Mediating effects of home-related factors on fat intake from snacks in a school-based nutrition intervention among adolescents

Wendy Van Lippevelde1*, Maartje van Stralen2, Maïté Verloigne3, Ilse De Bourdeaudhuij3, Benedicte Deforce4, Johannes Brug5, Lea Maes1 and Leen Haerens3

1Department of Public Health, Ghent University, 9000 Ghent, Belgium, 2Department of Public and Occupational Health, EMGO Institute for Health and Care Research, VU University Medical Center, 1081 BT Amsterdam, the Netherlands, 3Department of Movement and Sport Sciences, Ghent University, 9000 Ghent, Belgium, 4Department of Biomechanics and Human Biometry, VU Brussels, 1050 Brussels, Belgium and 5Department of Epidemiology, EMGO Institute for Health and Care Research, VU University Medical Center, 1081 BT Amsterdam, the Netherlands

*Correspondence to: W. Van Lippevelde. E-mail: wendy.vanlippevelde@ugent.be

Received on May 3, 2011; accepted on October 7, 2011

Abstract

The purpose of the present study was to investigate if the effects of the parental component of a school-based intervention on dietary fat intake from snacking were mediated by changes in home-related factors. A random sample of 10 schools with 2232 pupils aged 11–15 years was randomly assigned to one of two intervention groups [one with (n = 1226) and one without a parental component (n = 1006)]. Fat intake, home availability of low-fat foods and parental encouragement and support to eat a low-fat diet were assessed with validated self-administered questionnaires. Mediation was assessed with the product-of-coefficient test. Changes in home-related determinants were significantly related to changes in fat intake from snacks; therefore, school-based obesity programmes should try to address these determinants. In the present study, one of the three investigated home-related factors, namely parental support, was affected by the parental component intervention. Decreases in parental support were prevented. These changes in parental support were found to mediate the parental intervention effects on changes in fat intake from snacks. Home-related factors appear to be related to changes in adolescents’ snacking behaviour, therefore, school-based obesity programmes should target them. Nevertheless, more research is needed concerning effectively addressing the other determinants.

Introduction

Overweight and obesity in youth has increased dramatically and is linked with different physical and psychosocial health problems [1]. Overweight and obesity are caused by a lasting positive energy balance occurring when energy intake outweighs energy expenditure [2]. Therefore, overweight prevention initiatives promoting healthful diets and physical activity starting in childhood have high priority.

Snacking is an energy balance-related behaviour associated with excess energy intake and obesity [3–5] in children and adolescents; moreover, prevalence of snacking in children and adolescents has increased over the last decades[6]. Significant changes were observed among US children in the number of snacking occasions—but not in average snack size and snacks’ energy content—resulting in an increased proportion of both energy and fat from snacks [6, 7]. Children in the United States, especially the younger children, are consuming almost three snacks per day and snacking accounted for up to 27% of children’s daily caloric intake [7]. Mean

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daily intake of total fat varied between countries and ranged from 23 to 40% energy in children and from 25 to 40% energy in adolescents [8]. In European studies, snacking is also prevalent, with Scottish adolescents (aged 12–18 years) consuming at least 2.8 snacks per day [9] and Portuguese youth (aged 5–15 years) consuming 1.5 snacks per day [10].

The school environment is recognized as an important setting to address children’s dietary behaviour. Schools provide many opportunities to promote healthy eating through school food services, health education classes and health services. Therefore, many interventions developed to change children’s dietary behaviours took place in schools and included educational initiatives or environmental modifications or both [11]. Multi-component interventions appear to be most effective in changing nutrition behaviour [11]. Besides the school, also the home environment forms an important setting for healthy eating interventions since recent reviews indicated that home-related factors are important for dietary behaviour and behaviour change in youth [12, 13]. Moreover, home-related factors such as parenting practices including availability and accessibility of healthy food products at home and parental intake and role modelling appear to be associated with children’s snacking behaviour [14–16].

The school and the home environment are two important settings for targeting adolescents’ dietary behaviour. Despite that, only few school-based studies were designed to assess if adding a parental component enhanced the effectiveness of interventions aimed at changing children’s dietary intake [17]. Moreover, reaching parents is difficult since parents are often not eager to participate in school-based interventions because of several reasons such as a lack of spare time next to their work and household obligations [18].

Haerens et al. [19–21] investigated the effectiveness of a nutrition intervention with and without an explicit parent involvement component in middle schools. In addition, mediation analyses were conducted to explore if changes in psychosocial factors (attitude, social support, self-efficacy, perceived benefits and perceived barriers to eat a low-fat diet) mediated changes in total fat intake. However, no significant mediation was observed [22]. Nevertheless, significant changes in fat intake were observed, therefore, more research investigating other possible mediators is recommended. Because these effects on fat intake were only observed among adolescents that participated in the intervention with parental involvement, we wanted to further investigate if home environment factors that mediated the intervention effect could be identified. Earlier research was mostly focused on personal cognitive potential mediators [23, 24].

**Mediation analyses**

Interventions typically aim at influencing a set of intermediate variables (i.e. mediators) of dietary behaviours [25]. A mediator is a variable through which an intervention exerts its effect on behaviour [26, 27]. By conducting formal mediation analyses on intervention studies, more insight could be gained into which mechanisms are critical for influencing energy balance-related behaviours in children, e.g. insight into whether the prevention programme resulted in changes in the presumed mediator and whether this in turn led to changes in the outcome variable, i.e. energy balance-related behaviour [28]. Such insights inform further intervention development and theories of energy balance-related behaviour change [29, 30]. True mediation analyses of dietary behaviour change in youth are, however, scarce [23, 24]. A systematic review of studies examining mediators of dietary behaviour change in youth was conducted by Cerin et al. [23], only seven studies were identified which were all on school-based interventions. Their findings indicate that self-efficacy and outcome expectations were mediators of potential importance, but most reviewed interventions were relatively unsuccessful in changing mediators. van Stralen et al. [24] aimed to identify psychosocial and environmental mediators of energy balance-related behaviours interventions for youth. Eight studies focused on changing dietary behaviours in which strong evidence was found for attitude, knowledge and habit strength to be mediators of dietary behaviour interventions. None of the studies included in the reviews conducted mediation analyses on snack consumption.
**Snacking behaviour**

Snacking is an important target behaviour among children and adolescents because children and adolescents experience more control over their fat intake derived from snacks than from other sources such as family meals [31]. Moreover, as children grow older, greater freedom in decision-making and behaviour is given by the parents, which might in turn result in more snacking [32]. Given the increasing intake of fat from snacks in children [6], the present study focuses on this specific behaviour to inform development of future interventions specifically targeted at this behaviour. Considering the association between factors in the home environment and children’s overall nutrition behaviour, more in-depth research concerning such home-related factors and snacking behaviours is needed to fill up the gap of knowledge.

**The present study**

The present study has three aims. First, we aimed to investigate whether an intervention aimed at decreasing overall fat intake, also resulted in lowering fat intake from snacks. This way we can explore if an environment that supports youngsters to eat a low-fat diet is capable of influencing snacking, i.e. a specific nutrition behaviour contributing to fat and calorie intake. Secondly, we wanted to examine whether the parental component of the intervention resulted in favourable changes in home-related determinants for eating less fat. Finally, it was examined whether changes in home-related factors mediated the effects of a parental intervention component on changes in fat intake from snacks. It was hypothesized that the intervention with a parental component (I + P-group) would result in larger changes in the perceived home-related factors than the intervention without parental component (I-group).

**Methods**

**Participants**

The data for the present study were derived from a clustered randomized controlled trial (RCT) conducted in Flanders (Belgium) [19–21]. Fifteen schools participated in the latter study, of which five were randomly allocated to the control group and 10 schools were randomly assigned to one of two intervention arms (with and without parental support). For the present study, data from both intervention groups were included to identify if changes in home-related factors mediated intervention effects on changes in fat intake from snacks. Parental consent was obtained from 2232 pupils aged 11–15 years [19–21]. Comparing both intervention groups enables to assess the effects of the parental component per se. Table I presents the baseline data of the sample according to condition. The study protocol for the Belgian clustered RCT was approved by the Ethical Committee of Ghent University.

**Interventions**

A school-based intervention programme to promote healthy food and physical activity over two school years (October 2003–June 2005) was developed and implemented in 10 secondary schools [19–21]. In five of these schools, the intervention was supplemented with a parental component (I + P-group).

**School-based intervention**

The school-based healthy eating intervention has been extensively described elsewhere [19–21]. In summary, it had a school environmental and an individual-based part. The environmental intervention component focused on increasing school

<table>
<thead>
<tr>
<th></th>
<th>Total group</th>
<th>I + P</th>
<th>I</th>
</tr>
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<tbody>
<tr>
<td>Age (years)</td>
<td>13.06 ± 0.81</td>
<td>13.04 ± 0.79</td>
<td>13.24 ± 0.87</td>
</tr>
<tr>
<td>Girls (%)</td>
<td>36.6</td>
<td>40.1</td>
<td>15.6</td>
</tr>
<tr>
<td>Higher SES (%)</td>
<td>32.5</td>
<td>32</td>
<td>21.1</td>
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I, intervention alone condition; I + P, intervention condition with parental component. SES: An estimate of higher and lower SES was obtained by classifying the occupation of the father and mother into white- and blue-collar.
availability of food items generally regarded as contributing to a healthy food environment, such as water and fruit, and decreasing availability of foods not regarded as such (e.g. high fat and sugar snacks and sugar-sweetened beverages). The individual-based intervention component included a computer-tailored fat intake intervention during one class hour [19, 33] resulting in personal feedback about their fat intake and attitudes and intentions regarding fat reduction, informed by the theory of planned behaviour [34] and stages of change [35]. Examples of concrete feedback were ‘Search for support or help in your home environment to eat less fat because it is easier and more amusing when you are not on your own’ or ‘Specifically ask for support to eat less fat because your environment perhaps does not know that you want to reduce your fat intake’. The intervention was designed to be implemented by school staff with only minimal external support to make later implementation in all Flemish schools feasible. It was coordinated by a working group of school personnel that received background information, an intervention manual and educational material from the University team that developed the intervention.

Parental intervention

The parental intervention included different intervention components and aimed at promoting a supportive environment for healthy behaviours in the home environment. Parents received a free CD with a programme to obtain individually tailored fat intake feedback [33, 36] for use at home. This programme was aimed at making parents aware of their own fat intake and its possible consequences for health and to provide personalized advice to reduce fat intake. Parents were further informed, by means of a leaflet sent to their home address, about their child completing a similar computer-tailored programme and encouraged to discuss the feedback with their child. Finally, parents were invited to attend an interactive nutrition education meeting at the school, and regular newsletters were provided with information about healthy eating and how they could support their children to eat less fat. A more thorough intervention description is reported elsewhere [19–21].

Measurements

Questionnaires were completed by the adolescents at the beginning of the first school year (September 2003) and at the end of the first school year (May/June 2004). All measurements took place at school and questionnaires were filled out under supervision of teachers.

Fat intake

Fat intake was measured with a validated and reliable self-administered questionnaire developed at Ghent University together with the Flemish Institute for Health Promotion [33, 37]. The present study focused on fat intake from sweet and savoury snack foods including cake, cookies, pie, chocolate, crisps, nuts & peanuts, ice cream and cheese and meat snacks. Pupils were asked for each snack type on how many days per week or months they usually consumed the food items and how much they ate each day the food was consumed. A coefficient was calculated, representing fat content and portion size of each product [38, 39]. This coefficient was multiplied by the frequency of consumption, leading to mean fat intake scores per day for each snacking item, from which a total snack fat intake score was calculated. A more thorough description is reported elsewhere [19–21].

Home-related factors

To assess potential home-related determinants of fat intake, pupils were asked to rate the following items on a five-point scale: Home availability: ‘How hard is it to eat a low-fat diet at home?’ [very hard (1)–very easy (5)]; Parental encouragement: ‘My parents encourage me to eat less fat’, [certainly not (1)–certainly yes (5)] and Parental support: ‘There is a lack of support from my parents to eat foods with less fat’ [certainly not (1)–certainly yes (5)]. The latter item was recoded to have similar coding as the other items. It was not attempted to calculate an overall home environment score because the internal consistency was too low (Cronbach’s Alpha < 0.3).

Statistical analyses

Dropout analyses indicated few relevant differences between pupils lost and not lost to follow-up [19]:

Mediating effects of home-environmental factors
pupils lost to follow-up were somewhat older, and dropout was higher in the I-group; therefore, intention-to-treat analyses were conducted by carrying the last observation forward.

Changes in the three home-related determinants were examined as potential mediators of effects of the parental component on changes in snack fat intake. Measures of changes in fat intake from snacks between pre- and post-test (at 8 months) were created by regressing intake measures at post-test onto intake measures at baseline to compute the residualized change scores. The resulting residualized scores can be interpreted as the amount of increase or decrease in intake between baseline and post-tests, independent of baseline intake. In addition to this, also measures of changes in the home-related determinants were made by regressing the different items at post-test onto their baseline scores.

To identify if changes in home-related determinants mediated the effect of the parental component on changes in snack fat intake (research Question 1), regression analyses were conducted using SPSS software version 15.0 (SPSS, Chicago, IL, USA). To compare the effect of the two interventions with each other, the condition variable was recoded into two dummy variables in which the I-group was used as reference. All analyses were adjusted for age. To describe the main effects of the interventions, the regression coefficient \(c\) of the relation between the predictor variable (i.e. intervention condition) and the outcome variable (i.e. fat intake from snacks) was estimated. To assess mediating effects, the product-of-coefficient test was used [40]. This test consists of (i) estimating the effect of the intervention on changes in the potential mediator \(a\) coefficient; (ii) estimating the independent effect of changes in the potential mediator on changes in the outcome \(b\) coefficient and (iii) computing the product of the two coefficients \((a \times b)\), representing the mediated effect (see also Fig. 1). Furthermore, the proportion mediated to the total intervention effect \((ab/c)\) was estimated, wherein the product-of-coefficient \((a \times b)\) is divided by the total intervention effect \((c)\). The statistical significance of the mediated effect was estimated by dividing the product-of-coefficient by its standard error (SE). For the calculation of the SE, the Sobel test was used \((SE_{ab} = \sqrt{a^2 \times SE_a^2 + b^2 \times SE_b^2})\). Significance was at the \(P < 0.05\) level.

### Results

#### Study characteristics

As shown in Table I, 1226 adolescents [aged 13.0 ± 0.8 years; 40.1% girls and 32% higher socio-economic status (SES)] participated in the I + P-group and 1006 adolescents (aged 13.2 ± 0.9 years; 15.6% girls and 21.1% higher SES) in the I-group. At baseline, no significant differences in demographics were found between the two intervention conditions except for gender. Table II presents the baseline values of fat intake from snacks and the different home-related determinants. Significant differences in baseline fat intake from snacks were found between the two intervention conditions \((t = -5.686; P < 0.01)\); a lower baseline fat intake from snacks was found in the I + P-group.

#### Mediating effects of the home-related determinants on intervention effects on fat intake from snacks

**Intervention effect on fat intake from snacks \((c\) coefficient\)**

By calculating residual change scores instead of absolute change scores, we accounted for differences at baseline in fat intake from snacks. The change from baseline to follow-up in fat intake from snacks was significantly different between the two intervention groups \(t_{pre-post} = -3.24; 95\%\) confidence interval
Fat intake from snacks remained rather constant from baseline to follow-up in the I + P-group, whereas an increase was observed in the I-group (see Table II). Figure 2 presents the changes in fat intake from snacks in both intervention conditions from pre- to post-test.

**Action theory test (a coefficient)**

Also perceived parental support changed significantly different in both intervention groups. A significant smaller decrease in perceived parental support to eat a low-fat diet was observed in the I + P-group compared with the I-group. The parental intervention component did not lead to significant changes in the other home-related factors (perceived parental encouragement and home availability) (Table III).

**Conceptual theory test (b coefficients)**

Changes in all home-related factors were significantly and independently associated with changes in fat intake from snacks. These associations were all in the expected direction, i.e. higher scores on home-related factors were associated with lower fat intake from snacks (Table III).

**Mediated effects (ab coefficient)**

One of the examined home-related factors (perceived parental support to eat less fat) showed a significant mediating effect on the difference in effects between both intervention groups. Almost 5% of the effect of the parental intervention component was mediated by changes in perceived parental support, indicating that partial mediation occurred (Table III).

**Discussion**

Snacking contributes significantly to fat and calorie intake in children [6, 7] and children experience more control over their fat intake derived from snacks than from other sources such as family meals [31]. Hence, interventions aimed at this specific behaviour are needed. However, not much is known about determinants of snacking behaviour and how they mediate intervention effects. Given the increases in snacking behaviours of children and the association with overweight development [3–7], it is important to explore which factors influence snacking behaviour. Furthermore, parenting practices appear to be associated with children’s snacking
In the present study, we explored the importance of an additional parental component of a school-based intervention programme, aiming at creating a supportive home environment for the young adolescents to eat a low-fat diet. We explored if the parental component in the intervention influenced snacking behaviour and if changes in home-related factors mediated this effect.

Changes in parental support were found to mediate the intervention effects on changes in fat intake from snacks. The parental component appeared to have prevented a decrease in parental support over time. This, in turn, prevented an increase in dietary fat intake from snacks. As children grow older, parents might give more autonomy to their children with regard to their dietary intake [32], which might in turn result in more snacking. The results of the present study seem to suggest that a parental component might reincrease awareness among parents that it is still important to support their children to eat a low-fat diet, also when they grow older. Of course, more intensive measurements among parents are needed to confirm these assumptions about the underlying mechanisms explaining our results.

The other home-related determinants did not significantly mediate the intervention effects. The parental intervention component led to significant changes in one of the three home-related factors (this is perceived parental support). We would have hoped to be able to detect positive effects on all home-related factors, as all of these were consistently negatively associated with fat intake from snacks. As the latter indicates that these home-related determinants are important predictors of child fat intake from snacks and should be more effectively targeted in future interventions aimed at changing fat intake in children.

There are several possible explanations for the lack of an effect of the parental intervention component on the home-related determinants. First, the parental intervention component may not have been adequately implemented. The lack of process evaluation data on implementation and levels of parental involvement hinders the possibility to draw conclusions [19]. The positive effects on one of the three home-related factors (this is parental support) and the significant difference in fat intake from snacks when comparing both intervention groups indicate however that the family intervention was at least partly implemented. Another reason for the limited effects of the parental component on the home-related factors could be that measures for the home-related determinants were not sensitive enough to change [41]. A third reason concerns the possibility that the intervention strategies in the parental component targeting the home environment did not work. Different models, such as the social ecological model, highlight the importance of focussing on environmental determinants as targets for change in nutrition interventions [42], but only little information is available about how to modify these home-environmental constructs. Therefore, extensive experimental research is necessary to assess the effectiveness of each of the procedures targeting change in home-related mediators [43].

Another explanation for the failure to find mediation effects of some home-related factors on fat intake from snacks could be that an intervention focussing on total fat intake was too general to influence children’s snacking behaviour. Possibly, more specific intervention components focussing on snack avail-

<table>
<thead>
<tr>
<th>Home availability pre–post</th>
<th>a (SE)</th>
<th>b (SE)</th>
<th>ab (SE)</th>
<th>95% CI of ab</th>
<th>% Mediated effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre–post</td>
<td>0.06 (0.049)</td>
<td>−1.001 (0.357)*</td>
<td>−0.06 (0.054)</td>
<td>−0.165 to 0.045</td>
<td></td>
</tr>
<tr>
<td>Parental encouragement pre–post</td>
<td>0.105 (0.055)</td>
<td>−0.846 (0.324)*</td>
<td>−0.089 (0.058)</td>
<td>−0.202 to 0.024</td>
<td></td>
</tr>
<tr>
<td>Parental support pre–post</td>
<td>0.120 (0.048)*</td>
<td>−1.335 (0.371)*</td>
<td>−0.160 (0.078)*</td>
<td>−0.313 to −0.007</td>
<td></td>
</tr>
</tbody>
</table>

a, Effect of parental component on residualized change score of home-related determinants. b, Estimate of the independent effect of the mediator on residualized change score for fat intake from snacks. ab, Product-of-coefficient estimate; mediated effect; 95% CI of ab, 95% confidence interval of the mediated effect. *P < 0.05.
ability and parental support and encouragement specific for snacking need to be developed to find mediation effects of changes in home-related determinants on intervention effects of snacking behaviour.

The findings of the present study indicated that changes in home-related factors are indeed related to changes in dietary fat intake from snacks. However, as the I + P-condition did not result in positive changes in all of these determinants, no significant mediation effects were found for two of the three included factors. The I + P-intervention did however result in a lower decrease in parental support, which appeared to have contributed to prevention of an increase in dietary intake from snacks. Considering the association between home-related factors and snacking behaviours, more research is needed to find out how these determinants could be positively influenced by school-based interventions.

To date, there are no studies to compare these results with. To our knowledge, no fat intake intervention studies conducted a full mediation analysis of home-related factors in children or adolescents. In the study of Haerens et al. [22], the authors examined mediating effects of different psychosocial factors (including attitude, social support, self-efficacy, perceived benefits and perceived barriers to a low-fat diet) on changes in total fat intake in girls and found no significant mediators. A similar study as ours was conducted by Chin A Paw et al. [44] who aimed to identify the individual and environmental mediators of a school-based obesity prevention programme (Dutch Obesity Intervention in Teenagers) on high-caloric snack consumption. However, mediation analyses were not conducted [44].

In addition, only few other quasi-experimental studies comparing effects of nutrition interventions with and without parental component are available [45–47]. However, studies that used direct methods (e.g. parental participation at nutrition counselling sessions) to engage parents were more likely to report positive results compared with those studies that used more indirect methods (e.g. newsletters, ‘try this at home’ assignments) [17]. Nevertheless, involving parents in school-based obesity prevention remains challenging since parents are often not eager to participate in school-based interventions.

Some limitations should be noted when interpreting the study findings. First, social desirability bias could have occurred as all measurements were based on self-reports. Second, single items were used to assess the different home-related factors, which may have resulted in lower validity and reliability. Single item assessments were used because exploring home-environmental factors was not the primary aim of the original study, and the number of questionnaire items had to be restricted to enable questionnaire administration during school hours [19–21]. In addition, previous studies have shown that fat intake from snacks and psychosocial measures used in this intervention were reliable and valid [33, 48]. Despite the limitation of these single-item assessments, the present secondary analysis does provide a first valuable exploration of the importance of home-environmental factors as mediators of intervention effects on snacking behaviour, a crucially important at-risk behaviour in children and adolescents.

Third, it is impossible to determine which specific intervention strategies were responsible for which effects because of the multi-component nature of the intervention. Fourth, given the cross-sectional design of the study, no assumptions about causality can be made. Fifth, generalizing of the results might be biased by the initial response and selective dropout. Pupils lost to follow-up were somewhat older, and dropout was higher in the I-group. Finally, the lack of process evaluation information on levels of parental involvement makes it difficult to discover which elements are responsible for the lack of change in the mediators.

The strengths of the study are that it is a longitudinal RCT, which is unique because it includes two separate intervention conditions including an intervention group with and without parental support. In addition, fat intake from snacks and possible determinants were assessed in a large sample of adolescents at two different points in time (pre–post). Consequently, it was possible to detect effects of the added parental component on home-related mediators by comparing both intervention groups.

To our knowledge, we were the first that examined home-related factors as mediators of an
interventions’ effect on fat intake from snacks. The results indicated that an intervention with a parental component arm prevented a decrease in parental support to eat less fat, which resulted in positive effects on dietary fat intake derived from snacks. The results of the present study seem to suggest that a parental intervention might reincrease awareness among parents that it is still important to support their children to eat a low-fat diet, also at older ages. The present study advanced our understanding of the working mechanisms of a school-based intervention with parental support.

Conclusions

Changes in home-related determinants were related to dietary fat intake from snacks; therefore, school-based obesity programmes focusing on adolescents should also try to address these determinants. Effectively addressing these determinants is a challenge, as in the present study two of the three factors (parental encouragement and availability), no changes in home-related factors were found as a result of the intervention with parental component. However, less negative changes in parental support were found to mediate changes in fat intake from snacks when comparing the intervention group with and without parental support, indicating that parents were prevented from providing less support to eat a low-fat diet when their children get older. Future intervention studies aimed at targeting snacking behaviour can try to target the home-related factors identified as important correlates of snacking behaviour in the present study. However, for two of the three factors, more research is needed on how to realize changes in these factors.

Funding

This study was conducted as a part of the “European Energy balance Research to prevent excessive weight Gain among Youth” (ENERGY)-project. The ENERGY-project is funded by the Seventh Framework Programme (CORDIS FP7) of the European Commission, HEALTH (FP7-HEALTH-2007-B), Grant agreement no. 223254.

Conflict of interest statement

None declared.

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