these behaviors [6, 11]. Therefore, a comprehensive study was designed that examines key energy balance related behaviors, the individual and an environmental determinants of these behaviors and that contains objective measures of height, weight and waist circumference. The target population of the study is adolescents aged 12-15 years. The specific aims of the study are: (i) to identify important behaviors related to overweight (energy balance related behaviors), (ii) to examine important individual (cognitive) and environmental determinants for the energy balance related behaviors identified, (iii) to investigate the associations with and the interactions between these determinants and BMI in cross-sectional and prospective analyses with a two year follow-up, and (iv) to formulate objectives to be targeted in interventions aimed at the prevention of overweight in adolescents aged 12-15 years.

The ENDORSE study (Environmental Determinants of Obesity in Rotterdam's SchoolchildrEn) is conducted within the Center for Effective Public Health In the larger Rotterdam area (CEPHIR), an established collaboration between a university research center (Erasmus MC) and the Municipal Health Service Organization in the Rotterdam region. The data collection process takes place in close cooperation with the Municipal Health Service Rotterdam area, using an existing research infrastructure. In this article we describe the design and protocol of the ENDORSE study.

The study comprises of two parts. The first part focused on the identification of the key energy balance related behaviors and the important individual and environmental determinants to examine. Based on this identification, measurement instruments were developed. The second part consists of a combined cross-sectional and longitudinal study utilizing these instruments.

PILOT WORK: IDENTIFICATION OF RISK BEHAVIORS AND IMPORTANT ENVIRONMENTAL DETERMINANTS

This phase of the ENDORSE study involved the development of questionnaires for adolescents and parents, interview forms for school representatives and canteen managers, an audit instrument used to observe the school and the neighborhood around schools, and a list of important census data on neighborhood level. To develop these instruments systematically, important behaviors and determinants were identified in the following steps.

Identification of important energy balance related behaviors in youth

The most important energy balance related behaviors were identified to gain insight in the contribution of these behaviors to overweight and obesity in adolescents. Based on a review of relevant reviews of the literature, a preliminary list of specific relevant energy balance related behaviors was compiled. This list contained: watching television, computer use, sports, physical education, transport to school, leisure time activities, soft drink consumption, skipping breakfast, consumption of foods high in fat, fruit and vegetable consumption, portion sizes and dining out. Subsequently national experts on energy balance related behaviors were asked to review this list and suggest additional important behaviors and score the behaviors on the importance and changeability of each behavior. This procedure resulted in the following identification of behaviors to be examined in the present study: active transport to school, leisure time activities, sports, watching television, computer use, soft drink consumption, sweets/cookies/cake/chocolate bar consumption, savory snack consumption and breakfast consumption.

Identification of environmental and individual determinants of energy balance related behaviors among youth

In the ENDORSE study the environment was defined as 'anything outside the individual'. The environment can be subdivided by means of distinguishing various environmental factors. A suitable framework for the classification of environmental determinants is the Analysis Grid for Environments Linked to Obesity (ANGELO) [12]. This framework was specifically developed to conceptualize health behavior environments, and enables the identification of potential intervention settings and strategies. According to the ANGELO grid, environmental determinants can be grouped in four environmental types (physical, socio-cultural, economic, and political) and specific environmental levels (micro and macro). To integrate important environmental types and levels in the ENDORSE study; physical, socio-cultural, economic and policy determinants were examined at the micro level (home, school and neighborhood level). Combinations of perceived and objectively measured environmental determinants were used to investigate the interactions between environmental and individual determinants.

Environmental determinants previously shown to be important were identified by conducting two systematic reviews, one with physical activity as the outcome behavior [7] and the other with specific obesity related dietary behaviors as outcome [8]. The results from the reviews were categorized using the ANGELO grid. Convincing evidence of an important role for physical environmental determinants was not found. However, only a limited number of studies assessing physical environmental determinants of energy balance related behaviors were retrieved. Most consistent determinants of physical activity in adolescents were support from significant others, mother's education level, family income and non-vocational school attendance and low neighborhood crime incidence [7]. The most consistent determinants of obesity related dietary behaviors among adolescents were parental and family influences, e.g. parental and sibling intakes, parenting style, family connectedness and parental education [8]. The results of the reviews were used to guide the design of questionnaires and observation forms. Since the evidence from the reviews itself was not sufficient, potential determinants of physical activity and dietary behaviors were also included in the measurement instruments.

The theory of planned behavior (TPB) was used for the selection of potential individual determinants to be included in the study [13]. The TPB postulates that intention to perform a behavior, the determinant most proximal to behavior, is determined by three conceptually independent constructs: attitude, subjective norms and perceived behavioral control. To further explore what specific concepts, beliefs or perceptions would be important for adolescents; focus group interviews with adolescents were held. A focus group interview is conducted among a small group of people who, led by a moderator and following a predetermined interview scheme, discuss several topics related to a specific subject. The aim

of the focus groups was to gain insight in the individual and environmental determinants of snacking, soft drink consumption, eating breakfast and physical activity. Three schools participated and teachers were asked to select adolescents who would be able to function in a group discussion (i.e. who were not too shy or too dominant). Five focus groups were conducted with seven to nine adolescents aged 13-15 years old, and a total of 39 adolescents participated. Two of these groups consisted of boys only; two of girls only; and one was a mixed group with boys and girls. Three of the groups were composed of adolescents from cultural and ethnic minorities reflecting the cultural diversity of the residents of Rotterdam. Each interview was tape-recorded and lasted about 45 minutes. The focus groups were transcribed verbatim and from these transcripts, quotes were categorized into the determinants or concepts that they reflected. Many adolescents identified that seeing other people eating or drinking and smelling fast food were factors that influenced their eating and drinking patterns. These factors can be translated as the concept 'external cues'. Assessment of a tendency to respond to external cues was therefore included in the adolescent questionnaire as an individual determinant. Rules at home (e.g. not allowed leaving the house without eating breakfast) or the lack of rules (e.g. allowed to drink as much soft drinks the adolescent wants) were also mentioned by participants. Parental influences already were identified as potential important determinants from the systematic reviews, and based on the results of the focus group interviews, items examining parents' rules or 'parenting practices' were included in the adolescent and parent questionnaires.

METHODS

Design

The ENDORSE study has a cross-sectional and a prospective two year follow-up component. Data will be collected at baseline (2005/2006) when adolescents aged 12-15 years, and two years later (2007/2008). Outcome measures are body mass index (BMI), waist circumference, physical activity, sedentary behaviors, and soft drink, snack and breakfast consumption. The study is an integral part of the ongoing health surveillance system of the Municipal Health Service in the Rotterdam area (Youth Monitor Rotterdam), in which general health, well being and related factors of youth aged 0-19 years are monitored. The Medical Ethics Committee of Erasmus University Medical Center reviewed the proposal and issued a "declaration of no objection" for the ENDORSE project.

Recruitment of schools

Schools located in the Rotterdam area that participate in the Youth Monitor Rotterdam (YMR) (N=56) were invited for participation in the ENDORSE study. A letter and an information sheet explaining the goals and the logistics of the study were sent to school principals. The schools Principals were contacted by a researcher, upon which they could express their interest in participating in the study. If necessary, additional information to make a more informed decision was provided. Subsequently, a random sample of 17 school locations was drawn from the pool of schools that were willing to participate, after stratification of the schools according to the area in the city in which they are located. Stratification was done, to ensure a range of physical and cultural environments. Rotterdam is the second largest city of the Netherlands. It has approximately 600,000 inhabitants of which 46% are of non-Dutch origin [14].

Recruitment of participants within schools

Five classes in each participating school were randomly selected for participation in the cross-sectional study, which took place in 2005/2006. All adolescents in one class participated in the study, unless they or their parents indicated that they were not willing to participate. The adolescents in the first year classes were also asked to complete the questionnaires at two years follow up. To have sufficient power, we assumed (conservatively) that obesity inducing risk behaviors will be present among at least 40% of adolescents, and we assumed moderate effect sizes of determinants on behaviors. With a significance level of .05 and 80% power, a sample size of approximately 600 students would be sufficient. Since we plan to do separate analyses for girls and boys we aimed at including 1200 students. First year adolescents were over-sampled to 800 as these adolescents will be followed up two years later.

Procedure

The ENDORSE study follows the logistics of the YMR. The YMR routinely collects data among adolescents in the first and third year of secondary school. The school levels vary from lower vocational training to high school. According to the usual procedure of the YMR, the ENDORSE study was announced through a letter to the parents. This letter explained that the YMR was extended with an extra part, aimed to gain insight in the prevalence and causes of overweight. Parents could keep their child from participating in the study by sending the attached form to the adolescent's teacher (passive consent procedure). Approximately two weeks after the usual YMR questionnaire, the adolescents completed the ENDORSE questionnaire confidentially during a school hour with a teacher and a research assistant present. Within a month after completion of the ENDORSE questionnaire, two

trained research assistants measured height, weight, waist circumference and pubertal development according to standardized procedures described in a measurement protocol. The adolescents were asked to come in succession to a private room where they were measured without shoes. After the anthropometrical measurements, the adolescents completed a Tanner scale to assess pubertal development [15]. To guarantee confidentiality the adolescents could put the Tanner scale form in an envelope before handing it over to the research assistant. After these measurements, the adolescents received a Frisbee as a compensation for their participation and were requested to give an envelope with a questionnaire to their parents. The envelope contained a letter explaining the purpose of the study and the reason why the parents were asked to complete the questionnaire, a pre-addressed and stamped envelope and a card which they could complete to participate in a raffle to win one of five I-pods. Parents were reminded twice to complete and return the questionnaires by means of reminder cards delivered to parents via the adolescents. Parents were not addressed directly, since the YMR procedure did not allow us to have any personal or address details.

Two observers independently conducted audits of the schools, school canteens, schoolyards, and an area of 300 meter radius surrounding the schools. The observations were conducted within three months from the completion of the adolescent questionnaire. A brief interview with canteen managers and school representatives was part of the audit. One of the observers conducted the interviews with school representatives, and the other observer conducted the interviews with the school canteen managers.

Census data (year 2005/2006) from the Center for Research and Statistics (COS), the research center of the municipality of Rotterdam was collected on all neighborhoods of Rotterdam.

In the follow-up data collection the same procedures are used. All measurements (questionnaire, anthropometrics, audits and interviews) are conducted within one week per school. As an incentive for their participation, the adolescents received a key holder.

Measurements

The ENDORSE questionnaires were developed by using existing validated Dutch questionnaires where possible. If no validated questionnaires were available the ENDORSE questionnaires were informed by questionnaires on related topics that were used in ongoing projects in the Netherlands, and questionnaires used in other countries. Relevant parts of these questionnaires were adapted to tailor the specific behaviors identified. If no relevant and validated questionnaires were available, new questions were developed for the ENDORSE study. The ENDORSE study contained the following measurements: adolescent questionnaire, parent questionnaire, interviews with school representatives and canteen managers, observations of the school environment, census data collection and adolescent

body measurements. These are described in detail in the following paragraphs. All determinants measured in the ENDORSE study are listed in Table 2.1.

Table 2.1 Individual and environmental correlates measured in the ENDORSE study

	Perceived / self-reported variables			**Objectively measured variables**	
	Adolescent questionnaire	**Parent questionnaire**	**Interview**	**Observation**	**Census data**
Individual variables	attitude; parental norms; modeling; perceived behavior control; intention; habit; external eating behavior				
Physical environment	**Home*:** availability of sports facilities, bicycle; soft drinks, breakfast products, snacks/ sweets, television set in bedroom. accessibility of soft drinks, snacks/sweets, breakfast products, television set **School:** amount of traffic; safety for cycling; availability of sidewalks and cycle lanes; availability of a bicycle shed **Neighborhood**: amount of traffic; safety for cycling; availability of sidewalks and cycle lanes; safety and attractiveness of neighborhood; availability of playgrounds, parks, squares, sports clubs	**Home:** availability of bicycles, cars, soft drinks, breakfast products, snacks/ sweets Accessibility of soft drinks, snacks/sweets, breakfast products, television set **Neighborhood**: amount of traffic; safety for cycling; availability of sidewalks and cycle lanes; safety in neighborhood; attractiveness of neighborhood		**School :** Availability of bicycle shed, food products in the school canteen and vending machines, PA facilities on the school playground; Shops, fast food restaurants & PA facilities in the school neighborhood. Traffic amount and safety Facilities and frequency of public transport	**School:** availability of shops, sports facilities and playgrounds for children > 12 years old; areas of sidewalks, bicycle lanes, roads, grass, plants, water; traffic accidents; criminality, crime reports **Neighborhood:** availability of shops, sports facilities and playgrounds for children > 12 years old; areas of sidewalks, bicycle lanes, roads, grass, plants, water; traffic accidents; criminality, crime reports

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	Perceived / self-reported variables			Objectively measured variables	
	Adolescent questionnaire	**Parent questionnaire**	**Interview**	**Observation**	**Census data**
Economic environment	**Home:** income; amount of money that can be spent in 1 week	**Home:** having a paid job; educational level		**School:** pricing of school canteen products; pricing of products in shops around the school	**Neighborhood**: residential types; household income; educational level; % unemployment, % living on social security: % rented houses / owner-occupied properties; mean value of houses; % various ethnic groups
Political environment			**School**: Food & physical activity policy		

Adolescent questionnaire

Physical activity and sedentary behaviors were assessed with an adapted version of the Activity Questionnaire for Adolescents & Adults (AQuAA) [Chin A Paw MJ, Slootmaker SM, Schuit AJ, van Zuidam M, Van Mechelen W, unpublished] which is a short questionnaire to assess physical activity at school and during leisure time, active transportation to school and sedentary behaviors in leisure time. The structure of the AQuAA was obtained from the SQUASH-questionnaire [16]. The AQuAA refers to activities in the past week (7-day recall). The test-retest reproducibility was fair to moderate for this questionnaire, with intra-class correlations ranging from 0.46 to 0.59.

Dietary intake was assessed with food frequency questions referring to a general week, and a 24-hour recall question. The questionnaire included TPB items for all behaviors. All the questions on TPB variables were measured on a five-point bipolar scale. Attitude was assessed with two items by asking if the adolescent considered the behavior as good or bad, and as pleasant or unpleasant ('e.g. Regular physical activity is very good (+1) – very bad (-1)'). Subjective norm was assessed with one item, for example 'my parents consider eating breakfast as very good (+2) – very bad (-2)'. Modeling was assessed with two items by asking if the parents and friends perform the behavior (' My friends eat snacks…a lot (+2) – very little (-2)'). Perceived behavioral control was assessed with two items by asking how easy or

difficult the behavior is to perform (How easy/difficult is it for you to eat breakfast? Very easy (+2) – very difficult (-2)), and by asking if the decision to perform a behavior is completely under the control of the adolescent (Do you decide by yourself if you eat breakfast? Yes, that is completely my own decision (+2) – no, that is not fully my own decision (-2)). Intention to perform the behavior was assessed with one item asking how certain the adolescent is to perform the behavior in the coming six months (Do you intend to eat breakfast the next six months? Yes, certainly do (+2) – no certainly do not (-2)).

Habit strength of dietary and physical activity behaviors was measured by means of the Self Report Habit Index [17]. This questionnaire assesses three features of habitual behavior: the extent to which a behavior is automatic, the repeated character of the behavior and the sense of identity the behavior reflects. Three items assessed these features, namely: the behavior 'x' is something…. 'I do frequently', 'is something I do automatically' and 'is something that's typically 'me". These items were measured on a five-point scale, ranging from 'I completely agree' (+2) to 'I completely disagree' (-2).

External cues that can influence eating and drinking patterns were questioned with nine items on a four point Likert scale (always (+2) – never (-2)), for example 'I get hungry when I see snacks or candy' or 'When I walk past a fast-food restaurant, I feel like buying something. These questions were based on the external eating behavior questions from the Dutch Eating Behavior Questionnaire [18] and adapted to address the topics adolescents mentioned in the focus group interviews.

In the adolescent questionnaire the following perceived environmental determinants were assessed: availability and accessibility of facilities for physical activity and food, school factors, neighborhood factors, parenting factors and economic factors. Demographic factors (gender, age, ethnicity) were available for each adolescent through the YMR questionnaire.

The adolescent questionnaire was pre-tested among ten adolescents by means of cognitive interviewing. Subsequently, the questionnaire was completed twice by 89 schoolchildren (aged 13-14) ten-days apart to assess the test-re-test reliability and other psychometrics of the questionnaire. Items with low reliability were adjusted or deleted from the questionnaire.

Parent questionnaire

Parental behavior, family and household environmental determinants were assessed in the parent questionnaire. Parental physical activity and sedentary behaviors were assessed with the adapted version of the AQuAA [Chin A Paw MJ, Slootmaker SM, Schuit AJ, van Zuidam M, Van Mechelen W, unpublished], referring to activities in the past week (7-day recall). Dietary behaviors were assessed with food frequency questions referring to a general week. Neighborhood factors as perceived by the parents, such as safety in neighborhood and attractiveness of neighborhood, parenting practices, parental allowance, availability and accessibility of soft drinks, breakfast products, snacks/sweets, television set and parental

self-reported body weight and height, and demographics (gender, educational level, having a paid job) were assessed. One parent completed this questionnaire.

Interview questionnaires

To assess school food and physical activity factors, pre-structured interview forms were developed for interviews with the school canteen managers and with a school representative. The interview form for canteen managers contained questions on the availability of food products, opening hours of the canteen, pricing policy, who will receive profits from the foods sold, and canteen policies, for example if there are agreements on the assortment with the catering organization. The form also included information about the soft drink and snack vending machines, e.g. how often the vending machines are filled. The interviews with a school representative were aimed at gaining insight in school policies regarding diet and physical activity. As a basis for the interview form, the 7-item school-wide food practices scale was used [19]. This scale assesses food practices allowed at school with the following items: 'Are students allowed to have food in the classroom', 'Are students allowed to have beverages in the classroom?', 'Are students allowed to have snacks in the hallways?', 'Are students allowed to have beverages in the hallways?', 'Are food or food coupons used as reward or incentive for students?', 'Do you have classroom fundraising that includes food sales?', and 'Do you have school wide fundraising that includes food sales?'. The questionnaire furthermore contained questions about whether or not the school has a formal food or physical activity policy and if yes, to indicate what this policy is. Questions on what health education programs they use in schools and possibilities and promotion activities for the adolescents to be active before, during and after school time, were also included.

Audit instrument for area observations

An audit instrument was developed to assess the availability and accessibility of foods and physical activity facilities in the schools, in the schoolyards and in the neighborhood around schools. The audit instrument consists of a pre-structured form with five parts: school information, school building, nutrition, physical activity and school environment. As much as possible, the instrument had a 'tick box' answering format and included observation of 'objective' characteristics. When more subjective characteristics such as 'state of maintenance of the school yard', or 'traffic situation around the school' were reported, photographs were taken from pre-defined angles. The audit instrument included also a description of the item to be observed. The neighborhoods around schools that were observed were defined as a radius of 300 meters from the school. This definition was based on the basic assumption that the facilities in the neighborhood around schools should be accessible in a general school lunch break of approximately 30 minutes, and that adolescents use facilities that are close by the school. The audit instrument included maps of the 300-meter radius around the schools, on which the route walked to observe the area could be drawn and the location of green

spaces could be indicated. The first part (A) of the audit instrument involved some general school information e.g. the address and number of pupils. Part B involved items on the school building e.g. number of floors, entrance for schoolchildren, availability of an elevator and location and visibility of stairs. Part C involved observation of the school canteens e.g. counting the number of soft-drink and snack vending machines in the canteen, checking the items that are available in these machines, how well they were filled and advertising in the canteen. Part D involved observation of the school physical activity facilities e.g. the bicycle shed, facilities for activity and aesthetics of the schoolyards. Part E involved observation of the neighborhood around schools e.g. the facilities for physical activity (e.g. parks, fields, playing and sports fields) that were visible from the schoolyards and that were present in the neighborhood (300 meters). The component of the neighborhood observation related to dietary intake involved observation of the food retail outlets (baker's shops, snack bars, fast-food chains, supermarkets, kiosks, gas stations, tobacco shops, chemist's shops) that were visible from the schoolyards and that were present in the neighborhood around schools.

The audit instrument first was reviewed by experts on accuracy and completeness of the instrument for its intended purpose. Secondly, the instrument was pilot tested by conducting the observations at two schools and in the corresponding neighborhoods with two observers. Important aspects of the pilot test were the completeness of the forms and feasibility and suitability of using the definition of 300-meter radius for school environment. After the pilot tests at the two schools, the audit forms were adapted if needed. The adapted forms were tested at a third school, by three observers.

Census data

Census data was utilized to gather additional environmental data regarding the neighborhoods around schools and the neighborhoods in which the children live. The data included area-level household income, educational level, residential types, percentage of residents aged 10-19, percentage unemployment, percentage living on social security, percentage of rented houses and owner-occupied properties, mean value of houses, percentages of various ethnic groups, number of stores, fast food restaurants and the amount and type of green spaces, water, bicycle tracks and foot paths. The census data could be linked to the home environment of the adolescents with information on the ZIP code, which was asked in the adolescent and parent questionnaires. Neighborhoods were defined based on a formal classification from Statistics Netherlands.

Body measurements

Body height was measured without shoes with a Seca 225 mobile height rod with an accuracy of 0.1 cm. A calibrated electronic digital floor scale (SECA 888 class III) was used to determine body weight of the participant in street clothes, without shoes, with an accuracy

of 0.1 kg. Waist circumference was measured using a spring loaded measuring tape (SECA 200) to the nearest 0.1 cm. The waist circumference was measured twice. In case of a difference of more than 1.0 cm between these two measurements, the waist circumference was measured twice again. Adolescents self-reported on their stage of pubertal development using drawings of Tanner stages [15] in the baseline data collection only.

DISCUSSION

The ENDORSE study is a comprehensive, longitudinal study in which both individual and environmental determinants of selected obesity related behaviors in adolescents are examined. The study has several strengths. It examines both sides of the energy balance equation. It was designed to examine the influence of environmental factors on obesity related behaviors and BMI and objective measures for mapping the environment were included. Moreover, the study includes environmental factors in various settings, including the home, school and neighborhood. The study involves assessments of both individual and environmental determinants, as opposed to many previous studies, that focused on one or the other. The study has a longitudinal design, allowing analyses of prediction rather than cross-sectional associations only. To date, there are very few studies that examine environmental factors of energy balance related behaviors longitudinally. There is an urgent need for such studies, in order to be able to draw stronger inferences for relationships between environmental factors and BMI. However, there were also some limitations in the study protocol. For instance previously validated instruments were not available for all necessary measures. Another limitation is that assessments of adolescents' and parental physical activity and dietary behaviors are self-reported. The definition of environment and neighborhood is also somewhat arbitrary. The scale of environment to be studied needs further conceptual development [20]. A clear definition of 'the neighborhood' is needed in terms of measurement of respondent perceptions and objective measures of the environment. However there is to date little evidence or consensus as to what constitutes a neighborhood. There is poor agreement about which boundary or scale to use, and how this might impact on the association between predictor and outcome variables is unknown. Moreover the boundary to be used might differ for different target groups and different settings (school or home environments) [20].

The ENDORSE study contains rich data examining individual and environmental determinants of energy balance related behaviors among adolescents. With this information the influence of risk behaviors for overweight and relationships with socio-economic status and ethnicity can be investigated. Individual and environmental determinants of obesity-related behaviors among adolescents can be examined as well as the interactions between individual and environmental determinants of obesity inducing behaviors. Therefore,

data will be analyzed by means of multi-level regression analyses and structural equation modeling. Eventually, the ENDORSE study will provide objectives and entry points for prevention of overweight interventions in younger adolescents. In 2008 the questionnaires for adolescents and parents, the school policy interview forms and the audit instrument will be made available on the Internet [21].

ACKNOWLEDGEMENTS

This study was financially supported by a grant from ZonMw, The Netherlands Organization for Health Research and Development (grant ID no 2100.0103).

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Part II Environmental correlates of energy balance-related behaviors: reviews of the literature

3 A systematic review of environmental correlates of obesity-related dietary behaviors in youth

van der Horst K, Oenema A, Ferreira I, Wendel-Vos W, Giskes K, van Lenthe F, Brug J. A systematic review of environmental correlates of obesity-related dietary behaviors in youth.

Health Education Research 2007, 22(2): 203-226.

ABSTRACT

Background: There is increasing interest in the role the environment plays in shaping the dietary behavior of youth, particularly in the context of obesity prevention. An overview of environmental factors associated with obesity-related dietary behaviors among youth is needed to inform the development of interventions.

Methods: A systematic review of observational studies on environmental correlates of energy, fat, fruit/vegetable, snack/fast food, and soft drink intakes in children (4-12) and adolescents (13-18) was conducted. The results were summarized using the Analysis Grid for Environments Linked to Obesity (ANGELO).

Results: The 58 papers reviewed mostly focused on socio-cultural and economical environmental factors at the household level. The most consistent associations were found between parental intake and children's fat, fruit/vegetable intakes, parent and sibling intake with adolescent's energy and fat intakes, and parental education with adolescent's fruit/vegetable intake. A less consistent but positive association was found for availability and accessibility on children's fruit/vegetable intake.

Conclusion: Environmental factors are predominantly studied at the household level and focus on socio-cultural and economic aspects. Most consistent associations were found for parental influences (parental intake and education). More studies examining environmental factors using longitudinal study designs and validated measures are needed for solid evidence to inform interventions.

INTRODUCTION

The promotion of healthful eating in children and adolescents has become an increasingly important public health and research priority as the prevalence of overweight and obesity among children and adolescents continues to rise [1, 2]. Preventing the onset of obesity inducing dietary behaviors or modifying these behaviors at an early age is likely to contribute to the prevention of overweight and obesity. A detailed understanding of factors that determine these behaviors is essential, to be able to effectively prevent or modify obesity inducing eating patterns. The research of determinants of dietary intake in children and adolescents has predominantly focused on individual level determinants of these behaviors, such as attitudes, taste preferences, social influences and perceived behavioral control. However, more recently a shift in attention to environmental determinants of behavior has occurred as it has been acknowledged that a major driving force for the increasing obesity prevalence may be the environment that encourages eating and discourages physical activity [3, 4]. These environmental factors are highlighted in so-called ecological models, and are conceptualized as being interrelated with factors at the individual level [5]. As stated by Rothschild [6], the likelihood that an individual will engage in a healthy behavior is largest when someone is motivated to act healthily, has the abilities to engage in the healthy behavior, and the environment offers the right opportunities to engage in the healthy behavior. Motivation and abilities can be regarded as individual determinants of health behavior, whereas opportunities depend on environmental factors.

Child and adolescent dietary behavior is likely to be strongly influenced by environmental factors, since children may have less autonomy in food choice. From the age of about three years, children's eating behavior is influenced by their responsiveness to environmental cues, and a variety of family and social factors start to influence children's eating behaviors [7]. The role of parents is considered to be of particular importance, since parents directly determine the child's physical and social environment, and indirectly influence behavior and habits through socialization processes and modeling [8]. When children grow older and move into adolescence they become more autonomous, and lifestyle, developmental, social and environmental changes take place. During this transition to adolescence, dietary intake patterns change and decline in quality compared to childhood. Intakes of fruit, vegetables, milk and fruit juice decrease, whereas intake of soft drink increases during this time [9].

The expected importance of the environment for obesity related behaviors in children and adolescents is well documented in position papers and narrative reviews [3, 7-11]. The number of studies examining the influence of environmental factors on behavior is expanding, but there is no systematic overview of which environmental factors have been studied extensively, and what aspects of the environment are more influential than others. Such an

overview is needed to identify a research agenda for further investigation and to inform interventions that take environmental factors into account.

We conducted a systematic review of environmental factors that may potentially influence obesity related dietary behaviors of children and adolescents. We focused our review on energy, fat (total and percent energy), fruit/vegetable, snack/fast food, and soft drink intake. These behaviors have been identified as factors most strongly associated with obesity in adults [4], and are considered to be important obesity inducing behaviors in children and adolescents as well [12, 13]. The environment was defined as 'anything outside the individual'. Many classifications have been proposed to order the complexity of potential environmental factors. We chose to use the ANGELO framework (Analysis Grid for Environments Linked to Obesity) [14] as a tool to classify the various environmental determinants. The ANGELO framework dissects the environment by two dimensions: the size (micro and macro) and the type of environment. Micro-environments are environmental settings where groups of people meet and gather (e.g. homes, schools, restaurants, neighborhoods). Macro-environments include the broader infrastructure that may support or hinder health behaviors (e.g. town planning, transport infrastructure, the health system, the media). The 'types' of environments distinguished in the ANGELO framework are the physical, socio-cultural, economic, and political environment. The physical environment refers to the availability of opportunities for healthy and unhealthy choices, for instance the availability and accessibility of healthy and unhealthy foods. The socio-cultural environment refers to the social and cultural subjective and descriptive norms and other social influences such as parental influences and peer pressure. The economic environment refers to the costs related to healthy and unhealthy behaviors for instance costs of fruit and vegetables and household income. The political environment refers to the rules and regulations that may influence food choice or availability, for example bans on snack vending machines in schools.

The review aimed to address the following specific research questions:
Which environmental correlates have been studied in relation to child and adolescent energy, fat (total and energy percent), fruit, vegetable, snack, fast food, and soft drink intake?
Which environmental factors are consistently associated with these obesity-related dietary behaviors?

METHODS

Data sources and search strategy

Studies eligible for inclusion in the review were located from the Medline (PubMed), PsychInfo, Web of Science, and Human Nutrition databases, from January 1980 to December 2004. Our search strategy involved using a combination of the broad indexing terms of each database and searching for terms in article titles and abstracts. We used the combination of dietary intake keywords with environmental factor keywords to locate suitable articles. For dietary intake the following keywords were used: energy intake, caloric intake, fat intake, fat consumption, soft drink, soft drink consumption, soft drink intake, sweetened beverage, fruit, fruit consumption, fruit intake, vegetable, vegetable consumption, vegetable intake, eating, diet, nutrition, food habits, food preferences. For environmental factors the following keywords were used: physical environment, social environment, cultural environment, socio-cultural environment, socio-economic environment, social influences, neighborhood, political environment, built environment, urban environment, rural environment, local environment, school environment, home environment, availability, accessibility, residence characteristics, environment design, parental influence, parenting. Key terms were matched to database specific indexing terms. The sensitivity of the search strategy was verified by checking whether key articles from our personal databases that should be selected through the search strategy, were actually retrieved. In addition to database searches, reference lists of review studies and of articles included in the review were screened for titles that included key terms.

Inclusion / exclusion criteria

A study had to meet the following criteria to be eligible for inclusion: healthy young people in the age range of 3-18 years (or mean age within this range) as subjects of study; a measure of energy and/or fat intake (total or percent energy), fruit, vegetable, snack, fast food or soft drink consumptions as the dependent variable(s); an outcome measure that was assessed for at least one complete day (for example, studies assessing fruit intakes at just one meal were not eligible). The study samples had to be drawn from countries with established market economies as defined by the World Bank, and the paper had to be published in international peer-reviewed journals in English. Intervention studies and studies that included only overweight/obese children were excluded.

Identification of relevant studies

Potentially relevant papers were selected by screening the titles (first step), abstracts (second step) and the entire article (third step) retrieved through the database searches. Two researchers (KVDH, IF) independently conducted this screening. Disagreement about eligibility between the reviewers was solved through discussion with a third co-author (JB).

Data extraction

Two authors (KVDH and AO) extracted the data from the included studies. Each study's findings and methodological details, such as study design, sample size, dietary outcome(s), environmental determinant(s) assessed, assessment methodology (child and/or parent-report, objectively measured), and statistical analysis methods were listed in tables.

Summarizing study findings

Associations between environmental factors and dietary outcomes were coded as '+' for a positive association, '-' for an inverse association and 'o' for no association. Associations were regarded significant when the p-value reported in the study was smaller than .05. In studies that reported results from univariate and multivariate analysis, only the multivariate results were included. To reduce the number of specific environmental correlates studied, conceptually similar environmental factors were combined (e.g. intakes from father and mother to parental intake). An independent sample was used as the unit of analysis and was defined as the smallest independent sub-sample for which relevant data were reported (e.g. boys/girls) [15].

Categorization of variables

Study findings were tabulated by categorizing the distinct dietary outcomes in a grid dissecting different environmental settings, i.e. home/household, educational institutions, neighborhoods, city/municipality, and the various types of environmental factors: physical, socio-cultural, economic and political, following the ANGELO framework [14] (Tables 3.2 and 3.3).

RESULTS

Search and selection of studies

The databases search located 6616 titles (Pubmed 1975; PsychInfo 317; Web of Science 2932; Human Nutrition 1392), resulting in 6121 unique titles of potentially relevant articles. Reference sections of earlier reviews and primary studies added 44 titles. Screening the titles and abstracts resulted in a selection of 81 articles, for full text review. Twenty-three of these articles did not meet the inclusion criteria, resulting in a final inclusion of 58 articles with 77 samples.

Characteristics of included studies

Most of the studies were cross-sectional (n=55) (Table 3.1). Twenty-nine studies (37 samples) had children as the study population [16-44], and 27 (40 samples) included adolescents [45-71]. One study included a child and adolescent sample [72]. In one paper the age of the population was unclear, and this study was reviewed under an adolescent sample [73]. Environmental determinants of fruit/vegetable intake were examined in 34 studies, determinants of fat intake in 23 studies, determinants of fast food/snack intake in 21 studies, determinants of energy intake in 17 studies and determinants of soft drink intake in 10 studies. Only five studies reported the validity, and seven studies reported the reliability of the dietary intake measurements used.

Potential environmental correlates of children's dietary behaviors

The findings from the studies are summarized in Tables 3.2 and 3.3. Table 3.4 provides a summary of the number of studies and the consistent associations in each cell of the ANGELO framework. In the following sections a summarized description of the results is provided for the various behaviors. The factors examined on each environmental level and the environmental factors that showed consistent associations with dietary behaviors in at least two replicated studies are described.

Environmental correlates of energy intake

At the household environmental level, physical factors (one study/sample), socio-cultural factors (five studies, six samples), and economic factors (five studies/samples) were examined in relation to energy intake (Table 3.2). One study examined factors in the school environment, no studies examined factors in the neighborhood environment, and two studies examined factors at the city/municipality level. At the household socio-cultural level, an inverse association with energy intake was found for encouragement, offering assistance and giving prompts to increase food intake during meals in two out of three samples [35, 36, 40].

Table 3.1 Characteristics of studies included in the review: sample size; sex; study design; assessment of dietary intake; data analysis; country

	Children (3-12 years)			Adolescents (13-18 years)		
	References	Samples		References	Samples	
		Number	%		Number	%
Sample size		37	100		40	100
<100	[25M/I, 29, 35, 37, 40, 43M/F]	8	21.6	[61M]	1	2.5
100-199	[19, 25F, 26F, 27F, 32, 33F]	6	16.2	[45M/F, 60]	3	7.5
200-299	[28]	1	2.7	[46]	1	2.5
300-499	[16, 24, 36, 38, 44]	5	13.5	[56, 68M/F, 71M/F]	5	12.5
500-999	[17, 18]	2	5.4	[47M/F, 48, 49I, 50, 51M/F, 54M/F, 62-64, 73M/F]	14	35.0
1,000-2,999	[21I/II, 23, 30, 34M/F, 39F, 41, 42]	9	24.3	[55, 72M/F]	3	7.5
3,000-4,999	[22M/F, 72M/F]	4	10.8	[49II, 59, 65-67, 70]	6	15.0
≥5000	[20, 31]	2	5.4	[52M/F, 53, 57M/F, 58, 69]	7	17.5
Sex						
Girls only	[26, 27, 33, 39]	4	10.8		-	-
Boys only		-	-	[61]	1	2.5
Boys and girls combined	[16-20, 21I/II, 23, 24, 25I, 28-32, 35-38, 40-42, 44]	23	62.2	[46, 48, 49I/II, 50, 53, 55, 56, 58-60, 62-67, 69, 70]	19	47.5
Boys and girls, separately	[22M/F, 25I/M/F, 34, 43M/F, 72M/F]	10	27.0	[45M/F, 47, 51, 52, 54, 57, 68, 71, 72M/F, 73]	20	50.0
Study design						
Cross-sectional	[16-20, 21I/II, 22M/F, 23, 24, 25M/F/I, 26F, 27F, 28-32, 33F, 34M/F, 35, 37, 38, 39F, 40-42, 43M/F, 44, 72M/F]	36	97.3	[46, 47M/F, 48, 49I/II, 50, 51M/F, 52M/F, 53, 54M/F, 55, 56, 57M/F, 58-60, 61M, 63-67, 68M/F, 69, 70, 71M/F, 72M/F, 73M/F]	37	92.5
Longitudinal (length of study)	[36] (2.5 years)	1	2.7	[62](6 years)	1	2.5
Case-control		-	-	[45M/F]	2	5.0
Dietary outcome						
Energy intake	[23, 33F, 35, 36, 38, 39F, 40, 41, 43M/F]	10	27.0	[45M/F, 46, 50, 54M/F, 56, 67, 70, 73M/F]	11	27.5
Energy from fat (%)	[23, 27F, 36, 38, 39F, 41, 44]	7	18.9	[47M/F, 50, 51M/F, 54M/F, 56, 60, 64, 67, 70, 71M/F, 73M/F]	16	40.0
Total fat intake (g)	[22M/Fa, 43M/F]	4	10.8	[45M/F, 47M/F, 57M/F, 68M/F, 71M/F, 73M/F]	12	30.0
Fruit intake	[16, 18, 24, 28, 32, 37, 72M/F]	8	21.6	[48, 50, 53b, 57M/F, 58, 60, 61M, 63, 64, 67, 69, 70, 72M/F]	15	37.5

	Children (3-12 years)			Adolescents (13-18 years)		
	References	Samples		References	Samples	
		Number	%		Number	%
Vegetable intake	[16, 18, 24, 28, 32, 37, 42, 72M/F]	9	24.3	[50, 53b, 57M/F, 58, 60, 61M, 64, 67, 69, 70, 72M/F]	13	32.5
Juice intake	[28, 32]	2	5.4	[48, 61M]	2	5.0
Composite measure FV intake	[21M/F, 22M/F, 26F, 30, 31, 34M/F, 42]	10	27.0	[52M/F, 62, 64-67]	7	17.5
Composite measure of FJV intake	[25I/M/F, 28, 29c, 32]	6	16.2	[61M]	1	2.5
Fast food consumption	[20, 24]	2	5.4	[57M/F, 59d]	3	7.5
Snack food intake	[19, 31, 42, 72M/F]	5	13.5	[49I/IIe, 52M/Fe, 60, 67, 72M/F]	8	20.0
Pizza & snack	[29f]	1	2.7	[56]	1	2.5
Soft drink consumption	[16, 17, 24, 29f, 72M/F]	6	16.2	[48, 55, 57M/F, 60, 67, 72M/F]	8	20.0
Assessment of dietary outcome						
Self-report	[17, 19, 21I, 22M/F, 25M/F, 28-32, 34M/F, 36, 38, 39F, 42]	18	48.6	[46, 47M/F, 48, 49I/II, 52M/F, 53, 54M/F, 55, 56, 57M/F, 58-60, 61M, 62-67, 68M/F, 69, 70, 71M/F, 72M/F, 73M/F]	35	87.5
Parent-report	[16, 18, 21II, 25I, 26F, 33F, 35, 40, 41, 44, 72M/F]	12	32.4		-	-
Self- or parent-report	[20, 23]	2	5.4	[45M/F, 50]	3	7.5
Parent- and self-report (together)	[24, 27F, 37, 43M/F]	5	13.5	[51M/F]	2	5.0
Measurement instrument dietary outcome						
24-hour recall	[20, 23, 26F, 27F, 29, 30, 33F, 34M/F, 38, 42]	11	29.7	[46, 49I, 61M, 64]	4	10.0
48-hour recall		-	-	[50]	1	2.5
Food frequency questionnaire	[16, 18, 19, 21M/F, 22M/F, 24, 31]	9	24.3	[51M/F, 53, 56, 57M/F, 58, 60, 63, 65-67, 68M/F, 70, 71M/F]	17	42.5
2-day food record	[28, 32]	2	5.4		-	-
3-day food record	[37, 39F, 43M/F]	4	10.8	[54M/F, 73M/F]	4	10.0
7-day food record	[25I/M/F, 40]	4	10.8	[45M/F]	2	5.0
Questionnaireg	[17, 35, 36, 72M/F]	5	13.5	[48, 49II, 52M/F, 55, 59, 62, 69, 72M/F]	10	25.0
24-hour recall & 2-day food record	[41, 44]	2	5.4	[47M/F]	2	5.0

	Children (3-12 years)			Adolescents (13-18 years)		
	References	Samples		References	Samples	
		Number	%		Number	%
Reliability of dietary intake measurement						
Unknown / not reported	[16-20, 22M/F, 23, 24, 25I/M/F, 26F, 30, 31, 33F, 35-38, 39F, 40-42, 43M/F, 44, 72M/F]	29	78.4	[45M/F, 46, 47M/F, 48, 49I/II, 50, 51M/F, 52M/F, 53, 54M/F, 57M/F, 58, 60, 63-65, 69, 72M/F]	26	65.0
Reported elsewhere	[27F, 28, 29, 32, 34M/F]	6	16.2	[56, 59, 67, 71M/F, 73M/F]	7	17.5
< 0.7		-	-	[61M, 66, 68M/F, 70]	5	12.5
≥ 0.7	[21M/F]	2	5.4	[55, 62]	2	5.0
Validity of dietary intake measurement						
Unknown / not reported	[17-20, 23, 24, 26F, 30, 33F, 35-38, 39F, 40-42, 43M/F, 44, 72M/F]	22	59.5	[45M/F, 46, 47M/F, 48, 49I/II, 50, 52M/F, 53, 54M/F, 55, 57M/F, 58, 61M, 62, 69, 72M/F, 73M/F]	25	62.5
Reported elsewhere	[22M/F, 25I/M/F, 27F, 28, 29, 32, 34M/F]	11	29.7	[51M/F, 56, 59, 60, 63-65, 67, 68M/F, 71M/F]	13	32.5
< 0.6	[16fruit, veg., 21M/F, 31]	4	10.8	[66, 70]	2	5.0
≥ 0.6	[16soft drinks]	1	2.7		-	
Data analysis						
Univariate	[19, 24, 28, 32, 35, 38, 39F, 72M/F]	9	24.3	[45M/F, 48, 50, 51M/F, 54M/F, 56, 57M/F, 68M/F, 71M/F, 72M/F, 73M/F]	19	47.5
Multiple	[20, 23, 31, 36, 40, 41]	6	16.2	[47M/F, 49I/II, 52M/F, 55, 58-60, 63-65, 67, 69, 70]	16	40.0
Univariate & multiple	[16-18, 21M/F, 22M/F, 27F, 29, 37, 42, 43M/F, 44]	14	37.8	[46, 53, 61M, 62]	4	10.0
Model testing (Structural equation modeling)	[25I/M/F, 26F, 30, 33F, 34M/F]	8	21.6	[66]	1	2.5
Country						
North America	[17, 20, 23, 25M/F/I, 26F, 27F, 28-32, 33F, 34M/F, 35, 36, 38, 39F, 41, 42, 43M/F, 44]	25	67.6	[46, 47M/F, 49I/II, 52M/F, 53, 58, 61M, 64-67, 68M/F, 69, 70, 73M/F]	20	50.0
Europe	[16, 18, 19, 21I/II, 22M/F, 24, 37, 40]	10	27.0	[45M/F, 48, 50, 51M/F, 54M/F, 56, 57M/F, 60, 62, 63, 71M/F]	16	40.0
Oceania				[55, 59]	2	5.0

	Children (3-12 years)			Adolescents (13-18 years)		
	References	Samples		References	Samples	
		Number	%		Number	%
Asia	[72M/F]	2	5.4	[72M/F]	2	5.0

F = girls only; M = boys only; M/F = boys and girls analyzed separately; I/II = two independent samples based on different age groups

[a] Frequency of high fat food consumption

[b] Inadequate fruit / vegetable consumption (less than once a day)

[c] Percent of total daily energy intake contributed to fruit, vegetable and juice intake

[d] Frequency of take-away food consumption

[e] Low nutrient dense / high fat snacks consumption

[f] Percent of total daily energy intake contributed by that food group & consumption frequency per day

[g] Unclear whether dietary intake was measured with a food-frequency questionnaire or with another questionnaire

Table 3.2 Summary of micro and macro environmental correlates of dietary intakes among children (3 to 12 year olds)

	Correlate	Related to dietary behaviors	Assoc (+ or -)†	Unrelated to dietary behaviors	# Samples	Summary (n)		
		References		References		+	-	0
Home/household	**Physical**							
	Energy							
	Accessibility to food	[36]	-		1	0	1	0
	Minutes foods present at home			[36]	1	0	0	1
	Fat (total fat, en% fat)							
	Accessibility to food			[36]	1	0	0	1
	Minutes foods present at home			[36]	1	0	0	1
	Fruit, Juice, Vegetables							
	Availability	*[25F, 28, 30, 34F]*	+	*[25M/I, 34M]*	*7*	*4*	*0*	*3*
	Accessibility	*[21I/II, 25F/I]*	+	*[25M, 28]*	*6*	*4*	*0*	*2*
	Home FJV barriers	[28]	-		1	0	1	0
	Television on during meals	[29]	-		1	0	1	0
	Snacks, Fast food							
	Television on during meals	[29]	+		1	1	0	0
	Soft drink							0
	Television on during meals	[29]	+		1	1	0	0
	Availability	[17]	+		1	1	0	0
	Socio-Cultural							
	Energy							
	Parental intake			[43M/F]	2	0	0	2
	Parenting practices							
	Control/restriction/discouragement	[33F]	-	[35, 36]	3	1	0	2
	Encouragement/assistance/prompts to increase food intake	*[35, 40]*	-	*[36]*	*3*	*0*	*2*	*1*
	Food as reward			[36]	1	0	0	1
	Parents negative statements about foods	[40]	-		1	0	1	0
	Family support			[36]	1	0	0	1
	Minutes spent eating at home			[36]	1	0	0	1
	No. meals eaten out			[36]	1	0	0	1
	Marital status parents			[36]	1	0	0	1
	Food presentations/ food offers	[35]	+		1	1	0	0

Correlate	Related to dietary behaviors	Assoc (+ or -)†	Unrelated to dietary behaviors	# Samples	Summary (n)		
	References		References		+	-	0
Fat (total fat, en% fat)							
Parental intake	*[27F, 43M/Fmother]*	+	*[43M/Ffather]*	*3*	*3**	*0*	*2**
Parenting practices							
Control/restriction	*[36**]*	-		*2*	*2**	*1**	*0*
	[27F, 36$]	+					
Prompts to increase/decrease food intake	[36increase]	-	[36decrease]	1	0	1*	1*
Food as reward			[36]	1	0	0	1
Pressure to eat	[27F]	+		1	1	0	-
Mothers monitoring			[27F]	1	0	0	1
Family support			[36]	1	0	0	1
Minutes spent eating at home			[36]	1	0	0	1
No. meals eaten out			[36]	1	0	0	1
Marital status parents			[36]	1	0	0	1
Single parent family	[38]	+		1	1	0	0
Fruit, Juice, Vegetables							
Modeling (parents, important others)	*[21I, 28]*	+		*2*	*2*	*0*	*0*
Mothers intake of soft drinks and sweets			[16]	1	0	0	1
Avoidance of negative modeling			[16]	1	0	0	1
Parental intake	*[16, 18, 21II, 26F, 37fruit]*	+	*[37veg]*	*5*	*5**	*0*	*1**
Parental intake if FV are highly available	[30]	+		1	1	0	0
Parent FV intake if FV are low available			[30]	1	0	0	1
Parenting style	[32negative]	-	[32authoritative]	1	0	1*	1*
Parenting practices			[18]	1	0	0	1
Food as reward			[16]	1	0	0	0
Encouragement / verbal praise	[16veg]	+	[16fruit, 32]	2	1*	0	2*
Discouragement to eat sweets, soft drinks			[16]	1	0	0	1
Control / restriction			[28, 32]	2	0	0	2
Permissiveness			[16]	1	0	0	1
Negotiation			[16]	1	0	0	1
Pressure to eat	[26F]	-	[16]	2	0	1	1
Catering on children's demands			[16]	1	0	0	1

Correlate	Related to dietary behaviors	Assoc (+ or -)†	Unrelated to dietary behaviors	# Samples	Summary (n)		
	References		References		+	-	0
Parental preparation practices			[32]	1	0	0	1
Age of introduction of FJV (late)	[18fruit]	-	[18Veg]	1	0	1*	1*
Breastfeeding	[18fruit]	+	[18Veg]	1	1*	0	1*
Parent preparation of quick & easy food			[29]	1	0	0	1
Two parent family			[29]	1	0	0	1
One parent family	[42]	-		1	0	1	0
Family dinner	[31]	+	[72Ffruit] [72Mfruit/veg]	3	1*	1*	3*
	[72Fveg]	-					
Family breakfast	[72Ffruit] [72Mfruit/veg]	+	[72Fveg]	2	3*	0	1*
Snacks, Fast food							
Parental intake	[19]	+		1	1	0	0
Parenting practices (general)	[19]	+		1	1	0	0
Control / reward			[19]	1	0	0	1
Parent preparation of quick & easy food			[29]	1	0	0	1
Two parent family			[29]	1	0	0	1
One parent family			[42]	1	0	0	1
Family dinner	[31 fried snack foods]	-	[31 snack foods, 72M/F]	3	0	1*	3*
Family breakfast	[72F]	-	[72M]	2	0	1	1
Soft drink							
Parental intake	*[16, 17]*	+		*2*	*2*	*0*	*0*
Refraining from negative modeling			[16]	1	0	0	1
Parenting practices							
Food as reward			[16]	1	0	0	1
Discouragement to drink soft drinks			[16]	1	0	0	1
Encouragement to eat fruit, vegetables			[16]	1	0	0	1
Control / pressure			[16]	1	0	0	1
Verbal praise			[16]	1	0	0	1
Permissiveness	[16]	+		1	1	0	0
Negotiation			[16]	1	0	0	1
Catering on children's demands			[16]	1	0	0	1
Parent preparation of quick & easy food			[29]	1	0	0	1

Correlate	Related to dietary behaviors	Assoc (+ or -)†	Unrelated to dietary behaviors	# Samples	Summary (n)		
	References		References		+	-	0
Two parent family			[29]	1	0	0	1
Family dinner	[31]	-	[72M]	3	1	1	1
	[72F]	+					
Family breakfast	[72M/F]	-		2	0	2	0
Economic							
Energy							
Income sufficiency			[38]	1	0	0	1
Household income (high)	[23]	-	[39F, 41]	3	0	1	2
Parents educational level (high)	[23]	+	[39F]	2	1	0	1
# persons/household			[36, 38, 41]	3	0	0	3
Occupation			[23]	1	0	0	1
Parents live less than 10y in present house	[23]	+		1	1	0	0
Fat (total fat, en% fat)							
Income sufficiency			[38]	1	0	0	1
Household income (high)	[39F]	-	[27F, 41]	3	0	1	2
Parents educational level (high)	*[23, 39F]*	-		*2*	*0*	*2*	*0*
Maternal employment			[44]	1	0	0	1
# persons/household	[38]	-	[36, 41]	3	0	1	2
Parents live less than 10y in present house	[23]	-		1	0	1	0
Fruit, Juice, Vegetables							
Household income (high)			[29]	1	0	0	1
Deprivation index (high)	[37fruit]	-	[18, 37veg]	2	0	1*	2*
Parents educational level (high)	[18veg, 37fruit]	+	[16, 18fruit, 29, 37veg]	4	2*	0	4*
Number of hours/week worked by mother			[29, 42]	2	0	0	2
SES / occupational class	[24veg]	+	[24fruit, 42]	1	1*	0	2*
Snacks, Fast food							
Household income (high)	[20]	+	[23, 29]	3	1	0	2
Parents educational level			[29]	1	0	0	1
Number of hours/week worked by mother	[42white children]	-	[29]	2	1*	1*	1*
	[42black children]	+					
SES / occupational class	[42]	+	[23, 24]	3	1	0	2
Soft drink							

	Correlate	Related to dietary behaviors	Assoc (+ or -)†	Unrelated to dietary behaviors	# Samples	Summary (n)		
		References		References		+	-	0
	Household income			[29]	1	0	0	1
	Parents educational level			[16]	1	0	0	1
	Occupational class			[24]	1	0	0	1
	Number of hours/week worked by mother			[29]	1	0	0	1
Educational Institutions	**Physical**							
	Energy							
	Minutes food present at school			[36]	1	0	0	1
	Fat (total fat, en% fat)							
	Minutes food present at school			[36]	1	0	0	1
	Soft drink							
	Availability	[17]	+		1	1	0	0
	Socio-Cultural							
	Energy							
	Prompts to increase food at school lunch			[36]	1	0	0	1
	Fat (total fat, en% fat)							
	Prompts to increase food at school lunch	[36]	-		1	0	1	0
	Fruit, Juice, Vegetables							
	Modeling peers FJV			[28]	1	0	0	1
	Soft drink							
	Friends intake	[17]	+		1	1	0	0
[Neighbourhood	**Economic**							
	Fruit, Juice, Vegetables							
	Area deprivation index (most deprived)	[22F]	-	[22M]				
	Snack, Fast food							
	Area deprivation index (most deprived)	[22M/F]	+		2	2	0	0
City/municipality	**Physical**							
	Energy							
	Non-metropolitan residence	[41]	+	[23]	2	1	0	1
	Fat (total fat, en% fat)							
	Non-metropolitan residence	[41]	+	[23]	2	1	0	1
	Snack, Fast food							
	Region (southern USA vs. other)	[20]	+		1	1	0	0
	Urbanization			[20]	1	0	0	1

† Associations between environmental factors and dietary outcomes were coded '+' for a positive association, '-' for an inverse association

* If in one study, a determinant is examined in relation to two outcomes (e.g. fruit intake and vegetable intake), and the results differ for the two outcomes (e.g. a positive association was found for fruit intake, and no association was found for vegetable intake), the study is counted once in the column '# of samples', and twice in the summary column.

** Parental control over child's fat intake

$ Parental control over child's food intake

Italic printed text, indicate factors with consistent associations.

Environmental correlates of fat intake

At the household environmental level, physical factors (one study/sample), socio-cultural factors (four studies, five samples), and economic factors (seven studies/samples) were examined in relation to fat intake. One study examined factors in the school environment, no studies examined factors in the neighborhood environment, and two studies examined factors at the city/municipality level. At the household socio-cultural level a positive association was found for parental fat intake (three out of three samples) [27, 43] , and parental control over food intake (two out of two samples) [27, 36]. Parental education was inversely associated with fat intake in two out of two samples [23, 39].

Environmental correlates of fruit and vegetable intake

At the household environmental level, physical factors (six studies, eleven samples), socio-cultural factors (twelve studies, 14 samples), and economic factors (six studies/samples) were examined in relation to fruit/vegetable intake. One study examined factors in the school environment, one study (two samples) examined factors in the neighborhood environment, and no studies examined factors at the city/municipality level. At the household physical level, availability of fruit/vegetables was associated with higher fruit/vegetable intake in four out of seven samples [25, 28, 30, 34]. Accessibility of fruit/vegetables was positively associated with fruit/vegetable intake in four out of six samples [21, 25, 28]. At the household socio-cultural level positive associations were found for modeling (two out of two samples/studies) [21, 28] and parental intake of fruit/vegetables (six out of six samples) [16, 18, 21, 26, 30, 37].

Environmental correlates of snack/fast food intake

At the household environmental level, physical factors (one study/sample), socio-cultural factors (five studies, six samples), and economic factors (five studies/samples) were examined in relation to snack/fast food intake. No studies examined factors in the school environment, one study (two samples) examined factors in the neighborhood, and one study examined factors at the city/municipality level. None of the factors examined showed consistent associations with snack/fast food intake.

Environmental correlates of soft drink intake

At the household environmental level, physical factors (two studies/samples), household socio-cultural factors (five studies, six samples), and household economic factors (three studies/samples) were examined in relation to soft drink intake. One study examined factors in the school environment, no studies examined factors in the neighborhood or city/municipality environment. At the household socio-cultural level, parental soft drink intake was positively associated with children's soft drink intake in two out of two samples [16, 17].

Potential environmental correlates of adolescent's dietary behaviors

Environmental correlates of energy intake

At the household environmental level, socio-cultural factors (six studies, nine samples) and economic factors (two studies/samples) were examined as potential correlates of energy intake (Table 3.3). No studies examined factors in the school, neighborhood or city/municipality environment. At the household socio-cultural level parental energy intake was positively associated with adolescent's energy intake (six out of six samples) [46, 54, 56, 73]. A positive association was also found for sibling intake (four out of four samples) [54, 73].

Environmental correlates of fat intake

At the household environmental level, nine studies (15 samples) examined socio-cultural factors and five studies (eight samples) examined economic factors as potential correlates of fat intake. One study examined factors in the school environment, no studies examined factors in the neighborhood. One study (two samples) examined factors at the city/municipality level. At the household socio-cultural level parental fat intake was found to be positively associated with adolescent's fat intake (eight out of nine samples) [51, 54, 56, 68, 73]. A positive association was also found for sibling intake (four out of four samples) [54, 73].

Environmental correlates of fruit and vegetable intake

At the household environmental level, physical factors (two studies/samples), socio-cultural factors (ten studies, eleven samples) and economic factors (eight studies, ten samples) were examined as potential correlates of fruit/vegetable intake. One study examined factors in the school environment, one study examined factors in the neighborhood environment, and one study (two samples) examined factors at the city/municipality level. At the household socio-cultural level an authoritative parenting style was positively associated with fruit/vegetable intake (two out of two samples) [63, 65]. Family connectedness was positively associated with adolescent fruit/vegetable intake (two out of two samples) [53, 58]. At the household economic level parent educational level was found to be positively associated with fruit/vegetable intake (six out of six samples) [50, 52, 65, 69, 70].

Environmental correlates of snacks/fast food intake

At the household environmental level, socio-cultural factors (four studies, six samples) and economic factors (three studies, five samples) were studied in relation to snack and fast food intake. One study examined factors in the school environment, no studies examined factors in the neighborhood environment, and one study (two samples) examined factors at the city/municipality level. None of the factors examined showed consistent associations with snack/fast food intake.

Table 3.3 Summary of micro and macro environmental correlates of dietary intakes among adolescents (>12 to 18 year olds)

	Correlate	Related to dietary behaviors	Assoc	Unrelated to dietary behaviors	# Samples	Summary (n)		
		References	(+ or -)†	References		+	-	0
	Physical							
	Fruit, Juice, Vegetables							
	Availability	[66]	+	[61M]	2	1	0	1
	Socio-Cultural							
	Energy							
	Parental intake	*[46, 54M/F, 56, 73M/F]*	+		*6*	*6*	*0*	*0*
	Siblings intake	[54M/F, 73M/F]	+		4	4	0	0
	Single mother family	[45M]	+	[45F]	2	1	0	1
	Frequency of family meals	[67]	+		1	1	0	0
	Fat (total fat, en% fat)							
	Parental intake	*[51M, 54M/F, 56, 68F, 73M/F] [51Fmother]*	+	*[51Ffather, 68M]*	*9*	*8**	*0*	*2**
	Siblings intake	*[54M/F, 73M/F]*	+		*4*	*4*	*0*	*0*
	Friends intake			[56]	1	0	0	1
	Communication strategies			[60]	1	0	0	1
	Family food routines			[60]	1	0	0	1
	Food rules			[60]	1	0	0	1
	Frequency of family meals			[67]	1	0	0	1
	Shopping:							
	Healthy food is asked for	[60]	-		1	0	1	0
	Food asked for is bought			[60]	1	0	0	1
	Shopping alone / family			[60]	1	0	0	1
	Single mother family			[45M/F]	2	0	0	2
	Head of household status (male vs. other)	[47M]	+		2	1	1	0
		[47F]	-					
	Fruit, Juice, Vegetables							
	# of evening meals eaten with parent present	[69]	+		1	1	0	0
	Frequency of family meals	[67]	+		1	1	0	0
	Breakfast with family			[72M/F]	2	-	0	2
	Dinner with family	[72Ffruit]	+	[72M/Fveg] [72Mfruit]	2	1*	0	3*

Home/household

Correlate	Related to dietary behaviors	Assoc	Unrelated to dietary behaviors	# Samples	Summary (n)		
	References	(+ or -)†	References		+	-	0
Shopping:							
Healthy food is asked for	[60fruit]	+	[60veg]	1	1*	0	1*
Food asked for is bought	[60fruit/veg]	-		1	0	2*	0
Shopping alone/ family			[60fruit/veg]	1	0	0	2*
Negative communication strategies	[60veg]	-	[60fruit]	1	0	1*	1*
Family food routines			[60]	1	0	0	1
Food rules			[60]	1	0	0	1
Parent present during leave/return from school			[69]	1	0	0	1
Parental control on food choice			[69]	1	0	0	1
Parenting style (authoritative, indulgent vs. authoritative, neglective)	*[63, 65authoritative]*	+		*2*	*2*	*0*	*0*
Residence other than with family:							
J, F in summer	[48]	+		1	1	0	0
F in winter			[48]	1	0	0	1
Family connectedness (high vs. mod/low)	*[53, 58]*	+		*2*	*2*	*0*	*0*
Positive relation with parents	[62]	+		1	1	0	0
Positive relation with peers							
F& V intake at 15 years	[62]	+		1	1	0	0
F& V intake at 21 years			[62]	1	0	0	1
Snacks, Fast food							
Parental and friends' intake of foods	[56]	+		1	1	0	0
Frequency of family meals, breakfast/dinner with family			[67, 72M/F]	3	0	0	3
Breakfast, lunch, dinner at home vs. school			[49I/II]	2	0	0	2
Breakfast at other site than home or school	[49I]	+		1	1	0	0
Lunch at other site than home or school	[49I/II]	+		2	2	0	0
Breakfast/dinner at other site than home or school			[49II]	1	0	0	1
Dinner at other site than home			[49I]	1	0	0	1
Soft drink							
Parental intake	[55]	+		1	1	0	0

Correlate	Related to dietary behaviors	Assoc	Unrelated to dietary behaviors	# Samples	Summary (n)		
	References	(+ or -)†	References		+	-	0
Friends intake	[55]	+		1	1	0	0
Frequency of family meals	[67]	-		1	0	1	0
Breakfast with family	[72M]	-	[72F]	2	0	1	1
Dinner with family			[72M/F]	2	0	0	2
Residence other than with family	[48]	-		1	0	1	0
Shopping:							
Healthy food is asked for			[60]	1	0	0	1
Food asked for is bought			[60]	1	0	0	1
Shopping alone / family			[60]	1	0	0	1
Communication strategies			[60]	1	0	0	1
Family food routines			[60]	1	0	0	1
Food rules	[60]	-		1	0	1	0
Economic							
Energy							
Family income			[70]	1	0	0	1
Fathers occupation			[50]	1	0	0	1
Parental education			[50, 70]	2	0	0	2
Fat (total fat, en% fat)							
Family income / household income			[47M/F, 70]	3	0	0	3
Fathers occupation	[50]	-		1	1	0	0
Parental education	[70]	-	[50, 71M/F]	4	0	1	3
Socio-economic index			[57M/F]	2	0	0	2
Household size			[47M/F]	2	0	0	2
Fruit, Juice, Vegetables							
Family income			[52M/F, 61M, 70]	4	0	0	4
Fathers occupation			[50]	1	0	0	1
Parental education	*[50fruit, 52M/F, 65, 69, 70]*	+	*[50veg]*	*6*	*6**	*0*	*1**
Socio-economic index / SES	[53, 57Mveg]	+	[57Mfruit/Fveg]	3	2*	1*	2*
	[57Ffruit]	-					
Snacks, Fast food							
Household income			[52M/F]	2	0	0	2
Education of responsible parent	[52F]	-	[52M]	2	0	1	1

	Correlate	Related to dietary behaviors	Assoc	Unrelated to dietary behaviors	# Samples	Summary (n)		
		References	(+ or -)†	References		+	-	0
	Socio-economic index			[57M/F]	2	0	0	2
	Pocket money > $20/week	[59]	+		1	1	0	0
Educational Institutions	**Physical**							
	Fat (total fat, en% fat)							
	A la carte program	[64]	+		1	1	0	0
	Snack vending			[64]	1	0	0	1
	Fruit, Juice, Vegetables							
	A la carte program	[64fruit] [64fruit&veg]	-	[64veg]	1	0	2*	1*
	Snack vending	[64fruit]	-	[64veg] [64fruit&veg]	1	0	1*	2*
	Beverage vending			[64veg] [64fruit] [64fruit&veg]	1	0	0	3*
	Socio-Cultural							
	Snacks, Fast food							
	School social environment			[59]	1	0	0	1
	Teacher support							
	Highly supportive – fairly unsupportive			[59]	1	0	0	1
	Highly unsupportive	[59]	+		1	1	0	0
Neighbour-hood	**Physical**							
	Fruit, Juice, Vegetables							
	Availability in restaurant menu	[61Mveg/fruit juice/FJV]	+	[61Mfruit]	1	3*	0	1*
	Availability in grocery stores			[61M]	1	0	0	1
City/municipality	**Physical**							
	Fat (total fat, en% fat)							
	Geographic region (southern USA vs. other)	[47F]	-	[47M]	2	0	1	1
	Degree of urbanization			[47M/F]	2	0	0	2
	Fruit, Juice, Vegetables							
	City vs. county	[57M/F]	+		2	2	0	0
	Snacks, Fast food							
	Geographic region (west, Midwest, south)	[49II]	-	[49I]	2	0	1	1
	Soft drink							
	City vs. County			[57M/F]	2	0	0	2

† Associations between environmental factors and dietary outcomes were coded '+' for a positive association, '-' for an inverse association
* If in one study, a determinant is examined in relation to two outcomes (e.g. fruit intake and vegetable intake), and the results differ for the two outcomes (e.g. a positive association was found for fruit intake, and no association was found for vegetable intake), the study is counted once in the column '# of samples', and twice in the summary column.
Italic printed text, indicate factors with consistent associations.

Table 3.4 ANGELO framework with the number of studies and the associations found in each cell.

		Physical		Socio-cultural		Economic		Political	
	Home/ household	**# studies**	**Assoc.**	**# studies**	**Assoc.**	**# studies**	**Assoc.**	**# studies**	**Assoc.**
Micro	Energy	1		11	Encouragement/ assistance (-;c) Parental intake (+;a)** Sibling intake (+;a)	7			
	Fat	1		13	Control over intake (+;c) Parental intake (+;c) Parental intake (+;a) Sibling intake (+;a)	12	Parental education (+;c)		
	Fruit/ vegetables	8	Availability (+;c)* Accessibility (+;c)	16	Modeling parents (+;c) Parental intake (+;c) Parenting style (+;a) Family connectedness (+;a)	12	Parental education (+;a)		
	Snack/fast food	1		9		8			
	Soft drink	2		10	Parental intake (+;c)	3			
	Educational institutions								
	Energy	1		1					
	Fat	2		1					
	Fruit/ vegetables	1		1					
	Snack/fast food			1					
	Soft drink	1		1					
	Neighborhood								
	Energy								
	Fat								
	Fruit/ vegetables	1				1			
	Snack/fast food					1			
	Soft drink								
Macro	**City/ municipality**								
	Energy	2							
	Fat	3							
	Fruit/ vegetables	1							
	Snack/fast food	2							
	Soft drink	1							

c Positive association found for children

a Positive association found for adolescents

Environmental correlates of soft-drink intake

At the household environment level, socio-cultural factors (five studies, six samples) were examined as potential environmental correlates of soft drink intake. No studies examined factors in the school and neighborhood environment. One study (two samples) examined factors at the city/municipality level. None of the factors examined showed consistent associations with soft drink intake.

Summary in ANGELO framework

Socio-cultural factors on the household level are the most studied environmental factors for all dietary behaviors, followed by economic factors on the household level (Table 3.4). Factors studied on the school environmental level (physical and socio-cultural) were mostly single studies. At the city/municipality level only physical factors were studied.

DISCUSSION

The present systematic review of the literature on environmental correlates of energy, fat, fruit, vegetable, snack/fast food, and soft drink intake in children and adolescents showed that household socio-cultural factors (e.g. parental and sibling intake, parenting practices) and household economic factors (e.g. household income, parent educational level) were studied most extensively as potential environmental determinants. Few studies examined the influence of physical environmental factors, few looked at environmental factors in schools, neighborhoods and city/municipality, and none looked at political factors. This review showed consistent evidence (findings replicated in multiple studies), for the relationship between parental intake and children's fat, fruit and vegetable intake, for parent and sibling intakes with adolescent's energy and fat intake, and for parent educational level with adolescent's fruit and vegetable intake. A positive association was found for the relationship between availability and accessibility with children's fruit and vegetable intake, even though the samples that found a positive association only slightly outnumbered the samples that found no association. Further positive associations were found for controlling/restrictive practices (fat), parent educational level (fat), modeling (fruit/vegetable), parental intake (soft drink) parenting style (fruit/vegetable), family connectedness (fruit/vegetable) and encouragement to increase food intake (fruit/vegetable). A negative association was found for encouragement/assistance/prompts (energy). These factors were examined in only two studies, which limits the possibility to draw firm conclusions regarding consistency of associations. The direction of the association for encouragement/assistance/prompts seems unexpected. However, since these studies were cross-sectional, it could also be that a low child food intake provokes parental encouragement, assistance and prompts to increase in-

takes. All other associations studied between dietary behaviors and potential environmental factors were inconsistent, appeared non-existent, or were not replicated.

A major limitation of the currently available published research papers is that many potential environmental determinants have been examined for a variety of dietary behaviors, but that only few studies have been conducted on the same specific environmental factor – dietary behavior combination. Replication of studies on such combinations is necessary, to generate more compelling evidence for associations between environmental factors and dietary intake. With regard to the strength of the study designs, most of the included studies were cross-sectional, making conclusions about direction and possible causality of associations impossible. Furthermore, most studies relied on self-reported data, of which the validity and reliability of the instruments used was hard to judge, since this information was not reported in the majority of the studies. We retrieved few studies that used objective observation instruments to assess factors in the physical environment or to measure the behavioral outcome. The behavioral outcome measures in the studies included, may be somewhat biased because the studies mostly relied on self-reports.

There are some issues and limitations that have to be taken into account in interpreting the results of the review. In order to summarize the findings of the studies we collapsed conceptually similar environmental determinants into one category, although potential determinants in the same category were often dissimilar or measured in different ways. Our search strategy only included studies that were published in English in peer-reviewed journals and referenced in electronic databases; therefore our findings may be influenced by a publication bias. However, the high number of non-associations reported in the included studies may indicate that a bias towards publication of significant results only, was not very strong. The studies included were heterogeneous in the conceptualization, measurement of the environmental determinant and/or dietary intakes, samples and analyses used, and therefore it was not possible to assess the overall strength of associations. Finally, we included multiple environmental factors examined in one study in the review, and it must be kept in mind that these associations are not independent.

Previously published reviews on the associations of environmental factors regarding eating behaviors in children and adolescents were narrative as opposed to systematic reviews [7-9, 11, 74, 75]. The main conclusions from those reviews were that the role of parents is particularly important, that parents should create supportive food environments for their children [7-9, 74], and that school food environments may have a large impact on food choices [9, 11, 74]. In the present review we indeed found that parental intake and to a lesser extent availability and accessibility were associated with intakes in adolescents and children. Furthermore, some evidence (examined in two studies) was found for a positive association

between an authoritative parenting style and adolescent's fruit and vegetable intake, and for specific parenting practices and children's energy and fat intakes. Only very few studies on peer influences were retrieved in this systematic review. The importance of the school food environment can also not be substantiated with the evidence from the studies included in the present review.

We identified several gaps in the currently available evidence of relationships between environmental factors and child and adolescent dietary intakes. First, we were able to identify very few studies examining associations between micro environmental factors in school and neighborhood settings, and on macro environmental factors in city/municipality settings: the broader, more anonymous infrastructure that may support or hinder health behaviors. It must, however, be noted that there are studies available that examine the effects of advertising and marketing on eating behaviors of youngsters [10, 76], but since these studies are mostly intervention studies, these were not included in the review. Secondly, the studies mainly depended on perceived and self-reported environmental information, as opposed to more objective observations of environments. Objectively assessing characteristics of the environment (observations or Geographic Information System), is a topic of recent interest [77, 78]. Furthermore, we retrieved only a limited number of studies assessing environmental determinants of snack and soft drink intakes, while these two behaviors may be of specific importance in obesity prevention [4, 12]. An important reason for some of the gaps may be that attention to the role of the physical environment is of recent interest, and many studies that examine possible influences of the physical environment may be underway.

The current evidence of associations between environmental determinants and dietary intakes among children and adolescents suggests that parental intakes, sibling intakes and educational level of parents are environmental determinants most consistently associated with intakes. A less consistent repeated but positive association was found for availability and accessibility on child fruit and vegetable intake. The finding that parental behavior is associated with child and adolescent intakes implies that interventions should take the behavior of parents into account, or desensitize adolescents for the (unfavorable) behavior of their parents. Parents should be more strongly encouraged to give the right example, especially where fat and energy intakes are concerned. Fruit and vegetable promotion should focus especially on adolescents from parents with lower levels of education. To get a broad understanding of the influence of environmental factors associated with obesity inducing behaviors in children and adolescents at the various levels distinguished in the ANGELO framework, studies are needed that target the environmental levels and factors that have found to be (nearly) empty in the ANGELO grid (Table 3.4), such as physical, socio-cultural, economic and political factors in the school (e.g. school food policy and food prices), neighborhood (e.g. availability and accessibility of foods in shops) and city/

municipality environment (e.g. food policy, food prices, marketing). Furthermore factors such as availability and accessibility at home, school and neighborhood should be studied in relation to energy, fat, soft drink, snacks and fast food intake. For all environmental factors, including the factors that have already been studied, there is a need for longitudinal studies in which valid or objective measurement instruments are used.

ACKNOWLEDGEMENTS

The authors wish to thank Carlijn Kamphuis and Gert Jan de Bruijn for their assistance in the review process.

This study was financially supported by a grant from ZonMw The Netherlands Organization for Health Research and Development. Dr. Katrina Giskes is supported by an Australian National Health and Medical Research Council Sidney Sax Fellowship (grant ID number: 290540).

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4 Environmental correlates of physical activity in youth – a review and update

Ferreira I, van der Horst K, Wendel-Vos W, Kremers S, van Lenthe FJ, Brug J. Environmental correlates of physical activity in youth – a review and update.

Obesity Reviews 2007, 8(2): 129-154.

ABSTRACT

Background: Obesogenic environments are thought to underlie the increased obesity prevalence observed in youth during the past decades. Understanding the environmental factors that are associated with physical activity (PA) in youth is needed to better inform the development of effective intervention strategies attempting to halt the obesity epidemic.
Methods: We conducted a systematic semi-quantitative review of 150 studies on environmental correlates of youth PA published in the past 25 years. The ANalysis Grid for Environments Linked to Obesity (ANGELO) framework was used to classify the environmental correlates studied.
Results: Most studies retrieved used cross-sectional designs and subjective measures of environmental factors and PA. Especially variables of the home and school environments were associated with PA in youth. Most consistent positive correlates of PA were father's PA, school PA-related policies (in children), and support from significant others, mother's education level, family income, and non-vocational school attendance (in adolescents). Time spent outdoors (in children) and low crime incidence (in adolescents) were characteristics of the neighborhood environment associated with higher PA. Convincing evidence of an important role for many other environmental factors was however not found.
Discussion: Further research should aim at longitudinal study designs and use more objective measures of PA and its potential (environmental) determinants.

INTRODUCTION

Physical activity (PA) is a health enhancing behavior: when practiced regularly, PA reduces the risk for a range of chronic disease [1-4]. Also among the young current and future health benefits can be obtained through engaging in physically active lifestyles [5]: it helps building strong bones, healthy joints, a strong heart, a good mental health and prevents today's major public health concern – obesity[6-9]. Despite these health benefits, many young people are not engaging in recommended levels of PA [10-12]. In addition, longitudinal studies have shown that a steep decrease in PA levels occurs during adolescence [13-15] and that PA levels established in youth tend to track into adulthood[16-20]. PA promotion in youth is thought to facilitate a carryover of healthful habits into adulthood and a lifelong protection from other risk factors, and is therefore a priority in current public health policies [4, 21].

Given the short time frame in which the obesity prevalence has increased to epidemic scales many scientists postulate that this is more likely due to changes in environments than in biology [22-26]. In this vein, recent studies have indeed demonstrated associations between childhood obesity and environmental features, namely at the home and neighborhood [27-32]. Consequently, it is important to understand, measure and alter environments that promote or hinder obesity-inducing *behaviors*, such as low physical activity [7, 33-38]. Environmental influences can be especially relevant to children and adolescents since they have less autonomy in their behavioral choices [39]. Specific recommendations for research on the determinants of PA in youth have emphasized the need to examine environmental influences on youth PA at different levels (e.g. home, neighborhood, school)[40-42] to better inform the development of interventions attempting to improve PA levels [43, 44].

Now that more and more studies focus on potential environmental influences on children's and adolescents' PA behavior, it is important to get a detailed overview of the evidence these studies have provided so far, to define a research agenda in this area. In the year 2000, a comprehensive review of personal and environmental correlates of PA in children and adolescents[45] identified several variables which were consistently associated with children/adolescent's PA levels, including social and physical environmental factors such as direct help and support from parents and significant others, access to programs/facilities, opportunities to be active and time spent outdoors. We now update the review of evidence provided by Sallis *et al.* focusing specifically on, and characterizing into more detail, the *environmental* correlates of PA in children and adolescents.

METHODS

Search strategies and procedures

Relevant studies were located from 2 main sources. Firstly, the computerized literature databases MedLine (PubMed), PsychInfo, Web of Science, EMBASE and SportDiscuss were searched. The following keyword combinations were used: physical activity, physical active lifestyle, vigorous activity, leisure activities, recreation, exercise, sport(s), motor activity, physical education, walking, running, (bi)cycling, commuting, determinants, correlates, influences, associations, environment, physical environment, built environment, psychosocial determinants, social environment, social norms, socio-economic status, socio-cultural environment, parents, peers, neighborhood, school, facilities, recreation, equipment, safety. These searches were restricted to studies performed in humans aged up to 18 years, and published between January 1980 and December 2004. After excluding duplicate studies, over 5,000 articles were hereby identified. Two independent reviewers (IF, KvdH) screened and selected the articles retrieved whenever it could be ascertained first, from the title (304 articles), second from the abstract (88 articles), and finally from the full text (84 articles), that the selection criteria (see below) were met. These stepwise analyses were performed separately by each reviewer, and at each step an article was kept whenever selected by at least one of the reviewers.

Secondly, manual searches using the reference of the previous systematic review from Sallis *et al,*[45] primary studies located from the previous source and our personal databases were performed and cross-checked with the articles found through the previous source. This led to the inclusion of 66 additional articles. Together, these search strategies resulted in a total of 150 articles, which are reviewed herein.

Inclusion/exclusion criteria

Types of studies

The present review was concerned with PA levels occurring 'naturally' in populations of children and adolescents. Therefore, only observational studies (either cross-sectional or longitudinal) were included, whereas studies investigating samples of PA-related interventions or with a quasi-experimental design were excluded (with exception of studies reporting on baseline data from intervention studies). Qualitative studies or studies that were solely descriptive in nature (i.e., reporting only frequency data), abstracts, case reports, expert opinions, dissertations and unpublished data were also excluded.

Participants and country

Subjects (or the majority of the participants) had to be in the age range of 3-18 years old; similarly to the review by Sallis et al., we have divided studies among children (i.e., 3-12 years old) and adolescents (>12-18 years old). Studies on children and adolescents with chronic diseases (that may affect PA levels) or children participating in top-level competitive sports were not included. Only studies from samples drawn in countries with established market economies (as defined by the World Bank) and published in English as papers in international peer-reviewed journals were included.

The dependent variable(s) - PA

The dependent variable was any measure of (overall) PA of various types (i.e., play, games, sports, work, transportation, recreation, physical education, or planned exercise) performed in the context of home/family, school and community, and expressed in terms of duration (e.g. in minutes), or frequency (e.g. times per week), or intensity (e.g. vigorous) or a combination of these, i.e. in terms of volume (e.g. METs or Kcal) [46]. When studies had multiple dependent measures of PA; the correlates of mutually exclusive outcomes (e.g. habitual levels of moderate- *and* vigorous-intensity PA) were investigated and reported separately.

Studies in which the dependent variable was aerobic fitness, intention, self-efficacy, or other intermediate (non-behavioral) measures were not included; physical inactivity/sedentary behavior was not considered as outcome because PA and inactivity are distinct behaviors, often unrelated and with distinct determinants [47-51]. In addition, although we acknowledge physical inactivity as an important heath-impairing behavior, a recent systematic review of its determinants among youth has been published recently [52].

The predictor variable(s) - environmental characteristics

Environmental variables were broadly defined as 'anything outside the individual that can affect its PA behavior'. To structure our review we were in need of a conceptual framework to categorize the various environmental factors studied. Different classifications of possible environmental determinants of health behaviors have been proposed [36, 38, 50, 53, 54], all of them showing great overlap and similarities. In the present review we have adopted The ANalyses Grid for Environments Linked to Obesity (ANGELO) conceptual framework [55] to classify potential environmental determinants of PA in children and adolescents. This framework was specifically developed to conceptualize '*obesogenic*' environments (i.e. those that promote excessive energy intake and low PA), enabling the identification of specific areas and settings to be targeted by intervention programs. Specifically, environmental variables can be distinguished within two 'sizes' (micro and macro) and four types (physical, socio-cultural, economic and political) of environment. Micro-environments are defined as environmental settings where groups of people meet and gather. Such settings are often geographically distinct and allow direct mutual influences between individuals and the

environment. Examples of micro-environmental settings are homes, schools, and neighborhoods. Macro-environments, on the other hand, include the broader, more anonymous infrastructure that may support or hinder health behaviors. Examples of macro-environments are the town planning, the transport infrastructure, the media and the health-care system. All studies reviewed herein were required to examine at least one environmental variable (the independent variable), and this variable needed to be tested for its association with a measure of PA (the dependent variable), obtained at the individual level.

Data analyses

Due to the great variety of variables and methods drawn from diverse samples, a meta-analytical review was not possible to conduct. We have therefore adopted the same semi-quantitative approach outlined by Sallis *et al.*,[45] recently also used by Gorely *et al.*[52], in a review of the correlates television viewing among youth. An independent sample, i.e. the smallest independent sub-sample (based on age and gender) for which relevant data was reported (e.g. studies reporting findings for boys (M) and girls (F) separately, provide 2 independent samples) was used as the unit of analyses [56].

Study characteristics

The relevant characteristics from all the selected publications listed in the Bibliography section were retrieved and registered in detailed tables (which are available upon request from the corresponding author), according to current review guidelines [57, 58]. This extensive information was then summarized in one background table (Table 4.1).

Categorization of variables

Correlates of PA investigated in the studies reviewed were categorized in the ANGELO grid, i.e. were grouped in 4 environment types (physical, socio-cultural, economic, and political) for each environmental setting (Micro and Macro) with a further distinction in specific levels (home, educational institution, neighborhood, city/municipality, region). These data was then summarized in two tables providing an overview of the potential determinants of PA of children and adolescents separately (Tables 4.2 and 4.3, respectively).

Coding and summarizing associations with PA

A variety of statistical techniques (e.g. correlations, t-tests, linear or logistic regression analyses, ANOVA and structured equation models) were used to evaluate the associations. Most studies not only reported univariate but also multivariate analyses (e.g., with adjustment for demographic and/or other potential correlates investigated); whenever possible findings reported here were those from the fully adjusted models. As with regard to prospective studies, the associations found within the shortest follow-up period were

the ones considered, and the cross-sectional findings embedded within these studies were disregarded.

Studies reporting positive (coded as '+') or inverse (coded as '-') association(s) between the independent variable and PA were registered under the column '*related to PA*'; non-significant associations were coded under the column *'unrelated to PA'* (coded as 'o'). Findings for each independent variable were summarized by adding the number of associations in a given direction (+, -, o); a final summary association code for each correlate examined was derived as follows: ≥60% of the associations in any direction was considered evidence for a positive (summary code '+'), negative (summary code '-') or non-association (summary code 'o'); a mixed pattern of associations <60% (but above 50%) was considered evidence for probable but inconsistent association (summary code '+?' or '-?' or 'o?'); a variable that has been frequently studied (i.e., in ≥10 independent samples) but with considerable lack of consistence was attributed a summary code of two questions marks (??); where findings were consistent, the codes '++', '- -' or 'oo' were attributed. Final summary codes were only computed for variables that have been studied in at least 3 independent samples; otherwise a 'non-applicable' (N/A) summary code was attributed

RESULTS

General characteristics of the studies reviewed (Table 4.1)

We have identified a total of 150 publications that presented an empirical association between PA and at least one environmental correlate. The vast majority of studies (71.3%) were published in the last decade (Fig.4.1) and a steep, almost 3-fold increase in adolescent studies was noticed in the last 5 years. The overall studies reported data on 225 independent samples. Sixty-six studies (91 independent samples) of children were reviewed, representing 40.4% of the total independent samples; only 16 (17.6%) of those independent samples included more than 1,000 subjects. Eighty-four studies of adolescents (134 independent samples; 59.6%) were reviewed (4 of which provided also data on children); about one third included more than 1,000 subjects. In both children and adolescents, the vast majority of the studies used a cross-sectional design reported results for boys and girls separately, relied on child and/or parental self-reports as method of PA data collection (about half of which with acceptable reliability/validity), and were mostly conducted in North America. Studies that used objective methods of PA assessment were in the great majority restricted to studies among children; direct observation and doubly labeled water assessment were never used in studies of adolescents.

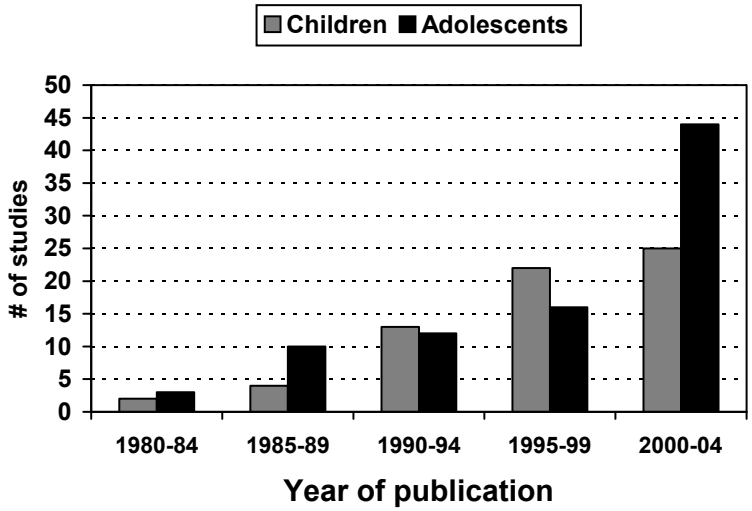

Figure 4.1 Distribution of the 150 publications by year of publication (1980-2004).

Potential environmental determinants of children's PA (Table 4.2)

Potential determinants at the home level

We have identified a total of 17 independent samples investigating the associations between variables of the home *physical environment*, namely the amount of cars in the family and the availability and access of exercise equipment (e.g. PA promoting toys), and PA levels of children. Both variables were unrelated to children's PA. *Socio-cultural environmental* correlates of children's PA at the home/family level were the most frequently investigated. Family structure variables such as single-parent family, household size or number of children in the family, dog ownership and level of acculturation to the country of residence, were unrelated to children's PA. Modeling of PA from parents, siblings and friends were extensively examined (96 independent samples in total). Studies that have examined the relationship between children's PA levels and those of their parents, not disentangling those of the father from those of the mother, as well as those from other significant others (e.g. parents, siblings or friends), found no relevant associations. However, in studies where father's and mother's PA levels were disentangled from each other, father's PA levels emerged as a probable positive correlate (in 52% of the cases), whereas mother's PA levels were mostly unrelated to children's PA. Studies investigating potential familial influences other that modeling, namely support, encouragement and PA-related social norms of parents, friends and significant others, have also been numerous (a total of 99 independent samples). These variables were generally unrelated to children's PA. The *economic environment* of children's

Table 4.1 Child and adolescents studies categorized by sample size, sex, study design, physical activity measurement issues, and country

	CHILDREN (3-12 years)			ADOLESCENTS (>12-18 years)		
	Bibliography no.	N Samples	%	Bibliography no.	N Samples	%
SAMPLE SIZE		91	100		134	100
<100	5F, 15M/F, 25, 32, 39, 66, 71, 82, 89M/F, 111, 113MI,V/FI,II,V, 129, 134M	19	20.9	20I, 23M/F, 24M/F, 26M/F, 30F, 50M, 68, 69, 90M/F, 106F, 113MIV,VI/FVI, 123, 126M, 133M, 138I,II	22	16.4
100-199	10*, 21, 22F, 31*, 42, 46, 51, 58, 75M, 76, 103M/F, 108M/F, 113MII, 124M/F, 131MI/FI, 134F, 150	20	22.0	14, 44M/F, 45M/F, 48II, 49, 50F, 101, 102F, 110II, 113MIII/FIII,IV, 126F, 128, 133F	17	12.7
200-299	13F, 28, 37, 38, 41, 63M/F, 70, 75F, 96, 109, 110I, 112MI/FI, 118	15	16.5	12, 16M/F, 20II, 93F, 102M, 112MII,III/FII,III, 125, 148MIII	12	8.9
300-499	27M/F, 56F, 81, 97, 107M/F, 115, 131MII/FII, 132, 148MI/FI	13	14.3	8M/F, 34M/F, 40F, 43, 67M, 79M/F, 105, 116F, 135, 147, 148MII/FII,III	16	11.9
500-999	56M, 64, 84M/F, 100, 104, 119, 144	8	8.8	4M/F, 7M/F, 17F, 18F, 29, 33, 36, 40M, 47, 48I, 61M/F, 62, 67F, 87F, 99, 145, 149M/F	21	15.7
1,000-2,999	11M/F, 57, 73, 85, 86M/F, 88, 95M/F, 120, 122, 137, 143M/F	15	16.5	1M/F, 3M/F, 6, 35F, 54, 65M/F, 80M/F, 87M, 91F, 94I,II, 114F, 117M/F, 136, 139, 141, 142M/F, 146M/F	25	18.7
3,000-4,999				2M/F, 72, 78, 83, 121, 140	7	5.2
≥5,000	19	1	1.0	9, 52, 53, 55, 59M/F, 60, 74, 77, 92, 98, 127M/F, 130	14	10.5
SEX						
Girls only	5F, 13F, 22	3	3.3	17, 18, 30, 35, 91, 93, 106, 114, 116	9	6.7
Boys and girls combined	10/31, 19, 21, 25, 28, 32, 37, 38, 39, 41, 42, 46, 51, 57, 58, 64, 66, 70, 71, 73, 76, 81, 82, 85, 88, 96, 97, 100, 104, 109, 110I, 111, 115, 118, 119, 120, 122, 129, 132, 137, 144, 150	42	46.2	6, 9, 12, 14, 20I,II, 29, 33, 36, 43, 47, 48I/II, 49, 52, 53, 54, 55, 60, 62, 68, 69, 72, 74, 77, 78, 83, 92, 94I,II, 98, 99, 101, 105, 110II, 121, 123, 125, 128, 130, 135, 136, 138, 139, 140, 141, 145, 147	49	36.6

	CHILDREN (3-12 years)			ADOLESCENTS (>12-18 years)		
	Bibliography no.	N Samples	%	Bibliography no.	N Samples	%
Boys and girls, separately	11, 15, 27, 56, 63, 75, 84, 86, 89, 95, 103, 107, 108, 112I, 113I,II,V, 124, 131I,II, 134, 143, 148I	46	50.5	1, 2, 3, 4, 7, 8, 16, 23, 24, 26, 34, 40, 44, 45, 50, 59, 61, 65, 67, 79, 80, 87, 90, 102, 112II,III, 113III,IV,VI, 117, 126, 127, 133, 142, 146, 148II,III, 149	76	56.7
STUDY DESIGN						
Cross-sectional	5F, 10/31, 13F, 15M/F, 19, 21, 22F, 25, 27M/F, 28, 32, 37, 38, 39, 41, 46, 51, 56M/F, 57, 58, 63M/F, 64, 66, 70, 71, 73, 75M/F, 76, 81, 84M/F, 85, 86M/F, 88, 89M/F, 95M/F, 96, 97, 100, 103M/F, 104, 108M/F, 109, 110I, 111, 112MI/FI, 113MI,II,V/FI,II,V, 115, 119, 120, 122, 124M/F, 129, 131MI,II/FI,II, 132, 134M/F, 143M/F, 144, 150	81	89.0	1M/F, 3M/F, 4M/F, 6, 7M/F, 8M/F, 9, 12, 14, 16M/F, 17F, 18F, 23M/F, 24M/F, 29, 30F, 33, 34M/F, 35F, 36, 43, 44M/F, 47, 48I/II, 49, 50M/F, 52, 53, 54, 55, 59M/F, 60, 61M/F, 62, 65M/F, 67M/F, 68, 69, 72, 74, 77, 78, 79M/F, 80M/F, 83, 87M/F, 90M/F, 91F, 92, 94I,II, 98, 99, 101, 105, 106F, 110II, 112MII,III/FII,III, 113MIII,IV,VI/FIII,IV,VI, 114F, 116F, 117M/F, 121, 123, 125, 126M/F, 127M/F, 128, 130, 135, 136, 138I,II, 139, 140, 141, 142M/F, 145, 146M/F, 147, 149M/F	115	85.8
Longitudinal (length of study)	11M/F (1 year), 42(1 year), 82(8 weeks), 107M/F (2 years), 118(1 year), 137(1 year), 148MI/FI (3 years)	10	11.0	2M/F (2,5 years), 20I (1 week), II (9 months), 26M/F (3 years), 40M/F (1 year), 45M/F (3 years), 93F (8 months), 102M/F (4 months), 133M/F (1 year), 148MII,III/FII,III (3 years)	19	14.2
ASSESSMENT OF PHYSICAL ACTIVITY						
Collection method						
Self-report	11M/F, 25, 27M/F, 38, 41, 42, 46, 56M/F, 57, 58, 64, 75M/F, 84M/F, 85, 86M/F, 95M/F, 97, 103M/F, 104, 110I, 115, 118, 119, 120, 124M/F, 132, 137, 143M/F, 144, 148MI/FI	41	45.1	1M/F, 2M/F, 3M/F, 4M/F, 6, 7M/F, 8M/F, 9, 14, 16M/F, 17F, 18F, 20I,II, 26M/F, 30F, 33, 34M/F, 35F, 36, 40M/F, 43, 44M/F, 45M/F, 47, 48I/II, 49, 50M/F, 52, 53, 54, 55, 59M/F, 60, 61M/F, 62, 65M/F, 67M/F, 68, 69, 72, 74, 77, 78, 79M/F, 80M/F, 83, 87M/F, 91F, 92, 93F, 94I,II, 98, 99, 102M/F, 105, 106F, 110II, 114F, 116F, 117M/F, 121, 125, 126M/F, 127M/F, 128, 130, 133M/F, 135, 136, 139, 140, 141, 142M/F, 145, 146M/F, 147, 148MII,III/FII,III, 149M/F	112	83.6

	CHILDREN (3-12 years)			ADOLESCENTS (>12-18 years)		
	Bibliography no.	N Samples	%	Bibliography no.	N Samples	%
Parent-report	15M/F, 21, 66, 73, 88, 100, 113MI,II/FI,II, 122, 129, 131MI,II/FI,II, 150	18	19.8			
Composite: self- & parent-report	19, 76, 112MI/FI	4	4.4	12, 29, 112MII,III/FII,III, 113MIII,IV/FIII,IV	10	7.5
Accelerometer	5F, 13F, 37, 63M/F, 89M/F, 96, 113MV/FV, 134M/F	12	13.2	113MVI,FVI, 123	3	2.2
Direct observation	10/31, 28, 70, 71, 81, 82, 109, 111	8	9.0			
Doubly labeled water	51	1	1.1			
Self-report & accelerometer/hear rate monitor	32, 108M/F	3	3.4	23M/F, 24M/F, 90M/F, 101, 138I,II	9	6.7
Parent-report & accelerometer	39	1	1.1			
Composite: self- & parent-report & accelerometer	107M/F	2	2.3			
Composite: 2 self-reports + fitness test	22F	1	1.1			
Reliability/validity of self- and parent reported methods						
Poor or unknown	19, 21, 22F, 27M/F, 32, 38, 46, 56M/F, 57, 58, 66, 73, 88, 100, 103M/F, 118, 122, 129, 131MI,II/FI,II, 143M/F, 148MI/FI, 150	30	42.9	1M/F, 2M/F, 3M/F, 6, 7M/F, 8M/F, 9, 12, 14, 18F, 23M/F, 24M/F, 29, 34M/F, 36, 40M/F, 43, 44M/F, 45M/F, 54, 55, 60, 62, 65M/F, 67M/F, 68, 69, 72, 74, 77, 78, 87M/F, 92, 94I,II, 98, 105, 106F, 116F, 121, 125, 126M/F, 128, 130, 136, 139, 140, 141, 145, 148MII,III/FII,III	68	51.9

	CHILDREN (3-12 years)			ADOLESCENTS (>12-18 years)		
	Bibliography no.	N Samples	%	Bibliography no.	N Samples	%
Acceptable	11M/F, 15M/F, 25, 39, 41, 42, 64, 75M/F, 76, 84M/F, 85, 86M/F, 95M/F, 97, 104, 107M/F, 108M/F, 110I, 112MI/FI, 113MI,II/FI,II, 115, 119, 120, 124M/F, 132, 137, 144	40	57.1	4M/F, 16M/F, 17F, 20I,II, 26M/F, 30F, 33, 35F, 47, 48I,II, 49, 50M/F, 52, 53, 59M/F, 61M/F, 79M/F, 80M/F, 83, 90M/F, 91F, 93F, 99, 101, 102M/F, 110II, 112MII,III/FII,III, 113MIII,IV/FIII,IV, 114F, 117M/F, 127M/F, 133M/F, 135, 138I,II, 142M/F, 146M/F, 147, 149M/F	63	48.1
COUNTRY						
North America	5F, 10/31, 11M/F, 13F, 21, 22F, 25, 28, 32, 37, 39, 41, 42, 46, 51, 57, 63M/F, 70, 71, 75M/F, 76, 81, 82, 84M/F, 85, 86M/F, 88, 89M/F, 95M/F, 96, 97, 100, 103M/F, 104, 107M/F, 108M/F, 109, 110I, 111, 112MI/FI, 113MI,II,V/FI,II,V, 115, 118, 120, 122, 124M/F, 132, 134M/F, 137, 144	68	74.7	4M/F, 6, 9, 16M/F, 17F, 18F, 20I,II, 26M/F, 29, 30F, 33, 34M/F, 35F, 36, 47, 48I/II, 49, 50M/F, 52, 53, 54, 55, 59M/F, 60, 61M/F, 62, 68, 69, 74, 77, 78, 79M/F, 80M/F, 87M/F, 90M/F, 91F, 92, 93F, 98, 99, 101, 102M/F, 106F, 110II, 112MII,III/FII,III, 113MIII,IV,VI/FIII,IV,VI, 114F, 116F, 117M/F, 121, 123, 125, 126M/F, 127M/F, 128, 133M/F, 135, 149M/F	85	63.4
Europe	38, 56M/F, 64, 66, 73, 119, 129, 143M/F, 148MI/FI	12	13.5	1M/F, 2M/F, 3M/F, 7M/F, 8M/F, 12, 14, 23M/F, 24M/F, 40M/F, 44M/F, 45M/F, 65M/F, 67M/F, 72, 94I,II, 105, 130, 136, 138I,II, 139, 140, 141, 142M/F, 145, 146M/F, 147, 148MII,III/FII,III	47	35.1
Oceania	15M/F, 19, 27M/F, 58, 131MI,II/FI,II, 150	11	12.4	43, 83	2	1.5

* These two studies report on the exact same dataset and were therefore considered as one individual sample only (hereafter coded as 10/31);
F, girls only; M/F, boys and girls analysed separately; I,II,III, IV, V, VI, data reported for different age sub-groups, separately.

home/family in relation to their PA levels was studied in 102 independent samples. Different estimates of family/parental SES were generally unrelated to children's PA. Finally, and within the household's '*political' environment,* parenting styles were also unrelated to children' PA.

Potential determinants at the school level

Aspects of the school environment were studied seldom (most of them only once or twice, which has not enabled us to calculate a summary association). Only one aspect of the school *political environment* – PA policies (i.e., time allowed from free play, time spent outdoors, and number of field trips) - was investigated in three or more independent samples, with 60% of the cases showing a positive association with children's PA levels.

Potential determinants at the neighborhood level

A total of 90 independent samples have examined associations between environmental characteristics at the neighborhood levels and PA levels of young children. We have identified a total of 8 potential correlates of PA at the neighborhood *physical environment*, 5 of which studied more than 3 times. Among these, time spent outdoors was consistently associated with higher PA levels of children, whereas availability and accessibility of PA programs or facilities, neighborhood safety and neighborhood hazards (e.g., many roads, no lights crossings, heavy traffic, physical disorder and pollution - estimated as perceived by parents in almost all studies) were consistently unrelated to children's PA. Aspects of the *social* and *economic environments* were unrelated to children's PA.

Potential determinants at the city/municipality and region/country level

Only few studies have investigated differences in PA levels between children living in urban vs. suburban (only examined twice) and coastal vs. mountainous locations (only examined once). Whether residence in urban vs. rural regions is associated with children's PA levels was undetermined by the available studies. Seasonal 'effects' on children's PA were also undetermined by the available literature.

Potential environmental determinants of adolescents' PA (Table 4.3)

Potential determinants at the home level

We have identified a total of 20 independent samples investigating the associations between variables of the home *physical environment*, namely the availability and accessibility of exercise equipment, and PA levels of adolescents; these variables were mostly unrelated to adolescents' PA. *Socio-cultural environmental* correlates of adolescents' PA at the home/family level were the most frequently investigated. Family structure variables such as single-parent family and household size or number of children in the family were unrelated to

Table 4.2 Summary of correlates of physical activity among children (3 to 12 year olds)

	Correlate	Related to PA	Assoc. (+ or -)	Unrelated to PA	# Samples	Summary (n)			
		Biblio. no.		Biblio. no.		+	-	0	Assoc
	MICRO ENVIROMENT								
Home/household	**Physical**								
	# cars in household	19, 131FI	-	131MI,II/FII	5	-	2	3	0
	Access/availability of exercise equipment	30F, 124F, 134F	+	30F, 81, 97, 109, 124M, 132, 134F, 134M/F,	12	3	-	9	00
	Socio-Cultural								
	Single-parent family	103F, 108M, 113MI	+	95M/F, 95M/F, 103M, 107M/F, 108F, 108M/F, 112MI/FI, 113MII,V/FI,II,V	20	3	-	17	00
	# household residents/children	-		38, 95M/F, 95M/F, 113MI,II,V/FI,II,V	11	-	-	11	00
	Acculturation (language spoken at home; lifetime in the county; index)	**11M**, 95M/F 19**, 137**	+ -	**11F, 11M/F**, 13F, 95M/F, **137**	12	3	2	7	0
	Dog ownership		-	131MI,II/FI,II	4	-	-	4	0
	Parents' PA	32, 63M, 89M/F, 100, **107M,** 111, 112MI, 144, 150 124F	+ . -	**11M/F**, 25, 32, 63F, **107F**, 108M/F, 108M/F, 112FI, 113MI,II,V/FI,II,V, 124M	29	10	1	18	00
	Father's PA	22F, 38, 39, 39, 46, 89M/F, 95M, 119M/F, 134M, **148MI/FI**, **148MI/FI**	+	15M/F, 15M/F, 84M/F, 95M/F, 95F, 97, 110I, 134M/F, 134F	29	15	-	14	+?
	Mother's PA	15F, 38, 39, 39, 95F, 110I, 124F, 134M, 148FI, **148FI**	+	15M/F, 15M, 22F, 84M/F, 89M/F, 95M, 95M/F, 97, 109, 119M/F, 124M, 134M/F, 134F, 148MI, **148MI**	31	10	-	21	00
	Sibling's PA	110I	+		1	1	-	-	N/A
	Friend's PA	46	+	97, 134M/F, 134M/F	6	1	-	5	0
	PA from significant others (parents, siblings, friends)			41	1	-	-	1	N/A
	Encouragement from parents	71, **82**, 95F, 95F, **107M**, 144	+	**11M/F,** 63M/F, 70, 95M, 95M, 95M/F, 95M/F, **107F**, 108M/F, 108M/F	22	6	-	16	00

Correlate	Related to PA	Assoc. (+ or -)	Unrelated to PA	# Samples	Summary (n)			
	Biblio. no.		Biblio. no.		+	-	0	Assoc
Support (logistic) from parents (transports child to play, plays with child, pays fees	5F, 22F, **107M, 107M**, **107M**, 108M/F, 108M, 144, 144	+	5F, 22F, 63M/F, 63M/F, 70, **107F**, **107F 107F**, 108F, 108M/F, 108M/F, 112MI/FI	28	10	1	17	00
Support/encouragement from significant others (family, peers, teachers)	112MI/FI, 113MI/FI,V, 115, 115, 120, 124M	+	41, 97, 97, 109, 113MI,II,V/FI,II,V, 113MII,V/FII, 124F	24	9	-	15	0?
Social norms (value/enjoyment of PA of significant others - parents, siblings, peers)	25, 75M/F, 75M/F, 134M,134M, 150	+	25, 25, 41, 84M/F, 97, 100, 112MI/FI, 112MI/FI, 124M/F, 129, 129, 134F, 134F	25	8	-	17	00
Economic								
Parental SES	27F, 27M/F, 32, 72, 88, 95F, 122 58	+ -	27M, 27M/F, 32, 71, 72, 95M, 95M/F, 103, 109, 119, **137**	22	8	1	13	0?
Parental occupational status	**148FI** 19	+ -	123, 148MI/FI, **148MI**	6	1	1	4	0
Father occupational status			**11M/F**, 95M/F, 95M/F	6	-	-	6	0
Mother occupational status	**11F**, 56M/F	+	**11M**, 95M/F, 95M/F	7	2	-	5	0
Parental education	63M, 112MI 108F	+ -	37, 37, 37, 63F, 96, 103, **107M/F**, 108M, 38, 46, 108M/F, 112FI, 113MI,II,V/FI,II,V, **137**	24	2	1	21	00
Father's educational level	56M/F, 95F, 148MI, **148MI** 57	+ -	95M, 95M/F, 148FI, **148FI**	11	5	1	5	??
Mother's education level	148MI	+	19, 46, 95M/F, 19, 46, 95M/F, 131MI,II/FI,II, 148FI	12	1	-	11	00
# hours parents work		+	95M/F, 108M/F, 108M/F, 150	7	-	-	7	0
House owned			19	1	-	-	1	N/A
Political								
Parenting styles (PA rules, control)	109, 109	-	43, 109, 112MI/FI	6	2	-	4	0

	Correlate	Related to PA	Assoc. (+ or -)	Unrelated to PA	# Samples	Summary (n)			
		Biblio. no.		Biblio. no.		+	-	0	Assoc
Educational Institutions (Schools,…)	**Physical**								
	Distance (from home)	150	-		1	-	1	-	N/A
	Availability of PA equipment			81	1	-	-	1	N/A
	Socio-Cultural								
	Teacher's PA			100	1	-	-	1	N/A
	Teacher's attitudes toward PA			100	1	-	-	1	N/A
	Teachers specific education level	28, 100	+		2	2	-	-	N/A
	Economic								
	School type attended (public vs. private; nursery vs. day care)	19, 100	+		2	2	-	-	N/A
	Political								
	Support from community PA organizations			28	1	-	-	1	N/A
	PA related policies (e.g. time allowed for free play/spent outside, # field trips)	28, 81, 96	+	28, 28	5	3	-	2	+
	Class size	28	+		1	1	-	-	N/A
	School quality			28	1	-	-	1	N/A
Neighbourhood	**Physical**								
	Distance to destinations	58	-		1	-	1	-	N/A
	Access/availability to PA facilities/ programs	41, 109, 131FII	+	5F, 5F, 30F, 30F, 131MI,II/FI,II, 131MI,II/ FI, 113MI,II,V/FI,II,V	20	3	-	17	00
	Available shelters/foot path conditions			150, 150	2	-	-	2	N/A
	Time spent outdoors	10, 70, 81, 109, 109	+		5	5	-	-	+

Correlate	Related to PA	Assoc. (+ or -)	Unrelated to PA	# Samples	Summary (n)			
	Biblio. no.		Biblio. no.		+	-	0	Assoc
Neighbourhood hazards (e.g. many roads/no lights crossings; heavy traffic; physical disorder; pollution)	123 58, 131MII, 131MII, 131MI	+ -	58, 88, 113MI,II,V/FI,II,V, 150, 131MI/FI,II, 131MI/FI,II 131MII/FI,II, 150	24	1	4	19	00
Neighbourhood physical disorder			88	1	-	-	1	N/A
Limited public transport	131FI,II	-	131MI,II	4	2	-	2	?
Social								
Neighbourhood social disorder	88	-		1	1	-	-	N/A
Involvement in community PA organizations	132, 134M, 134M	+	**11M/F**, 132, 134F, 134F	8	3	-	5	0
Length of residence in community	30F	+	30F	2	1	-	1	N/A
Safety	88	-	5F, 5F, **107M/F,** 113MI,II,V/FI,II,V, 131MI,II/FI,II, 150	16	-	1	15	00
Economic								
Neighbourhood SES/education level	143F 64, 64	+ -	30F, 30F, 88, 143M,	6	1	2	3	0
MACRO ENVIRONMENT								
Physical								
Urban vs. suburban	21	-	66	2	1	1	-	N/A
Urban vs. rural	27M/F, 56M/F, 66, 72, 72, 118 27M/F, 27M/F	+ -	46, 57, 85, 86M/F	17	8	4	5	??
Coastal vs. mountains	46	-		1	1	-	-	N/A
Season (spring, summer)	**42**, 51, 100, **118** 10&31, **118**	+ -	21, 37, 37, 37	10	4	2	4	??

Biblio. no., reference number under the *Bibliography* section; Assoc., association; +, positive; -, negative; 0, no relation; ?, indeterminate; N/A , summary code not applicable because the number of independent samples investigating the relationship is below 3; PA, physical activity; M, boys only; F, girls only; SES, social-economic status; studies with prospective study designs are highlighted in bold.

adolescents' PA as were indicators of acculturation. Modeling of PA from parents, siblings and friends were extensively examined (in 149 independent samples). Overall, all these studies found no relevant associations. However, this lack of associations was somewhat undetermined with regard to father's PA levels and those from significant others, since they were observed in less than 60% of the cases. Studies investigating potential familial influences other than modeling were also numerous (a total of 127 independent samples) but mostly unrelated to adolescents' PA. However, a trend toward a positive association was found with regard to general support from significant others. The relationship between the *economic environment* of adolescents' home/family and their PA levels was examined in 100 independent samples. Studies in which parental SES was defined as a composite of parent's education and income levels/occupational status were generally unrelated to children's PA. However, studies in which the specific association between parent's education levels was analyzed separately from parent's occupational status or income level revealed that higher mother's education levels and family (per capita) income were positively associated with PA; occupational status of the household's head emerged as an undetermined correlate of PA. With regard to the *political environment,* parenting styles were unrelated to adolescents' PA.

Potential determinants at the school level

Similarly to what we have described in children, aspects of the school physical, socio-cultural, economic or political environment were studied relatively seldom in adolescents. Regarding the *socio-cultural environment*, role modeling and support from teachers were generally unrelated to adolescents' PA, whereas the existence of problems with (or teasing from) classmates was undetermined. Finally, the type of school attended, namely high- vs. vocational school, was positively, whereas the provision of instruction on PA or sport-related health benefits and special Physical Education programs and/or school sports, were unrelated to adolescents' PA.

Potential determinants at the neighborhood level

A total of 92 independent samples have examined associations between environmental characteristics at the neighborhood level and PA levels of adolescents. Although we have identified a wide range of potential correlates at the physical, socio-cultural and economical level, only few were examined in more than 3 independent samples. Among these, and within the *physical environment*, the availability and/or accessibility of PA equipment or facilities, was unrelated to PA. Within the *socio-cultural environment*, crime incidence (measured objectively) was inversely associated with adolescents' PA in 2 out of the 3 studies available, a finding that was at odds with the lack of association between adolescents' PA and neighborhood safety estimates perceived by them.

Potential determinants at the city/municipality and region/country level

Only few studies have investigated differences in PA levels between adolescents' residence location. Residence in urban vs. rural regions was not associated with adolescents' PA levels; seasonal 'effects' on adolescents' PA were undetermined; and exposure to or interest in sports media was not associated with adolescents' PA.

DISCUSSION

Overall, the current review of the literature on environmental correlates of PA in children and adolescents provided us with a broader and more detailed overview of the specific research performed through the course of the past 25-years. In the past 5 years in particular an increased attention to this field was observed, that may reflect a paradigm shift from intra-personal to ecological conceptual models in the study of health-related behaviors such as PA.

Updating the previous review: current *vs.* previous findings

We have updated the review of Sallis *et al.* by merging 51 of its original studies (those reporting on environmental potential determinants of PA, as defined in the present study) with 99 additional publications; twenty-three of the 99 additional studies had not been included in the previous review although they were published within the same period covered by it (1970-1998); interestingly half of those studies (12 out of 23) were performed in Europe, a region that may have thus been under-represented in that review. With regard to the main findings, a comparative summary between the two reviews is presented on Table 4.4; in children, time spent outdoors remained a main correlate of children's PA, although this was due to the fact that no additional studies in this regard were included in the present review. The correlates of children and adolescents' PA that have emerged in the present review differ considerably from those in the previous review. Overall, we can argue that the additional publications of which 76 were published in the last 5 years), have thus contributed significantly to a better understanding of factors associated with the PA behaviors of children and adolescents, and have led to the identification and addition of new potential determinants to the body of knowledge in the field. However, the fact that the associations coded and summarized in our review were those derived, whenever possible, from multivariate rather than from univariate analyses may also have contributed to the differences between the two reviews. The previous review, which drew exclusively from univariate models may have thus been somewhat inflated (since significant correlates are generally more abundant in univariate analyses).

Table 4.3 Summary of correlates of physical activity among adolescents (13 to 18 year olds)

Correlate	Related to PA	Assoc + or -	Unrelated to PA	N Samples	Summary (%)			
	Bibliography no.		Bibliography no.		+	-	0	Assoc.
MICRO ENVIRONMENT								
Physical								
Access/availability of PA equipment	18F, 18F, 33 24F	+ -	18F, 23M/F, 23M/F, 24M, 24M/F, **26M/F**, **93F, 93F 133M/F, 133M/F**	20	3	1	16	00
Socio-Cultural								
Single-parent family	29, 76, 113MIV 76, 130	+ -	45M/F, 61M/F, 67M/F, 76, 112MII,III/ FII,III, 113MIII,VI/FIII,IV,VI, 128, 142M/F	24	3	2	19	00
# household residents/children			61M/F, 113MIII,IV,VI/FIII,IV,VI, 142M/F, 149M/F	12	-	-	12	00
Acculturation (adolescent/ parent born abroad; generation of residence in country)	**45F**, 52	+	**45M**, 52, 53, 116F	6	2	-	4	0
Parents' PA	33, 54, 98, 99, 142M/F	+	17F, 26M/F, 68, 79M/F, 79M/F, 90M/F, 90M/F, 112MII,III/FII,III, 113MIII,IV,VI/FIII,IV,VI, 135, 149M/F	31	6	-	25	00
Father's PA	23M, 24F, 48I, 49, 98, 105, 110II, 140, 140, 141, 142M/F, **148MII,III**	+	3M/F, 23F, 23M/F, 24M, 24M/F, 48II, 48II, 49, **133M/F, 133M/F, 148FII,III**	31	14	-	17	0?
Mother's PA	3F, 23F, 48I, 49, 98, 106F, 110II, **133F,** 142M/F, **148FII,III**	+	3M, 23M, 23M/F, 24M/F, 24M/F, 26M/F, 48II, 48II, 49, 105, **133M, 133M/F**, 140, 141, **148MII,III**	33	12	-	21	00
Sibling's activity	3M/F, 98, 99, 110II, 141		23M/F, 23M/F, 24M/F, 24M/F, 110II, 140, 140, 141	18	6	-	12	00
Friend's PA	24M, 33, 116F, 140, 140	+	17F, 23M/F, 23M/F, 24F, 24M/F, **133M/F, 133M/F**, 141, 149M/F	20	5	-	15	00

Home/household

Correlate	Related to PA	Assoc + or -	Unrelated to PA	N Samples	Summary (%)			
	Bibliography no.		Bibliography no.		+	-	0	Assoc.
PA from significant others (parents, friends, other adults)	8M/F, 9, 18F, 24M, 102F, 126M	+	14, 18F, 18F, 24M/F, 24F, 102M, 126F, 141	16	7	-	9	0?
Support/encouragement from parents	8M/F, 18F, 18F, 29, 44M, 61M/F, 68, 79M/F, 79M/F, 90F, 112MII,III/FII,III, 112MII,III, 113FIII, 114F, 114F, 135, 139, 149F	+	17F, 18F, 18F, 18F, 18F, 44F, **45M/F,** 90M, 90M/F, 90M/F, 90M/F, 101, 101, 101, 113MIII,IV,VI/FIV,VI, 112FII,III, 149M	52	26	-	26	??
Support/encouragement from friends	44F, 83, 101, 113MIII,VI, 149M	+	17F, 44M, 101, 113MIV/FIII,IV,VI, 139, 149F	15	6	-	9	00
Support/encouragement from significant others	8M/F, 12, 14, 18F, 18F, 24F, 24F 44M/F, 93F, 114F, 114F	+	18F, 24M, 24M, 60, 93F, **133M/F, 133M/F,** 139	18	12	-	10	+?
Social norms (value/enjoyment of PA of significant others - parents, siblings, peers)	9, **26F,** 47, 47, 48I/II, 80M/F, 80M/F, 87M, 91F, 91F, 112FIII, 123, 127M/F	+	8M/F, 16M/F, 16M/F, 17F, 26M, 47, 68, 68, 69, 79M/F, 87F, 112MII,III/FII, 112MII,III/FII,III, 114F, 114F, 123	42	17	-	25	0?
Economic								
Parental SES	9, 12, 18F,18F, 121, 145, 147	+	4M/F, 7M/F, 7M/F, 17F, 18F, 48II, 76, 76, 76, 128	19	7	-	12	00
Occupational status of household head	**45F**, 65M/F, 73, 140	+	**45M**, 67M/F, 140, 141	10	5	-	5	??
Father's occupational status	54, 94I, 136	+	**2M/F**, 94II, **148MII,III/FII,III**, **148MII/FII**	12	3	-	9	00
Mother's occupational status	**2M**, 94I	+	**2F**, 94II, 136	5	2	-	3	0
Parents' educational level	74, 77, 112MIII, 117F, 142M/F	+	61M/F 112MII/FI,II,III, 113MIII,IV,VI/FIII,IV,VI, 117M	19	6	-	13	00
Father's educational level	136	+	48II, **148MII,III/FII,III**, **148MII/FII**	8	1	-	7	0

Correlate	Related to PA	Assoc + or -	Unrelated to PA	N Samples	Summary (%)			
	Bibliography no.		Bibliography no.		+	-	0	Assoc.
Mother's educational level	53, 92, 136	+	48II, 116F	5	3	-	2	+
Family (per capita) income	29, 53, 74, 77, 142M/F	+	50M/F, 60, 73	10	6	-	4	++
# parents working full time	117M	+	117F	2	1	-	1	N/A
Adolescent's paid work/pocket money	34M/F, 83, 141	+	53, 116F, 125, 149M/F	9	4	-	5	0?
Political								
Parenting styles (authoritative; PA rules)	87M, 117M, 90M	-	87F, 90F, 117F, 90M/F, 112MII,III/FII,III	12	3	-	9	00
Physical								
School facilities/resources	33	+		1	1	-	-	N/A
Socio-Cultural								
Main teacher's/coach PA	90M	+	90M/F, 90F, 140, 140, 141, 149M/F	9	1	-	8	0
Support from teacher/coach	**45M**, 83, 149F	+	**45F**, 149M/F, 149M	7	3	-	4	0?
Classmates problems/teasing	**45F, 45F**	-	**45M, 45M**	4	2	-	2	?
School support			44M/F, 83	3	-	-	3	0
Relationship with PE teacher			33	1	-	-	1	N/A
Economic								
Public vs. private school	34M/F	-		2	-	2	-	N/A
Political								
School type (high school vs. vocational/alternative)	1M/F, 2M/F, 7M/F, 55, 55, 55, 55 **40M**	+ -	7M/F, 40F, 55	15	10	1	4	++
School provide (special) PE program/sport teams	53	+	36, 133M/F, 133M/F	6	1	-	5	0

Education Institutions (childcare, schools)

Correlate	Related to PA	Assoc + or -	Unrelated to PA	N Samples	Summary (%)			
	Bibliography no.		Bibliography no.		+	-	0	Assoc.
Instruction on sport/health benefits	140	+	140, 141, 141	4	1	-	3	0
Physical								
Distance to PA facilities	50M	-	50F	2	1	-	1	N/A
Access/availability to PA equipment/facilities/programs	33, 44M/F, 61M/F, 61M/F, 61F, 61M/F, 113FVI 29, 29	+ -	17F, 23M/F, 23M/F, 24M/F, 24M/F, 61M/F, 90M/F, 112MII,III/FII,III, 113MIII,IV,VI/FIII,IV,VI, 113MIII,IV,VI/FIII,IV, 125, 149M/F, 61M	45	11	2	32	00
Level of urbanization			74	1	-	-	1	0
Dogs unattended			90M/F, 90M/F	4	-	-	4	0
Socio-cultural								
% married couples			67M/F	2	-	-	2	N/A
% youth			67M/F	2	-	-	2	N/A
Neighbourhood exercisers			90M/F, 90M/F, 149M/F	6	-	-	6	0
Social disorganization			74	1	-	-	1	N/A
Ethnic minority concentration			74	1	-	-	1	N/A
Crime incidence	50F, 53	-	50M	3	-	2	1	-
Safety	50F	-	50M, 90M/F, 90M/F, 113MIII,IV,VI/FIII,IV,VI, 149M/F	14	-	1	13	00
Economical								
SES			74	1	-	-	1	N/A
% upper occupational status			67M/F	2	-	-	2	N/A
% owner occupied housing	67F	+	67M	2	1	-	1	N/A

Correlate	Related to PA	Assoc + or -	Unrelated to PA	N Samples	Summary (%)			
	Bibliography no.		Bibliography no.		+	-	0	Assoc.
% dwellings provided by employer			67M/F	2	-	-	2	N/A
% unemployment among residents	67F	-	67M	2	-	1	1	N/A
Length of unemployment			67M/F	2	-	-	2	N/A
MACRO ENVIRONMENT								
Physical								
Urban vs. suburban	67F	-	67M	2	1	-	1	N/A
Town size	73	+		1	1	-	-	N/A
Urban vs. rural	140	+	35F, 53, 140, 141	5	1	-	4	0
Season	20II, 138I		53, 138II	4	2	-	2	?
Unsuitable weather	**20I**		125	2	1	-	1	N/A
Socio-cultural								
Exposure to/interest in sports media	62, 62	+	17F, **26M/F**	5	2	-	3	0
Wanting to look like media figures	127M/F	+		2	2	-	-	N/A

City/Municipality/Region

Biblio. no., reference number under the *Bibliography* section; Assoc., association; +, positive; -, negative; 0, no relation; ?, indeterminate; N/A , summary code not applicable because the number of independent samples investigating the relationship is below 3; PA, physical activity; M, boys only; F, girls only; SES, social-economic status; PE, physical education; studies with prospective study designs are highlighted in bold.

Home/family correlates of children's and adolescents PA levels

Characteristics of the home environment, particularly those related to parental influences, were by far the most explored in the literature, in both children and adolescents.

Parents as roles models

Research findings regarding the relationship between PA levels of parents and those of their children have been mixed. Most of the studies have in fact failed to find any association. Nevertheless, fathers appear to be more important role models as compared to mothers, especially in childhood; fathers' PA may be related to their child's PA regardless of their gender, whereas mothers' PA appears to be more often associated with girls' rather than boys PA; however, parents' PA has been generally unrelated to children's future PA levels (as could be ascertained by the few prospective studies examining this issue).

In samples of children, parental PA levels were almost always assessed by the parents themselves (self-reports) whereas in the adolescent samples they were assessed by both adolescents' reports ('perceived' parental PA levels) and parents' self-reports. It is thus possible that differences in the agent reporting on parental PA levels (parent vs. offspring) may explain some of the lack of associations found. Indeed, there is some evidence that a low agreement exist between parents and children reports with regard to the levels of parental PA [59] and we have noticed that associations between PA of mothers or fathers and those of their offspring (adolescents) tended to be more often positive when the mothers or fathers reported their own level of PA (Table 4.5).

Parental support, encouragement and beliefs

It has been hypothesized that the support and encouragement parents provide, rather than their own PA behavior, may influence the PA behavior of their offspring. In the present review, these potential influences could not be clearly found, particularly among children; however, as many studies have shown parental support to be positively or not to be associated with PA levels of adolescents. Taken together, these findings lend some support to the view that parents may need to be more than just active role models if their child is to lead a physical active lifestyle [32, 60]. This is supported by several (school-based) risk-reduction programs that have included and evaluated (generally positively) parental involvement as a means to enhance program effectiveness (e.g. The San Diego Family Heart Project [61]; the Children and Adolescent Trial for Cardiovascular Health (CATCH I and II) [62, 63]; The Minnesota Home Team [64, 65]).

Parental Socioeconomic status (SES)

Parental/family SES is associated with a wide array of health, cognitive and socio-emotional outcomes in children, throughout their development from (even before) birth to adulthood

Table 4.4 Comparative summary of the main environmental correlates of physical activity in children and adolescents: earlier *vs.* current review

Children		Adolescents	
Previous Review	Current review	Previous Review	Current review
Program /facility access (+)	Father's PA (+?)	Support from significant others (++)	Support from significant others (+?)
Time spent outdoors (+)	School PA-related policies (+)	Parent support (++)	Mother's education level (+)
	Time spent outdoors (+)	Sibling PA (++)	Family income (++)
		Direct help from parents (+)	Non-vocational school (++)
		Opportunities to exercise (+)	Neighbourhood crime incidence (-)

PA, physical activity; +, positive association; -, inverse association; ?, indeterminate.

[66, 67]. In the studies reviewed herein, several measures of SES have been used, most including some quantification of family income, parental education and occupational status (or a combination of these). Mother's education level and family income emerged as independent correlates of adolescents' (but not children's) PA levels. These findings not only emphasize the need to disentangle such aspects as education, occupational status and income levels, but suggest also that on reaching adolescence and young adulthood, those who have lower income may be more restricted in their PA choices and opportunities. In younger children, PA is mostly of informal nature, and may therefore not involve much extra financial cost. Possibly, with increasing age participation in physical activities becomes more elaborate and financial costly (e.g. sport clubs fees), which may reduce the likelihood of PA in adolescents from lower income families [68]. This needs further investigation.

School influences on children and adolescents' PA

Schools offer many opportunities for young people to engage in physical activities, such as Physical Education classes, recess periods, extracurricular sports or PA programs, leisure time free use of its playing fields and playgrounds. Schools have also the personnel who, with sufficient training and commitment can define and deliver PA programs and policies that support the adoption of healthy lifestyles. The literature showing that well-designed and well implemented school-based programs can improve PA of young people is paramount [69-71] and guidelines for school programs to promote lifelong PA actually exist [72-74]. Despite this, little research has investigated specific features of the school environment that impact on youth PA. Indeed, although most studies reviewed herein, have recruited their target populations from school settings, aspects of the school physical, socio-cultural, economic or political environment, remained however relatively unexplored. Most of the

Table 4.5 Analyses of the review findings regarding the association between physical activity (PA) levels of parents and their offspring (adolescents) according to the agent reporting on parental PA levels

	Association		Chi-squared (P value)
	+	0	
(a) studies examining parental associations (total of 31 independent samples)			
Assessment of parents' PA			
Parent self-report	4 (98, 99, 142M/F)	16 (68, 79 M/F, 79M/F, 112 MII,III/FII,III, 113MIII,IV,VI/FII,III)	0.02 (0.90)
Perceived by the child	2 (33, 54)	9 (17F, 26M/F, 90M/F, 90M/F, 149M/F)	
(b) studies examining paternal associations (total of 31 independent samples)			
Assessment of father's PA			
Father's self-report	7 (98, 105, 110II, 142M/F, 148 MII,III)	4 (3M/F, 148 FII,III)	2.35 (0.13)
Perceived by the child	7 (23M, 24F, 48I, 49, 140, 140, 141)	13 (23F, 23M/F, 24M, 24M/F, 48II, 48II, 49, 133M/F, 133M/F)	
(c) studies examining maternal associations (total of 33 independent samples)			
Assessment of mothers' PA			
Mother's self-report	7 (3F, 98, 110II, 142M/F, 148FII,III)	6 (3M, 26M/F, 105, 148MII,III)	2.83 (0.09)
Perceived by the child	5 (23F, 48I, 49, 106F, 133F)	15 (23M, 23M/F, 24M/F, 24M/F, 48II, 48II, 49, 133M, 133M/F, 140, 141)	

Data are number of independent samples (bibligraphy #).

characteristics of the school environment identified were almost never tested in more than 10 and often in less than 3 independent samples. Despite this, the present review has identified '*school policies related to PA*' to be positively associated with children's PA and '*school type*' (i.e. attending high- rather than vocational-schools) to be a positive correlate of adolescent's PA.

Additionally, we have identified an interesting set of studies that have investigated PA levels of classes/groups of youngsters in the context of PE lessons or recess time. One study

found that: classes of children taught by PE specialists (as compared to generalists) received longer as well as more very active lessons, leading to higher energy expenditure rates; outdoor lessons generated more time spend in vigorous activities and higher total energy expenditures than indoor classes [75]. In another study, school size, length of recess and the availability of balls in the playground were identified as additional correlates of higher engagement in physical activities by children [76]. In adolescents, teacher's specialty and gender were not associated with classes PA levels, neither was the location where the lesson were taught; the only significant correlates were class size and lesson specific context (fitness activities; free play, game play and skill drills; management time, and knowledge) (inversely associated with class PA) [77]. Another study found that, despite the availability of the PA facilities, they were used by very few students during their leisure time at school (i.e., before and after school classes, and lunch break) [78]. These findings were then further explored and followed by the observation that not only the availability of PA facilities, but its size and state of conservation, and particularly the existence of supervision/organized activities, were decisive of adolescents' engagement in physical activities during their leisure time at school [79]. These findings and those of the present review, together with the observation that many schools are not providing enough time for physical activities [80, 81], emphasize the important role school's environments may play in children and adolescents PA levels [74, 82]. Further, school-based PA may represent an important equalizing factor for opportunities for PA in children and adolescents of different SES backgrounds [83].

Neighborhood influences on children and adolescents' PA

Recently, the importance of neighborhood physical and socio-cultural characteristics in shaping PA of individuals has been increasingly investigated, but relatively few studies in the current review had already addressed these possible associations. Among these studies, features of the physical environment (also commonly referred in the literature as the 'built environment'), in particular the availability and accessibility to PA equipment, facilities or programs were investigated more often, but were generally unrelated to youth PA. The present review identified time spent outdoors to be positively associated with children's activity levels; in adolescents, crime incidence, as measured through objective police reports, was inversely associated with adolescents PA levels, a finding that apparently contrasted with the lack of association between perceived neighborhood safety levels and adolescents PA. This contradiction suggests that the differential associations with youth PA may depend on the method assessment (perceived vs. objective) of environmental characteristics. Which features are more important remains unknown, an issue that therefore deserves further investigation within the same population (see methodological considerations below).

The importance of understanding neighborhood effects on health-related behaviors rely on their potential to influence large populations [84, 85]. Although researchers are start-

ing to address the potential effects of communities and neighborhoods in individuals' PA behavior, few empirical studies have determined, using appropriate multilevel statistical techniques, whether relations between the environment and PA actually exist at the neighborhood rather than the individual level [86, 87].

Methodological considerations

Measurement of PA and environmental characteristics

The selection of the an appropriate instrument depends on the specific research question(s) to be addressed and on an 'accuracy-practicality' trade off' [88-90]. The majority of the research on the potential determinants of PA reviewed herein relied on (parental or child/adolescent) self-reports, which included diaries and recall instruments; these methods may pose serious limitations since they provide less accurate estimates of PA levels than those obtained by more objective methods such as direct observation, motion sensors, heart rate monitors, and doubly-labeled water [91]. In addition, because the degree of the relationship between objectively and self-report measures of PA is only moderate, notably among self-report methods with 'acceptable' validity [92], there may be a substantial amount of variance not shared by the two methods; in other words, different instruments (objective vs. self-report) may have measured different aspects of the PA behavior, and therefore those measures are not interchangeable. As such, the correlates of PA may also differ as a function of the method used to measure the behavior, thereby impairing the generalization of the findings obtained with the use of one or the other method [93]. In the present review we were able to identify seven publications (10 independent samples – 3 in children and 7 in adolescents; all with a cross-sectional design) which enable a more close examination of this issue, by providing self-report and objective data in the same samples (Table 4.6). In these studies, the magnitude of the associations between the two measures of PA was at the most moderate. Furthermore, clear discrepancies between correlates of objectively measured and self-reported PA levels were found. Several factors may explain these discrepancies: the proposed correlates investigated in each study may have more explanatory power for self-reported measures (e.g. # of vigorous activities) than for total PA levels (mostly computed by the objective measures); in addition, accelerometers, the most frequently used objective measure, are unable to access common activities such as bicycling riding and swimming that could have been (self-) reported, but pick-up incidental physical activities throughout the day, which in turn could have been forgotten on self-reports that usually refer specifically to intentional physical activities; finally, there may be a shared method variance between self-reported PA and self-reported potential determinants, which then leads to an inflated association between the two.

Furthermore, self-reports of environmental factors represent *perceived* rather than *'real'* features of the physical, socio-cultural, economic and political environments. Little is know

about the accuracy of such perceived features [94]. In adults, some studies have shown objective environmental measures to be associated with PA whereas the same features measured through self-reports where not [95, 96].

Limitations of study design and data analyses methodologies

The studies incorporated in the present review had mostly a cross-sectional design and therefore their findings were limited in that only association could be established and not prediction or causation. Nevertheless, all those cross-sectional studies have interpreted the results as if 'causality' existed and to be uni-directional (e.g., parents may influence their children). It is of course possible that reverse or reciprocal influences are operative as well (e.g., children influence their parents), an issue that needs to be further explored.

In an attempt to disentangle the information provided by prospective from cross-sectional studies we have highlighted those studies in tables 4.2 and 4.3. However, their low number does not enable solid conclusion with regard to the potential environmental predictors of PA change.

The main question of how such environmental features influence youth PA remained further largely unanswered due to the data analytical methods used. Conceptually, environmental influences can play a direct role in shaping PA behavior or can be mediated by cognitive processes [97-99]. In order to understand these mechanistic processes better data analytical methods (and study designs) are needed (for details see Bauman et al. [100]). The majority of the findings reviewed herein were those that resulted from adjusted models (most often, for potential confounders such as age, sex, and ethnicity, but in many studies for potential mediators such as self-efficacy and attitudes), and thus concern the independent contribution of environmental characteristics in the explanation of PA behavior.

Further, although most of the data included in the present review have an intrinsic multilevel structure, they were most frequently analyzed as obtained in simple random samples of a single population. As such, the potential inter-dependence within clusters (e.g. schools and/or neighborhoods) has been ignored, which can have led to inflated estimation of the associations, and multilevel or hierarchical analytic approaches are thus needed.

Limitations of the present review

We acknowledge several limitations of our current review. First, the search terms used to retrieve studies from existing databases may have not been sensitive enough. This is sustained by the fact that almost half of the studies included in this review were found through the literature sections of articles primarily retrieved in those databases. This may have been due to the fact that some articles included are simply not registered within those databases, and/or in many articles retrieved, environmental correlates of children/adolescents' PA were not the primarily research goal but were embedded within a broader (i.e. health-enhancing be-

haviors in general) or related research question. Nevertheless, better search terms may still need to be defined. However, the vast amount of studies included suggests we have covered the existing literature in a quite satisfactory way. Second, the use of only English published data may have discarded some studies that could have added relevant information into the field. Third, the main outcome was any form of PA. In most studies this was measured across several settings (e.g. the total amount of moderate-to-vigorous PA, performed at school and during leisure time – either at home or in the neighborhood, or in sport clubs, accumulated throughout the day or the past week), not enabling us to determine the specific environmental correlates of specific physical activities. Fourth, the conceptual framework we have used may have led to disputable categorizations of the correlates of PA investigated.

Conclusions, implications and recommendations

Clearly, many factors influence the complex behavior of youth PA. We have identified father's PA habits, school PA-related policies and time spent outdoors as potential determinants of PA in children; in adolescents, such potential determinants were support from significant others, mother's education levels, family income, attendance of a non-vocational school and low neighborhood crime incidence have emerged as potential determinants of adolescents' PA. These variables need to be target by multi-level interventions aiming at the increase of youth PA. The other variables, however, should not be discarded without further investigation, namely those whose associations with PA were undetermined or not possible to infer from the limited number of existing studies (particularly those at the neighborhood and school settings as well as at the macro-environment level).

Future studies that use prospective or intervention designs enabling the analyses of whether the environment-PA behaviors of children and adolescents associations are casual and which (if any) cognitive processes may mediate or contextual variables may moderate such associations, are in great need. In addition, it is important to conduct future research with clear, possibly standardized definitions and objective methods of environmental attributes and PA behavior assessment, within the strongest study design possible.

Table 4.6 Determinants of objective vs. self-report measured physical activity - summary of findings

Bibliography no.	Method of Physical Activity (PA) Assessment			Environmental correlates of PA*	
	Objective	**Self-report**	**Correlation between PA assessed by the 2 methods**	**Objective**	**Self-report**
23	Heart-rate monitoring (1 week – time spent in moderate-to-vigorous PA, >140 beats min^{-1})	Recall of PA and sport participations (1 week; hours)	*'not associated'* (estimate size not reported)	Father's PA (M)	Mother's PA (F)
24	Heart-rate monitoring (1 week – time spent in moderate-to-vigorous PA, >140 beats min^{-1})	Recall of PA and sport participations (1 week; hours)	*'not associated'* (estimate size not reported)	-	Father's PA (F) Friends' PA (M) Parental encouragement (F) Parental support (F) Home equipment (F)
32	Accelerometer (2 week days + 1 weekend day); METs	Frequency, duration and types of PA (2 week days + 1 weekend day; (METs)	r=0.46	Parental PA Parental SES	-
39	Accelerometer (2 weekdays + 1 weekend day; counts d^{-1})	Frequency, duration and types of PA (2 week days + 1 weekend day; (METs)	r=0.39 (Light PA) r=0.35 (moderate-to-high intensity PA)	Father's PA Mother's PA	Father's PA Mother's PA
90	Accelerometer (up to 8 d; counts h^{-1})	PA Record of hard and very hard intensity PA (7 d; h $week^{-1}$)	*'Not associated'* (estimate not reported)	Teacher's PA (M) PA rules (M)	Parent transports child to PA location (F)
101	Accelerometer (5-day period; min d^{-1})	Participation in PA for ≥60 min (PACE+) (past week; d $week^{-1}$)	r=0.46	-	Parent support Peer support
110	Accelerometer (1 week day + 2 weekend days); score	Recall checklist of PA performed for at least 15 min (1 week day + 1 weekend day; score)	? (Not reported)	Parental education (F) Single-parent status (M)	Parent transports child to PA location (F) Parent plays with child (M)

* Only the environmental variables that were correlated with physical activity levels measured either by one or the other method are reported (i.e., listed variables do not cover all the variables investigated in each study).
PA, physical activity; M, boys only; F, girls only; SES, socioeconomic status.

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Part III Socio-demographic correlates of energy balance-related behaviors

5 Gender, ethnic and school type differences in overweight and energy balance-related behaviors among Dutch adolescents

van der Horst K, Oenema A, te Velde SJ, Brug J. Gender, ethnic and school type differences in overweight and energy balance-related behaviors among Dutch adolescents.

International Journal of Pediatric Obesity 2009, May 15:1-10. [Epub ahead of print].

ABSTRACT

Objective: The aim of this study was to investigate gender, ethnic and school type differences in overweight and energy balance-related behaviors: snack, soft drink and breakfast consumption, walking, bicycling, and playing sports during leisure time, active commuting to school, television viewing and computer use among 12- 15- year-old adolescents.

Methods: Cross-sectional data on weight status and energy balance-related behaviors were obtained from 1206 adolescents (2005-2006). Energy balance-related behaviors were self-reported and body mass index was calculated from measured height and weight. Gender, ethnic and school type differences in weight status and behaviors were examined with multi-level logistic regression analyses.

Results: Overweight and unfavorable energy balance-related behaviors were more likely among youth from non-Western ethnic backgrounds and those attending vocational schools. Analyses stratified by ethnicity showed that girls from non-Western ethnic backgrounds were more likely to be overweight (OR=1.5) and to report not bicycling (OR=2.4) and watching more than two hours of television (OR=2.3) compared to boys from non-Western ethnic backgrounds. Vocational students from Western ethnic backgrounds were more likely to report high levels of soft drink consumption (OR=3.2), watching television (OR=2.9) and computer use (OR=2.1) compared to higher-level education students from Western ethnic backgrounds.

Conclusions: The study findings indicate important ethnic and educational differences in overweight and energy balance-related behaviors. Future research should focus on what kind of interventions work and for which target groups they work, taking demographic variables such as gender, ethnicity, school type into account.

INTRODUCTION

To curb the obesity epidemic, it is important to identify and target adolescents at risk for overweight and obesity. Because obesity persists into adulthood [1] and is associated with severe health consequences [2], a detailed understanding of risk behaviors related to the development of obesity is essential to developing preventive interventions. It is also important to identify specific target groups of adolescents who are more at risk of becoming obese by engaging in more (or specific) obesity-related risk behaviors. Being able to distinguish specific target groups provides the opportunity to better tailor interventions to the needs and perceptions of those most at risk [3]. Recent overviews have suggested a range of specific energy balance-related behaviors (EBRB, i.e. behaviors that contribute to energy intake or expenditure) that may contribute substantially to a higher or lower risk for unnecessary weight gain [4-6]. Currently, there is insufficient insight into the occurrence of a number of overweight risk behaviors among adolescents and whether it is possible to distinguish specific subgroups that are more likely to engage in specific risk behaviors for overweight and obesity.

Earlier evidence points out that the prevalence of overweight is considerably greater among youth from racial or ethnic minority backgrounds [7-9]. In addition to genetic, economic and environmental factors, ethnic disparities in overweight and obesity are likely due to differences in EBRB [10, 11]. Studies conducted in different countries indicate that ethnic minority groups participate less in physical activity, spend more time watching television [5, 12-14], are less likely to eat breakfast regularly [13], consume soft drinks and savory snacks and visit fast-food restaurants more often [15], but also have higher fruit intakes [16]. The higher rates of overweight among ethnic minority groups might be explained in part by their lower educational levels. Educational level has also been found to be an independent determinant of overweight [17] and to be associated with adolescent health behavior such as physical activity [18]. Furthermore, differences have been found between boys and girls in overweight and obesity and related risk behaviors, with girls being more likely to be overweight [9, 19, 20] and to engage in less physical activity [14, 21].

Although most of the previous studies examined single behaviors, it is most likely that a number of risk behaviors contribute to an increased risk for overweight. Therefore, we examined how overweight and specific unfavorable EBRB (high soft drink intake, high snack consumption, not eating breakfast on a daily basis, high amounts of television viewing and computer use, little participation in sports, little walking and bicycling during leisure time, and an absence of active commuting to school) vary by gender, ethnicity and school type. In addition, we investigated possible interaction effects between gender, ethnicity and school type, and performed stratified analyses when interaction effects were significant. Based on

the findings of previous studies, we hypothesized that girls, adolescents from non-Western ethnic backgrounds, and adolescents attending vocational schools have a higher risk of overweight and obesity and unfavorable EBRB compared to boys, adolescents from Western ethnic backgrounds, and adolescents participating in higher-level education.

METHODS

Study design and sample selection

Data from the ENvironmental Determinants of Obesity in Rotterdam SchoolchildrEn (ENDORSE) study were used. The ENDORSE study is a prospective two-year study among adolescents aged 12 to 15, with assessments at baseline and a two-year follow-up. More details on this project are described elsewhere [22]. The Medical Ethics Committee of Erasmus University Medical Center reviewed the proposal and issued a "declaration of no objection" for the ENDORSE project.

After stratification according to the area in the city in which the schools are located, seventeen school locations were randomly selected from 24 out of a total of 54 schools that were willing to participate in the ENDORSE study. Stratification was done, to ensure a range of physical and cultural environments. An average of five classes per school location was randomly selected to participate in the study, and 1668 adolescents from these classes were eligible for participation. In the baseline survey, 187 adolescents were absent during the questionnaire assessment. Due to printing mistakes, it was necessary to delete 120 adolescents, including one entire school. Respondents with missing data on ethnicity were deleted from the sample (n=155). This meant that the study sample included 1206 participants (72%) from 71 classes and 16 schools.

Procedure

The ENDORSE study collects data among adolescents in the first (12- to 13-year-olds) and third (14- to 15-year-olds) years of secondary school. The school types varied from lower vocational schools to higher-level secondary education. All data were gathered within the ongoing health surveillance system of the local Municipal Health Service and as a part of the government approved routine health examinations of the preventive youth health care [22]. Separate informed consent therefore was not requested. ENDORSE classroom questionnaires and anthropometrics were completed on a voluntary basis. Parents received written information on these measurements and were free to object to participation of their child. From October 2005 to May 2006, the students completed the ENDORSE questionnaire in the classroom in the presence of a teacher and a trained research assistant during one

class period of approximately 50 minutes. Within a month after completing the ENDORSE questionnaire, two trained research assistants measured height and weight. The adolescents were asked to come into a private room one by one, where they were measured in street clothes without shoes and heavy clothes.

Measures

Weight, height and body mass index

Body height was measured using a Seca 225 mobile height rod with an accuracy of 0.1 cm. A calibrated electronic digital floor scale (Seca 888 class III with accuracy of 0.1 kg) was used to determine the body weight of the participants. Body mass index (BMI) was calculated from the measured height and weight (kg/m^2). BMI cut points for children/adolescents from the International Obesity TaskForce (IOTF) were used to define overweight and obesity [23].

Energy balance-related behaviors

The following EBRB were assessed: snack, soft drink and breakfast consumption, walking, bicycling and playing sports during leisure time, active commuting to school (walking and bicycling), television viewing and computer use.

Snacks were defined as sweet (candy, candy bars, chocolate, cake, cookies) and savory (fast food, pizza, fries, chips, nuts) snacks. Sweet snacks were assessed by two questions: "How many days a week do you usually eat sweet snacks or cookies?" and "On average, how many times a day do you eat sweet snacks or cookies?" The same two questions were asked for savory snacks. These questions were combined to compute a single score for the mean snack intake in times per day.

Soft drinks were defined as carbonated soft drinks, other non-carbonated sugar-sweetened drinks (water-based beverages that contain sugar) and sport drinks. The consumption of soft drinks was assessed by two questions: "How many days a week do you usually drink sugar-sweetened (not 'light' or 'diet') beverages?" and "If you drink sugar-sweetened beverages, how many glasses, cans, and/or bottles do you drink on average per day?" Total soft drink consumption was expressed in milliliters per day and therefore, serving sizes were transferred to a quantification in milliliters using the Dutch standard serving sizes (1 glass = 200 ml, 1 can = 330 ml, 1 bottle = 500ml).

Breakfast consumption was assessed with two questions: "How often do you eat breakfast on school days?" and "How often do you eat breakfast on weekend days?" These questions were combined to compute a single score for breakfast consumption in days per week.

Ten-day test-retest reliability for snack consumption, soft drink consumption and breakfast consumption was r=0.46, r=0.59 and r=0.65 respectively.

An adapted version of the Activity QUestionnaire for Adolescents & Adults (AQUAA) was used to assess physical activity (transportation, activities and sports during leisure time)

and sedentary behaviors (television viewing, computer use). The structure of the AQUAA is obtained from the validated Short QUestionnaire to ASses Health-enhancing physical activity (SQUASH) [24]. The frequency (days per week) and duration (hours and minutes) of the activities were multiplied, and then divided by the total number of days to provide the average minutes per day of the physical activity and sedentary sub-behaviors.

As most behaviors were not normally distributed the EBRB were dichotomized to express these behaviors in "favorable" and "unfavorable" categories. If possible, categories were distinguished based on participating in a behavior (favorable group) and not participating in a behavior (unfavorable group) (bicycling during leisure time, playing sports and commuting to school). Variables that could not be dichotomized by engaging or not engaging in behavior were dichotomized based on recommendations (television viewing, soft drink consumption) or the median value in the data set (snacking, breakfast consumption, walking, computer use).

The questions, response options and the cut-off points for all EBRB are provided in the appendix to this paper.

Demographics

Ethnicity was defined according to the definition used by Statistics Netherlands [25]. Adolescents were considered to be from a Western ethnic background if both parents had been born in an European country, North America, Oceania, Indonesia or Japan. Adolescents were considered to be from a non-Western ethnic background if one or both parents had been born in a non-Western country. School type was categorized into two levels: vocational schools and higher-level secondary education. The schools provided this information. Age was determined based on the date of the anthropometrical measurements and the date of birth (provided by the schools).

Data analyses

Chi-square tests were used to test differences in gender, school type, overweight status and EBRB between the participants who were included and not included in the analyses (i.e. those with and without data on ethnicity). Chi-square tests were also used to test differences in gender, ethnicity and school type between adolescents with missing values on the EBRB and weight status and adolescents with reported EBRB and weight status. Respondents with missing data on the behavior variables were not deleted from the sample, but were deleted from the analysis. Because of this, the numbers of students in the analyses are different for various outcome variables.

Categorical data were described using frequencies and percentages. To examine if gender, ethnicity and school type are significant correlates of the EBRB and weight status, multi-level logistic regression analyses were performed with the demographic factors as independent variables.

Interaction effects between gender and ethnicity and school type and ethnicity were examined by adding interaction terms into the regression models. If the interactions had P values <0.1, stratified analyses were conducted for ethnicity. Multi-level models with a three-level structure were used (child, class and school) in order to take into account that children were nested within classes and schools. The univariate analyses were conducted in SPSS version 15 and the multi-level analyses were performed using MlwiN version 2.02.

RESULTS

Adolescents from Western ethnic backgrounds and adolescents attending vocational schools had significantly more missing values on several EBRB compared to adolescents from Western ethnic backgrounds and adolescents attending higher-level education (data not shown).

Table 5.1 presents the frequency of demographics, weight status and EBRB in the study population. Among the respondents, 45.1% was female, the mean age was 14.1 years, 56.7% was attending vocational schools and 50.5% was from non-Western ethnic background. Overweight or obesity was present in 20.2% of the participating adolescents. Unfavorable sedentary and dietary behaviors such as consuming more than two glasses of soft drink per day (67.2%) were more often reported compared to unfavorable physical activity behaviors such as not playing sports (19.8%).

Gender differences

In the multivariate analyses (Table 5.2), we found girls to be more likely to report low breakfast consumption (OR=1.8), not bicycling during leisure time (OR=1.6), no sports participation (OR=3.0) and high television viewing (OR=1.8). Girls were less likely to report high soft drink consumption (OR=0.6). There were no differences between boys and girls in weight status.

Ethnic differences

The multivariate analyses (Table 5.2) demonstrated that adolescents from non-Western ethnic backgrounds were more likely to be overweight or obese (OR=1.8), to not eat breakfast everyday (OR=1.9), to do no bicycling during leisure time (OR=3.2), to not participate in sports (OR=1.7), to use non-active modes of transportation to school (OR=1.6) and to spend more than two hours watching television (OR=2.4). A significant inverse association was found for walking during leisure time, indicating that adolescents from non-Western ethnic backgrounds were less likely to report low levels of walking (OR=0.6).

Table 5.1 Frequency of demographics, weight status and energy balance-related behaviors.

	Frequency in study population (%) (unless otherwise specified)
Demographic variables	
Mean age of respondents in years	14.1 (SD=1.2; range 10-17)
Girls	544 (45.1)
Non-Western ethnic background	609 (50.5)
Vocational education	684 (56.7)
Weight status	
Overweight (according to IOTF)	189 (15.7)
Obesity (according to IOTF)	54 (4.5)
Mean BMI	20.7 (SD=3.6; range 14.2-36.1)
Boys	20.2 (SD=3.6)
Girls	21.3 (SD=3.6)
Western ethnic background	20.0 (SD=3.1)
Non Western ethnic background	21.4 (SD=4.0)
Vocational education	21.1 (SD=3.8)
Higher-level education	20.2 (SD=3.3)
Dietary behaviours	
Soft drinks > 2 glasses/day	811 (67.2)
Snacks > 2 times/day	603 (50.0)
Breakfast 0-6 days/week	525 (43.5)
Physical activity	
Walking during leisure time < 60 min/day	531 (44.0)
Not bicycling during leisure time	344 (28.5)
Not playing sports	239 (19.8)
Non-active commuting to school	398 (33.0)
Sedentary behaviours	
Television viewing > 120 min/day	490 (40.6)
Computer use > 90 min/day	568 (47.1)

School type differences

The multivariate analyses (Table 5.2) showed that vocational students were more likely to be overweight or obese (OR=1.7) and to report high soft drink consumption (OR=2.0), high snack consumption (OR=1.5), no sports participation (OR=2.5) and to spend more than two hours watching television (OR=1.7). A significant inverse association was found for walking during leisure time, indicating that vocational students were less likely to report low levels of walking (OR=0.5).

Table 5.2 Results of multiple logistic regression analyses (odds ratios (OR) and 95% confidence intervals (95% CI)) with gender, ethnicity and school type as independent variables and energy-balance related behaviours as dependent variables

	Gender (girls)* OR (95% CI)	**Ethnicity (non-Western)*** OR (95% CI)	**School type (vocational)*** OR (95% CI)
Weight status			
Normal weight	1.00	1.00	1.00
Overweight and obesity	1.2 (0.91-1.65)	**1.8** (1.29-2.39)	**1.7** (1.19-2.33)
Dietary behaviours			
Soft drink consumption			
≤ 2 glasses	1.00	1.00	1.00
> 2 glasses	**0.6** (0.43-0.76)	1.2 (0.88-1.64)	**2.0** (1.19-3.22)
Breakfast consumption			
Every day	1.00	1.00	1.00
0-6 days/week	**1.8** (1.30-2.36)	**1.9** (1.35-2.58)	1.5 (0.88-2.39)
Snack consumption			
≤ 2 times/day	1.00	1.00	1.00
> 2 times/day	1.0 (0.80-1.33)	1.2 (0.91-1.52)	**1.5** (1.16-2.00)
Physical activity			
Walking during leisure time			
≥60 min/day	1.00	1.00	1.00
<60 min/day	1.1 (0.79-1.39)	**0.6** (0.46-0.85)	**0.5** (0.32-0.79)
Bicycling			
Bicycling during leisure time	1.00	1.00	1.00
Not bicycling during leisure time	**1.6** (1.14-2.12)	**3.2** (2.29-4.58)	0.9 (0.55-1.34)
Sports			
Playing sports during leisure time	1.00	1.00	1.00
Not playing sports during leisure time	**3.0** (1.98-4.48)	**1.7** (1.11-2.62)	**2.5** (1.37-4.43)
Commuting to school (walking/bicycling)			
Active commuting	1.00	1.00	1.00
Non-active commuting	0.9 (0.66-1.25)	**1.6** (1.13-2.32)	1.4 (0.62-3.20)
Sedentary behaviours			
Television viewing			
≤ 2 hours per day	1.00	1.00	1.00
> 2 hours per day	**1.8** (1.33-2.38)	**2.4** (1.74-3.25)	**1.7** (1.08-2.71)
Computer use			
≤ 90 minutes per day	1.00	1.00	1.00
> 90 minutes per day	0.8 (0.59-1.04)	1.3 (0.98-1.80)	1.4 (0.90-2.14)

Odds ratios in **bold** indicate a significant association. All analyses were adjusted for age.
* Reference groups were boys (gender), Western ethnic background (ethnicity) and higher-level education students (school type).

Interaction effects between ethnicity and gender

Interaction effects between ethnicity and gender were significant for weight status, soft drink consumption, bicycling during leisure time, playing sports, television viewing and computer use. The stratified analyses (Table 5.3) showed that compared to boys from non-Western ethnic backgrounds, girls from non-Western ethnic backgrounds were more likely to be overweight (OR=1.5), to do no bicycling during leisure time (OR=2.4) and to spend more than two hours watching television (OR=2.3). These gender differences were not significant for adolescents from Western ethnic backgrounds. Compared to boys, girls from both non-Western (OR=3.5) and Western ethnic backgrounds (OR=2.0) were more likely to report no sports participation. Compared to boys from Western ethnic backgrounds, girls from Western ethnic backgrounds were less likely to report high soft drink consumption (OR=0.4) and using the computer for more than 90 minutes (OR=0.6).

Interaction effects between ethnicity and school type

Interaction effects between ethnicity and school type were significant for soft drink consumption, television viewing and computer use. The stratified analyses showed that compared to high-level education students from Western ethnic backgrounds, vocational students from Western ethnic backgrounds were more likely to report high soft drink consumption (OR=3.2), more than two hours of television viewing (OR=2.9) and more than 90 minutes of computer use (OR=2.1). There were no significant school type differences for adolescents from non-Western ethnic backgrounds.

DISCUSSION

This study examined gender, ethnic and school type differences in weight status and EBRB among Dutch adolescents aged 12 to 15. As expected, we found girls to be more likely than boys to engage in unfavorable behaviors (i.e. low breakfast consumption, not bicycling during leisure time, not playing sports and spending more than two hours a day watching television). Adolescents from non-Western ethnic backgrounds and vocational schools were more likely to be overweight or obese and to engage in unfavorable EBRB. These results are in accordance with studies from other countries in which girls were also found to be less physically active [14, 19, 21] and minority groups were more likely to be overweight and showed more unhealthy EBRB [5, 7-9, 12-15, 26] such as watching television [5, 12-14], low breakfast consumption [13], soft drink and snack consumption [15]. That ethnic minority groups have higher rates of overweight and unhealthy behaviors might partly be due to their lower educational levels. However the examination of potential ethnicity by school

Table 5.3 Results of multiple logistic regression analyses with energy balance-related behaviours as dependent variables (odds ratios (OR) and 95% confidence intervals (95% CI)) stratified by ethnicity with gender and school type as independent variables

	Gender (girls)*		**School type (vocational)***	
	Western OR (95% CI)	**Non-Western** OR (95% CI)	**Western** OR (95% CI)	**Non-Western** OR (95% CI)
Weight status				
Normal weight	1.00	1.00	1.00	1.00
Overweight	0.9 (0.55-1.51)	**1.5** (1.05-2.26)	NA	NA
Dietary behaviours				
Soft drink consumption				
≤ 2 glasses	1.00	1.00	1.00	1.00
> 2 glasses	**0.4** (0.28-0.64)	0.7 (0.50-1.08)	**3.2** (1.63-6.34)	1.5 (0.92-2.30)
Breakfast consumption				
Every day	1.00	1.00	1.00	1.00
0-6 days/week	NA	NA	NA	NA
Snack consumption				
≤ 2 times/day	1.00	1.00	1.00	1.00
> 2 times/day	NA	NA	NA	NA
Physical activity				
Walking during leisure time				
≥60 min/day	1.00	1.00	1.00	1.00
<60 min/day	NA	NA	NA	NA
Bicycling				
Bicycling during leisure time	1.00	1.00	1.00	1.00
Not bicycling during leisure time	0.8 (0.45-1.25)	**2.4** (1.64-3.45)	NA	NA
Sports				
Playing sports during leisure time	1.00	1.00	1.00	1.00
Not playing sports during leisure time	**2.0** (1.07-3.77)	**3.5** (2.20-5.67)	NA	NA
Commuting to school (walking/bicycling)				
Active commuting	1.00	1.00	1.00	1.00
Non-active commuting	NA	NA	NA	NA
Sedentary behaviours				
Television viewing				
≤ 2 hours per day	1.00	1.00	1.00	1.00
> 2 hours per day	1.1 (0.69-1.63)	**2.3** (1.60-3.30)	**2.9** (1.55-5.46)	1.3 (0.82-1.96)
Computer use				
≤ 90 minutes per day	1.00	1.00	1.00	1.00
> 90 minutes per day	**0.6** (0.38-0.85)	0.9 (0.66-1.35)	**2.1** (1.25-3.59)	1.2 (0.70-1.97)

NA = not applicable, no significant interaction by ethnicity. Odds ratios in **bold** indicate a significant association. All analyses were adjusted for age. * Reference groups were boys (gender) and higher-level education students (school type).

Appendix Items on the energy balance-related behaviours questionnaire

Items	Response categories
Sweet and savoury snacks (≤ 2 times/day; > 2 times/day)	
How many days a week do you usually eat sweet snacks or cookies?	8-point scale: from 0 = never to 7 = 7 days per week
On average, how many times a day do you eat sweet snacks or cookies?	10-point scale: from 1 = 1x to 10 = 10x or more
How many days a week do you usually eat savoury snacks?	8-point scale: from 0 = never to 7 = 7 days per week
On average, how many times a day do you eat savoury snacks?	10-point scale: from 1 = 1x to 10 = 10x or more
Soft drinks (≤ 2 glasses/day (400 ml); > 2 glasses/day)	
How many days a week do you usually drink sugar-sweetened (not "light" or "diet") beverages?	8-point scale: from 0 = never to 7 = every day
If you drink sugar-sweetened beverages, how many glasses, cans, and/or bottles do you drink on average per day?	8-point scale: from 0 = none to 7 glasses 8- point scale: from 0 = none to 7 cans 8-point scale: from 0 = none to 7 bottles
Breakfast consumption (every day; 0-6 days/week)	
How often do you eat breakfast on school days?	5-point scale: from 0 = I never eat breakfast on school days to 5 = 5 days
How often do you eat breakfast on weekend days?	3-point scale: 0 = I never eat breakfast on weekend days 1 = I eat breakfast on one weekend day (Saturday or Sunday) 2 = I eat breakfast on both weekend days (Saturday and Sunday)
Bicycling during leisure time (bicycling; not bicycling)	
How many days a week do you bicycle during leisure time? (include things like bicycling to the supermarket, sports club and movie theatre)	8-point scale: from 0 = never to 7 = 7 days per week
On a day that you bicycle, how long do you bicycle on average?	Open question (hours and minutes could be reported).
Walking during leisure time (≥60 min/day; <60 min/day)	
How many days a week do you walk during leisure time? (include things like walking to the supermarket and sports club and walking the dog)	8-point scale: from 0 = never to 7 = 7 days per week
On a day that you walk, how long do you walk on average?	Open question (hours and minutes could be reported).
Active commuting to school (active commuting; non-active commuting)	
How many days a week do you walk from home to school?	6-point scale: from 0 = never to 5 = 5 days per week
How long does it take you to walk from home to school (one way only)?	Open question (minutes could be reported).
How many days a week do you bicycle from home to school?	6-point scale: from 0 = never to 5 = 5 days per week
How long does it take you to bicycle from home to school (one way only)?	Open question (minutes could be reported).
Sports during leisure time (playing sports; not playing any sports)	
Which sports did you play last week (at a sports club or with friends)?	Open question (three sports could be reported).
How many days did you play this sport last week?	7-point scale: from 1 = 1 day per week to 7 = every day. This scale could be filled in for the three sports listed in the preceding question.
On a day that you participate in this kind of sport, how long do you do this on average?	This open question could be filled in for the three sports listed in the first question (hours and minutes could be reported).
Watching television (≤ 120 min/day; > 120 min/day)	
How many days a week do you watch television?	8-point scale: from 0 = never to 7 = 7 days per week
On a day that you watch television, how long do you watch television on average?	Open question (hours and minutes could be reported).
Computer use (≤ 90 min/day; > 90 min/day)	
How many days per week do you use the computer (include things like the internet, games, X-box and PlayStation)?	8-point scale: from 0 = never to 7 = 7 days per week
On a day that you use the computer, how long do you use the computer on average?	Open question (hours and minutes could be reported).

type interaction effects and subsequent stratified analyses showed that differences according to school type were not found among adolescents from non-Western ethnic backgrounds. Cultural differences or level of acculturation [27, 28] might account for individual differences in unhealthy behaviors in non-Western ethnic groups. These findings indicate that especially adolescents attending vocational schools and all adolescents from non-Western ethnic backgrounds have to be targeted with interventions, since they are most likely to engage in risk behaviors. Developing and implementing school based healthful diet and physical activity promotion interventions that were specifically designed for lower vocational schools is a promising strategy to prevent overweight and obesity [29, 30].

Examining gender by "ethnicity interaction effect" and subsequent stratified analyses showed that girls from non-Western ethnic backgrounds were more likely to be overweight or obese compared to boys from non-Western ethnic backgrounds and that they were more likely to engage in risk behaviors. These gender differences were not found for adolescents from Western ethnic backgrounds. This indicates that girls from non-Western ethnic backgrounds in particular are an important target group. The same pattern of higher overweight prevalence among non-Western female groups has also been found in the United States. Ethnicity-overweight differences were greater among females, showing a higher overweight prevalence among African-American girls compared to boys [9, 13]. We also found that girls from non-Western ethnic backgrounds had a significantly higher risk of not bicycling, not participating in sports and watching television for more than two hours compared to boys from non-Western ethnic backgrounds. These similarities in patterns are interesting, because the non-Western ethnic groups in the US are different from those in the Netherlands. Whereas in the US ethnic minority groups are African American and Hispanic, in the Netherlands the most important ethnic minority groups are Turkish, Moroccan, Surinamese and Cape Verdean. Our findings are consistent with other studies that found especially non-Western migrant women (Turkish and Moroccan) to be less physically active [28, 31]. Hosper et al. (2007) also found that the prevalence's for physical inactivity and overweight of second-generation Turkish and Moroccan women seem to converge towards the prevalence rates in the Dutch population [28]. Because it is unclear whether this acculturation process will occur for all risk behaviors and for all non-Western ethnic groups[27], preventive interventions should still target these high-risk groups.

The following limitations should be taken into account when interpreting the results of this study. The cross-sectional design of the study did not allow us to determine causal effects. Longitudinal data are needed to see whether changes in weight status are associated with changes in the differences in EBRB between boys and girls, Western and non-Western adolescent and higher-level and lower-level education students. No test-retest data exists for the physical activity measures and validation data is lacking for both dietary intake and

physical activity measures. The use of self-reported measures of EBRB could have caused an overestimation of intakes and activities. The categorization of the data could also have influenced the outcomes. In this study we made a distinction between adolescents from Western and non-Western ethnic backgrounds. However, the group of adolescents from non-Western ethic backgrounds was quite diverse, including adolescents with parents born in Turkey, Morocco, Cape Verde and Surinam. We were not able to examine the differences between these groups.

Examining gender, ethnic and educational differences in overweight and risk behaviors for overweight is important for target group segmentation and intervention development. In this study, we observed the most differences in overweight and EBRB for ethnicity and school type. Therefore, adolescents from non-Western ethnic backgrounds (girls in particular) and adolescents attending vocational schools (particularly those with Western ethnic backgrounds) are important target groups for preventive interventions aimed at preventing overweight and obesity. Interventions should focus on behaviors that are of specific importance to these high-risk groups. The effectiveness of interventions will probably increase when they also take differences in individual cognitions, cultural influences and environmental determinants of EBRB into account.

Conclusion

The results of this study showed that adolescents from non-Western ethnic backgrounds and those attending vocational schools are important target groups for obesity prevention. Given the relatively few published obesity-prevention and treatment studies that are designed for specific educational or ethnic groups, it is important to promote the development of culturally appropriate intervention strategies that are shown to be effective among youth of diverse backgrounds. Future research should consider subgroups in the adolescent population and focus on what kind of interventions work and for which target groups they work taking demographic variables such as gender, ethnicity and school type into account. Further qualitative and longitudinal research is needed to examine determinants of the EBRB to better tailor interventions to the needs and perceptions of these specific target groups.

ACKNOWLEDGEMENTS

Financial support for this study was provided by a grant from ZonMw, the Netherlands Organization for Health Research and Development (grant ID no. 2100.0103). This study was part of CEPHIR: the Center for Effective Public Health in the larger Rotterdam Area.

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6 Socio-demographic factors as correlates of active commuting to school in Rotterdam, the Netherlands

Bere E, van der Horst K, Oenema A, Prins R, Brug J. Socio-demographic factors as correlates of active commuting to school in Rotterdam, the Netherlands.

Preventive Medicine 2008, 47: 412-416.

ABSTRACT

Objective: Report frequencies of adolescents' active commuting to school in an inner city environment in the Netherlands, and to explore potential socio-demographic correlates of active commuting to school.

Methods: Cross-sectional data were obtained from the ENDORSE-study (2005–2006) including 1361 adolescents (response=82%), aged 12-15 from 16 schools in Rotterdam. Socio-demographic variables were assessed by questionnaire, height and weight were measured and distance to school was calculated based on route planner information. Multilevel logistic regressions were performed to analyze the data.

Results: The proportions of participants categorized as walkers, cyclists, non-active commuters were 12%, 35% and 34% respectively. With cyclists as the reference category, adolescents of non-Western ethnic background were more likely to be walkers (OR=4.1; 95%CI=2.1-8.2) and non-active commuters (OR=5.1; 95%CI=3.3-7.9), compared to native Dutch adolescents. A further distance from home to school was inversely associated with being a walker (OR=0.22; 95%CI=0.17-0.29) and being a cyclist (OR=0.83; 95%CI=0.79-0.86) and positively associated with being a non-active commuter (OR=1.2; 95%CI=1.16-1.23).

Conclusion: Almost 50% of the adolescents reported to actively commute to school, and mode of commuting was associated with ethnicity and distance. Further research is needed to examine main barriers to active commuting among adolescents from non-Western ethnic background.

INTRODUCTION

The prevalence of overweight and obesity among adolescents is increasing worldwide, as is also the case in the Netherlands [1]. Evidence indicates that engaging in at least 60 minutes of moderate intensity physical activity on preferably all days of the week, contributes to prevention of overweight and obesity and to better health [2, 3]. Active commuting to school is one of the daily activities that could be an important component of the daily-recommended level of physical activity for adolescents. A meta-analytic review stated recently that active commuting (among adults) was associated with an 11% reduction in cardiovascular risk [4].

There is a lack of research on trends in mode of transport to school over the past years. In the US and Australia low and decreasing frequencies of active commuting to school have been reported [5-8]. Different reasons have been suggested for these low and decreasing levels of active commuting such as safety concerns, traffic, road-crossing, crime, convenience to drop children off on way to work and environmental factors such as walkability and distance to school [5, 9-14].

In the Netherlands between 1985 and 2005 no clear decreases in the total number of cycling and walking trips and distances have been seen in the Dutch population [15]. Between 2004 and 2006, 12-16 year old adolescents reported to cycle approximately 6 km/per day and to walk approximately 0.33 km/day [16]. The built environment in cities in the Netherlands appears to be good for cycling compared to cities in other countries. The Netherlands have a long tradition of cycling, which has resulted in a cycling-friendly infrastructure making it more convenient and safer to cycle than in other countries. However, no study has reported frequencies of active commuting to school in the Netherlands and few studies in general have reported socio-demographic determinants of active commuting to school. In the Netherlands, a large number of adolescents from non-Dutch ethnic backgrounds live in the larger cities and we expect that differences between cultures exist for the mode of commuting to school. Better insight in socio-demographic factors associated with active commuting to school will enable tailoring interventions aimed at the prevention of overweight to the needs of specific risk groups. Therefore, the aim of the present study was to report frequencies of adolescents' active commuting to school in Rotterdam, the second-largest city in the Netherlands, and to explore potential socio-demographic correlates of active commuting to school.

METHODS

The present study is part of the ENDORSE (Environmental Determinants of Obesity among Rotterdam SchoolchildrEn) project on identification of important individual and environmental determinants of adolescent behaviors related to overweight and obesity. The EN-

DORSE study is an integral part of the ongoing health surveillance system of the Municipal Health Service in the Rotterdam area (Youth Monitor Rotterdam, YMR). The Medical Ethics Committee of the Erasmus University Medical Center approved the ENDORSE project.

Procedure and sample

The YMR and ENDORSE studies collected data in school year 2005/2006 among adolescents in the first (12-13 year olds) and third year of secondary school (14-15 year olds). A total of 24 schools from the 56 schools participating in the YMR were willing to participate also in the ENDORSE study. After stratification according to location in the city, seventeen school locations were randomly selected. On average five classes per school location were selected at random to participate and a total of 1668 adolescents were eligible to participate in the ENDORSE study. Between October 2005 and May 2006, the adolescents completed the YMR and the ENDORSE questionnaires. Within a month after completion of the ENDORSE questionnaire, two trained research assistants measured height and weight.

During administration of the ENDORSE survey 187 adolescents were absent. Due to printing mistakes, it was necessary to delete 120 adolescents, including one complete school from the sample. Therefore, the study sample includes 1361 participants (82%), from 71 classes and 16 schools; 55% boys, 6.5% non-Dutch Western ethnic background and 53% non-Western ethnic background. Mean age was 14.1 years (SD=1.2; range 11.0-17.6).

Measures

Commuting to school was measured by three questions: How many days a week do you travel to school; (1) walking, (2) cycling, (3) by public transport or car. Response categories were never, one day/week, two days/week, three days/week, four days/week, and five days/week. The three items were combined to one variable with four categories: (1) walking 3 days/week or more (WALKERS), (2) cycling three days/week or more (CYCLISTS), (3) non-active commuting three days/week or more (NON-ACTIVE COMMUTERS), (4) pupils where the sum of the three answers counted up to less than or more than five days/week (PUPILS NOT CATEGORIZED INTO MODE OF COMMUTING).

Sex, school level (vocational or university preparatory high school) and date of birth were provided by the schools. Age was determined on the date of the anthropometrical measurements. Employment of parents was assessed in the YMR questionnaire by two questions asking whether their mother and father had paid work or not (0=mother or/and father have NOT paid work, 1= both mother and father have paid work). Ethnicity was assessed in the YMR questionnaire by two questions asking in which country their mother and father had been born. Ethnicity was defined upon the definition used by Statistics Netherlands [17]. The pupils were considered to be native Dutch if both parents had been born in the

Netherlands, the pupils were considered to be from Western ethnic background if one or both parents had been born in another European country, North America, Oceania, Indonesia or Japan. Adolescents with one or both parents born in a non-Western country were considered as from non-Western ethnic background. Body Mass Index was calculated from the measurements of height and weight, carried out by research assistants. Age and sex specific cut off points were used to categorize adolescents in categories of normal weight and overweight or obese [18]. Distance from home to school was calculated from pupil's reports of home address postal codes. The home address postal codes and the exact school addresses were entered into the route planner www.routenet.nl (in March 2007). The length of the optimal route for cars was derived from this service and entered into the data set for each pupil. Distances over 45 km were regarded as outliers, and therefore, pupils living further than 45km from school were not included in the analyses (6 pupils).

Statistics

Descriptive analyses of commuting to school in relation to the potential determinants were conducted using SPSS version 14. Multilevel logistic regression analyses, taking the clustering of pupils within schools into account, were preformed with walking, cycling or non-active commuting to school as dependent variables, using MLwiN version 2.02. Walking, cycling and non-active commuters were first compared to the rest of the sample (e.g. walkers, were compared to non-walkers (i.e. cyclists, non-active commuters and pupils not categorized into mode of commuting)), and then walkers and non-active commuters were compared to cyclists. All regression models included sex, work status of parents, ethnicity, weight status, age, distance from home to school and school level (high school or vocational). Three dummy variables were created and included in the analyses in order to keep adolescents with missing values on one or more of the following variables in the models: (1) Work status: quite a few adolescents (n=244) reported not to know whether their parents had paid work or not, or reported to have no parent or no contact with their mother and/or father. (2) Weight status: due to absence, anthropometrical measurements were lacking for 143 adolescents. (3) Ethnicity and work status: due to absence, 133 adolescents did not participate in the YMR survey. Odds ratios (OR) with confidence interval (95%) are given for each independent variable.

RESULTS

Table 6.1 shows descriptive characteristics of the sample and how the different potential correlates were bivariately related to commuting to school. The proportions of participants categorized as walkers, cyclists, non-active commuters and 'pupils not categorized into mode

Table 6.1 Description of the proposed determinants and the unadjusted relationship between these factors and commuting to school among adolescents in Rotterdam, the Netherlands, school year 2005/2006 (proportions of total sample, or mean, with 95% CI)

		WALKERS (n=168)		CYCLIST (n=471)		NON-ACTIVE COMMUTERS (n=465)		PUPILS NOT CATEGORISED INTO COMMUTING MODE (n= 257)	
	N	Proportion	(95% CI)	Proportion	(95% CI)	Proportion	(95% CI)	Proportion	(95% CI)
All	1361	12%	(11, 14)	35%	(32, 37)	34%	(32, 37)	19%	(17, 21)
Sex									
Boys	752	10%	(8, 12)	37%	(33, 40)	36%	(32, 39)	18%	(15, 20)
Girls	609	16%	(13, 18)	32%	(28, 36)	32%	(28, 36)	21%	(17, 24)
Work status parents									
Both parents have work	611	9%	(6, 11)	44%	(40, 48)	31%	(27, 35)	16%	(13, 19)
Not two working parents	338	18%	(14, 22)	24%	(20, 29)	37%	(32, 42)	21%	(16, 25)
Ethnicity									
Native Dutch	512	4%	(2, 6)	54%	(49, 58)	28%	(24, 32)	14%	(11, 17)
Western ethnicity	75	5%	(0, 11)	40%	(29, 51)	36%	(25, 47)	19%	(10, 28)
Non-Western ethnicity	614	20%	(17, 23)	18%	(15, 21)	39%	(35, 43)	23%	(19, 26)
Weight status									
Normal weight	919	11%	(9, 13)	39%	(36, 42)	32%	(29, 35)	17%	(15, 20)
Overweight or obese	299	16%	(12, 20)	26%	(21, 31)	37%	(31, 42)	21%	(17, 26)
Age (years, mean)	1361	14.5	(14.3, 14.7)	14.0	(13.9, 14.1)	14.1	(14.0, 14.2)	14.1	(14.1, 14,2)

		WALKERS (n=168)		CYCLIST (n=471)		NON-ACTIVE COMMUTERS (n=465)		PUPILS NOT CATEGORISED INTO COMMUTING MODE (n= 257)	
Distance to school	1308								
Mean, km		1.4	(1.3, 1.6)	4.8	(4.5, 5.0)	9.7	(8.9, 10.4)	6.9	(6.0, 7.8)
Type of school									
High school	553	11%	(9, 14)	42%	(38, 46)	33%	(29, 37)	14%	(11, 17)
Vocational school	808	13%	(11, 15)	30%	(27, 33)	35%	(32, 38)	22%	(19, 25)

of commuting' were 12%, 35%, 34% and 19% respectively. The majority within the walking, cycling and non-actively commuting categories, respectively, reported to walk (88%), cycle (92%) or non-actively commute (95%) all five school days/week (data not shown). Mean distances from home to school were 1.4 km, 4.8 km, 9.7 km, and 6.9 km respectively for the walkers, the cyclists, the non-active commuters and the pupils not categorized into mode of commuting. The proportion of walkers, cyclists and non-active commuters living less than three km away from school were 97%, 30% and 10% respectively. Of the cyclists and the non-active commuters 96% and 70% lived within ten km from school. Fewer adolescents from non-Western (47%) and Western (non-Dutch) ethnic background (67%) reported to have bikes at home than native Dutch adolescents (83%). Adolescents with two working parents (73%) and with at least one parent not working (53%) reported to have bikes at home.

Comparing walkers, cyclists and non-active commuters respectively to the remaining sample (including also the pupils not categorized into mode of commuting) (Table 6.2); adolescents from non-Western ethnic background (OR=2.0; 95%CI=1.0-4.0) and older adolescents (OR=1.3; 95%CI=1.0-1.7) were more likely to be walkers, while adolescents living further away from school (OR=0.22; 95%CI=0.17-0.29) were less likely to be walkers. Those having a parent without paid work (OR=0.6; 95%CI=0.4-0.9), from Western (OR=0.5; 95%CI=0.3-0.8) and non-Western ethnic background (OR=0.3; 95%CI=0.2-0.4), as well as those living further away from school (OR=0.83; 95%CI=0.79-0.86) were less likely to be cyclists. Adolescents from Western (OR=2.3; 95%CI=1.3-4.2) and non-Western ethnic background (OR=3.0; 95%CI=2.1-4.4), as well as those living further away from school (OR=1.20; 95%CI=1.16-1.23) were more likely to be non-active commuters.

Comparing walkers to cyclists (Table 6.3); adolescents from non-Western ethnic background (OR=4.1; 95%CI=2.1-8.2) were more likely to be a walker than a cyclist, while adolescents living further away from school (OR = 0.3; 95%CI=0.3-0.4) were less likely to be a walker than a cyclist. Comparing non-active commuters to cyclists; those having at least one parent without paid work (OR=1.7; 95%CI=1.1-2.6), being from Western (OR=2.6; 95%CI=1.3-5.2) and non-Western ethnic background (OR=5.1; 95%CI=3.3-7.9) and those living further away from school (OR=1.4; 95%CI=1.3-1.4) were all more likely to be non-active commuters than cyclists.

DISCUSSION

Almost half (47%) of the sample do actively commute to school most school days. In the present study, differences in mode of commuting to school were found between adolescents from Dutch, non-Western and Western ethnic backgrounds. Cycling was the dominant

Table 6.2 Odds ratios for being a walker, cyclist or non-active commuter among adolescents in Rotterdam, the Netherlands, school year 2005/2006 (reference is "all other adolescents")

	WALKER		CYCLIST		NON-ACTIVE COMMUTER	
	OR	(95%CI)	OR	(95%CI)	OR	(95%CI)
Girls vs. boys	0.9	(0.5, 1.4)	0.8	(0.6, 1.0)	1.0	(0.7, 1.3)
Not two working parents vs. both working	0.8	(0.4, 1.5)	0.6	(0.4, 0.9)	1.2	(0.9, 1.7)
Western ethnicity vs. native Dutch	0.7	(0.2, 2.7)	0.5	(0.3, 0.8)	2.3	(1.3, 4.2)
Non-western ethnicity vs. native Dutch	2.0	(1.0, 4.0)	0.3	(0.2, 0.4)	3.0	(2.1, 4.4)
Overweight vs. non-overweight	1.1	(0.6, 1.9)	0.8	(0.6, 1.1)	1.1	(0.8, 1.6)
Age (years)	1.3	(1.0, 1.7)	0.9	(0.8, 1.0)	1.1	(0.9, 1.2)
Distance (km)	0.22	(0.17, 0.29)	0.83	(0.79, 0.86)	1.20	(1.16, 1.23)
Vocational vs. high school	1.2	(0.6, 2.7)	0.6	(0.3, 1.2)	0.9	(0.5, 1.7)

Table 6.3 Odds ratios for being a non-active commuter (compared to cyclists) and for being a walker (compared to cyclist) among adolescents in Rotterdam, the Netherlands, school year 2005/2006

	WALKER vs. CYCLIST		NON-ACTIVE COMMUTER vs. CYCLIST	
	OR	(95% CI)	OR	(95% CI)
Girls vs. boys	0.9	(0.6, 1.6)	1.2	(0.9, 1.7)
Not two working parents vs. both working	1.1	(0.5, 2.1)	1.7	(1.1, 2.6)
Western ethnicity vs. native Dutch	1.0	(0.3, 4.1)	2.6	(1.3, 5.2)
Non-western ethnicity vs. native Dutch	4.1	(2.1, 8.2)	5.1	(3.3, 7.9)
Overweight vs. non-overweight	1.2	(0.6, 2.2)	1.3	(0.9, 2.0)
Age (years)	1.3	(1.0, 1.7)	1.1	(0.9, 1.3)
Distance (km)	0.32	(0.25, 0.43)	1.36	(1.28, 1.44)
Vocational vs. high school	1.7	(0.7, 4.4)	1.3	(0.5, 3.4)

mode of transport among the native Dutch adolescents, and 54% travel to school by bike at least three days per week. Non-active commuting was the dominant mode of transport among adolescents from non-Western ethnicity (39%), followed by walking (20%). The findings are in line with a study from de Bruijn et al. [19], which found native Dutch adolescents (mean age 14.8 years) to be nearly three times as likely to use a bicycle for general transportation as adolescents from other ethnic backgrounds. This difference may be explained by a difference in culture. In the Netherlands the bicycle is traditionally an important mode of transport and most Dutch families do have bikes [19]. In the present

study, lower proportions of immigrants (47% of non-Western and 67% of Western ethnicity) reported to have bikes at home than native Dutch (83%).

Cycling seems to be a more prominent transportation mode among adolescents of higher socio-economic position in Rotterdam. Adolescents with at least one parent without a paid job were less likely to be cyclists, and more likely to be non-active commuters. There was also a disparity in the parental work status measure on having bikes at home; 73% vs. 53% respectively among the "two working parents" and the "at least one parent not working" groups. Higher SES groups have previously been reported to cycle more often to school in Australia; living in a high SES area increased the odds for walking and cycling to school [14]. However, in the USA and Portugal opposite results have been reported; adolescents from lower socio-economic positions were more likely to walk or cycle to school [5, 20].

Bivariately an association between weight status and cycling to school was observed (Table 1). However, no significant associations between mode of commuting to school and weight status were seen in the multivariate analyses. Similarly, other studies did not find clear associations between active commuting to school and overweight or BMI [21-23]. However, it has been reported that increased walking or cycling distance was significantly associated with lower fat mass [22]. Although some studies failed to find an association with overweight, active commuting to school is still an opportunity to increase physical activity levels, and therefore contribute to a healthy lifestyle [24].

Few evidence-based indications have been reported in the international literature about how far we can expect adolescents to walk and/or cycle to school. Studies have reported that most adolescent 'walkers' live within a distance of 2.5 km from school [5, 12]. Colabianchi et al. [25] found that girls think of an 'easy' walking distance as 15 minutes (approximately 0.75 miles/1.2 km). In Australia, parents reported 1.6 km as an appropriate walking distance for 10-12 year old children [26], which is rather similar to the median walking distance for the walkers in the present study (1.3km). However, walking to and from school, a total of 1-2 km probably does not lead to significant increases in energy expenditure and will probably not have an impact on weights status. The current study indicates that adolescents can commute rather long distances in the Netherlands, at least up to 3km of walking and 10km of cycling (one way), and actively commuting such distances might make a difference for obesity prevention. Further research is needed to examine individual and environmental barriers to active commuting especially for adolescents from non-Western ethnicities who live within cycling and walking distance to school to tailor interventions better to the needs and perceptions of this target group. The cultural differences in transportation to school might also indicate that other strategies for increasing physical activity are needed for adolescents from non-Western ethnic background.

Study limitations

There are some limitations of the present study. Only one Dutch city was included in the study and since cycling in the Netherlands is so typical for the native-Dutch population, generalization of the findings to other countries might be difficult. No test/retest or validation data exist for the commuting to school measure. The measure can neither differentiate public transportation commuters from car commuters, which would be an interesting comparison since public transportation commuters do more physical activity than car commuters [27]. Using public transportation to work has also been negatively associated with overweight and obesity among both Swedish [28] and Australian [29] men. The SES measures used in this paper are rather simple and including more proper measures for SES (family educational level, type of work, and income) might explain more of the large ethnicity disparities observed. Ethnicity is clearly not as homogenous as the three classified groups. Stratifying the results on more specific ethnicities would be interesting, and this clearly is an issue for future research. Distance to school was calculated as the optimal route for cars, and not necessarily reflecting the true walking or cycling distance. The strength of the study is that the analyses were adjusted for an objective measure of distance to school, and that it reports walking and cycling rates from a cycling country, which might serve as a good example for other countries.

Conclusion

Almost half of the adolescents living in an inner city environment in the Netherlands actively commuted to school on most school days, and mode of commuting was strongly associated with ethnicity. Adolescents from non-Dutch ethnicities and from lower SES groups are important target groups for the promotion of active commuting to school. However, further research is needed to examine determinants of active and inactive commuting to school to better tailor interventions to the needs and perceptions of these target groups.

ACKNOWLEDGMENTS

This study was financially supported by grants from ZonMw, The Netherlands Organization for Health Research and Development (grant ID no 2100.0103). Elling Bere had a post doc grant from the Norwegian Research Council, and spent one year (2006/07) at Department of Public Health, Erasmus MC Rotterdam. This study was part of CEPHIR: the Center for Evidence-based Public Health In the Rotterdam area.

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Part IV Individual and environmental correlates of energy balance-related behaviors

7 The school food environment: associations with adolescent soft drink and snack consumption

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American Journal of Preventive Medicine 2008, 35(3): 217-23.

ABSTRACT

Background: Because students may purchase food and drinks in and around their schools, the school food environment may be important for obesity-related eating behaviors such as soft drink and snack consumption. However, research exploring the associations between school environments and specific eating behaviors is sparse.

Methods: Associations of the availability of canteen food and drinks, the presence of food stores around schools, and individual cognitions (attitudes, norms, modeling, perceived behavioral control, and intentions) with soft drink and snack consumption were examined in a cross-sectional study (2005–2006) among 1293 adolescents aged 12–15 years. Soft drink and snack consumption and related cognitions were assessed with self-administered questionnaires. The presence of food stores and the distance to the nearest food store were calculated within a 500-meter buffer around each school. Data on the availability of soft drinks and snacks in school canteens were gathered by observation. In 2007, multilevel regression models were run to analyze associations and mediation pathways between cognitions, environmental factors, and behaviors.

Results: Adolescents' attitudes, subjective norms, parental and peer modeling, and intentions were positively associated with soft drink and snack consumption. There was an inverse association between the distance to the nearest store and the number of small food stores with soft drink consumption. These effects were mediated partly by cognitions.

Conclusions: This study provided little evidence for associations of environmental factors in the school environment with soft drink and snack consumption. Individual cognitions appeared to be stronger correlates of intake than physical school-environmental factors. Longitudinal research is needed to confirm these findings.

INTRODUCTION

Obesity is a major problem in many countries, and its prevalence is increasing [1, 2]. Dietary patterns such as the consumption of fast food, snacks, and soft drinks may contribute to the development of overweight and obesity through the foods' high energy density and large portion sizes [3-9].

The theory of planned behavior (TPB) has proven to be useful in understanding correlates or determinants of soft drink and snack consumption [10-13]. According to the TPB, behavior can be predicted from the intention to perform behavior that is determined by attitudes, subjective norm, modeling, and perceived behavioral control [14-16]. However, obesogenic dietary behaviors may also be influenced by the environmental opportunities to eat food [17-19]. In social-ecologic models, (e.g., the Environmental Research framework for weight Gain prevention [the EnRG framework]), it is proposed that environmental factors indirectly influence behavior via the individual's cognitions [20]. Environments that offer appealing opportunities for unhealthy foods may result in positive cognitions regarding the consumption of these unhealthy foods, resulting in higher intake of them.

Schools may be an important setting for obesity-prevention interventions, as many schools provide extensive facilities for selling food and drinks [21, 22]. During breaks, adolescents may also purchase food items in the immediate area around the school. Relatively few studies [18, 23, 24] are available that examine environmental factors in a school setting. These studies found that the number of snack vending machines was associated with student snack purchases and lower fruit intake, and that in schools where soft drink machines were turned off during lunch time, adolescents purchased fewer soft drinks [23, 24]. Many fast-food restaurants are located within walking distance of a school, and an open-campus policy during lunchtime was found to be associated with a higher likelihood of students' eating lunch at a fast-food restaurant [24-27].

The present study expands on the limited literature that explores the role of school food environments in influencing the dietary behaviors of youth. The overall hypothesis for this study was that a greater availability of soft drinks and snacks at school and in the school neighborhood as well as positive cognitions would lead to a higher intake of soft drinks and snacks. A second hypothesis was that environmental factors influence behavior via cognitions, that is, that cognitive factors mediate the association between environmental factors and behavior. This study specifically aimed to (1) examine the associations between school food availability and food stores in the school neighborhood with soft drink and snack consumption, (2) examine the associations between cognitions and soft drink and snack consumption, and (3) examine whether the effect of environmental factors on soft drink and snack consumption is partly mediated by cognitions (mediation effect).

METHODS

Study Design and Sample Selection

The Environmental Determinants of Obesity in Rotterdam SchoolchildrEn (ENDORSE) study is a prospective 2-year study among adolescents (aged 12–13 years) in the first year and third year (aged 14–15 years) of secondary school [28]. In 2005–2006, 24 of 56 schools in Rotterdam participated in the ENDORSE study. After stratification according to city region, 17 schools were selected. From them, a total of 78 classes (1668 adolescents) were randomly selected to participate in the ENDORSE study. Because of absence, printing mistakes, and a school location outside the municipal border, it was necessary to omit 375 respondents from the sample. The study sample therefore included 1293 participants (78% of those eligible) from 66 classes and 15 schools. The Medical Ethics Committee of the Erasmus University Medical Center reviewed the proposal and gave a declaration of no objection for the ENDORSE project.

Procedure

The ENDORSE study was announced through a letter to parents. Parents could refuse to allow the participation of their child(ren). From October 2005 to May 2006, the adolescents completed a questionnaire in a lesson of approximately 50 minutes in the presence of a teacher and a trained research assistant. Observations of the school canteens were performed in the same time period.

Measures

Sugar-sweetened soft drink and snack consumption

Soft drinks were defined as carbonated drinks, other noncarbonated sugar-sweetened drinks (water-based beverages that contain sugar), and sport drinks. The consumption of soft drinks was assessed by two questions: *How many days a week do you usually drink sugar-sweetened (not "light" or "diet") beverages?* and *If you drink sugar-sweetened beverages, how many glasses, cans, and/or bottles do you drink on average per day?* Total soft drink consumption was expressed in liters per day, and was calculated from the two questions according to Dutch standard serving sizes (1 glass=200 ml, 1 can=330 ml, 1 bottle=500 ml). The soft drink consumption variable was normally distributed, allowing linear regression analysis.

Snacks were classified as *sweet* (candy, candy bars, chocolate, cake, biscuits) and *savory* (fast-food, pizza, fries, chips, nuts). Sweet-snack consumption was assessed by two ques-

tions: *How many days a week do you usually eat sweet snacks or cookies?* and *On average, how many times a day do you eat sweet snacks or cookies?* Two similar questions were asked for savory snacks. These questions were combined so that a single score could be computed for the mean snack intake in times per day. As this variable was not normally distributed, snack consumption was dichotomized by means of a median split, distinguishing adolescents consuming two or fewer times per day (reference group) from those consuming more than two times per day.

Personal factors

Cognitions specific to soft drink and snack consumption (attitude, subjective [parental] norm, modeling, perceived behavioral control, and intention) were assessed according to the TRB, using a 5-point bipolar scale [14]. Attitude was assessed with two items that asked if the adolescent considered the behavior as good or bad and as pleasant or unpleasant. The two items were collapsed in a single attitude variable by calculating the mean item score (Cronbach's α=0.74 soft drink, 0.61 snack consumption). Parental norm was assessed with one item: *My parents consider consuming soft drinks/snacks as good/bad*. Modeling was assessed with two items that asked if parents and friends consume a lot of or very little/very few soft drinks/snacks. Perceived behavior control was assessed with two items that asked how easy or difficult it is to consume soft drinks/snacks, and then asking if the decision to consume soft drinks/snacks is completely or not completely under the control of the adolescent. The two items were collapsed into one variable by calculating the mean item score (Cronbach's α=0.61 soft drink, 0.65 snack consumption). The intention to consume soft drinks, snacks, or both was assessed with a single item that asked about the adolescent's intention to consume soft drinks/snacks in the next 6 months. Because of a skewed distribution, responses to all variables were dichotomized to indicate agreement with the statement (i.e., very good or good=1) or otherwise (i.e., neither good/bad, bad, very bad=0).

School food environment

Two observers audited each school. An audit instrument was developed to assess the availability of food in the schools (see Appendix). The instrument was reviewed by experts and pilot-tested. It included observations of the different types of soft drinks/snacks that were available from vending machines and at the canteen counter. Eight availability variables were created: the availability of sugar-sweetened soft drinks in vending machines (1) and at the canteen counter (2); the total availability of low-calorie drinks (3); the availability of energy-dense snacks in vending machines (4) and at the canteen counter (5); the availability of low-energy snacks in vending machines (6) and at the canteen counter (7); and the total availability of fruit and vegetables at school (8).

Products from one brand with different flavors (e.g. Coke and Coke with vanilla flavor) were counted as two distinct products. The availability variables were re-coded into variables with two or three categories. Where possible, a group with no products available was created; otherwise, the variables were categorized into tertiles or dichotomized, depending on the variation in the data.

Local neighborhood environment around school

The neighborhood around a school was defined as a crow-fly buffer of 500 meters (stores that could be accessed within a lunch break of 30 minutes). Each school address was geocoded using ArcView Version 3.3, and 500-meter buffers were created around each school. The municipality of Rotterdam supplied cadastral data as well as road and road-attribute information. Records from Locatus, a company that provides information on stores in The Netherlands, were used to identify the locations of the food establishments surrounding each school. These locations were geocoded, and the availability of stores (the total number within 500 meters) was computed for five types of food establishments: (1) fast-food outlets; (2) large supermarkets; (3) small food stores (small supermarkets, ethnic-food stores, news agencies, stores at petrol stations); (4) bakeries; and (5) fruit/vegetable stores. The distance to the nearest food store was calculated using the street network (walking route). All variables were re-coded to categories based on tertiles (small food stores, bakeries, fruit/vegetable stores, distance); the median value (fast-food outlets); and the possibility of distinguishing a no-availability category (large supermarkets).

Demographics

Age was derived from date of birth and date of measurement. Ethnicity was defined according to the definition used by the Netherlands Statistics. Adolescents were considered to be from a Western ethnic background if both parents had been born in the Netherlands; in another European country; or in North America, Oceania, Indonesia, or Japan. Adolescents with one or both parents born in a non-Western country were considered to be from a non-Western ethnic background. Schools provided the school-level information (higher-level secondary education or vocational training).

Analyses

Respondents with missing data on relevant cognitive variables and soft drink or snack consumption were deleted from the sample, resulting in study samples of 1174 and 1139 adolescents for soft drink and snack consumption, respectively. In 2007, multilevel linear (soft drinks) and logistic (snack) regression analyses were performed, using MLwiN version

2.02. A three-level structure was used to take into account that adolescents were nested within classes and classes were nested within schools [29].

First, a 3-level, random-intercept model was fitted without any explanatory variables to examine the significance of the between-school and between-class variance (Model 0). A significant variance would indicate that the individual behavior clustered within schools and/or classes [30]. Second, demographic factors were included in Model 1. To control for possible confounding, these factors were included in all other models that were fitted. Third, school-canteen factors were added (Model 2) as well as school-neighborhood factors (Model 3). Fourth, a model was fitted with individual cognitions (Model 4). To examine individual cognitions as mediators of the associations between environmental factors and behavior, the four-step procedure indicated by Baron and Kenny [31] was used. Mediation can be established if (1) environmental factors are associated with the outcome behavior (Models 2 and 3); (2) the individual cognitions are associated with the outcome behavior (Model 4); (3) the environmental variables are associated with the individual cognitions (model not presented); and (4) the association between the environmental factor and the outcome behavior decreases when controlling for the mediators (Mediation Model).

RESULTS

School Environment and Participant Characteristics

Four of the 15 schools sold fruit/vegetables, and two schools had low-energy snacks available in their vending machines. A small food store was the closest store for five schools, while only one school had a fruit/vegetable store as the closest store. The mean number of food establishments within 500 meters of schools was 16.7 (range=1–45), and consisted mostly of small food stores (M=6.7, range=0–21), followed by fast food outlets (M=4.7, range=1–12); bakeries (M=2.9, range=0–8); fruit/vegetable stores (M=1.3, range=0–4); and large supermarkets (M=1.2, range=0–4). The mean street-network distance from a school to the nearest food establishment was 284 meters (range=89–619) (data not presented).

The demographic, cognitive, and behavioral characteristics of the sample are shown in Table 7.1. Adolescents reported drinking an average of 1 liter (SD=0.97) of soft drink per day, and 51.5% reported consuming more than two portions of snacks per day. The adolescents had particularly positive cognitions regarding soft drink consumption.

Table 7.1 Demographic, cognitive, and behavioral characteristics of the study population

	Soft drink (*n*=1174)[a]	Snack (*n*=1139)
Demographics		
Age (mean, SD), years	14.1 (1.2)	14.1 (1.2)
Gender (boys), %	52.9	53.6
Ethnicity (Dutch + Western immigrants), %	49.2	50.2
School level (high school), %	46.1	46.8
Individual cognitions		
Attitude (*I think consuming … is good and pleasant*), %		
Disagree/unsure	26.7	43.3
Agree	73.3	56.7
Parental subjective norm (*If I consume…, my parents think it's good*), %		
Disagree/unsure	54.2	78.4
Agree	45.8	21.6
Parental modeling (*My parents consume a lot of…*), %		
Disagree/unsure	79.5	92.0
Agree	20.5	8.0
Friends modeling (*My friends consume a lot of…*), %		
Disagree/unsure	32.8	35.2
Agree	67.2	64.8
Perceived behavioral control (*I am able to determine my own consumption, and I think it is easy for me to consume …*), %		
Disagree/unsure	9.3	22.1
Agree	90.7	77.9
Intention (*I intend to consume … in the coming 6 months*), %		
Disagree/unsure	20.0	35.3
Agree	80.0	64.7
Behavior		
Soft drink consumption (mean, SD), liters	1.05 (0.97)	—
Snack consumption, %		
≤2 pieces/day	—	48.5
>2 pieces/day	—	51.5

[a]The number of respondents is different for soft drink and snack consumption as the respondents with missing data on a behavior were excluded from the sample.

Soft Drink Consumption

Table 7.2 shows the multivariate associations of the potential correlates with soft drink consumption. Significant between-school variance was found in the null model, which was explained by the individual-level demographics of the students (when controlling for demographics, there remained no between-school variance).

Gender, ethnicity, and school level were significantly associated with soft drink consumption. School canteen–availability factors were not associated with soft drink intake. An intermediate distance to the nearest store of 200–300 meters and the number of small food stores were inversely associated with soft drink consumption. Attitude, parental norm, modeling from friends and parents, and intention were positively associated with soft drink consumption. No significant association was found for perceived behavioral control.

In the mediation analyses, significant inverse associations were found between cognitions and the distance to the nearest store and the number of small food stores, with ORs ranging between 0.6 and 0.7 (results not presented). The association between environmental factors and soft drink consumption decreased, with percentages ranging from 19% to 48% after controlling for the significant cognitive variables, indicating that more small food stores and a 200–300 meter distance to the nearest shop decreased the positive cognitions toward soft drink consumption, resulting in lower intake.

Snack Consumption

No significant between-school and between-class variance was found for snack consumption. Vocational-training students were more likely to have high snack intake compared to those attending higher-level education (OR=1.5; 95% CI=1.1, 2.1). No significant associations were found for school-canteen and school-neighborhood factors. Adolescents with positive scores on attitude (OR=1.6; 95% CI=1.2, 2.1); modeling parents (OR=2.0; 95% CI=1.2, 3.5); modeling friends (OR=1.5; 95% CI=1.1, 2.0); parental norm (OR=1.4; 95% CI=1.0, 2.0); and intention (OR=2.5; 95% CI=1.8, 3.4) were more likely to report high snack intake compared to adolescents with more negative cognitions toward snack consumption.

DISCUSSION

This is one of the first studies to systematically examine the association of self-reported cognitive factors and objectively measured school-environment factors with soft drink and snack consumption among adolescents. As in other studies [10-13], significant positive

Table 7.2 School and class differences in soft drink consumption,a and the effect of individual cognitions, school-canteen availability, and school-neighborhood factors on soft drink consumption in liters per day (unstandardized regression coefficients)b

	Model 0[c]	Model 1	Model 2	Model 3	Model 4	Mediation
Random effects						
Between-school variance	**0.074***	0.029	0.006	0.000	0.015	0.000
Between-class variance	0.029	0.013	0.017	0.008	0.009	0.007
Demographics						
Gender (girls)		**−0.231****	**−0.247****	**−0.245****	**−0.177*****	**−0.180****
Age		0.008	0.022	−0.005	−0.017	−0.026
Ethnicity (non-Western)		**0.162***	**0.141***	**0.157***	**0.168*****	**0.179*****
School level (vocational)		**0.282*****	**0.561****	**0.355****	**0.270*****	**0.258****
School canteen						
Sugar-sweetened soft drink counter (0=ref)						
Medium			−0.373			
High			−0.168			
Sugar-sweetened soft-drink vending (0=ref)						
Medium			−0.258			
High			−0.066			
Low-calorie drinks (low=ref)						
Medium			−0.086			
High			0.010			
School neighborhood						
Supermarket (0=ref)				0.077		
Fast food (low=ref)				−0.055		
Small food stores (low=ref)						
Medium				**−0.322*****		**−0.167***
High				**−0.259***		**−0.211***
Distance to nearest store (<200m=ref)						
200–300 meters				**−0.376****		**−0.246*****
>300 meters				−0.098		−0.015
Individual cognitions						
Attitude					**0.324****	**0.352****
Modeling parents					**0.294****	**0.320****
Modeling friends					**0.190****	
Parental norm					**0.203****	**0.214****
Perceived behavioral control					0.038	
Intention					**0.424****	**0.426****

Note: Beta's in **bold** indicate a significant association.
[a]School and class differences are indicated by the between-school and between-class variance. Significance was calculated with the Wald statistic following a chi-square distribution with 1 df. A significant variance would indicate that the individual behavior clusters within schools and/or classes. [b]Unstandardized regression coefficients express the likelihood of soft drink consumption in liters per day. [c]All models are adjusted for between-school and -class variance and all variables that were included in the specific model.
*p<0.05; **p<0.001; ***p<0.01

associations were found for individual cognitions for both behaviors. This may indicate that cognitions are important factors to target in interventions, that is, by means of health education techniques.

Only small associations between environmental factors and intake were found. No associations were found for the availability of products in school canteens, and associations with school-neighborhood factors were found only for soft drink consumption. The associations found did not clearly confirm the hypothesis that a higher availability of snack food and soft drink in the school environment would be associated with higher intake of such items. The association between the distance to the nearest food store and soft drink consumption was inconsistent, as no significant inverse association was found for food stores located farther than 300 meters away from a school. This might indicate that adolescents consider 300 meters too far to walk and do not visit these stores to buy drinks. Another study found that residing closer to a fast-food restaurant was associated with increased high-fat vegetable intake (e.g., fried potatoes) by adolescents [32]. However, the current study did not find this association for snack intake, indicating that the distance to food stores may not be important for all dietary behaviors. The inverse association between the number of small food stores and soft drink consumption was unexpected, and the opposite of the hypothesis that the presence of more food stores would have a positive effect on intake. The inverse association that was found might indicate that the presence of a greater range of food stores close to schools provides a larger variety of food and drinks from which student can choose, including more healthful options; this may account for the inverse association, but more research is necessary.

The mediation effect that was found provides some evidence for the hypothesis that environmental factors influence soft drink consumption via the cognitions, as proposed by Kremers and colleagues [20] in their EnRG framework. A possible reason why associations between school-environment factors and intake were not detected might be that only crude measures of the complex constructs of proximity and availability were used, without taking into account traffic safety, food prices, policy, and social factors [24, 33, 34]. The use of a broad crow-fly buffer instead of a network buffer (a boundary based on potential walking routes) may also be a reason for the lack of findings. In addition, all adolescents may have enough access to soft drinks and snacks, so that the minor differences in the availability of products in the school environment are not a limiting factor. This is expressed in the nonsignificant between-school variance for snack consumption and in the between-school difference for soft drink consumption that was, in large part, accounted for by differences in demographic factors. Furthermore, intake was assessed based on the average intake per day instead of the intake at school. Other studies found that adolescents consume soft drinks and snacks mainly in other settings—for instance, at home and in fast-food restaurants [35, 36].

The results of the present study must be interpreted in the light of several limitations. The cross-sectional design of the study did not allow the determination of causal effects. The use of self-reported measures of intake is a well-known source of potential bias. The categorization of the in-school availability measures could have led to nonsensitive categorization. Testing the validity of the audit instrument was not possible, because a gold standard does not exist for assessing environmental factors in the school environment. The strength of this study is the combination of individual and objective environmental measures. However, there are also limitations concerning GIS data, as the number of food stores in the commercial database might be an under- or over-representation of the actual number of stores.

Conclusion

This study provided little evidence for associations of environmental factors in the school environment with soft drink and snack consumption, while finding clear positive associations between cognitions and soft drink and snack intake. This indicates that such cognitions, rather than environmental factors, should be the primary target for interventions. However, the inverse associations between environmental factors and soft drink intake might indicate that the environment can also exert a positive influence on dietary behaviors and cognitions. As this is one of the first studies to examine these factors in the school environment, longitudinal and experimental studies are needed to draw firmer conclusions.

ACKNOWLEDGEMENTS

This study was financially supported by a grant from ZonMw, The Netherlands Organization for Health Research and Development (2100.0103). AT and DC are supported by fellowships from the Victorian Health Promotion Foundation, Australia.

Appendix. Audit instrument for school canteen availability of drinks and snacks

	Yes	# of products	Category
Availability of drinks in vending machines			
Sugar-containing carbonated soft drinks	☐		Sugar-sweetened soft drinks
Sugar-containing noncarbonated soft drinks	☐		Sugar-sweetened soft drinks
Carbonated diet drinks	☐		Low-calorie drinks
Noncarbonated diet drinks	☐		Low-calorie drinks
Sport drinks	☐		Sugar-sweetened soft drinks
Water products	☐		Low-calorie drinks
Availability of drinks at canteen counter	☐		
Sugar containing carbonated soft drinks	☐		Sugar-sweetened soft drinks
Sugar containing noncarbonated soft drinks	☐		Sugar-sweetened soft drinks
Carbonated diet drinks	☐		Low-calorie drinks
Noncarbonated diet drinks	☐		Low-calorie drinks
Sport drinks	☐		Sugar-sweetened sof drinks
Water products	☐		Low calorie drinks
Availability of snacks in vending machines			
Candy bars/chocolate products	☐		Energy-dense snacks
Peppermints/candy in a roll	☐		Energy-dense snacks
Candy in a bag	☐		Energy-dense snacks
Chips	☐		Energy-dense snacks
Cake	☐		Energy-dense snacks
Biscuit	☐		Energy-dense snacks
Low-calorie biscuits	☐		Low-energy snacks
Gingerbread	☐		Low-energy snacks
Russian salad	☐		Energy-dense snacks
Raw vegetables / salads	☐		Low-energy snacks
Fruits	☐		Low-energy snacks
Availability of snacks at canteen counters			
Candy bars/chocolate products	☐		Energy-dense snacks
Peppermints/candy in a roll	☐		Energy-dense snacks
Candy (small bag)	☐		Energy-dense snacks
Candy (a piece)	☐		Energy-dense snacks
Chips	☐		Energy-dense snacks
Cake	☐		Energy-dense snacks
Biscuit	☐		Energy-dense snacks
Low-calorie biscuits	☐		Low-energy snacks
Gingerbread	☐		Low-energy snacks
Warm savory snacks	☐		Energy-dense snacks
Ice cream (cream-based)	☐		Energy-dense snacks
Water ice	☐		Energy-dense snacks
Russian salad	☐		Energy-dense snacks
Raw vegetables/salads	☐		Low-energy snacks
Fruits	☐		Low-energy snacks

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8 Do individual cognitions mediate the association of socio-cultural and physical environmental factors with adolescent sports participation?

Van der Horst K, Oenema A, te Velde SJ, Brug J. Do individual cognitions mediate the association of socio-cultural and physical environmental factors with adolescent sports participation?

Public Health Nutrition (submitted).

ABSTRACT

Objective: To examine the associations of perceived physical environmental factors (availability of physical activity attributes at home, physical activity facilities in the neighbourhood, neighbourhood pleasantness and safety) and social environmental factors (parental sports behaviour and parental rule regarding sports participation) with adolescent leisure time sports participation, and to explore whether the associations found were mediated by individual cognitions as derived from the Theory of Planned Behaviour (TPB).
Design: Cross-sectional
Setting: Adolescents from 17 schools in Rotterdam, the Netherlands, completed a questionnaire during school hours that included self-report measures of leisure time sports participation, the perceived physical environmental factors and TPB variables. Information about parental sports behaviour and parental rule was obtained from a questionnaire that was completed by one parent of the adolescents.
Subjects: Data was collected from 584 adolescent – parent combinations.
Results: Data was analyzed with multilevel logistic regression analyses. Availability of physical activity attributes at home (OR = 1.26), parents' sports behaviour (OR = 2.03) and parental rule (OR = 1.64) were associated with a higher likelihood of adolescents' leisure time sports participation. These associations were partly mediated by attitude and intention.
Conclusions: Adolescents were more likely to engage in leisure time sports when PA attributes were available at home, when parents participated in sports activities and had a rule about their offspring participation in sport activities. These associations were partly mediated by attitude and intention. These results suggest that parents can importantly promote sports participation among their offspring by making sports activities accessible and a family routine.

INTRODUCTION

Insufficient physical activity (PA) is a risk factor for a range of chronic conditions including obesity, among adults as well as adolescents [1, 2]. Most adolescents do not meet the recommended minimum levels of engaging in at least 60 minutes of moderate to vigorous intensity PA each day [3-6]. Adolescents are a particularly important target group to improve PA levels since physically active adolescents are more likely to become active adults [7]. To be able to increase PA levels among adolescents, it is important to develop interventions that target the most important determinants of PA.

In addition to individual cognitions such as attitude, subjective norm, perceived behavioural control and intention, as derived from the Theory of Planned Behaviour (TPB) [8] physical and social environmental factors may be important determinants of PA behaviour. Kremers and colleagues, in their Environmental Research framework for weight Gain prevention (EnRG) [9] suggest that environmental factors may have a direct and an indirect association with behaviour. The direct association reflects a more automatic and unconscious effect of the environment on behaviours. The indirect influence suggests that environmental factors influence PA via the individual cognitions, e.g. environments that offer appealing and easily accessible opportunities for PA may result in more positive attitudes, perceived behavioural control and intentions toward leisure time PA, which may result in higher PA levels. The TPB also assumes that the impact of various external variables such as physical and social environmental factors on behaviour is mediated by attitude, subjective norm, perceived behavioural control and intention.

Physical environmental factors such as the availability and accessibility of PA opportunities have received most attention in exploring environmental determinants of PA [9-11]. However, a recent review indicated that the evidence for the role of social environmental factors is stronger [12-14].

Earlier studies have found that among adults the association of perceived neighbourhood with walking was mediated by attitude [15] and that associations of perceived neighbourhood aesthetics with walking were mediated by attitude and intention [16]. De Bruijn and colleagues found that the association of environmental aesthetics and distance to PA facilities on PA among adolescents was mediated by intention to be physically active [17]. Motl and colleagues found that the association of equipment accessibility with adolescent girls PA was mediated by self-efficacy [18]. These previous studies indicate that some TPB variables may be more likely to serve as a mediators in environment – behaviour relationships than others [17, 19], with the strongest evidence for attitudes as a potential mediating variable [15-17, 19, 20]. Most previous studies have investigated mediation pathways for physical environmental factors.

The aim of the present study was to examine the associations between physical environmental factors (availability of PA attributes at home, PA facilities in the neighbourhood, neighbourhood pleasantness and safety) and social environmental factors (parents own sports behaviour and parental rule about sport participation) with adolescents' leisure time sports participation and to explore whether these associations are mediated by TPB variables (figure 1).

METHODS

Study design and sample selection

Baseline data from the ENvironmental Determinants of Obesity in Rotterdam SchoolchildrEn (ENDORSE) study were used [21] for which data were collected among adolescents in the first (12- to 13-year-olds) and third (14- to 15-year-olds) years of secondary school. The Medical Ethics Committee of Erasmus University Medical Center declared no objection to the project. Schools located in the Rotterdam area that participate in the Youth Monitor Rotterdam (YMR) (N = 56) were invited for participation in the ENDORSE study. Subsequently, a random sample of 17 school locations was drawn from the pool of 24 schools that were willing to participate. On average, five classes per school location were randomly selected to participate in the study and 1668 adolescents and their parents were eligible for participation. In the baseline survey, 187 adolescents were absent during the questionnaire assessment. Due to questionnaire printing mistakes, 120 records, including those from one entire school had to be removed. Response rate for the parent questionnaire was 43%, resulting in 584 adolescent – parent combinations. There was no data available on the parents and adolescents that did not participate in the study and examining response bias was therefore not possible. Compared to the data from the total adolescent sample, in the sample used for this study adolescents with a non-Western ethnic background (36.6% compared to 50.5%) and attending vocational schools (49.1% compared to 56.7%) were underrepresented.

Procedure

Parents received a letter announcing and explaining the ENDORSE study and could refuse participation of their child(ren) by sending a note to the adolescent's teacher. Between October 2005 and May 2006, the students completed the ENDORSE questionnaire in the classroom in the presence of a teacher and a trained research assistant within one school hour (50 minutes). The adolescents were handed a questionnaire with a pre-addressed and stamped envelope for completion by one of their parents. To increase the participation rates, five I-pods were raffled amongst the parent respondents and two reminders were send to the parents.

Measures

Leisure time sports participation

The relevant questions from the Activity QUestionnaire for Adolescents and Adults (AQUAA) were used to assess leisure time sports activities [22]. The test-retest reliability for this questionnaire was moderate (intraclass correlations 0.30-0.59) and validity with accelerometer data was low (Spearman correlation coefficient = 0.21 for vigorous activities) [22]. No validity data are available on sports behavior. First, adolescents were asked to write in text boxes in a pre-structured format up to three sports activities that they had engaged in, in the past week. Adolescents were asked to write down organized and unorganized sports they engaged in. Second, they had to tick on how many days in the past week (1 to 7) they had engaged in this activity. Third, they had to indicate how long on average they participated in this activity per occasion, in an open answering format with text boxes to indicate hours and minutes. The frequency and duration of the activities were multiplied, and then divided by the total number of days to provide the average minutes per day spent doing leisure time sports activities. As this variable was highly skewed and the distribution could not be improved through transformation, two categories were created: engaging in leisure time sports activities for less than 30 minutes per day (coded as 0), or 30 minutes or more per day (coded as 1). This cut-off point for sports behaviour was based on the Dutch physical activity recommendation that children and adolescents should engage in moderate to vigorous physical activity at least 30 minutes per day and practice sports at least 3 days a week.

TPB variables

Attitude, subjective parental norm, perceived behaviour control and intention were specifically assessed in relation to participation in leisure time sports activities. All questions could be answered on five-point bipolar answering scales. Attitude was assessed with two items asking if the adolescent considers sports and PA in leisure time as very good (+2) or very bad (-2) and as very pleasant (+2) or very unpleasant (-2). The mean item score (Cronbach's alpha = 0.79, Intraclass correlation = 0.66) for these items was calculated [35]. Subjective norm was assessed with one item: 'if I engage in sports and PA in leisure time, my parents consider that as very good (+2) – very bad (-2)'. Perceived behaviour control was assessed with one item asking how easy or difficult it is to engage in sports and PA in leisure time with an answering scale ranging from very easy (+2) to very difficult (-2). Intention to perform the behaviour was assessed with a single item: 'Do you intend to engage in sports and PA in leisure time in the next six months?' with an answering scale ranging from Yes, I certainly do (+2) to no, I certainly do not (-2).

Physical environmental variables

We assessed availability of PA opportunities at home by providing a list of ten sport 'attributes' (i.e. bicycle, dog, home trainer /treadmill, running shoes, stationary aerobic equipment, step aerobics, skates, balls, racquets, jumping rope). This list was translated from Sallis et al. [23]. The adolescents could tick which of these were available in their home. A score of PA attributes available at home was calculated by adding up the "yes" responses to these questions. Perceived neighbourhood pleasantness was assessed with two questions: "I think my neighbourhood provides a pleasant living environment", and "I think my neighbourhood is attractive", that could be answered on 5-point scales ranging from totally agree (+2) to totally disagree (-2). The mean item score (Cronbachs alpha = 0.78, Intraclass correlation = 0.64) of these two items was calculated. Perceived neighbourhood safety was assessed with four questions: "There is a lot of traffic in my neighbourhood", "It is unsafe to bicycle in my neighbourhood", "I feel safe when I am in my neighbourhood", and "It is unsafe to be outside in my neighbourhood", using the same five point answering scale format as neighbourhood attractiveness. The mean item score (Cronbachs alpha = 0.64) of these four items was calculated. Perceived availability of PA facilities in the neighbourhood was assessed by asking the adolescents to indicate whether or not (yes/no answering format) there were parks, sports clubs, sports/playing grounds present in the neighbourhood where they lived. The yes responses were summed to form one score for these four items.

Social environmental variables

Parental rule about PA was assessed with one question in the questionnaire for parents: "is it a rule in your household that your child has to participate in sport activities?" in a yes/no answering format. Parents own sports behaviour was assessed in the questionnaire for parents with two questions assessing frequency and duration, using the relevant questions from the SQUASH questionnaire [24]. The Spearman correlation for overall reproducibility of the SQUASH was 0.58 (95% CI = 0.36-0.74), and correlations for the reproducibility of leisure time sport was 0.90. Spearman's correlation coefficient between activity monitor readings and the total activity score was 0.45 (95% CI = 0.17-0.66) [24]. Frequency was assessed with: "How many days per week do you engage in sports activities?" on a 7-point scale from 1 = 1 day per week to 7 = every day. The duration was assessed with "On a day that you participate in sports activities, how long do you do this on average?" and hours and minutes could be reported. The frequency and duration of the activities were multiplied, and then divided by the total number of days to provide the average minutes per day. As this variable was highly skewed, two categories were created: engaging in sports activities (coded as 1) and not engaging in sports activities.

Demographics

To establish ethnicity according to the Statistics Netherlands definition, adolescents were asked to report in which country their parents had been born [25]. Adolescents were considered to be from a Western ethnic background if both parents had been born in a European country, North America, Oceania, Indonesia or Japan. Based on the socio-economic and cultural position of immigrants in the Netherlands from Oceania, Japan and Indonesia (a former colony of the Netherlands), children from these immigrants were also included in the Western ethnic group. Adolescents were considered to be from a non-Western ethnic background if one or both parents had been born in other countries. The school type the adolescents attended was categorized into two levels: vocational schools and higher-level secondary education (pre-academic). The schools provided educational level information. Age was determined based on the date of the measurements and the date of birth that were provided by the schools.

Data analyses

Possible multi-collinearity problems were examined with bivariate correlations and not encountered; all inter-correlations between predictors were below 0.6.

Mediation analyses according to suggestions of MacKinnon (2008) were used to identify total effects, direct effects and mediated effects in the associations of physical environmental factors (availability of PA attributes at home, availability of PA facilities in the neighbourhood, perceived neighbourhood pleasantness and safety) and socio-cultural environmental factors (parents sports behaviour and parental rule about sport participation) with adolescents' leisure time sports participation[26]. To do so, we explored associations between the environmental variables and TPB variables with multivariate linear regression analyses (step 1, path a in figure 1). Next, we examined if the potential mediators from the TPB were associated with leisure time sports, after adjustment for the environmental variables (step 2, path b in figure 1). The total effect of physical environmental factors and socio-cultural environmental factors on adolescents' leisure time sports participation (step 3, path c), and after adjustment for the possible mediator, the direct effect of environmental variables on sports participation (step 4, path c'), were examined in various models. As suggested by MacKinnon [26] and also outlined by Cerin and MacKinnon [27], a significant association between environmental variables (predictor variables) and sports participation (outcome variable) is not a requirement for mediation to occur, since absence of an overall relationship may be due to suppression effects. Therefore also non-significant environmental factors were included in the mediation analyses. Steps 2-4 were examined by means of multi-level multivariate logistic regression analyses. All analyses were adjusted for gender, age, ethnicity and school level, as these are possible confounding factors. All analyses were performed with MLwiN version 2.02. A three-level structure was used to take into account that adolescents

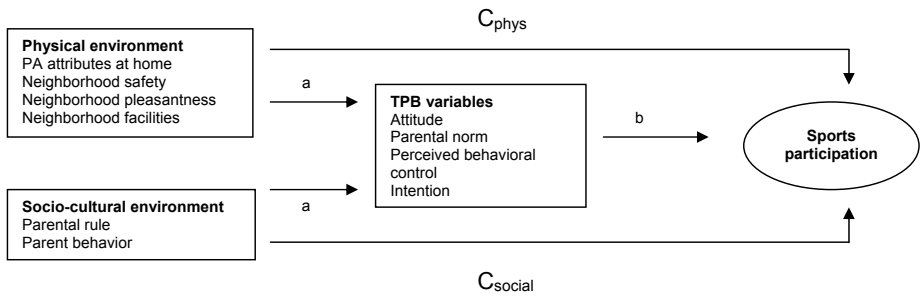

Figure 8.1 Conceptual model of the direct and indirect association of physical and socio-cultural environmental factors

were nested within classes and classes within schools [28]. Because of the dichotomous outcome variables there are different scales across the (logistic) regression analyses that makes it incorrect to use the 'difference-of-coefficients estimate' as an estimate of the mediation effect [27, 29]. One solution to overcome this difference in scaling is to standardize the regression coefficients before mediation is estimated [29, 30]. The standardized coefficients were subsequently used to estimate the proportion mediated (($c_{standardized} - c'_{standardized}$)/$c_{standardized}$) and were additionally entered in the Sobel test [31] to formally test the mediation effect.

RESULTS

Sixty percent of the adolescents reported to participate in leisure time sports for more than 30 minutes per day. The adolescents reported positive cognitions regarding leisure time sports participation. On average adolescents reported to have four of the listed PA attributes available at home (range 0-10) and to have three PA facilities available in their neighborhood (range 0-4), and reported positive perceptions of neighborhood safety (mean = 0.64, SD = 0.76) and pleasantness (mean = 0.76, SD = 0.99). A majority of the parents reported that it was a rule in the household that the adolescent had to do some kind of sports (66%) and 59% of the parents participated in leisure time sports activities themselves (Table 8.1).

Associations between environmental factors and TPB variables

Multivariate analyses showed that most of the physical and social environmental variables were significantly positively associated with TPB variables (Table 8.2). No associations were found for neighborhood facilities with attitude, perceived behavior control and intention. PA attributes at home and neighborhood safety were not associated with perceived behavior control. Parents' sport behavior was not associated with subjective parental norm.

Table 8.1. Characteristics of the study population (N=584)

Variable	Percentage / Mean; SD	Range	Cronbachs alpha / Intraclass correlation
Behavior			
Sports participation (>= 30 min/week)	59.8%		
Demographics			
Gender (girls)	45.2%		
Ethnicity (non-Western)	36.6%		
Age	M=13.91; SD=1.13	11.9 – 17.6	
Educational level (lower)	49.1%		
Individual cognitions			
Attitude	M=1.29; SD=0.64	-2 – 2	0.79 / 0.66
Parental norm	M=1.50; SD=0.61	-2 – 2	
Perceived behavior control	M=1.12; SD=0.81	-2 – 2	
Intention	M=1.57; SD=0.79	-2 – 2	
Physical environment			
PA attributes at home	M=3.97; SD=2.08	0 – 10	
Neighborhood safety	M=0.64; SD=0.76	-2 – 2	0.64
Neighborhood pleasantness	M=0.76; SD=0.99	-2 – 2	0.78 / 0.64
Neighborhood facilities	M=3.26; SD=0.95	0 – 4	
Socio-cultural environment			
Parental rule to play sports (yes)	65.8%		
Parent behavior (parent does practice sports)	59.4%		

Associations of TPB variables with adolescents' leisure time sports participation

To establish a mediation effect, the potential mediators must be associated with the outcome variable after adjustment for de independent, environmental variables [26]. Multivariate analyses (Table 8.3) showed that attitude and intention were found to be significantly associated with a higher likelihood of participating in leisure time sports after adjustment for physical environmental variables (attitude OR = 2.30; intention OR = 2.10) and after adjustment for social environmental variables (attitude OR = 2.24; intention OR = 2.03).

Mediating effects of TPB variables

As neighborhood facilities were not associated with attitude and intention, this factor was not included in the mediation models (Table 8.4). The association of PA attributes at home with a higher likelihood of participating in leisure time sports was partly mediated by attitude (17.4%) and intention (21.6%), as indicated by the significant Sobel test results. The

Table 8.2 Results of multivariate linear regression analyses (unstandardized regression coefficients) of physical and social environmental variables with TPB variables as dependent variables, adjusted for age, gender, ethnicity, school type and clustering within classes and schools

	Attitude	Parental norm	Perceived behavioral control	Intention
PA attributes at home	**0.039****	**0.042****	0.026	**0.056*****
Neighborhood safety	**0.146*****	**0.120*****	0.016	**0.186*****
Neighborhood pleasantness	**0.168*****	**0.090*****	**0.105****	**0.115*****
Neighborhood facilities	0.035	**0.059****	0.028	0.049
Parental rule	**0.141***	**0.121***	**0.174***	**0.166***
Parent behavior	**0.135***	-0.001	**0.185****	**0.180****

*p<0.05; **p<0.01, ***p<0.001

Table 8.3 Results of multivariate logistic regression analysis (odds ratios) examining the association between potential mediators (TPB variables) and leisure time sports participation (>= 30 min), adjusting for the physical (model 1) and social (model 2) environmental factors[a]

	Model 1		Model 2	
	OR	**95% CI**	**OR**	**95% CI**
Physical environmental factors				
PA attributes at home	**1.20**	1.07-1.35		
Neighborhood safety	1.22	0.86-1.73		
Neighborhood pleasantness	0.89	0.68-1.16		
PA facilities in the neighborhood	1.02	0.83-1.23		
Socio-cultural environmental factors				
Parental rule			1.37	0.85-2.20
Parents sports behavior			**1.79**	1.14-2.80
TPB variables				
Attitude	**2.30**	1.46-3.61	**2.24**	1.48-3.39
Parental norm	1.21	0.82-1.80	1.29	0.87-1.92
Perceived behavioral control	1.00	0.76-1.33	0.96	0.72-1.27
Intention	**2.10**	1.47-3.02	**2.03**	1.42-2.91

[a] Multivariate logistic regression analyses adjusted for age, gender, ethnicity, school type and clustering within classes and schools

association between neighborhood safety and sports participation was significantly mediated by intention; however, both direct and indirect associations were not significant. The direction of the association between neighborhood pleasantness and sports participation changed after adjustment for attitude, which suggests an inconsistent mediation model.

The associations of parental rule and parents' sports behavior with a higher likelihood of participating in leisure time sports were also partly mediated by attitude and intention with

Table 8.4 Results of logistic regression analyses to examine the mediation of the association between physical environmental factors with leisure time sports participation (>= 30 min) by attitude (model 2) and intention (model 3) [a]

	Model 1		Model 2		Sobel test	Proportion mediated [b]	Model 3		Sobel test	Proportion mediated [b]
	OR	**95% CI**	**OR**	**95% CI**	***z* score**	**%**	**OR**	**95% CI**	***z* score**	**%**
Physical environmental factors										
PA attributes at home	**1.26**	1.13-1.42	**1.24**	1.10-1.39	2.54 **	17.4	**1.22**	1.09-1.37	2.86**	21.6
Neighborhood safety	1.28	0.93-1.77	1.32	0.94-1.86	3.40 ***	-3.4[c]	1.16	0.83-1.63	3.37***	44.3
Neighborhood pleasantness	1.06	0.83-1.36	0.87	0.66-1.13	4.40***	312.2[d]	1.01	0.78-1.31	2.92**	82.2
TPB variables										
Attitude			**3.44**	2.33-5.08						
Intention							**2.71**	1.93-3.80		

[a] Multivariate logistic regression analyses adjusted for age, gender, ethnicity, school type and clustering within classes and schools

[b] as calculated with the standardized coefficients (see methods section)

[c,d] Negative values and values > 100% indicate inconsistent mediation models and the results cannot be interpreted.

* p< 0.05; ** p< 0.01; *** p< 0.001

percentages ranging between 20.1 and 31.7 (Table 8.5). The associations of PA attributes at home and parent behavior with leisure time sports remained statistically significant, while the association of parental rule lost significance in the mediation models.

DISCUSSION

In this study, associations of socio-cultural and physical environmental factors with adolescents' leisure time sports participation were examined and it was explored if these associations were mediated by individual cognitions such as attitudes and intentions. Results showed that parents' sport behaviour, parental rule about sports behaviour and availability of PA attributes at home were associated with a higher likelihood that adolescents engaged in sports behaviour. We cannot draw conclusions upon the findings that resulted from an inconsistent mediation model [32]. The inconsistent model is a result of the fact that the direct association between neighbourhood pleasantness and sports participation was weak but positive, while the indirect association was also weak and non significant, but negative.

Table 8.5 Results of logistic regression analyses to examine the mediation of the association between social environmental factors with leisure time sports participation (>= 30 min) by attitude (model 2) and intention (model 3) [a]

	Model 1		Model 2		Sobel test	Proportion mediated [b]	Model 3		Sobel test	Proportion mediated [b]
	OR	**95% CI**	**OR**	**95% CI**	***z* score**	**%**	**OR**	**95% CI**	***z* score**	**%**
Social environmental factors										
Parental rule	**1.64**	1.05-2.56	1.51	0.95-2.42	2.20*	23.1	1.45	0.91-2.78	2.43*	31.7
Parent behavior	**2.03**	1.26-3.25	**1.85**	1.19-2.87	2.29*	20.1	**1.80**	1.16-2.78	2.13*	23.3
TPB variables										
Attitude			**3.38**	2.32-4.91						
Intention							**2.77**	2.00-3.85		

[a] Multivariate logistic regression analyses adjusted for age, gender, ethnicity, school type and clustering within classes and schools

[b] as calculated with the standardized coefficients (see methods section)

* $p<0.05$

Evidence was found for partial mediation of social and physical environmental factors by attitude and intention. However, also a direct significant association remained of PA attributes at home and parental behaviour with leisure time sports participation. These findings are in accordance with those of earlier studies where attitudes were found to be strong mediators of the association between physical environmental factors and PA [15-17, 19, 20]. The results suggests that both direct, automatic influences of the environment and more reasoned cognitive processes are important in adolescents' sports participation as suggested in the EnRG framework [9] However, as we found rather strong associations of attitude and intention with leisure time sports participation in this study, adolescents leisure time sports behaviour seems to be, at least partly, also the result of a more reasoned, deliberate process, that is not influenced by the environmental factors considered in the present study. This does make sense, since sport activities are less likely to be part of routine habits, more likely to need to be planned in advance and to be dependent on explicit positive motivation, than, for example, daily activities. The present results support this hypothesis to a certain extend, as we found significant but small correlations between environmental factors and cognitions. This association of cognitions, independent from the environmental factors is not clearly stated in the EnRG framework that focuses on cognitions as mediators of environmental influences. Two of the four cognitions included in the present study, i.e. parental subjective norm and perceived behavioural control, were not found to be associated with

sports behaviour. This might indicate that not all cognitions as suggested by the Theory of Planned Behaviour are important mediators or play a role in the suggested reasoned process for this particular behaviour in this population group. On the other hand, the non-significant results might be caused by the limited assessment of these constructs with only one or two items.

In accordance with other studies, social factors seem to be more strongly associated with physical activity behaviour than physical environmental factors [12-14]. The direct associations of parents' sports behaviour and the availability of PA equipment at home, support earlier evidence that parental example and support (for instance through providing good sports equipment at home), are important for PA promotion. The range of social factors considered in the present study was narrow, and factors such as social networks, friends' support and behaviour and the perceived behaviour of parents should be included in future studies to provide further insight into the specific aspects of the social environment that are most important for adolescents PA behaviours [18, 33]. Next to this, future research should address the moderating effects of socio-demographic factors mentioned in the EnRG framework as there are clear gender differences in sports participation and correlates of physical activity might be different for boys and girls. For example, mothers' physical activity appears to be more often associated with girls' rather than boys' physical activity [12].

One possible limitation of this study was that we used perceptions of the environment instead of more objective measures of the physical environment. Perceived environmental factors are, of course, also cognitive representations (i.e. of environmental factors), and different mediating pathways may be apparent with more objective assessments of the environment. Evidence points out that perceived and objective environmental factors are different constructs [34] and that perceptions of the environment only partly depend on what is objectively available in the environment [35]. Studies exploring TPB variables as well as perceived environmental factors as mediators of the associations between objective environmental characteristics and PA behaviour may help to unravel the interplay between individual and environmental factors in influencing energy balance-related behaviours as proposed in the EnRG framework.

The following limitations should be taken into account when interpreting the results of this study.

The cross-sectional design of the study did not allow us to determine causal effects and is an important limitation in research examining mediation pathways. Physically active adolescent might be more aware of physical activity equipment in their environment and they might select more or less the neighbourhood they are active in by having a specific definition about how large the neighbourhood is. Having positive cognitions towards sports

might shape the adolescents environment. For instance, adolescents might influence their parents by promoting sports activities and asking for more equipment. Next to this, the sample size of this study was restricted because of the rather low response rate for the parent questionnaire. The fact that adolescents from non-Western ethnic background and lower educational level were underrepresented in the sample suggests selection bias. Several limitations relate to the measurement instruments used in the study. First, adolescents sports behaviour was based on self-report and in a validation study with use of accelerometers was shown that the questionnaire had limited validity and that adolescents over-reported their activity levels [22]. Second, the TPB variables were assessed with only one or two items leading to limited reliability. The TPB variables, particularly perceived behaviour control, might have been not robust enough to demonstrate associations and to show up as a mediator. Environmental constructs were often measured with only one ore two items with only moderate reliability. In explorative research more effort needs to be done to construct better scales that examine all aspects of the perceived environmental factors. More qualitative research is needed to improve existing measurement instruments and scales. Next to this, only a limited set of perceived environmental variables was used in this study. Especially other social environmental influences such as encouragement of parents and friends might be important in explaining physical activity behaviours [12, 14, 36]. Parents' sports behaviour was also assessed with other questions compared to adolescents' sports participation and other cut-off points were used. This could also have affected the associations found. Third, adolescents with overweight or lack of physical activity might have given social desirable answers on sports behaviour and on the theory of planned behaviour items as well, which could have influenced the associations between cognitions and behaviour.

Nevertheless, this explorative study contributes to the structured examination of the associations between environmental factors and physical activity and the suggested mediation by TPB variables as supposed by the EnRG framework.

Conclusion

Dutch adolescents were more likely to engage in leisure time sports when PA attributes were available at home, when parents participated in sports activities and when parents had the rule in their household that the child has to play a sport. These associations were partly mediated by attitude and intention. This indicates that parents are important actors in shaping the environmental factors of interest by making sports activities accessible and a family routine. Therefore, not only adolescents, but also parents should be targeted in interventions aiming to improve PA among adolescents. However, the cross-sectional design of this study should be taken into account and the findings have to be verified in longitudinal and experimental studies. Effort needs to be done to construct better measurement instruments and scales to examine perceived environmental factors.

Acknowledgements

This study was part of CEPHIR: the Center for Effective Public Health in the larger Rotterdam Area. Financial support for this study was provided by grants from ZonMw, the Netherlands Organization for Health Research and Development (grant ID no. 2100.0103) and The World Cancer Research Fund - WCRF-NL (Grant number; 2007/47). This paper has been facilitated by the EU funded HOPE project: "Health-promotion through Obesity Prevention across Europe (the Commission of the European Communities, SP5A-CT-2006-044128). The study does not necessarily reflect the Commission's views and in no way anticipates the Commission's future policy in this area'.

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9 Perceived parenting style and practices and sugar-sweetened beverage consumption by adolescents

van der Horst K, Kremers S, Ferreira I, Singh A, Oenema A, Brug J. Perceived parenting style and practices and sugar-sweetened beverage consumption by adolescents.

Health Education Research 2007, 22: 295-304.

ABSTRACT

Purpose: To investigate whether perceived parenting practices and parenting style dimensions (strictness and involvement) are associated with adolescents' consumption of sugar-sweetened beverages.

Methods: In this cross-sectional study, secondary-school students (n = 383, mean age 13.5) completed a self-administered questionnaire on their consumption of sugar-sweetened beverages, attitude, social influences, self-efficacy, habit strength, food-related parenting practices, and the general parenting style dimensions of 'strictness' and 'involvement'. Data were analyzed using multiple linear regression analyses.

Results: More restrictive parenting practices were associated with lower consumption of sugar-sweetened beverages (β = -38.0 ml, 95% CI = -48.1; -28.0). This association was highly mediated (about 55%) by attitude, self-efficacy, and modeling from parents. Nevertheless, a significant direct effect remained (β = -17.1 ml, 95% CI = -27.2; -6.90). Interactions between perceived parenting style and parenting practices showed that the association between parenting practices and sugar-sweetened beverage consumption was stronger among adolescents who perceived their parents as being moderately strict and highly involved.

Conclusions: Parents influence their children's sugar-sweetened beverage consumption and should therefore be involved in interventions aimed at changing dietary behaviors. Interventions aimed at the promotion of healthy parenting practices will improve when they are tailored to the general parenting style of the participants.

INTRODUCTION

The prevalence of overweight among adolescents has increased rapidly over the last decades [1, 2]. Overweight is caused by an imbalance between energy intake and energy expenditure. Various behaviors, such as watching television [3-5], fast food consumption [6, 7], and consumption of large serving portions [8, 9] have been identified as determinants of a positive energy balance. Additionally, consumption of sugar-sweetened soft drinks has been found to be positively associated with adolescent obesity [10-13]. Effective promotion of healthful eating requires a detailed understanding of the factors influencing dietary behavior. This is especially important for sugar-sweetened drinks, given the large increase in soft drink consumption in adolescents in recent years and the increase in soft drink consumption throughout adolescence [14]. Between 1977 and 1998, the consumption of carbonated soft drinks by school-aged children in the United States (aged 6-17 years) has increased from 5 fluid oz. (148 ml) to 12 fluid oz. (355 ml) per day [15], contributing 8% to the total daily energy intake of adolescents (10.3% and 8.6% in overweight males and females respectively) [16, 17]. In Dutch adolescents (aged 13-18 years), similar trends have been reported between 1987 and 1998, with sugar sweetened carbonated and non-carbonated soft drink consumption increasing by 50.2% (317 ml - 476 ml) and 32.5% (212 ml - 281 ml) per day for boys and girls, respectively [18].

Research indicates that parents play an important role in the eating behavior of adolescents [19]. Parents influence the availability of soft drinks at home, but can also exert their influence through food related parenting practices [20-24]. Parenting practices are directly related to specific behaviors of their children, such as the consumption of soft drinks, and parents use different parenting practices for different behaviors. Studies on food-related parenting practices have reported contradictory results: on the one hand, the results of some studies indicate that strict parenting practices may increase children's preference for (and the intake of) the restricted foods [23, 25, 26], whereas an other study suggests that adolescents have a healthier diet and consume less soft drinks when they report more food related rules in their family [27]. These mixed results suggest that additional factors play a role. For instance Darling & Steinberg [28] postulated that parenting style modifies the association between parenting practices and adolescent behavior (figure 1). Parenting style refers to general patterns of parenting and the emotional climate in which the parents' behaviors are expressed. In contrast to parenting practices, parenting style refers to parent-child interactions in general, whereas parenting practices are related to specific behaviors, and are reflected in things like food rules [28]. Thus, parenting practices operate in the context of parenting style. Parenting styles are classified according to two dimensions of parental behavior: 'strictness' or parental control, and 'involvement' or parental warmth and acceptance [29]. Food-related parenting practices might have a different effect

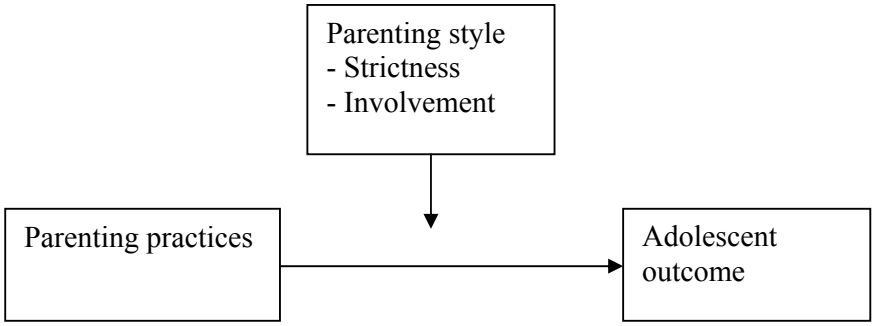

Figure 9.1 Moderating contextual model of parenting style

on adolescents' behavior depending on the parenting style of their parents. Few studies have proposed this interaction effect between parenting style and parental child-feeding practices [19, 30]. Elaborating on the model of Darling & Steinberg, we aimed to examine the interactive nature of parenting style dimensions in more detail.

Cognitive variables, such as attitude, social influence, self-efficacy or habit strength may also be predictors of the consumption of sugar-sweetened beverages [21, 22]. Whether behavior-specific cognitions and habit strength can explain the link between parenting practices and adolescents' sugar-sweetened beverage consumption is not known, but most social cognitive theories assume that environmental influences are mediated by behavior-specific cognitions.

In this cross-sectional study, we investigated (a) whether behavior-specific cognitions from the Attitude, Social influence, self-Efficacy (ASE) model and habit strength are associated with sugar-sweetened beverage consumption by adolescents, (b) whether perceived parenting practices are associated with adolescent sugar-sweetened beverage consumption and whether cognitions and habit strength explain such an association, (c) possible interactions between perceived parenting style dimensions and perceived parenting practices. We combined the contextual model of parenting style [28] with the ASE model [31] and habit strength [32] to investigate sugar-sweetened beverage consumption by adolescents.

METHODS

Study population and procedure

This study was part of the Dutch Obesity Intervention in Teenagers. The medical ethical committee of the VU University Medical Center granted ethical approval for this study.

Data were collected at Dutch secondary schools in May and June 2003. The subjects were 383 adolescents from 16 first and second grades of five secondary schools. The questionnaires were completed in the classroom. No refusals to complete the questionnaire were reported. The mean age (SD; range) of the respondents was 13.5 years (0.62; 12 to 17); 211 (55.1%) were female; and 55 (14.4%) were of recent immigrant origin, defined as one or both parents born abroad.

Measurements

The questionnaire was based on other validated questionnaires that assessed dietary intakes and behavior-specific cognitions, habit strength and parenting variables in adolescent populations [30-34]. The self-administered questionnaire was pre-tested for clarity and length, by means of cognitive interviewing among four adolescents not participating in the study.

Outcome measure: Sugar-sweetened beverage consumption

Sugar-sweetened beverages were defined as carbonated soft drinks, other non-carbonated sugar-sweetened drinks (water-based beverages that contain sugar), and so-called sport drinks. The consumption of sugar-sweetened beverages was assessed by two questions: 'On how many days a week do you drink sugar-sweetened (not 'light' or 'diet') beverages?', with answering categories ranging from zero to seven days per week, and 'On days that you drink sugar-sweetened beverages, how many glasses, cans, and/or bottles do you drink?', with the amount to be filled in by hand. Total sugar-sweetened beverage consumption was expressed in milliliters per day and calculated from these two questions according to Dutch standard serving sizes (1 glass = 200 ml; 1 can = 330 ml; 1 bottle = 500 ml). Reported consumption of more than 4 l per day (n = 5) was recoded as 4 l.

Behavior-specific cognitions

Cognitions specific to sugar-sweetened beverage consumption, i.e. attitude, subjective norm, social modeling, social pressure and self-efficacy were assessed according to the ASE Model [31]. All cognitions were assessed by two questions on a five-point bipolar scale. The internal consistency of the constructs was assessed using Cronbach's alpha (α). In the case of Cronbach's alpha > 0.6, the items were combined in one scale by calculating the mean item score [35].

Attitude was assessed using the statements 'I think it is good to drink a lot of sugar-sweetened beverages' and 'I think it is pleasant to drink a lot of sugar-sweetened beverages'. Answering categories ranged from: 'I completely agree' (2) to 'I completely disagree' (-2) (α=0.65). Social influences were assessed by three constructs: subjective norms, modeling and social pressure. Subjective norm was assessed by: 'My friends think that I should drink sugar-sweetened beverages' and 'My parents think that I should drink sugar-sweetened

beverages', with answering categories ranging from 'Yes, definitely' (+2) to 'No, definitely not' (-2) (α=0.50). Modeling was assessed by: 'Do your friends drink sugar-sweetened beverages?' and 'Do your parents drink sugar-sweetened beverages?', with answering categories ranging from 'Yes, a lot' (+2) to 'No, very little' (-2) (α=0.34). Social pressure was assessed by two questions: 'Do your parents encourage you to drink sugar-sweetened beverages?', and 'Do your friends encourage you to drink sugar-sweetened beverages?', with answering categories ranging from 'Yes, a lot' (+2) to 'No, very little' (-2) (α=0.73). Self-efficacy was assessed by asking 'Do you think you are able to drink less sugar-sweetened beverages?', and 'Does drinking less sugar-sweetened beverages seem difficult to you?', with answering categories ranging from 'Yes, definitely' (+2) to 'No, definitely not' (-2) (α=0.72).

Habit strength

We assessed habit strength of sugar-sweetened beverage consumption by means of the Self Report Habit Index [32]. This questionnaire assesses three features of habitual behavior: (1) the extent to which a behavior is automatic, e.g. 'drinking sugar-sweetened beverages is something I do without thinking', (2) the repeated character of the behavior, e.g. 'drinking sugar-sweetened beverages is something I have been doing for a long time', and (3) the sense of identity the behavior reflects, e.g. 'drinking sugar-sweetened beverages, that's typically "me"'. These three features were assessed by twelve questions on a five-point bipolar scale, ranging from 'I completely agree' (+2) to 'I completely disagree' (-2). An overall score for habit strength was constructed by summing the item scores (α = .88).

Perceived parenting practices and parenting style dimensions

Based on the parent–child food control questionnaire developed by Cullen et al.[33], we assessed perceived parenting practices using nine items. Four questions (identical for fathers and mothers) assessed specific practices regarding sugar-sweetened beverage consumption (e.g. 'My father/mother tells me *how much* sugar-sweetened beverages I am allowed to consume', 'My father/mother tells me *which* sugar-sweetened beverages I am allowed to consume'). An additional item assessed the availability of soft drink in the home environment: 'My mother always has my favorite sugar-sweetened beverage available at home'. All parenting items were measured on five-point bipolar scales ranging from completely agree (+2) to completely disagree (-2). A single score was computed by summing the scores on these items (α = .86), in such a way that a higher score reflects more restrictive parenting practices.

We assessed two parenting style dimensions, perceived strictness and perceived involvement, according to den Exter and colleagues [34, 36]. Strictness was assessed by seven items, e.g.: 'My parents know exactly where I am most afternoons after school' and 'At what time do you have to be at home at night on weekdays?'. Involvement was assessed by ten items, e.g.: 'My parents make time to talk to me' and 'When I get a poor grade in school, my parents

encourage me to do better'. Composite scores were computed for involvement (α = .83) and strictness (α = .77) by summing the scores on these items. Higher scores meant perceiving parents as more involved or stricter. The two dimensions of strictness and involvement can be used to define four parenting styles: authoritarian, authoritative, indulgent and neglectful, by dichotomizing the scores on both dimensions. In this study, however, we used the two continuous dimensions of strictness and involvement.

Data analyses

Missing data on the cognitions, habit strength and parenting variables were imputed using the median value of all respondents without missing values. The missing data on sugar-sweetened beverage consumption were replaced by the group mean. The highest frequency of missing values was 10 (2.6%), for a parenting practice item. Multi-collinearity problems were not encountered; all inter-correlations between predictors were below 0.5 [37].

In all conducted analyses, we used multiple linear regression analyses to examine whether the associations between the determinants of interest and sugar-sweetened beverage consumption differed with age, sex, and ethnicity. Since no significant interactions were found (all $p>0.05$), data are presented for the whole sample with adjustments for these variables as potential confounders.

The first set of multiple linear regression analyses examined whether cognitions and habit strength were associated with sugar-sweetened beverage consumption. A second set of multiple regression analyses investigated whether perceived parenting practices were associated with sugar-sweetened beverage consumption, and the possible mediating effects of the behavior-specific cognitions. It used the following requirements for establishing mediation effects: (a) perceived parenting practices must be associated with sugar-sweetened beverage consumption, (b) the potential mediators must be associated with sugar-sweetened beverage consumption, and (c) the mediators must cause a significant reduction in the association between perceived parenting practices and sugar-sweetened beverage consumption, after controlling for the mediator [38]. A p-value below 0.05 was considered to be significant. A Sobel test was conducted [39] to examine whether the strength of the association between perceived parenting practices and sugar-sweetened beverage consumption (given by the regression coefficient) decreased significantly after a potential mediator was added to the model. Finally, we investigated the interaction between perceived strictness and perceived parenting practices, and between perceived involvement and perceived parenting practices. To this end, interaction terms between parenting practices and the strictness and involvement dimensions were added to the regression model testing the association between parenting practices and sugar-sweetened beverage consumption. If the interactions had p-values below 0.1, stratified analyses were conducted for the quartiles of strictness and involvement.

RESULTS

Table 9.1 shows the mean scores of the studied variables for boys and for girls. A significant difference between boys and girls in perceived strictness, attitude, and self-efficacy was found. Overall, respondents reported to perceive their parents using restrictive parenting practices regarding sugar-sweetened beverage consumption and they perceived the parenting style of their parents as low in strictness and high in involvement.

Behavior-specific cognitions, habit strength, and associations with sugar-sweetened beverage consumption

In the first set of regression analyses (adjusting for age, gender and ethnicity), all cognitions, except the social norm of friends, were significantly associated with sugar-sweetened beverage consumption (Table 9.2). When all significant cognitions were included in the regression model, only attitude, self-efficacy, and modeling from parents remained significantly associated with sugar-sweetened beverage consumption. Habit strength was also associated with sugar-sweetened beverage consumption (β=35.4, 95%CI=28.8; 42.1).

Mediation of the association between perceived parenting practices and sugar-sweetened beverage consumption

Perceiving more restrictive parenting practices was associated with less consumption of sugar-sweetened beverages (Table 9.3, model 1). Further adjustments for habit strength and cognitions significantly reduced the strength of this association, which nevertheless remained significant. Habit strength explained 44% of the association between perceived parenting practices and sugar-sweetened beverage consumption, as can be inferred from the reduction of the unstandardized regression coefficient from -38.0 ml/day to -21.3 ml/day. Among the cognitions, attitude was the strongest mediator (22.7%; β -38.0 to β -29.4), followed by modeling from parents (17.6%; β -38.0 to β -31.3) and self-efficacy (9.9%; β -38.0 to β -34.3) (Table 9.3). The cognitions, age, gender, ethnicity, and habit strength together (model 6) explained 55.0% of the association between perceived parenting practices and sugar-sweetened beverage consumption (β changed from -38.0 to β -17.1 ml/day).

Interaction between perceived parenting style dimensions and parenting practices

We further examined whether the perceived dimensions of parenting style (involvement and strictness) modified the associations between parenting practices and sugar-sweetened beverage consumption. P-values of interaction terms between perceived parenting practices and strictness (p=0.065), and between perceived parenting practices and involvement

Table 9.1 General characteristics of the study population.

Variable (scale range)	Mean (SD)		P-value* T-test
	Boys (n=172)	Girls (n=211)	
Age	13.4 (.542)	13.5 (.679)	NS
Ethnicity (% native)	86.6	84.8	NS
Sugar-sweetened beverage consumption (ml /day)	809 (854)	674 (677)	NS
Parenting practices (-18; 18)	-7.0 (7.25)	-7.1 (7.15)	NS
Strictness (-14; 14)	2.0 (5.42)	3.8 (4.50)	.000
Involvement (-20; 20)	10.5 (5.68)	11.1 (5.78)	NS
Habit strength (-24; 24)	-2.8 (10.2)	-3.5 (10.0)	NS
Attitude (-2; 2)	0.39 (.883)	0.12 (.904)	.003
Self-efficacy (-2; 2)	0.54 (1.19)	0.82 (1.03)	.013
Modeling from parents (-2; 2)	-0.23 (.887)	-0.34 (.950)	NS
Modeling from friends (-2; 2)	0.90 (.726)	0.90 (.654)	NS
Social norm of parents (-2; 2)	-0.20 (.942)	-0.28 (.978)	NS
Social norm of friends (-2; 2)	-0.08 (.812)	-0.13 (.779)	NS
Social pressure (-2; 2)	-1.2 (.903)	-1.3 (.724)	NS

* P-values represent the differences between genders

Table 9.2 Associations between cognitions and sugar-sweetened beverage consumption.

	'Univariate[a]		Multivariate[b]	
Cognitions	ß[c]	95% CI	ß[c]	95% CI
Attitude	282.7[f]	201.6; 363.7	189.3[f]	105.8; 272.8
Self-efficacy	-204.2[f]	-269.7; -138.7	-128.2[f]	-194.1; -62.3
Modeling from parents	269.8[f]	191.6; 347.9	191.2[f]	110.6; 271.8
Modeling from friends	117.7[d]	7.5; 228.0	-28.1	-132.7; 76.4
Social norm of parents	103.9[e]	24.8; 183.0	-12.2	-88.7; 64.2
Social pressure	161.8[e]	68.0; 255.5	36.1	-56.3; 128.5
Social norm of friends	17.3	-78.8; 113.4	-	-

Abbreviation: 95% CI = 95% confidence interval

[a] Univariate = model adjusted for age, gender, and ethnicity.

[b] Multivariate = model further adjusted for cognitions.

[c] β (unstandardized coefficient) indicates the change in soft drink consumption (in ml) for a 1 unit increase in the ASE variable.

[d] p<.05, [e] p<.01, [f] p<.001

(p=0.069), were below 0.1. Further stratified analyses revealed that the association between perceived parenting practices and sugar-sweetened beverage consumption varied by different quartiles of strictness and involvement (Table 9.4): parenting practices were most effective (i.e. associated with less sugar-sweetened beverage consumption) in the second and third quartiles of strictness and in the highest quartile of involvement.

Table 9.3 Mediation of the association between parenting practices and daily sugar-sweetened beverage consumption

Model	ß (ml/day)	95% CI	R^2	Sobel test z-score	Percentage of the total effect that is mediated
1	-38.0[c]	-48.1; -28.0	.154	NA	NA
2	-21.3[c]	-31.4; -11.2	.280	-5.88[c]	44.0
3	-29.4[c]	-39.8; -19.0	.203	-3.97[c]	22.7
4	-34.3[c]	-44.0; -24.5	.217	-2.44[a]	9.9
5	-31.3[c]	-41.3; -21.3	.241	-3.63[c]	17.6
6	-17.1[b]	-27.2; -6.90	.325	NA	55.0

Abbreviation: NA, not applicable
Model 1: adjusted for age, gender, and ethnicity
Model 2: model 1 + adjusted for habit strength
Model 3: model 1 + adjusted for attitude
Model 4: model 1 + adjusted for self-efficacy
Model 5: model 1 + adjusted for modeling from parents
Model 6: model 1 + adjusted for habit strength, attitude, self-efficacy, and modeling from parents
[a] p<.05, [b] p<.01, [c] p<.001

Table 9.4 Associations between parenting practices and sugar-sweetened beverage consumption, stratified by the quartiles of strictness and involvement.

Quartiles[a]	Strictness			Involvement		
	ß[b] (ml/day)	95% CI	R^2	ß[b] (ml/day)	95% CI	R^2
1 (lowest)	-11	-36; 14	.500	-9	-30; 13	.397
2	-27[c]	-49; -5	.404	-18	-40; 3	.395
3	-35[d]	-55; -14	.319	-15	-38; 8	.325
4 (highest)	-15	-32; 3	.182	-28[d]	-46; -10	.433

[a] Ranges for strictness (-14; 14) per quartile: (1) -14;-1 , (2) 0;3, (3) 4;6, (4) 7;14, Ranges for involvement (-20; 20) per quartile: (1) -12;7, (2) 8;11, (3) 12;15, (4) 16;20
[b] Unstandardized beta, adjusted for age, sex, ethnicity, habit strength, attitude, modeling from parents, and self-efficacy
[c] p<.05
[d] p<.01

DISCUSSION

The present study investigated the association between perceived parenting practices and sugar-sweetened beverage consumption by adolescents on the one hand, and the influence of perceived parenting style dimensions on this association on the other. Perceiving more restrictive parenting practices was found to be associated with less soft drink consumption, which is in agreement with the findings of the study by De Bourdeaudhuij & Van Oost (2000). [27]. However, findings from studies among younger children suggest that strict

parental practices can in fact increase children's preferences for, and intake of, the restricted foods [23, 25, 26]. These contrasting outcomes may have been caused by the difference between parenting practices that are used in childhood and in adolescence. For instance, parents might use pressure to get their young children to eat, or may restrict access to foods. For adolescents, parents might use clearly defined rules about the times when a certain food can be eaten and how much of a certain food they can eat.

In our study, the model with age, gender, ethnicity, habit strength, modeling from parents, attitude, and self-efficacy explained 55% of the relationship between perceived parenting practices and sugar-sweetened beverage consumption, the largest contribution being that by habit strength (44%). Nevertheless, perceived parenting practices had a direct association with sugar-sweetened beverage consumption unmediated by cognitions and habit strength. Sugar-sweetened beverage consumption may thus not always be reasoned behavior, and this finding has some theoretically important implications. Potential distal determinants of intakes in the social, cultural or physical environment may increase our understanding of sugar-sweetened beverage consumption in adolescents. In addition, since perceived parenting practices were still independently associated with the consumption of sugar-sweetened beverages, other factors may also be involved in the association between perceived parenting practices and sugar-sweetened beverage consumption by adolescents, for instance the influence of taste preferences [20]. Parents shape their children's eating environment in different ways. Parental feeding practices in early childhood, for instance using foods as a reward or to comfort [40], exposure to foods [41], and parental control of how much and what children eat [42] can influence a child's taste preferences which may persist into adolescence. In addition, the amount and diversity of sugar-sweetened beverages parents make available and accessible at home can influence the amount of such beverages adolescents consume [15, 20]. It has been suggested that the exposure to soft drink advertising may lead to a higher consumption of soft drinks during TV watching [20, 43], an activity which constitutes a considerable part of adolescents' leisure time activity. Finally, the availability of soft drink vending machines in the adolescents' immediate environment (e.g. schools) could also contribute to a higher consumption of soft drinks [15, 20, 44].

We also explored whether the association between perceived parenting practices (specific rules about sugar-sweetened beverage consumption) and sugar-sweetened beverage consumption by adolescents was different depending on the perceived parenting style of their parents. We therefore examined if the dimensions of parenting style strictness (parental control) and involvement (parental warmth and acceptance) modified the association between parenting practices and the consumption of such beverages. The results indicated that the effect of parenting practices in this respect was most pronounced in those families with a highly involved or moderately strict parenting style. Kremers et al. (2003) also found that

adolescents raised in a family with authoritative parenting style (highly strict and highly involved) showed the most favorable consumption of fruits and vegetables [30]. In the highest quartile of strictness, we found no significant association between perceived parenting practices and sugar-sweetened beverage consumption. This indicates that if parents use a very strict parenting style, parenting practices relating to sugar-sweetened beverage consumption may not have an additional direct limiting effect on their children's consumption of these beverages. The strongest association between perceived parenting practices and sugar-sweetened beverage consumption was found in the highest quartile of involvement indicating a stronger direct effect of parenting practices on adolescent behavior, in the case of involved parents.

The results of our study and that by Kremers et al. (2003) are not entirely comparable. We used the continuous measures of the two perceived parenting style dimensions instead of the four categories of parenting style. There were several reasons why we chose to use the two dimensions of strictness and involvement instead of the four parenting style categories. First, the skewed distribution on these dimensions would have caused misclassification when dichotomized into categories. Second, dichotomization itself is quite arbitrary since there are no 'universal' cut-off values for those dimensions and the cut-offs will therefore vary for different populations. Third, classification of two continuous variables into four categorical parenting styles means loss of information. Since we were interested in the role of various types and dimensions of parenting we chose to include the two dimensions as continuous variables and investigate the existence of interactions.

To our knowledge, this is the first study to indicate the role of parenting styles as an environmental context factor that can influence the effectiveness of food-related parenting practices in terms of adolescents' consumption of sugar-sweetened beverages. As such, it contributes to theory development of the influence of parents on adolescents' dietary behaviors. In contrast to assumptions that underlie theories such as the Theory of Planned Behavior [45] the results indicate that sugar-sweetened beverage consumption may not always be reasoned or planned [46]. Additionally, contextual variables may moderate the associations between cognitive variables and intake levels. Notably, Bandura's Social Cognitive Theory [47] does include the reciprocal interaction of person, environment and behavior. Such a theoretical approach may guide future research aimed at examining potential moderators of the environment – behavior relationship.

There are several limitations to the interpretation of the results of this study. Since the design of this study was cross-sectional, inferences regarding cause and effect must be made with caution and will not be conclusive. Parenting practices could determine, but also be a result of children's behavior regarding sugar-sweetened beverage consumption (and indeed that of other food items). Another limitation is that the schools and classes included in this

study were not randomly selected. In addition, the study population included few children from the various ethnic minorities in the Netherlands, which made it impossible to examine the potential role ethnic background in sugar-sweetened beverage consumption. We used adolescents' reports of parenting practices and parenting style dimensions. Therefore, it could be that parental reports of practices and style would differ from their children's perceptions. In addition, what adolescents perceive as 'strict' and 'involved' may vary among individuals. Obtaining data from multiple sources (adolescents, parents and siblings) would probably result in data that are more valid. Finally, the assessment of sugar-sweetened beverage consumption relied on self-report and was not supported by any objective assessment. Assessment of validity and reliability data were not available for this measure. Although the measurement instrument used in this study was designed to be as clear as possible, it is not known whether adolescents under-reported or over-reported their sugar-sweetened beverage consumption. Validation studies on measures of sugar-sweetened beverage consumption are clearly needed, and might be undertaken as part of future research to improve the assessment of this behavior.

Despite these limitations, our findings emphasize the importance of parental rules and the interaction between these rules and parenting style dimensions for sugar-sweetened beverage consumption by adolescents. The central role parents can play on the primary prevention of obesity-related behaviors was clearly illustrated: a one 'unit' decrease on the parenting practice scale accounted for an increase of 38 ml per day in sugar-sweetened beverage consumption. Small increases in energy intake, not accompanied by concomitant increasing energy expenditure, will substantially contribute to weight gain.

Parents are thus important intermediates for changing dietary behaviors of adolescents and should therefore be involved in interventions aimed at changing dietary behaviors, and reducing overweight. The present study showed that interventions aimed at the promotion of healthy parenting practices will improve when they are tailored to the general parenting style of the participants.

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10 General Discussion

ABSTRACT

The studies described in this thesis aimed at gaining insight into important individual and environmental correlates of energy balance-related behaviors among adolescents. The aims of this thesis were based on the EnRG framework [1] and were to (I) examine individual and environmental correlates of energy balance-related behaviors and (II) explore to what extent the association between environmental factors and energy balance-related behaviors is mediated by individual cognitions. In this chapter the main findings of this thesis are summarized. Next, methodological issues are discussed, followed by an integration of findings. Finally implications for research and practice will be formulated to inform future research and intervention development.

10.1 MAIN FINDINGS

Environmental correlates of energy balance-related behaviors: reviews of the literature

Two systematic reviews (chapters 3 and 4) were conducted to get an overview of the existing evidence-base regarding important environmental correlates of energy balance-related behaviors and to inform the development of measurement instruments. The ANGELO framework was used in these reviews to categorize the environmental factors [2]. The review on dietary behaviors revealed that consistent evidence was found for associations between parent and sibling intakes with adolescent's energy and fat intake, and between parents' educational level and adolescent's fruit and vegetable intake. In the review on adolescents' physical activity behaviors, support from significant others, mother's education level, family income, non-vocational school attendance, and low crime incidence were found to be associated with higher physical activity. Several gaps in the available evidence of associations between environmental factors and energy balance-related behaviors were identified, such as the lack of high-quality studies and study replications. Many potentially relevant environmental factors have not been studied at all [3] and the available research focused mainly on factors in the home environment such as parental influences. Only a limited number of studies assessing environmental correlates of snack and soft drink intakes were retrieved, while these two behaviors may be of specific importance in obesity prevention [4, 5].

Demographic correlates of energy balance-related behaviors

The second part of this thesis reports on two studies in which associations between demographic correlates and overweight and energy balance-related behaviors were explored. Chapter 5 reports on gender, ethnic and educational differences in overweight and energy balance-related behaviors. The study findings indicate important ethnic and educational differences in overweight and energy balance-related behaviors. In line with previous findings, youth from non-Western ethnic backgrounds, especially girls and those attending vocational schools were more likely to be overweight and to engage in unfavorable energy balance-related behaviors [6, 7].

Chapter 6 reports on adolescents' active commuting to school and in this chapter we explored potential socio-demographic correlates of active commuting to school. Almost half of the adolescents reported to actively commute to school. Adolescents of non-Western ethnic background were more likely to be walkers and non-active commuters than cyclists compared to native Dutch adolescents. A further distance from home to school was inversely associated with being a walker or cyclist and positively associated with being a non-active commuter.

Individual and environmental correlates of energy balance-related behavior

The final part of this thesis explored possible mediating effects of individual cognitions. According to the EnRG framework [1] we examined the direct association of environmental correlates on energy balance-related behaviors, but also the suggested mediating effect of individual cognitions between environmental factors and energy balance-related behaviors.

In chapter 7 associations of the availability of foods/drinks in school canteens, the presence of food stores around schools and individual cognitions with soft drink and snack consumption were examined. Mediation of the environment – behavior relationship by individual cognitions was also examined. This study indicated that individual cognitions appeared to be stronger correlates of intakes than physical school environmental factors and little evidence for associations of environmental factors in the school environment with soft drink and snack consumption was found. There was an inverse association between distance to the nearest store and the number of small food stores with soft drink consumption and these associations were partly mediated by cognitions. Therefore, this study provides some evidence for the hypothesis that environmental factors are associated with soft drink consumption via the cognitions, as proposed in the EnRG framework.

The possible mediation effect of cognitions was also examined in chapter eight and in this study significant mediation effects were also found for the individual cognitions. A direct association of environmental factors on sports participation was found for availability of physical activity attributes at home, parents sports behavior and parental rule about sports participation. These associations were partly mediated by attitude and intention. This study provided evidence for the indirect effect of environmental factors on adolescent sports behavior

In chapter 9, we used another dataset to investigate the possible mediating role of cognitions in further detail. In this study we examined whether cognitions and habit strength mediated the association between parenting practices and sugar-sweetened beverage intake and possible moderating effects of the parenting style dimensions "strictness" and "involvement", because Darling and Steinberg [8] postulated that parenting style modifies the association between parenting practices and adolescent behavior. The results of this study indicated that more restrictive parenting practices were associated with lower sugar-sweetened beverage intake. Mediation was found for the cognitions attitude, self-efficacy and modeling. Nevertheless, a significant direct association between environmental parenting practices and intake also remained. A possible moderating effect of parenting style was found, showing that the association between parenting practices and sugar-sweetened beverage consumption was stronger among adolescents who perceived their parents as being moderately strict and highly involved.

10.2 METHODOLOGICAL ISSUES

The studies presented in this thesis have several limitations and the results and conclusions should be interpreted in the light of these limitations. In this section, considerations concerning the study design, sampling and subjects, the assessment of energy balance-related behaviors and individual and environmental factors are discussed.

Cross sectional study design

The studies in this thesis were based on the baseline data collection from the ENDORSE project as the longitudinal data collection took place in 2007/2008 and was not yet available. Therefore, causal conclusions cannot be drawn and caution is needed interpreting the findings reported in the studies. For instance, we found parental influences, such as parenting practices to have an important association with energy balance-related behaviors. However parenting practices could also be a result of the adolescents' behavior or weight status [9, 10]. Reciprocal determinism, where the causal relationships are bi-directional also exists for the associations found between perceptions of the environment and physical activity behavior. Physically active adolescent might be more aware of physical activity equipment in their environment. This makes discussion of traditional "causal" pathways more complex [11].

The cross sectional design of the study also made the investigation of mediating effects more difficult as mediation effects refer to causal mechanisms. We used the method suggested by Baron & Kenny [12, 13] which specifies a series of tests of the links in a causal chain to investigate mediation effects in a cross sectional design. Despite its widespread use, the Baron–Kenny method has some limitations. For instance, it does not provide a direct estimate of the size of the indirect (mediated) effect, and the Baron–Kenny approach has low statistical power in studies with a relatively small sample size, even in the presence of large mediation effects [14, 15]. Nevertheless, the Baron–Kenny approach is useful in understanding mediating effects of environmental factors on energy balance-related behaviors as proposed in the EnRG framework because it specifically tests the direct and indirect associations of environmental factors on energy balance-related behavior. The mediation analyses that were conducted for this thesis should preferably be repeated with a longitudinal design. A cross-sectional approach to mediation can generate substantially biased estimates even under the ideal conditions when mediation is complete [16]. However, a cross-sectional study design is efficient for exploring and identifying environment – behavior associations in a relatively new research field. With the longitudinal data from the ENDORSE project, the results from various studies can be verified and further examined.

Sampling and subjects

City

The data collection process for the ENDORSE study took place in close cooperation with the Municipal Health Service Rotterdam area and was an integral part of their ongoing health surveillance, the Youth Monitor Rotterdam. Therefore, all participating schools were located in Rotterdam. Rotterdam is a city with a relatively high proportion of people from lower socio-economic positions and foreign ethnicity compared to the rest of the Netherlands. The results can thus not be generalized. The study described in chapter 9 was based on another dataset. This study was part of the Dutch Obesity Intervention in Teenagers [17]. Data was collected at Dutch secondary schools in May and June 2003. These schools were located in the eastern part of the Netherlands in smaller cities compared to Rotterdam. The subjects were 383 adolescents from 16 first and second grades of five secondary schools. The ethnic background of this study population was representative for the Dutch general adolescent population.

Schools

The study results must also be interpreted with the possibility of selection bias at the school level. Only schools that already participated in the Youth Monitor Rotterdam were contacted to participate in the study. Of these 54 schools, 24 were interested in participating. These schools might be more motivated and already involved in promoting healthy lifestyles than the other schools in Rotterdam. Subsequently, a random sample of 17 school locations was drawn from the pool of schools that were willing to participate, after stratification of the schools according to four city areas in which they were located. Stratification was done, to ensure variation in physical and cultural environments. No schools located in the western part of the city with more deprived neighborhoods were willing to participate in the study.

Students

No inclusion criteria were defined for participating in the ENDORSE study. Per school approximately five classes were selected to participate in the study. All adolescents in one class participated in the study, unless they or their parents indicated that they were not willing to participate or if they were absent on the day of the assessment. We did not obtain data from the adolescents that refused to participate, and thus we were not able to determine to what extent selection bias at this level may have occurred. However it is likely that overweight and obese adolescents were less likely to participate in the anthropometrical measurements. There were no significant differences in the number of missing values on weight status for gender, ethnicity and educational level.

Parents

To study the effects of parental behavior and parental rules on sports behavior (chapter 8) we used data from the parent questionnaire. However, the response rate for the parent questionnaire was quite low. Within the sample of full parent-adolescent combinations respondents from non-Western ethnic background were underrepresented, contrary to the other studies in which the full adolescent sample was used. This under-representation might have occurred because all materials were in the Dutch language. As the parents were mostly first generation immigrants, language problems could have been the main problem for answering and returning the questionnaire.

Measurement of energy balance-related behaviors

Validity and reliability

Measuring dietary intake and physical activity behaviors by self-reports is a major problem as the assessment relies on a child's recall of behaviors. No really valid questionnaires are available and the use of these self-reported measures of energy balance-related behaviors could have caused an overestimation or underestimation of behaviors. Therefore, the quality of the measurement instrument should be taken into account in evaluating the results of this study.

Food frequency questions to assess food intake are often used for epidemiological studies since they are relatively easy to administer and less expensive than other methods such as 24-hour recall and food records, but food frequency questionnaires tend to over- and underestimate energy and nutrient intakes [18]. A validation study to test the validity of the food frequency questions used in this study was not undertaken. However validation methods are also imperfect, since a gold standard does not exist for assessing dietary behaviors and developing a good food frequency questionnaire is therefore very difficult. The dietary intake measures used in the ENDORSE project were developed by adapting validated Dutch questionnaires on dietary intake to the ENDORSE study population and dietary behaviors [17, 19, 20]. The test-retest reliability for the dietary intake variables was considered to be reasonably good (soft drink r=0.59, breakfast consumption r=0.65; sweet & savory snack consumption r=0.46).

Also the assessment of physical activity and sedentary behaviors in adolescents is difficult. In our study we used the Activity Questionnaire for Adults & Adolescents (AQuAA) [21], which is a short questionnaire to assess physical activity at school and during leisure time, active transportation to school and sedentary behaviors in leisure time. The AQuAA refers to activities in the past week (7-day recall). The test-retest reproducibility was fair to moderate for this questionnaire; with intra-class correlations ranging from 0.46 to 0.59. The validation study with use of accelerometers showed that adolescents over-reported their activity levels and validity of this measure was low [21]. Examination of the self-reported

amounts of time adolescents spent on the various physical activity and sedentary behaviors in the ENDORSE dataset made clear that the overestimation of physical activity and sedentary behaviors was also present in the ENDORSE data. The average minutes per day spent on most of the behaviors was highly skewed, with some adolescents reporting very high amounts of physical activity and sedentary behaviors. We did not use more objective measurements such as accelerometers. Accelerometer data give an indication of overall physical activity and for the ENDORSE study we investigated various physical activity sub-behaviors such as walking in leisure time and active commuting to school. Another important weakness of accelerometers is that they are insensitive for many forms of activity, including cycling [22].

In spite of the limitations discussed, questionnaires are often used to assess behavior and they are considered to be easy and inexpensive in use. However, the quality of the measurement instruments should be taken into account in evaluating the results of this study. The development of valid and reliable questionnaires to examine energy balance-related behaviors needs more attention in future research.

Context specific assessment of behaviors

As described in the ANGELO framework, energy balance-related behaviors can occur in a wide range of behavioral settings, such as homes, schools, restaurants, and neighborhoods [2, 23, 24]. People may behave differently in different settings and it is important to incorporate the behavioral setting in the assessment of energy balance-related behaviors. For example, physical environmental correlates are likely to be different for physical activity at school and physical activity at home [24]. Research has begun to focus on specific behaviors such as walking to school or walking for recreation instead of a generic measure of walking, but still most research focuses on context-free behavioral outcomes. This is also the case for the ENDORSE study as in chapter 7 environmental correlates were assessed at the school level, but the behaviors of interest, soft drink and snack consumption were assessed in general measures as the average intake per day. If adolescents consume most soft drinks and snacks in other settings than at school, for instance at home, this might explain why no associations were found in this study.

The context specific approach may underestimate the association between environmental and behavioral variables [25]. However a context-specific approach to the assessment of energy balance-related behaviors does have its own limitations. Questionnaires will be too long and give insight in determinants of behaviors in specific situations while the results of this kind of research is often used to inform interventions aimed at changing the behavior regardless the context in which the behavior takes place.

Measurement of individual and environmental correlates

The following measurement instruments were used in the ENDORSE project: adolescent and parent questionnaires, interviews with school representatives and canteen managers, audits of the school environment, census data collection and adolescent body measurements. In this paragraph, the use of questionnaires, the audit instrument and information from Geographic Information Systems (GIS) to assess individual and environmental correlates will be discussed.

Assessment of individual correlates

The assessment of individual correlates of energy balance-related behaviors was based on the Theory of Planned Behavior (TPB). According to the TPB the assessment of cognitions should be action, target, time and context specific [26, 27]. The questions used in the ENDORSE study did not meet all of these criteria. For instance the questions on sports and physical activity were specific on action (sports and physical activity) and the context (in leisure time), but did not address the target and time in the question. Similar to measurements of behavior, pursuing such specificity would have made the questionnaire even longer, making administration within one school hour impossible. Besides, it would have made the questions too complicated and long for the study population and therefore could have led to incomplete or unreliable data. Therefore, we also assessed the cognitions through direct measures (good-bad, pleasant-unpleasant, easy-difficult) instead of underlying beliefs [28].

Some attempts to test the reliability and validity of the TPB questions were undertaken. The questions were formulated as much as possible according to generally accepted instructions provided from the TPB. In the developing phase, we pre-tested the adolescent questionnaire among ten adolescents by means of cognitive interviewing to examine the questions on clarity and comprehensibility. Subsequently, the questionnaire was completed twice by 89 schoolchildren (aged 13–14) ten-days apart to assess the test-re-test reliability and other psychometrics of the questionnaire. Items with low reliability were adjusted or deleted from the questionnaire.

Assessment of environmental correlates

In the ENDORSE project, environmental correlates were assessed with questionnaires, by audits of the schools and objective Geographic Information System (GIS) data. Potential important environmental correlates were categorized according to the ANGELO framework. In the ENDORSE study physical, socio-cultural, economic and policy correlates were examined at the micro level (home, school and neighborhood level), and combinations of perceived and objectively measured environmental correlates were used. Assessing environmental correlates is difficult as there is not much known about which correlates are important and how these correlates need to be measured. As it is impossible to assess all

potential important environmental factors in one study, several considerations should be taken into account. First, one should decide to what extent the complexity of the environment could be assessed. Second, one can assess environmental factors in a subjective way with questionnaires or more objectively with an audit instrument or census data. However the development of a valid audit instrument is difficult because of the limited available literature and instruments. Third, when we speak of assessing environmental factors in the neighborhood around school or homes, it is important to define what is considered as a neighborhood. These points will be further explained in the following paragraphs.

Complexity of environmental factors

A problem in environmental research is which aspects of the environment we should focus on. Most research has primarily focused on the availability of facilities and the attractiveness of neighborhoods. However, other or more complex measures of the environment might be necessary to assess environmental influences on behavior [24]. For example, in chapter 7 we focused on the school food environment using crude measures such as counting the availability of food products, the number of food shops and the distance to the nearest food shop. However, the nearest food shop might be desirable in that it is nearby school, but could have also undesirable characteristics for adolescents we did not assess, such as high prices, low availability of preferred foods and drinks, and inconvenient opening hours, so that the shop is never used. In chapter 8 crude measures of availability of physical activity equipment and facilities were used, while the quality of the facilities might also be important. These more complex aspects of environmental factors were not taken into account in this study.

Perceived versus objectively measured environmental factors

The development of objective measures of environmental factors is an important direction for research, as well as studies that compare self-reported perceptions with objective environmental factors. Studies that report the use of objective environmental measures to assess the food environment are limited. Therefore, we used objective measures to assess the availability of products in the school canteens and the distance and number of shops in the school neighborhood (Chapter 7). However, the perceived availability of products might also be important in explaining dietary behaviors [29]. In chapter eight we used perceived environmental measures such as perceived neighborhood safety and pleasantness. As we did not find significant associations with sports behavior it might be that more objective factors might play a role. Currently there is limited evidence about whether "objective" or "perceived" environmental factors are more strongly associated with energy balance-related behaviors. Previous studies have found associations between objective environmental measures with adolescents physical activity [30-32], active commuting to school [33, 34], fruit

and vegetable consumption [35, 36] and snack and soft drink consumption and purchases [37]. Studies that examined associations of perceived environmental factors and physical activity found also significant associations [38-40]. In a study in which perceived and objective environmental factors were compared, only the perceived environment was related to adolescent girls physical activity and perceived and objectively measured environmental factors were associated with each other [39]. In a recent study of Prins et al. [41] no agreement between the perceived and objective environmental factors was found, which is in line with studies conducted among adults [42-44]. This indicates that perceived and objective environmental factors are different constructs [44] and recent findings suggest that perceptions of the environment may depend on what is objectively available in the environment [39, 41]. It is therefore very relevant to combine the assessment of objective and perceived environmental factors in one study to establish their influence on each other and on energy balance-related behaviors.

Validity of the audit instrument and GIS data

Another limitation of the ENDORSE study was that the audit instrument to assess physical environmental correlates in the school environment was not tested on validity. Testing the validity of the audit instrument was not possible since a gold standard does not exist for assessing environmental factors in the school environment. Most existing instruments focus on the assessment of facilities for physical activities, aesthetics, traffic safety and food shops in the neighborhood instead of the school environment. It was also not possible to compare the results of the school canteen observations with product lists or sales records because these records were not always available.

In chapter 7 GIS data was used to examine the number of food stores around schools. However, the data in these kinds of databases might be an under- or over-representation of the actual number of stores, depending on the quality of the databases.

Definition of neighborhood

A problem that arises with assessing environmental factors in the school and home neighborhood is how neighborhoods are defined. Perceptions of the neighborhood environment are highly individual [45] and it is still unclear what people define as their "neighborhood" [24, 46]. To examine the perceptions of the neighborhood environment, we did not specify what we meant by "your neighborhood" in the questionnaire. The definition adolescent have of "their neighborhood" may depend on other environmental characteristics than distance, such as access to vehicles and public transport [46], the kind of facility one is traveling to [47] or living in rural or urban neighborhoods [48], making the area that adolescents perceive as their neighborhood quite variable [46]. It is therefore important to assess perceptions of the

neighborhood by explicit items such as "Are there any parks within a 10 minute walk from school" instead of "Are there any parks in your school neighborhood".

We used a neighborhood boundary of 500 meters from school to examine the food environment. However, there is little agreement in the literature as to what might constitute a good boundary from school or home. The choice for a neighborhood boundary might depend on the behavior of interest, the likelihood of the behavior to occur close to school or home and the age of the study population. Other problems with defining boundaries is that key factors located just outside the defined boundary are missed and that factors located inside the boundary are examined even if they are not used by the subjects because of the presence of main barriers such as busy roads. Further research should therefore not only assess facilities within the defined boundary but also combine these measures with the assessment of the use of facilities within and outside the neighborhood boundary.

10.3 INTEGRATION OF STUDY FINDINGS

This thesis provides important information on the associations between environmental factors and energy balance-related behaviors as proposed in the EnRG framework. The research questions for this thesis were:

I What are important individual and environmental correlates of energy balance-related behaviors?

II To what extent is the association between environmental factors and energy balance-related behaviors mediated by individual cognitions?

The associations as supposed by the EnRG framework (Figure 10.1) were used to facilitate the interpretation of the findings.

What are important individual correlates of energy balance-related behaviors?

This part of research question I relates to the association between cognitive factors and energy-balance related behaviors. Cognitive factors have been found to be associated with various health behaviors in many studies. This study contributes to the consistent evidence for a strong association between cognitive factors from the TPB and energy balance-related behaviors. Especially attitude was found to be a consistent correlate for various behaviors such as soft drink consumption, snack consumption and leisure time sports participation. However, perceived behavioral control was not found to be a correlate of soft drink and snack consumption and leisure time sports participation. An explanation for this might be that most adolescents perceive the dietary and physical activities as very easy to perform.

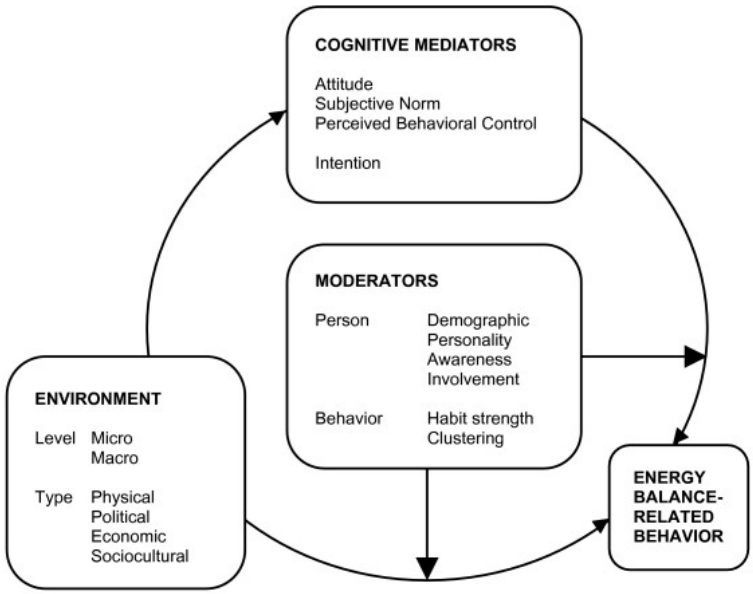

Figure 10.1 Environmental Research framework for weight Gain prevention [1].

Next to the changeable cognitive correlates we also examined demographic factors as individual correlates of energy balance-related behaviors. Ethnicity and the school type adolescents attended (vocational or higher education) were found to be important individual correlates of energy balance-related behaviors. Demographic factors might be important moderators of the environment – behavior relationship [1] as the environment – behavior association might be different for various demographic sub-groups of the population [49-53]. As there were relatively few published obesity-prevention and treatment studies that are designed for specific educational or ethnic groups, the results of these studies can be used to distinguish specific risk groups and target groups for preventive interventions.

What are important environmental correlates of energy balance-related behaviors?

This part of research question I relates to the direct association between environmental factors and energy-balance related behaviors. Literature reviews have shown that evidence on environmental factors was inconsistent or lacking for some energy balance-related behaviors such as snack and soft drink consumption [54, 55]. Therefore, the ENDORSE study focused on these gaps in the literature and mainly examined factors in the school and neighborhood environment to replicate studies and build evidence on environmental correlates of energy balance-related behaviors. In Table 10.1 an overview according to the ANGLO framework is given of the environment – behavior relationships that were investigated in this thesis.

Table 10.1 Investigated environment – behavior relationships, categorized according to the ANGELO framework

Types \ Levels	Home	School	Neighborhood
Physical	Availability of sport attributes – leisure time sports	Availability of snacks and soft drinks and drinks in school canteens – soft drink and snack consumption	Distance from home to school – mode of commuting
		Availability of snacks and soft drinks and drinks in vending machines – soft drink and snack consumption	Availability of food stores in the school neighborhood – soft drink and snack consumption
			Distance to the nearest food store – soft drink and snack consumption
			Neighborhood safety – leisure time sports
			Neighborhood pleasantness – leisure time sports
			Neighborhood facilities – leisure time sports
Economic			
Political			
Socio-cultural	Parents behavior – leisure time sports		
	Parenting practices – leisure time sports and soft drink consumption		

In line with results from the reviews, few significant associations between physical environmental factors and energy balance-related behaviors were found. We found availability of sports attributes associated with leisure time sports; the distance from home to school associated with the mode of commuting, and the distance to the nearest shop and the number of small food stores with soft drink consumption. Not all of these associations were very clear to explain, for example the inverse association found between the presence of small food shops nearby school and soft drink consumption.

In accordance with the review studies, our further studies suggest that social factors more strongly associated with physical activity and dietary behaviors than physical environmental factors [54, 55] as we found parenting practices or rules associated with soft drink consumption and leisure time sports and parents own sports behavior was associated with adolescents' leisure time sports. The range of social factors considered in this thesis was

narrow, and factors such as social networks, social capital, friends' support and behavior should be included in future studies to provide further insight into the specific aspects of the social environment that are most important for adolescents behaviors [3, 56].

The weak evidence found in the various studies should however not be interpreted as an absence of a direct environment – energy balance-related behavior relationship. The research field of environmental correlates of energy balance-related behavior is relatively new and in a developing phase. The environment is very large which means that there are many possible environmental factors that can be important for energy balance-related behaviors. Most research has focused on just a part of the potentially relevant environment. Therefore, future studies should focus on all aspects of the environment, also on economic and political factors such as pocket money and school policies to reveal to what extent environmental factors are associated with energy balance-related behaviors. Next to this, the development of valid and reliable measures of the environment is necessary. As the research field develops, more and more different instruments and definitions are used to assess environmental factors. This hinders the comparison of results between studies and makes the systematic development of theory for the relation of environment with energy balance-related behaviors difficult.

To what extent is the association between environmental factors and energy balance-related behaviors mediated by individual cognitions?

The second aim of this thesis was to investigate mediating factors to gain insight into the mechanisms that underlie environment – energy balance-related behaviors relationships. In this thesis cognitions partly mediated the association of the distance to the nearest shop and the number of small food shops (chapter 7) and of parenting practices (chapter 9) with adolescents soft drink consumption. Attitude and intention partly mediated the associations of physical activity attributes at home, parents' sport behavior and parental rule about sports participation with leisure time sports (chapter 8). This mediating effect of cognitions was also found in other studies. In a study of Jago et al. was found that the association between distance to a small food store and low fat vegetable consumption was mediated by low fat vegetable preferences [57]. De Bruijn and colleagues found that the association of environmental aesthetics and distance to PA facilities on PA among adolescents was mediated by intention to be physically active [58]. Motl and colleagues found that the association of equipment accessibility with adolescent girls PA was mediated by self-efficacy [56]. In these studies it is shown that not all cognitions from the Theory of Planned Behavior serve as a mediator. The studies described above indicate that some TPB variables may be more likely to serve as mediators in environment – behavior relationships than others [58, 59], with the strongest evidence for attitude as a potential mediating variable [58-62]. Next to an indirect association of environmental factors, in all studies on mediation, the environmen-

tal factors remained significantly associated with the outcome behavior after controlling for the mediating effect of cognitions. This is also shown in other studies that have combined environmental and cognitive factors [63-65]. According to the EnRG framework this partly unmediated environmental effect is an important explanatory mechanism and it can be argued that energy balance-related behaviors result partly from automatic and unconscious processes [66, 67].

As the EnRG-framework is specifically developed to generate hypotheses regarding when, how and for whom environmental factors might be influential, more research should focus on these questions instead of examining which environmental factors are important for energy balance-related behaviors. The studies in this thesis show that environmental factors can have both an indirect and direct association with energy balance-related behaviors. However, new questions also arise such as whether other mediating factors than cognitions for example preferences and environmental barriers play a role in the indirect association between environment and behavior. Baranowski et al. [68], proposed that there can be a range of mediating processes and cascading sequences of mediating processes. For instance, a child's self-efficacy for asking to be active after school will affect the likelihood that the child will ask to be active after school at home, which increases the likelihood that a parent will play with the child at home. Most previous studies have investigated mediation pathways for physical environmental factors. However, the studies in this thesis indicate that also social factors such as parents own behavior and parenting practices show an indirect association with energy balance-related behaviors. As the body of evidence on possible mediators grows, important questions for further research are whether mediating effects differ for different target groups and if some energy balance-related behaviors are more under the influence of automatic processes than others.

10.4 IMPLICATIONS OF THE STUDY FINDINGS

Findings from the studies reported in this thesis indicate that both individual and environmental factors are important for energy balance-related behaviors. However more research is needed to examine the relative influence and mechanisms behind these influences. Therefore, the results presented in this thesis have several implications for future research, theory and practice to assist further research and the development of obesity prevention interventions, which are described in this paragraph.

Implications for research

The research field of examining associations between environmental factors and energy balance-related behaviors is still in its infancy and needs further development and matura-

tion. More insight is needed in how specific aspects of the environment can be assessed for specific behaviors, what the best measurement instruments are, how the environment can be defined for different target groups, and how gathered data can be used in analyses.

First, a large variety of potential environmental determinants of energy balance-related behaviors have been studied, with few replicated studies for environment – behavior combinations. Further examination of potential relevant environmental factors is needed to provide public health practitioners with recommendations for intervention development and to improve theory and models on environmental determinants of health behaviors. Research should not only be restricted to just a part of the potentially relevant environment, but on all aspects listed in the ANGELO framework. Currently there is limited evidence about whether "objective" or "perceived" environmental factors are more strongly associated with energy balance-related behaviors. Objective measures are generally regarded as being superior to subjective self-reports. However, people may perceive their environments differently even if they live in the same "objective" environment. The assessment of objective and perceived factors should be combined in one study to establish their influence on each other and on behavior to gain insight in which kind of determinants should be targeted in preventive interventions: perceptions of the environment, the objective environment or a combination of both.

Second, most studies on environmental determinant still apply relatively weak study designs and measurement instruments. Longitudinal and intervention research is needed to gain better insight into the relative importance of individual cognitive determinants and environmental (physical, socio-cultural, economic, political) determinants for energy balance-related behaviors. With these studies it can be examined if and how changes in the environment lead to changes in behavior.

Third, valid and reliable measurement instruments to assess objective and subjective environmental factors should be developed. More effort should be put into the development of validated instruments that assess perceived environmental factors. Therefore, also qualitative research is needed to examine how the target group perceives their neighborhood taking the behavior of interest into account. More and more detailed objective measures of environmental factors are available, for example, those documented in geographic information systems (GIS). The use of GIS can be helpful to examine objective environmental factors as environmental factors within defined boundaries can be examined. Next to this research should also focus on developing good validated and reliable measurement instruments for assessing dietary and physical activity behaviors as in adolescents these behaviors are often over reported.

Finally, advanced research techniques need to be used to identify mediating and moderating factors of the environment – behavior relationship. It is important to examine which cognitive factors mediate the environment – behavior relationship and if there are other important mediators such as environmental barriers or parental influences.

Implications for theory development

The EnRG framework we used in this study was developed as a tool to help disentangle the role of obesogenic environments. It is specifically directed at generating questions regarding when, how and for whom environmental factors may be influential [1]. In this framework, environmental influences are supposed to influence behavior both directly and indirectly. In this thesis, individual cognitions were important correlates of soft drink and snack consumption and sports participation but also mediators of the environment – behavior relationship confirming the supposed indirect influence of the environment on behavior in the EnRG framework. This indicates that socio-ecological models in which individual cognitions and environmental factors are combined need specificity in the hypothesized pathways between individual and environmental factors. To further develop theory on environment – behavior relationships the mediation effects should be examined in longitudinal research and for other environment – behavior relationships. Also other possible mediators such as barriers and preferences should be examined. Future research is also needed to examine if mediating effects differ for different target groups and if some energy balance-related behaviors are more under the influence of automatic processes than others.

The direct association of environmental factors with energy balance-related behaviors indicates also that many behaviors are more or less 'automatic'. Environmental features can prompt behavioral choices, without mediation by conscious decision making and theoretical models are needed that focus also on environmentally cued habitual behavioral patterns [69].

Recommendations for practice

The findings and implications lead to the following recommendations for practice and intervention development.

Intervention approach

The partly mediated association between environmental factors and energy balance-related behaviors indicate that both a health education approach and a health protection approach by changing the environment might be appropriate strategies for behavior change interventions [3]. Both intervention approaches are important, but since individual cognitions are important correlates of energy balance-related behaviors, these factors remain important to be targeted in interventions.

Intervention ingredients

Parental influences, including their own behavior and parenting rules seem to be important factors for sports participation, soft drink and snack consumption. It is therefore recom-

mended to not only aim interventions at adolescents but also at the parents. Parents should be made aware of their important role in promoting healthy dietary and physical activity behaviors. Possibly it is important to start to target parents at an early stage in the development of the child, to teach parents to set clear rules and give a good example. The importance of parents for energy balance-related behaviors also means that intervention should not only take place at schools but also in the home environment. The results of this thesis do not give a clear view on which factors in the school environment should be changed to promote healthy energy balance-related behaviors. However, schools should promote healthy behavior and healthy food should be made available and accessible in school.

Target groups

Adolescents at lower educational levels and adolescents with a non-Western ethnic background, mainly girls, engage in the most risk behaviors for overweight. Interventions are needed that are effective in these groups. Therefore, studies to develop and evaluate interventions aimed at the promotion of healthy dietary and physical activity behaviors should study the effects for these different target groups.

10.5 GENERAL CONCLUSION

There is only little evidence for associations between objective or perceived physical environmental factors and energy balance-related behaviors. The evidence for social factors, mainly parental factors is stronger and these factors might be more important for energy balance-related behaviors among adolescents. Parents can importantly promote healthy energy balance-related behaviors among their offspring by shaping the environment by setting clear rules, setting a good example and creating opportunities for the behavior. Next to this we can conclude that environmental factors can have both an indirect and direct association with energy balance-related behaviors. Especially attitudes and intentions are likely to be important mediators of environment – behavior relationships. However, new questions also arise, such as if other mediating factors than individual cognitions such as preferences and environmental barriers play a role in the indirect association between environment and behavior. More research is also needed on the investigation of mediating effects for different target groups and if some energy balance-related behaviors are more under the influence of automatic processes than others.

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Summary

Over the past decades the numbers of children and adults being overweight or obese have increased so rapidly, that overweight and obesity are among the most important and challenging public health problems. It is therefore important to prevent overweight in all age groups. Children and adolescents may however be especially important groups to target. Obesity at young age is associated with a higher likelihood of the development of chronic diseases at an early age or later in life. Furthermore, overweight or obese children and adolescents are more likely to become overweight or obese adults.

It is already known that weight gain is the result of a positive energy balance in which the energy intake (via diet) exceeds energy expenditure (mainly via physical activity). So, to be able to successfully prevent overweight among children and adolescents, it is important to know which specific dietary and physical activity behaviors (energy balance-related behaviors - EBRB) contribute most to weight gain among children and adolescents.

Another important element for successful prevention of overweight is a detailed understanding of the factors that determine these EBRB. Individual determinants of behavior such as knowledge, attitudes, social influences, and motivation have been found to be relevant in earlier research. However, it is also likely that physical and social environmental factors such as availability of food products, opportunities to be active and parents can influence dietary and physical activity behaviors of children and adolescents.

To study this, and the interplay between potential personal and environmental determinants of behavioral nutrition as well as physical activity among young adolescents, the ENDORSE project (ENvironmental Determinants of Obesity in Rotterdam SchoolchildrEn) was initiated in 2004. The main goals of the ENDORSE project were: (1) to identify which energy balance-related behaviors are associated with overweight and obesity; (2) to examine important individual and environmental correlates of these energy balance-related behaviors; (3) to investigate the associations with and the interactions between these correlates and energy balance-related behaviors; and (4) to formulate objectives to be targeted in interventions aimed at the prevention of overweight in adolescents aged 12-15 years. This thesis presents a series of studies in which these questions are addressed.

In the general introduction (**Chapter 1**), the background, aims and theoretical framework used in the ENDORSE study are presented.

In **Chapter 2**, the study protocol of the ENDORSE study is described together with the design and the measurement instruments. Data were collected among adolescents in the first (12- to 13-year-olds) and third (14- to 15-year-olds) years of secondary school. Seventeen schools participated in the ENDORSE study and 1668 adolescents and their parents were selected to participate in the study. In this chapter the results of the explorative research on

the identification of risk behaviors for overweight and obesity are described as well. Based on a review of the literature and the opinion of consulted experts, the following EBRB were selected to be addressed in the ENDORSE study: active transport to school, leisure time activities, sports, watching television, computer use, soft drink consumption, sweet snack consumption, savory snack consumption and breakfast consumption.

Research into environmental influences on behavior is relatively new. Therefore, we started by searching literature on existing evidence on environmental correlates of energy balance-related behaviors (**Chapters 3 and 4**). Evidence was found for associations between parents' intake and the intakes of their children, especially for energy and fat intake. If parents had higher educational levels, their adolescent's had a higher fruit and vegetable intake. Social support, mother's education level, family income, non-vocational school attendance, and low crime incidence were associated with higher physical activity among adolescents. Both reviews showed that there were only a limited number of studies available that examined physical environmental factors, such as the availability of food products or facilities to be physically active. Although many studies were school-based studies, mainly home and neighborhood environmental factors were examined in these studies. School environmental factors were often left out of consideration.

The Chapters 5 and 6 focus on identifying important socio-demographic factors.

In **Chapter 5** differences in energy balance-related behaviors and overweight according to gender, ethnicity and school-level are studied. The results of this study showed that youth from a non-Western ethnic background and those attending lower-level secondary education were more likely to be overweight and to engage in unfavorable energy balance-related behaviors than youth from a Western ethnic background and higher-level secondary education.

In **Chapter 6** these differences are examined for commuting to school. Adolescents of a non-Western ethnic background were more likely to walk to school and use non-active transportation (public transport, scooter) compared to native Dutch adolescents, who were more likely to cycle to school. Adolescents were less likely to walk or cycle to school if they lived further away from school, in which case they were more likely to use non-active transportation.

The studies that are presented in chapters 7-9 examine the association of individual and environmental factors with energy balance-related behaviors. Moreover these studies explore *how* the environment may influence energy balance-related behaviors.

The study in **Chapter 7** examines whether the availability of snacks and drinks in school canteens and the presence of food stores in the school neighborhood were associated with a higher soft drink and snack consumption. The results showed that if the distance to the nearest food store was greater than 200 meters, and if there were more small food stores in

the school neighborhood, the adolescents drank less soft drinks. The availability of school canteen products and the availability food stores in the proximity of the school were not associated with snack consumption.

Chapter 8 focuses on whether the availability of sports facilities, neighborhood factors (availability of facilities, safety and pleasantness) and parental factors were associated with adolescent sports participation. The results showed that adolescents participated more in leisure time sports if they had more sports equipment at home, if their parents participated more in sports and if their parents endorsed the rule that their child should participate in sports. The influence of these environmental factors was not only direct (i.e., more equipment was associated with higher sports participation), but also indirect via personal factors. Adolescents with more sports equipment at home, with parents doing sports and the rule to participate in sports, had also a more positive attitude and intention towards sports, and were in turn also more likely to participate in sports.

Chapter 9 reports on a study about potential parenting influences on adolescent soft drink consumption. The results of this study indicated that more restrictive parenting practices (rules) were associated with less soft drink consumption. It appeared that the working mechanism was both direct (i.e., strict rules were associated with lower soft drink consumption) and indirect. Having stricter rules about consuming soft drinks at home was associated with a more negative attitude and cognitions towards soft drink consumption. These more negative cognitions in turn were associated with lower soft-drink consumption. Next to this, it was found that the association between parenting practices and soft drink consumption was stronger among adolescents who perceived the parenting style of their parents as being moderately strict and highly involved (authoritative parenting style).

In the general conclusion (**Chapter 10**) the findings of all studies are integrated and conclusions and recommendations for practice and future research are given.

There is only little evidence for associations between physical environmental factors and energy balance-related behaviors. The evidence for socio-cultural factors and in particular parental influences is stronger and might be more important for the prevention of overweight among adolescents. Parents can promote healthy energy balance-related behaviors by giving the right example, by setting clear rules and by creating possibilities for healthy behaviors.

Environmental factors can have both an indirect (via cognitions) and a direct (automatic, unconscious) association with energy balance-related behaviors. Future research should examine if some energy balance-related behaviors are more under the influence of automatic processes than others.

Adolescents attending lower level education and adolescents from a non-Western ethnic background are important target groups for the prevention of overweight. Interventions that target these groups should be developed and investigated. Next to this, parents should be made aware of their important role in the promotion of healthy behaviors of their children.

Samenvatting

Het aantal mensen dat in Nederland en andere Westerse landen aan overgewicht of obesitas lijdt, is de laatste decennia zo sterk gestegen dat overgewicht en obesitas inmiddels behoren tot de belangrijkste volksgezondheid problemen. Daarom is het van belang overgewicht in alle leeftijdsgroepen te voorkómen. Met name kinderen en adolescenten zijn daarbij een belangrijke doelgroep. Obesitas op jonge leeftijd gaat gepaard met een verhoogde kans op het ontstaan van chronische ziekten op jonge en latere leeftijd. Daarnaast hebben kinderen en jongeren met obesitas een grotere kans om ook overgewicht of obesitas te hebben als ze volwassen zijn.

Het is al bekend dat gewichtsstijging het gevolg is van een positieve energiebalans waarbij de energie-inname (via de voeding) groter is dan het energieverbruik (met name via lichamelijke activiteit). Voor de succesvolle preventie van overgewicht is het belangrijk te weten welke specifieke energiebalans gerelateerde gedragingen bijdragen aan gewichtsstijging bij kinderen en jongeren.

Een ander belangrijk element voor succesvolle preventie van overgewicht is het verkrijgen van een gedetailleerd overzicht van de factoren die deze energiebalans gerelateerde gedragingen beïnvloeden. Uit voorgaand onderzoek is gebleken dat persoonlijke determinanten van gedrag zoals kennis, attitudes, sociale invloed en motivatie belangrijk zijn. Echter, ook omgevingsfactoren zoals de beschikbaarheid van voedingsmiddelen, de mogelijkheden tot lichamelijke activiteit en de ouders kunnen voedings- en beweeggedrag van kinderen en jongeren beïnvloeden.

Om meer zicht te krijgen op het samenspel tussen de persoonlijke en omgevingsdeterminanten van voedings- en beweeggedrag bij jongeren, is in 2004 het ENDORSE project (ENvironmental Determinants of Overweight in Rotterdam SchoolchildEn) geïnitieerd. De doelen van het ENDORSE project waren (1) het identificeren welke energiebalans gerelateerde gedragingen gerelateerd zijn aan overgewicht, (2) het onderzoeken van individuele en omgevingsfactoren van deze energiebalans gerelateerde gedragingen, (3) het onderzoeken van het verband en het samenspel tussen deze factoren en energiebalans gerelateerde gedragingen en (4) het formuleren van doelstellingen voor interventies die gericht zijn op de preventie van overgewicht bij 12-15 jarige jongeren. In dit proefschrift worden studies gepresenteerd die de resultaten van dit onderzoek beschrijven.

In de algemene introductie (**hoofdstuk 1**) worden de achtergrond, de doelen en het theoretische raamwerk van de ENDORSE studie beschreven.

In **hoofdstuk 2** wordt het ENDORSE onderzoeksprotocol beschreven samen met de onderzoeksopzet en de meetinstrumenten. Het ENDORSE onderzoek vond plaats onder jongeren in de eerste (12 tot 13 jaar oud) en derde (14 tot 15 jaar oud) klas van het voortgezet

onderwijs. Zeventien scholen deden mee aan de ENDORSE studie en 1668 jongeren en hun ouders werden geselecteerd om deel te nemen. Daarnaast wordt in dit hoofdstuk het resultaat van een verkennend onderzoek beschreven waarin de risicogedragingen voor het ontstaan van overgewicht en obesitas werden verkend. Een literatuuronderzoek èn het raadplegen van experts resulteerde in de selectie van de energiebalans gerelateerde gedragingen die in het ENDORSE project nader onderzocht zouden worden: transport naar school, lichamelijke activiteit in de vrije tijd, sporten, televisie kijken, computer gebruik en de consumptie van suikerhoudende frisdranken, tussendoortjes en ontbijt.

Onderzoek naar omgevingsinvloeden op gedrag is relatief nieuw. Daarom is er eerst een literatuuronderzoek uitgevoerd om het beschikbare bewijs over de relatie tussen omgevingsfactoren en energiebalans gerelateerde gedragingen te inventariseren (**Hoofdstuk 3 en 4**). Met dit literatuuronderzoek werd consistent bewijs gevonden dat er een verband is tussen de inname van energie en vet door ouders en de inname van energie en vet door hun kinderen. Ook liet dit onderzoek zien dat bij een hoger opleidingsniveau van de ouders de jongeren meer groenten en fruit eten.

Sociale steun, het opleidingsniveau van de moeder, gezinsinkomen, het volgen van een hogere middelbare schoolopleiding en een lage criminaliteitsincidentie in de woonomgeving waren geassocieerd met meer lichamelijke activiteit bij jongeren. Het literatuuronderzoek liet verder zien dat er maar een beperkt aantal onderzoeken beschikbaar waren die fysieke omgevingsdeterminanten onderzoeken. Ondanks dat veel studies op scholen zijn uitgevoerd, werden voornamelijk factoren in de thuis- en woonomgeving onderzocht en bleef de schoolomgeving vaak buiten beschouwing.

De hoofdstukken 5 en 6 richten zich op het identificeren van belangrijke sociaaldemografische factoren.

In **hoofdstuk 5** werd onderzocht of er verschillen zijn in energiebalans gerelateerde gedragingen en overgewicht voor geslacht, etniciteit en schoolniveau. De resultaten van deze studie lieten zien dat jongeren met een niet westerse achtergrond en jongeren van het VMBO vaker overgewicht hadden en ongezondere energiebalans gerelateerde gedragingen vertoonden.

In **hoofdstuk 6** werden deze verschillen onderzocht voor vervoer naar school. Jongeren van een niet Westerse afkomst wandelden vaker naar school of gebruikten vaker niet actieve transportmiddelen (openbaar vervoer, scooter) dan Nederlandse jongeren, die vaker de fiets gebruikten. Jongeren gingen minder vaak fietsend of lopend naar school naarmate de afstand tot de school groter was.

De studies in hoofdstuk 7-9 onderzoeken het verband tussen de individuele en omgevingsfactoren met de energiebalans gerelateerde gedragingen. Daarnaast wordt in deze studies verkend *hoe* de omgevingsfactoren de energiebalans gerelateerde gedragingen beïnvloeden.

In **hoofdstuk 7** werd onderzocht of de beschikbaarheid van frisdranken en snacks in schoolkantines en de aanwezigheid van levensmiddelenwinkels rond scholen samenhangen met de inname van frisdrank en snacks. De resultaten lieten zien dat als de afstand van school tot de dichtstbijzijnde winkel meer dan 200 meter was en als er meer kleine winkels in de schoolomgeving waren, de jongeren minder frisdrank dronken. Er werd geen verband gevonden voor het aanbod in schoolkantines en de winkels in de schoolomgeving met snackconsumptie.

In **hoofdstuk 8** onderzochten we of de beschikbaarheid van sportfaciliteiten, buurtfactoren, en de invloed van ouders verband hielden met het sportgedrag van jongeren. De jongeren sportten meer in de vrije tijd als ze thuis meer sportfaciliteiten hadden, als de ouders zelf meer sportten en als de ouders de regel hadden dat hun kind aan sport moet doen. De relatie van deze omgevingsfactoren was niet alleen direct (b.v. meer faciliteiten hielden verband met meer sporten), maar ook indirect, via de persoonlijke factoren. Jongeren met meer sportfaciliteiten thuis, ouders die sporten en met de regel dat ze aan sport moeten doen, hadden ook een positievere attitude en intentie tot sporten, en vervolgens ook een grotere kans om meer te sporten.

Hoofdstuk 9 beschrijft een onderzoek naar de invloed van de ouders op het frisdrankgebruik van jongeren. De resultaten van dit onderzoek lieten zien dat meer restrictieve regels over frisdrankgebruik waren geassocieerd met minder frisdrank consumptie. Het werkingsmechanisme leek ook hier niet alleen direct (restrictieve regels resulteerden in minder frisdrank consumptie) maar ook indirect. Jongeren die meer regels ondervonden, hadden ook een negatievere attitude en andere cognities ten aanzien van frisdranken, die vervolgens verband hielden met minder frisdrank consumptie. Daarnaast werd gevonden dat het verband tussen opvoedingsregels en frisdrankconsumptie sterker was bij jongeren die hun ouders als matig strikt en zeer betrokken ervaren (autoritatieve opvoedingsstijl).

In de algemene conclusie (**hoofdstuk 10**) worden de resultaten uit de onderzoeken geïntegreerd en conclusies en aanbevelingen gegeven voor de praktijk en verder onderzoek. De belangrijkste conclusies zijn dat er weinig bewijs is voor een verband tussen fysieke omgevingsfactoren en energiebalans gerelateerde gedragingen. Voor sociaal-culturele omgevingsfactoren, met name de invloed van ouders, is het bewijs sterker en is mogelijk belangrijker voor de preventie van overgewicht bij jongeren. Ouders kunnen gezonde energiebalans gerelateerde gedragingen bevorderen, door het goede voorbeeld te geven, duidelijke regels te formuleren en mogelijkheden te creëren voor gezond gedrag.

Omgevingsfactoren kunnen op een indirecte (via individuele cognities) en directe (automatische en onbewuste) manier verband houden met energiebalans gerelateerde ge-

dragingen. In toekomstig onderzoek moet onderzocht worden in hoeverre de verschillende energiebalans gerelateerde gedragingen door automatische processen beïnvloed worden.

Voor de preventie van overgewicht zijn met name jongeren van het VMBO en jongeren met een niet-westerse achtergrond belangrijke doelgroepen. Interventies die gericht zijn op deze groepen moeten ontwikkeld en onderzocht worden. Daarnaast moeten ouders bewust gemaakt worden van hun belangrijke rol in het bevorderen van gezond gedrag bij hun kinderen.

Dankwoord

Toen ik besloot om in Maastricht Gezondheidsvoorlichting te gaan studeren wist ik dat ik hier verder mee wilde, maar het hoe en wat moest nog vorm krijgen. Nu, niet eens zo heel veel jaren later, ligt dit proefschrift er. Stef, je enthousiasme tijdens mijn jaarwerkstuk en afstudeeronderzoek was besmettelijk en doorslaggevend. Je overhandigde mij mijn diploma in Maastricht en ook nu ben je er weer bij. Dit keer in de grote promotiecommissie. Wie weet waar we elkaar de volgende keer treffen.

Bovenal wil ik Hans en Anke bedanken. Tenslotte hebben zij de grootste bijdrage geleverd aan dit proefschrift. Hans, je dacht altijd in oplossingen en zelden in problemen. Dat zijn voor een promotor goede kenmerken. Je zag overal kansen en mogelijkheden, zowel binnen als buiten je functie. Ik hoop dat ik daar wat van heb opgepikt! Anke, het was eerst even aftasten, maar we hebben altijd goed kunnen samenwerken. Je maakte wel veel werk van het begeleiden, ….waardoor de papers altijd beter zijn geworden. Bedankt voor de vele hulp en de fijne tijd samen.

Lottie & Nellie, mijn dappere onderzoeksassistenten! Gewapend met weegschaal, meetlat en vragenlijsten gingen jullie op pad om pubers te meten en te wegen. Meestal was het leuk, soms lastig. Met jullie enthousiasme, energie en blonde haren hebben jullie de leerlingen en leraren voor jullie gewonnen. Zonder jullie had ik het niet gekund! Hartelijk dank voor jullie inzet.

De samenwerking met de GGD Rotterdam is voor het ENDORSE onderzoek erg belangrijk geweest. Ik kon gebruik maken van de structuur van "de Jeugdmonitor" waardoor veel scholen, leraren, leerlingen en ouders bereid waren om deel te nemen. Petra en Wilma bedankt!

Een leuke sfeer en veel koffiepauzes maken werken makkelijker en leuker. Kamergenotes Birgitte, Willemieke en Wendy, bedankt voor alle gezelligheid. Paranimf Tinneke, wat hebben wij veel koffie gedronken en gekletst. Het was altijd gezellig om het leven van alledag met je te bespreken. Congresmaatje Carlijn; walvissenjacht in Boston, luxe kamer met ontbijt in Olso en de Gondola van Banff... we kwamen tenslotte niet alleen voor het congres. Appel Gert Jan, je favoriete koffiedrinkstagiaire is klaar! We hebben alleen nog steeds geen paper met elkaar geschreven, dus… toch nog maar een koffie date? Saskia bedankt voor de hulp met statistische problemen, het schrijven van papers en de fijne samenwerking. Nannah, Merel, Marianne, Rick, Hein en andere (ex) DGG-ers: het was leuk om jullie als collega's te hebben, bedankt voor de gezelligheid.

David and Anna, thanks for inviting me for a stay in Melbourne and the opportunity to work at the Centre for Physical Activity and Nutrition Research. It was a great life and work

experience with a nice paper as a result. Jo, Karen, Abbie, Clare, Kylie and Rebecca, thank you for making my stay so enjoyable!

Familie & vrienden, het 'gewoon mijn werk' is klaar. Steun bij mijn proefschrift heb ik niet echt nodig gehad, dat liep eigenlijk op rolletjes. Maar er is veel gebeurd de afgelopen jaren, leuke en verdrietige gebeurtenissen. Dank voor alle steun, maar vooral voor alle gezellige momenten.

Pa, misschien komt het er nog eens van, maar de eerste Dr. dat ben ik! Ma, bedankt voor de goede zorgen en gezelligheid! Het is altijd fijn om thuis te komen.

Bas, bedankt voor alles. Voor mij ben je de beste man die er is. Door jou is de combinatie carrière & Femke perfect!

Curriculum Vitae

Klazine van der Horst is geboren op 20 december 1978 in Zwolle. Na de middelbare school volgde ze de opleiding Voeding & Diëtetiek aan de Hogeschool van Arnhem en Nijmegen. Na haar afstuderen in 2001 volgde ze de Master Gezondheidsvoorlichting van de opleiding Gezondheidswetenschappen aan de universiteit van Maastricht. Tijdens en na haar afstudeeronderzoek werkte Klazine als onderzoeksmedewerker en junior onderzoeker bij het EMGO instituut van het VU Medisch Centrum in Amsterdam. In augustus 2004 kon ze beginnen met haar promotieonderzoek bij de afdeling Maatschappelijke Gezondheidszorg van het Erasmus MC Rotterdam. Daar voltooide zij gelijktijdig de Master of Public Health van het NIHES (2006). Vanaf mei 2008 werkte ze in Rotterdam als wetenschappelijk medewerker verder aan de follow-up studie van het ENDORSE project. Sinds december 2008 werkt ze als postdoctoraal onderzoeker in Zwitserland aan de ETH te Zürich bij de afdeling Consumer Behavior.

List of Publications

Hume C, van der Horst K, Brug J, Salmon J, Oenema A. Understanding the correlates of adolescents' TV viewing: a social ecological approach. *International Journal of Pediatric Obesity* (*in press*).

van der Horst K, Oenema A, te Velde SJ, Brug J. Gender, ethnic and school type differences in overweight and energy balance-related behaviours among Dutch adolescents. *International Journal of Pediatric Obesity* 2009, May 15:1-10. [Epub ahead of print].

DeJong CS, van Lenthe F, van der Horst K, Oenema A. Environmental and cognitive correlates of adolescent breakfast consumption. *Preventive Medicine* 2009, 48(4): 372-377.

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Ferreira I, van der Horst K, Wendel-Vos W, Kremers S, van Lenthe F, Brug J. Environmental correlates of physical activity in youth - A review and update. *Obesity Reviews* 2007, 8(2): 129-154.

Kremers SPJ, van der Horst K, Brug J. Adolescent screen-viewing behaviour is associated with consumption of sugar-sweetened beverages: the role of habit strength and perceived parental norms. *Appetite* 2007, 48: 345-350.

SUBMITTED

van der Horst K, Oenema A, te Velde SJ, Brug J. Do individual cognitions mediate the association of socio-cultural and physical environmental factors with adolescent sports participation? *Public Health Nutrition* (submitted).

Prins R, Oenema A**,** van der Horst K, Brug J. Objective and perceived availability of physical activity opportunities: differences in associations with physical activity behavior among adolescents. *International Journal for Behavioral Nutrition and Physical Activity* (submitted).

van der Horst K, Siegrist M, Orlow P, Giger, M. Residents' reasons for specialty choice: Gender, time, patient and career aspects. *Medical Education* (submitted)

PhD Portfolio

Summary of PhD training and teaching activities

Name PhD student: Klazine van der Horst
Erasmus MC Department: Public Health

PhD period: 2004-2008
Promotor: Prof.dr.ir. J. Brug
Supervisor: Dr. A. Oenema

	Year	Workload (Hours/ ECTS)
1. PhD training		
General courses		
Master of Science in Health Sciences, specialization Public Health, NIHES, Erasmus MC Rotterdam	2006	70 ECTS
Specific courses		
Theory construction and statistical modelling, Faculty of Social and Behavioural Sciences, Utrecht University	2006	1 ECTS
Presentations		
Van der Horst K, Kremers S, Ferreira I, Singh A, Oenema A, Brug J. "Perceived parenting practices and parenting styles and adolescent soft drink consumption". Paper presented at the European Congress on Obesity, Athens, Greece (June 1-4)	2005	1 ECTS
Van der Horst K, Oenema A, Ferreira I, Brug J. "Environmental determinants of weight gain-related behaviours in youth". Paper presented at the sixth Conference on Psychology and Health, Kerkrade, the Netherlands (May 8-10)	2006	1 ECTS
Van der Horst K, Oenema A, Ferreira I, Wendel-Vos W, Giskes K, Van Lenthe F, Brug J. **"**Environmental correlates of obesity related behaviors in youth". Paper presented at the fifth conference of the International Society of Behavioral Nutrition and Physical Activity, Boston, USA (July 13-16)	2006	1 ECTS
Research Meeting, CPAN Deakin University, Melbourne. '*The ENDORSE Study*'	2007	1 ECTS
Van der Horst K, Oenema A, Brug J. "Exploring environmental determinants of (in) activity in adolescents: the ENDORSE study". Paper presented at the European Health Psychology Society conference, Maastricht, the Netherlands. (August 15-18).	2007	1 ECTS
Van der Horst K, Oenema A, te Velde SJ, Brug J. "The influence of parenting styles and practices on adolescents' energy balance related behaviours in the Netherlands". Paper presented at the sixth conference of the International Society of Behavioral Nutrition and Physical Activity, Oslo, Norway (June 20-23)	2007	1 ECTS
Nederlands Congres Volksgezondheid, Groningen 'Frisdrank en snack consumptie bij jongeren: De invloed van voedingsmiddelen in schoolkantines & winkels in de schoolomgeving'	2008	1 ECTS
Van der Horst K, Oenema A, Brug J. "Are school physical activity policies and schoolyard facilities associated with sports and active commuting to school?" Paper presented at the seventh conference of the International Society of Behavioral Nutrition and Physical Activity, Banff, Canada. (May 21-24).	2008	1 ECTS

International Conferences

Fourth conference of the International Society of Behavioral Nutrition and Physical Activity, Amsterdam, the Netherlands (July 16-18)	2004	1 ECTS
European Congress on Obesity, Athens, Greece (June 1-4)	2005	1 ECTS
Sixth Conference on Psychology and Health, Kerkrade, the Netherlands (May 8-10)	2006	1 ECTS
Fifth conference of the International Society of Behavioral Nutrition and Physical Activity, Boston, USA (July 13-16)	2006	1 ECTS
Sixth conference of the International Society of Behavioral Nutrition and Physical Activity, Oslo, Norway (June 20-23)	2007	1 ECTS
Seventh conference of the International Society of Behavioral Nutrition and Physical Activity, Banff, Canada. (May 21-24).	2008	1 ECTS

2. Teaching activities

Supervising Bachelor thesis	2007	15 hours
Curriculum Medical students, 2nd year, Erasmus MC Rotterdam Theme 2.2: 'Disorders in nutrition, metabolism and hormonal regulation'. Supervising students.	2007	5 hours
Curriculum Medical students, 4th year, Erasmus MC Rotterdam	2006	15 hours
Theme 4.2: 'The population as a patient'. Coordination and supervising students.	2007	20 hours