



Behaviours contributing to positive energy balance

Review of Scientific Evidence and Policies on Nutrition and Physical Activity-Objective A1: A comprehensive review of the scientific evidence about behaviours contributing to positive energy balance

Summary Report



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Preface

About this project

Overweight, obesity and their related diseases represent a leading cause of morbidity and mortality, and pose a major challenge for the sustainability of healthcare systems of EU Member States. The growing prevalence of overweight and obesity among all age groups across Europe constitutes a serious concern for policy makers. Tackling this issue requires a comprehensive response that reflects the multifactorial and complex nature of obesity and overweight. One particularly important area of focus has been on the development of preventative strategies which include nutritional and physical activity interventions.

The European Commission Directorate General for Health and Food Safety (DG SANTE) recognises the significant challenges policy makers face in developing effective and efficient policy interventions relating to diet and physical activity. One such challenge includes the complexity and breadth of the evidence base. By providing independent, accurate summaries of recent and relevant information and statistics on determinants of diet and physical activity and their impact on health, this project aims to support policy makers to continue to develop policy instruments which enable people to make healthier lifestyle choices. In particular, this project aims to support the development of healthier behaviours in vulnerable and/or at-risk subpopulations (including children, pregnant and lactating women, and older adults) and low socio-economic status groups (including low income and education).

About this series

This evidence review is one of eight reviews relating to different determinants of diet and physical activity.

Seven of the reviews are of the scientific evidence and policies in the following areas:

- Knowledge, attitudes and behaviours contributing to positive energy balance (objective area A1);
- Dietary and physical activity patterns in Europe (objective area B1);
- Consumption of fruit juices, artificially and sugar-sweetened beverages and its impact on weight status and health (objective area B2);
- Consumption of high-fructose syrup and its impact on weight status and health (objective area B3);
- Relationship between weight status and physical activity with school and work performance outcomes (objective area C);
- Early warning indicators of obesity and physical inactivity trends (objective area D);
- Nutrition and physical activity guidelines for specific population groups (objective area E).

Building on these seven reviews, the final review (objective area A2) examines specifically the evidence for effective and efficient policies and interventions in terms of promoting, supporting and improving nutritional and physical activity behaviours at both individual and population level.

All reviews, and their summaries, are available on the DG SANTE webpage [here](#).

Approach and purpose

The reviews have been designed to provide policymakers with summaries of recent and relevant evidence in these key areas of interest. Given the broad scope of each of the reviews, it should be stressed that they are not intended to be rigorous systematic reviews of all literature published in this field. Rather, they are intended as pragmatic reviews combining a comprehensive search methodology with expert academic input,

facilitated through workshops, to provide a practical and accurate summary of key issues and tackling broad lines of enquiry, with the greater aim of supporting the development and improvement of policies in this area. Each of the project's eight methodologies and analyses was reviewed by DG SANTE and academic experts in these topics.

While the methods to conduct this comprehensive literature review are systematic, it is *not* a systematic review. This review does not systematically analyse literature to identify *all* relevant published data and/or appraise its quality. Methods to conduct the literature review consisted of five steps: (1) refining the research questions, (2) developing a search approach and databases, (3) conducting literature searches, (4) screening articles for inclusion; and (5) abstracting and synthesising relevant data.

To minimise bias, the literature search approach included identification of a priori search parameters (also considered first level inclusion and exclusion criteria), agreed with DG SANTE, to guide searches and inform screening and selection processes for data inclusion. Due to the immense number of literature search results at step 3, the application of quite limiting exclusion criteria at step 4 was deemed necessary. This may however have resulted in not screening all potentially relevant literature. All relevant articles that were found appropriate for inclusion were reviewed for relevance to each objective area, and the scope of the specific research questions. Furthermore, the inclusion of different types of scientific evidence (from systematic reviews and peer-reviewed original articles down to BSc theses) and the presentation of this scientific evidence next to grey literature information presented a challenge in terms of maintaining an understanding of the quality and weight of the evidence. The authors addressed this to some extent by structuring the document in such a way that peer-reviewed and grey literature are clearly identified. The full methodology and steps taken for each review is included in Annex of the full literature review documents.

DG SANTE and the Joint Research Centre (JRC) provided input on all stages of the project and comments on the literature reviews. Expert workshops were organised to discuss findings, highlight additional relevant sources to fill gaps and improve the series of reviews. Experts were carefully selected from academic and policy-making fields, based on expertise of the specific topics addressed.

The methodology used across all eight reviews remained consistent, and within each review a detailed summary of the approach is provided, along with a full bibliography for further reading.

Objective A1: Behaviours Contributing to Positive Energy Balance

This review describes the scientific evidence on behaviours associated with energy balance and factors influencing such behaviours (e.g., motivations, taste and eating preferences). It also looks at evidence on how people might be supported to adopt healthier behaviours, through nudging or influencing their choices at home, school, work or play.

1.1 Scope of this review

To ensure the most relevant sources were reviewed, we:

- Focused primarily on literature published after 2005, unless otherwise stated.
- Did not focus in detail on particular dietary behaviours e.g. the consumption of sugar sweetened beverages (SSBs), artificially sweetened beverages (ASBs) or high fructose corn syrup, as these are the focus of separate reviews published as part of this series, Objective B2 and Objective B3, respectively.
- Focused on nudging actions which affect an individual's micro-environment – home, school, work or leisure settings, and are non-regulatory. Policies which may affect the dietary or physical activity behaviours of people, but which are enacted on a macro-level and/or are legal or regulatory in nature are discussed in Objective A2, also published as part of this series.

1.2 Methodology

The review is based primarily on peer reviewed literature (which is prioritised), with grey literature used to supplement any gaps (but treated with caution and the strength of the evidence assessed). A full description of the methodology used for all literature reviews can be found in the original literature review report. The review draws on 48 peer-reviewed and 27 grey literature sources selected as relevant. These findings were presented at an expert workshop, following which one further peer-reviewed and one grey literature source were added.

1.3 Research questions

In the review, we focus on the most current literature (peer-reviewed research and systematic reviews, as well as grey literature) to answer the following questions:

- What behaviours contribute to positive energy balance?
- What are the main drivers for food purchasing, cooking and eating (and eating together) and physical activity choices?
- How can these choices/behaviours be efficiently framed or nudged so as to become healthier?

What behaviours contribute to positive energy balance?

This section focuses on the dietary and physical activity behaviours which may contribute to positive energy balance and how this can vary across age, nationality, gender and socioeconomic background.

Several peer-reviewed European studies of children and young people (Herzig et al., 2012; Van Stralen et al. 2012) have indicated that dietary behaviours alone do not necessarily lead to a positive energy balance and may vary by country. Among children aged 4-7, from six European datasets, Van Stralen et al. (2012) found associations between dietary behaviours and overweight varied by country in different ways. For example, fruit intake had a negative association with BMI in the Greek study; a positive association with BMI in the German study; and the Belgium study found no association between fruit intake and BMI. Likewise, vegetable intake was positively associated with BMI in the German study; negatively associated in the Belgian study with no association found in the Greek study.

Instead, these studies indicated that physical activity behaviours may contribute more to energy balance but that again, associations vary by country. Herzig et al. (2012) found that Swiss children's dietary habits were similar to those of children from six "European Energy balance Research to prevent excessive weight Gain among Youth" (ENERGY) countries.¹ However, the prevalence of obesity among Swiss children was significantly lower, potentially because they had higher levels of physical activity than the average level among children from the ENERGY countries, spending more time walking to school, more time engaged in sports activities per week, with fewer minutes per day watching TV and engaged in computer activities (Herzig et al., 2012). Meanwhile, van Stralen identified a significant positive association between total screen time and BMI but only among children in Belgium and Germany.

Some very limited (UK-specific) evidence indicates that among adults, gender may affect the interaction between dietary and physical activity behaviours and their contributions to positive energy balance. A UK-based cross-sectional study (Scarborough, et al., 2011) found that, increases in average body weight for women were associated with increased total calorie intake alone. However, the increases in average body weight among men was due to both increased calorie intake and reduced physical activity levels. No comparable studies for other EU countries were found.

Finally, socioeconomic background may also affect how these behaviours contribute to the positive energy balance although evidence identified only established this for young people; children of low-income/low educational attainment families may be at greater risk of positive energy balance when compared with children of higher income/high educational attainment families. Peer-reviewed studies either found an association between low parental SES (measured by parental education level) and children's overweight (van Stralen et al. 2012), or link between SES and individual energy balance-related behaviours among children e.g. fruit and fruit juice consumption, soft drink consumption and screen-time (Mantziki et al., 2015 and Herzig et al., 2012)

What are the main drivers for food shopping, cooking, eating and physical activity choices?

This section highlights different factors which are associated with, or have been shown to influence different food-related and physical activity choices. The factors relating to dietary behaviours (shopping, cooking and eating) are framed in terms of four concepts: food availability; food access; food knowledge and personal choices. Some identified

¹ Belgium, Greece, Hungary, the Netherlands, Norway, Slovenia, and Spain

factors related to multiple or interlinked behaviours (such as shopping *and* consumption)- findings related to specific behaviours are highlighted where possible.

Drivers of dietary behaviours (shopping, cooking and eating)

Food availability

There was very limited evidence identified relating to how food availability affects dietary behaviour. Survey evidence (Pettinger et al. 2007) did indicate though that food purchasing patterns vary according to nationality in terms of what kinds of shops people frequent, the availability of energy-dense foods in those shops and cultural attitudes to snacking, which may affect prevalence of obesity.

Food access

In contrast, surveys in US, France, and Australia, have found that lower socioeconomic status (SES) is a key driver of food purchasing and consumption, because it decreases the means to purchase particular food items and is associated with the perception that healthy foods (e.g., fruits and vegetables or foods high in fibre or low in fat, salt or sugar) are too costly to purchase. (Aggarwal et al., 2016; Bihan et al., 2010; Turrell and Kavanagh, 2006;). The grey literature indicated that people with low SES may also lack adequate transportation, which in turn, may create difficulties accessing stores where healthier foods are more affordable. (Robertson, Tirado and Lobstein et al., 2004).

Food knowledge

There was limited and mixed evidence that dietary behaviours are also influenced by levels of education, nutritional knowledge, perceived importance of taste, nutrition, cost and convenience. Turrell and Kavanagh's (2006) study of 1000 Australian adults, identified that respondents with low levels of education were less likely to purchase healthier foods (i.e., foods high in fibre or low in fat, salt or sugar) and identified an association between respondent knowledge about nutrition and food purchasing behaviour. European surveys (Grunert, et al., 2012) have found differences in level of nutrition knowledge are associated with socio-demographic characteristics, consumers' attitudes towards healthy eating and use of different sources of food knowledge, but no association with purchasing behaviour. Grey literature also highlighted the association between education and purchasing behaviour (Nordic Council of Ministers, 2014) but that knowledge or attitudes may be affected by advertising and marketing (including within stores), which in turn can influence consumption or purchasing behaviour, particularly among children and adolescents. (Dibbs and Harris 1996, Wolfram 2000; Tatlow-Golden et al., 2016)

Personal characteristics and knowledge

There was some limited, country-specific evidence that being female was a main driver of cooking and strongly associated with cooking skills, time spent cooking, and more often preparing food for the family. UK surveys have found women reporting more confidence with a greater number of cooking techniques when compared with men, as well as reporting more time spent cooking (Adams et al., 2015, Adams & White et al., 2015).

More internationally, surveys have indicated that higher SES, living with others and having more free time were also found to be associated with healthy dietary patterns and cooking in particular. Surveys and longitudinal studies from the UK, France and Canada (Adams & White, 2015, Berge et al., 2016 and Allès et al., 2016) found that higher education and having a non-physical occupation across one's lifetime was associated with a healthy dietary pattern while living with other adults or children, or household size were positively associated with time spent cooking. Parents who reported they stay at home or were employed part time were more likely to report that they prepared food for the family.

Drivers of physical activity behaviours

On an individual level, in the grey literature, improved health was the main motivator for engagement in physical activity, with other factors such as appearance and pleasure also being important. A Eurobarometer survey in both 2010 and 2013 found that EU citizens took part in sport or some form of physical activity for health reasons, to improve fitness, to relax to have fun (European Commission, 2010, 2013). Other reasons for physical activity across the two surveys were to improve physical image; spending time with friends; weight control; improving self-esteem; and counteracting the effects of aging.

A number of peer-reviewed sources including a meta-analysis (Duncan et al., 2015; Blanchard et al., 2005; De Bourdeaudhuij et al., 2005) and grey literature (Boyce, Robertson and Dixon, 2008; Edwards and Tsouros, 2006) confirm that physical activity is also associated with environmental factors including the (perceived) presence of sidewalks, shops nearby, physical activity facilities, higher connectivity of streets, and higher residential density. Social support and social norms increased the pleasure of physical activity for adults during their leisure-time but concerns about safety and security act as barriers to being physically active. (De Bourdeaudhuij et al., 2005)

How can these behaviours/choices be nudged so as to become healthier?

Making changes to the micro-environment that present ways in which people can be “nudged” to make healthier choices is a strategy that has been gaining attention in the public health community. Current findings related to interventions that nudge people to make the healthier choice are summarised here.

Nudging to make healthier dietary choices

Peer-reviewed studies (Babio et al., 2014; Aschemann-Witzel et al., 2013; Borgmeier & Westenhofer, 2009), have found that label colour coding, particularly multi-colour ‘traffic light’ labels can increase the healthiness of choices by adults and adolescents while the grey literature indicated that consumers are more likely to pay attention to front-of-packaging labelling (Engelhard and Garson, 2009; FLABEL 2012). However, the peer-reviewed literature also found that when consumers were left to select the food items they wanted most, food labelling did not have an influence in consumers making a healthy choice. In contrast, peer reviewed studies, including a systematic review and a control study (Bucher et al., 2016, Foster et al., 2014) have found that positional changes (e.g. the availability of products and attention-grabbing signage in their eye line, as well as location in stores) have a positive influence on food choice. Increasing the proportion of healthy options or reducing portion sizes available may also affect healthier food selection. Small-scale studies (Bucher et al., 2011; Burns and Rothman, 2015) have shown that providing a variety of healthy options increases the proportion people choose to include in their meals. A systematic review (Skov et al., 2013) highlighted that adjusting portion sizes can lead to decreased consumption of unhealthy foods and reduced wastage. However it can also lead to compensatory choices e.g. taking two smaller bags of chipped potatoes rather than one large.

Finally, incentivising healthier items through lower costs or using interventions that focus on payment methods may be promising strategies for encouraging healthier food/beverages choices. Systematic reviews (Grech and Allman-Farinelli, 2015; Skov et al., 2013) have found that reduced prices for healthier items, or providing a prepaid debit card restricted to healthy foods (instead of cash or a general debit card) contributed to an increase in sales of healthier options.

Nudging to Make Physical Activity Behaviours Healthier

Our review found fewer articles on this topic when compared to articles describing nudging to improve dietary intake. However, a useful summary provided by Kremers et al (2012) is that nudging people to be more physically active may include physical (stair prompts, increasing attractiveness of the physical activity environment), economic (decreasing the price associated with structured physical activities, increasing the cost of parking a car), or political (rewarding physical activity, dis-incentivizing physical inactivity) approaches.

Systematic review evidence (Soler et al., 2010) found that point-of-decision prompts were effective in increasing stair use. However, studies of multi-component stair climbing interventions involving a large group of UK tram users (Lewis and Eves, 2012) found that further motivational messaging placed at intervals on the stairwell may be needed rather than point-of-decision messaging alone.

There was inconclusive findings identified that the inclusion of small bouts of physical activity during the day in schools, worksites may also be a promising approach for increasing physical activity. Systematic review evidence (Barr-Anderson et al., 2011) found that only half of included school- and worksite-based studies of interventions (most involving the integration of 10 minute bouts of physical activity during the day or 10-15 minute physical activity breaks) found an association with improved levels of physical activity.

The grey literature found that altering the local environment to offer alternatives to motorised transport can increase physical activity. These alternatives include improving neighbourhood design e.g the diversity and interest of walking routes and the location of schools and businesses and assigning more priority to active transport options e.g. through the provision of cycle lanes and cycle hire schemes (Edwards and Tsouros, 2006).

Conclusion

The variation in associations between dietary and physical activity behaviours and positive energy balance seen across different geographical regions indicate that while obesity may be attributable to energy imbalance, it may not have universal causal factors. Research on how physical activity and diet interact together to effect weight loss would be beneficial in particular for understanding energy balance model of obesity.

Indeed, the review confirmed there are multiple factors/drivers that can influence dietary behaviours and physical activity, with varied and complex interplay. The drivers identified ranged from those linked to access (e.g., availability, affordability and transportation), social and physical environments (e.g., social support, culture, number of opportunities for physical activity or healthy food shopping) and individual characteristics (gender, taste preference, perceived benefit of healthy eating or physical activity). Socio-economic status was also identified as an important factor.

While there was some evidence identified for the effectiveness of nudging strategies for improving dietary choices (colour coding labelling, positioning of healthier food choices, offering a higher proportion of healthy options and reducing portion sizes) and that stair prompts can nudge people towards increased use of stairs, there was also some evidence that people can continue or find new ways to make unhealthy choices (e.g. choosing two portions where portion size has reduced). The review indicates there is a further need for more research about the use and effectiveness of choice architecture/nudging interventions, particularly those designed to increase physical activity.

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Annex 3 Glossary

The following definitions are common definitions that are used across all eight objective areas. Where a study uses a different definition, this is highlighted on an individual basis in the review reports.

Table 1. Definitions of terms used across the reviews

Term	Definition	Source
Adult obesity	An abnormal or excessive fat accumulation that presents a risk to health, with a BMI of 30 or more.	World Health Organisation (WHO) (http://www.who.int/topics/obesity/en/)
Adult overweight	An abnormal or excessive fat accumulation that presents a risk to health, with a BMI equal to or more than 25.	WHO (http://www.who.int/topics/obesity/en/)
Alcopops	Pre-mixed beverages containing a spirit, wine or malt combined with a non-alcoholic drink.	1. Anderson, P., Suhrcke, M. and Brookes, C. (2012) An overview of the market for alcohol beverages of potentially particular appeal to minors. London: HAPI.
Artificially sweetened beverages (ASBs)	Beverages sweetened with low-calorie or zero-calories sweeteners such as sucralose, aspartame, saccharin, stevia or sugar alcohols.	ICF definition based on all literature identified in objective area B2 literature review
Body Mass Index	A person's weight (in kilograms) divided by the square of his or her height (in metres).	WHO (http://apps.who.int/bmi/index.jsp?introPage=intro_3.html)
Child/adolescent obesity	There are different systems available to measure child or adolescent obesity for different ages. Children under 5 obesity is weight-for-height greater than 3 standard deviations above WHO Child Growth Standards median; Children aged 5-19 overweight is BMI-for-age greater than 2 standard deviation above the WHO	WHO http://www.who.int/mediacentre/factsheets/fs311/en/ (Other definitions are available for different national and international systems).

Term	Definition	Source
	Growth Reference median.	
Child/adolescent overweight	<p>There are different systems available to measure child or adolescent overweight for different ages.</p> <p>Children under 5 overweight is weight-for-height greater than 2 standard deviations above WHO Child Growth Standards median;</p> <p>Children aged 5-19 overweight is BMI-for-age greater than 1 standard deviation above the WHO Growth Reference median.</p>	<p>WHO</p> <p>http://www.who.int/mediacentre/factsheets/fs311/en/</p> <p>(Other definitions are available for different national and international systems).</p>
Exercise	Exercise, is a subcategory of physical activity that is planned, structured, repetitive, and purposeful in the sense that the improvement or maintenance of one or more components of physical fitness is the objective.	WHO (http://www.who.int/dietphysicalactivity/pa/en/)
Insufficient physical activity	Physical activity that does not meet WHO recommended levels of at least 60 minutes a day of moderate-vigorous activity for children and adolescents and at least 150 minutes of moderate-intensity aerobic physical activity throughout the week for adults.	WHO http://www.who.int/mediacentre/factsheets/fs385/en/
Physical activity	Any bodily movement produced by skeletal muscles that requires energy expenditure.	WHO (http://www.who.int/topics/physical_activity/en/)
Physical inactivity	A lack of physical activity	WHO (http://www.who.int/dietphysicalactivity/pa/en/)
Sedentary behaviour	Any waking behaviour characterized by an	Tremblay, M. S., et al. (2017). Sedentary

Term	Definition	Source
	energy expenditure ≤ 1.5 metabolic equivalents (METs) while in a sitting or reclining posture.	Behavior Research Network (SBRN) – Terminology Consensus Project process and outcome. <i>The International Journal of Behavioral Nutrition and Physical Activity</i> , 14, 75. http://doi.org/10.1186/s12966-017-0525-8
Sugar sweetened beverages (SSBs)	Any beverage with added sugars. This includes soft drinks, soda, fruit drinks, punch, sports drinks, sweetened tea and coffee drinks, energy drinks and sweetened milk. These beverages may be sweetened with added sugars such as sucrose (table sugar) or high fructose corn syrup, which is what distinguishes them from 100% fruit juice and beverages with non-caloric sweeteners (e.g., aspartame, saccharin or sucralose).	US Department of Agriculture. 2010. <i>US Department of Health and Human Services. Dietary guidelines for Americans, 2010</i> . 7th edition, Washington (DC): US Government Printing Office

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