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Do unfavourable alcohol, smoking, nutrition and physical activity predict sustained leisure time sedentary behaviour? A...
Do unfavourable alcohol, smoking, nutrition and physical activity predict sustained leisure time sedentary behaviour? A population-based cohort study

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Abstract
Comparing lifestyle of people remaining sedentary during longer periods of their life with those favourably changing their behaviour can provide cues to optimize interventions targeting sedentary behaviour. The objective of this study was to determine lifestyle predictors of sustained leisure time sedentary behaviour and assess whether these predictors were dependent on gender, age, socioeconomic position and occupational sedentary behaviour. Data from a large longitudinal population-based cohort of adults (aged 18-97 years) in Stockholm responding to public health surveys in 2010 and 2014 were analysed (n=49133). Leisure time sedentary behaviour was defined as >3 hours per day of leisure sitting time e.g. watching TV, reading or using tablet. Individuals classified as sedentary at baseline (n=9562) were subsequently categorized as remaining sedentary (n=6357) or reduced sedentary behaviour (n=3205) at follow-up. Lifestyle predictors were unfavourable alcohol consumption, smoking, nutrition, and physical activity. Odds ratios (OR) and corresponding 95% Confidence Intervals (CI) were calculated, adjusting for potential confounders. Unfavourable alcohol consumption (OR=1.22, CI:1.11-1.34), unfavourable candy- or cake consumption (OR=1.15, CI:1.05-1.25), and unfavourable physical activity in different contexts were found to predict sustained sedentary behaviour, with negligible differences according to gender, age, socioeconomic position and occupational sedentary behaviour. People with unfavourable lifestyle profiles regarding alcohol, sweets, or physical activity are more likely to remain sedentary compared to sedentary persons with healthier lifestyle. The impact of combining interventions to reduce leisure time sedentary behaviour with reducing alcohol drinking, sweet consumption and increasing physical activity should be tested as a promising strategy for behavioural modification.
Introduction

Prolonged periods of sedentary behaviour, defined as behaviour demanding only little energy such as sitting or lying, negatively affect the metabolic and cardiovascular systems independent of physical activity.[1] Sedentary time generally accounts for a large proportion of daytime[2], about two-thirds of daytime in the Swedish population.[3] Though there is currently insufficient evidence to issue detailed recommendations on sedentary behaviour, there is a general consensus that sedentary time should be limited.

Previous research is often limited by studying the total amount of sedentary behaviour and not taking into account in which context the behaviour occurs. However, in different contexts other factors are more determinative.[4] For instance, people with higher education are more likely to do deskwork and therefore to be more sedentary at work, while people with lower education often exhibit more sedentary leisure time, e.g. watching TV.[4] Not only the determinants, but also the consequences of contextual aspects of sedentary behaviour may differ. For instance, leisure time sedentary behaviour has been found to have stronger associations with all-cause mortality than total daily sitting time, possibly because it might be accompanied by unfavourable eating behaviours, e.g. high energy snacks.[5] The measurement of sedentary behaviour poses methodological challenges. Although accelerometers are considered to be the golden standard for the measurement of physical activity,[6] they do not provide information about the context in which the behaviour has been performed. Thus, self-reported information is important to be able to study the context in which sedentary behaviour takes place.

Recent reviews, including mainly cross-sectional studies, summarized evidence on behavioural correlates of sedentary behaviour in different contexts.[4][7] Concerning alcohol consumption, absence of an association with sedentary behaviour was suggested while studies were less conclusive concerning smoking behaviour.[4] Few studies on nutrition showed inconclusive results in adults, while among youths an association with sedentary behaviour was found.[7] Also, an expected negative association was found between sedentary behaviour and physical activity, but studies yielded different results based on the context of sedentary behaviour, during leisure or work.[4] Previous studies also indicated that lifestyle, including sedentary behaviour, is dependent on gender, age, and socioeconomic position.[4][8][9] However, it remains to be elucidated whether associations between sedentary leisure time and other lifestyle behaviours differ according to social and demographic characteristics.
Therefore, large longitudinal studies are warranted to study sedentary behaviour in different population groups.

Individuals who stay sedentary over longer periods of their life represent the most important target for interventions since they have the highest risk of health problems resulting in higher individual and societal costs.\textsuperscript{[10]} Cues to develop and optimize interventions can be acquired by comparing lifestyle behaviours of these sustained sedentary individuals with their counterparts reducing their sedentary behaviour. These cues are needed, since for currently available interventions it is unclear if they result in clinically meaningful and sustained improvements in health outcomes.\textsuperscript{[11]} As most individuals adopt multiple unhealthy lifestyles, an alternative strategy could be to combine interventions capitalizing on successful behavioural changes to increase confidence and motivation to improve other lifestyle behaviours. Therefore, it can be hypothesized that interventions to reduce sedentary behaviour would be more effective and easier to implement when combined with interventions on other modifiable lifestyle behaviours.\textsuperscript{[12]}

The primary objective of this study was to determine lifestyle predictors of sustained rather than reduced leisure time sedentary behaviour. We hypothesized that sustained leisure time sedentary behaviour could be predicted by unfavourable alcohol, smoking, nutrition and physical activity behaviour. A secondary objective was to assess whether the identified predictors were dependent on gender, age, socioeconomic position and occupational sedentary behaviour.

Methods

Study population
Data from the Stockholm Public Health cohort was used, a large population-based cohort in Stockholm County.\textsuperscript{[13]} Multiple-wave population samples were randomly selected in subsequent years from Statistics Sweden’s Register of the total population, after stratification according to residential municipality. Each sample was followed up through similar questionnaire-based surveys every 4 years. Register data from Statistics Sweden have been linked to the self-reported information. The present study was approved by the Stockholm Regional Ethical Review Board (case number: 2016/749-32).
Participants who reported information on leisure time sedentary behaviour in both 2010 (baseline) and 2014 (follow-up) were assessed for eligibility (n=49133). The response rate to the survey in 2014 of participants who filled out the survey in 2010 was 67%. Persons reported to be confined to bed on both occasions were excluded (n=26). In the current study, only those classified as sedentary at baseline were included, resulting in an analytical sample of 9562 participants.

Definition of variables
Leisure time sedentary behaviour was assessed with the PAQ-questionnaire [14 15], which has shown to be valid for classification into physically active and sedentary. The question on leisure time sedentary behaviour asked for leisure sitting time on e.g. watching TV, reading or using tablet. Participants were requested to answer on their average behaviour during the past 12 months, considering the week variability and seasonality. There were 7 response categories ranging from less than one hour per day to more than 6 hours per day. Responses were dichotomized into sedentary (at least 3-4 hours sedentary leisure time per day); or less sedentary if otherwise. There is currently no consensus on specific cut points for the definition of sedentary behaviour, but 3-4 hours of self-reported leisure time sedentary behaviour per day is known to result in negative health consequences. [16 17] Also, we wanted to include individuals whose sedentary behaviour was above the average for the whole study population (median 2-3 hours per day). Individuals classified as sedentary at baseline were subsequently categorized as sustained sedentary or as reduced sedentary depending on their reports at follow-up.

Predictors were potentially modifiable lifestyle behaviours measured at baseline, subsequently dichotomized into favourable or unfavourable, as indicated below. For alcohol drinking, participants were asked to indicate the average number and the type of drinks consumed on the different days of the week, which were recalculated into grams of alcohol per week. Smoking was investigated as current daily smoking. With regard to nutrition, participants were asked to indicate the average consumption of different types of food during the past 12 months. Physical activity was measured with the PAQ-questionnaire as described earlier.

Unfavourable lifestyle behaviours were defined as follows:
- Alcohol drinking: men ≥ 24 gram (14 glasses), women ≥ 15.4 gram (9 glasses) per week.
- Smoking: being a current daily smoker
- Vegetables and fruit: consumption of < 3 units per day
- Fish: consumption of < 2 times per week
- Candy/cakes: consumption of ≥ 3 times per week
- Sugar sweetened beverages: drinking ≥ 2 times per week
- Physical activity during home, household and gardening tasks: < 1 hour per day
- Walking/cycling: < 40 minutes per day
- Exercise < 1 hours per week

Whenever possible, the definitions of unfavourable behaviours were based on national guidelines. [18] The cut-off for vegetables and fruit consumption was set lower than recommended guidelines since consuming 5 or more units of vegetables a day was only reported by 8% of participants. Furthermore, no specific guidelines exist for physical activity during home, household and gardening tasks or walking/cycling, and therefore cut-off values were based on expert opinions from authors involved in the current study. Since exercise was specifically asked with reference to full hours of exercise other than the reported walking and cycling, we used a cut-off of 1 hour per week rather than 2 hours (the guidelines recommend 75 minutes of vigorous physical activity per week).

We identified as potential confounders personal characteristics at baseline likely to influence leisure time sedentary behaviour as well as the other lifestyle [4]: gender, age, socioeconomic position, BMI, body pain and mental health. For gender, age, and socioeconomic position data from registries were used. Education was used as an indicator of socioeconomic position and dichotomized into high (post-secondary education of at least one semester or more), versus low (no post-secondary education). BMI, pain, and mental health status were self-reported. Pain was dichotomous, currently no pain versus moderate to extreme pain. Mental health status was assessed with the General Health Questionnaire (GHQ-12): a reliable and valid scale, with scores ranging from 0 to 12, were a higher scores indicate higher psychological distress.[19]

The following stratification variables were defined based on baseline data: gender, age, socioeconomic position and work- or occupational sedentary behaviour. People were stratified into working-age population defined as 64 or younger, or retirement age (people 65 or older) at follow-up. We chose to stratify by retirement age since this is a clear cut-off age point that is known to have a large influence on leisure time sedentary behaviour.[20] Socioeconomic position was dichotomized into high versus low education as described above.
Work- or occupational sedentary behaviour was measured with the PAQ-questionnaire as described earlier, with sedentary defined as sitting at least half of the time at work.

**Statistical analyses**
Chi-square and t-test were used to explore differences in baseline characteristics among individuals with sustained sedentary behaviour and those who reduced their sedentary behaviour. Binary logistic regression analyses were performed using general linear models. First, unadjusted models were run to determine odds ratios (OR) of sustained sedentary behaviour separately for each predictor variable. Then, potential confounders were added one by one to each model. Variables were included in adjusted models when they changed the regression parameter by more than 10%. All analyses were performed taking into account non-participation, lost to follow-up, and sampling error by calibration weights.[13] We performed sensitivity analyses in order to explore whether the results were robust with respect to the chosen cut-off of leisure time sedentary behaviour. Therefore, we conducted binary logistic regression analyses using cut-offs of 2-3 hours per day and 4-5 hours per day. Results were defined as significantly different from those presented in the main analysis when the point estimates differed by more than 10%.

In addition, separate analyses were performed by gender, age, socioeconomic position, and work/occupational sedentary behaviour, this latter by including only the working-age population. When stratified analyses showed differences in ORs with non-overlapping confidence interval, we tested for the presence of multiplicative interaction.

All statistical analyses were performed in IBM SPSS Statistics version 23 (Armonk, NY: IBM Corp).

**Results**
Of the 9562 participants classified as sedentary at baseline, 6357 (66.5%) were categorized as being sustained sedentary and 3205 (33.5%) as reducing their sedentary behaviour. Baseline characteristics of these two groups are shown in Table 1.
Table 1. Baseline characteristics for the leisure time sedentary behaviour trajectory groups
Stockholm Public Health Cohort 2010-2014

<table>
<thead>
<tr>
<th></th>
<th>Sustained sedentary</th>
<th>Reduced sedentary</th>
<th>Between-group difference</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>N</strong></td>
<td>6357</td>
<td>3205</td>
<td></td>
</tr>
<tr>
<td><strong>Gender, % women</strong></td>
<td>51</td>
<td>56</td>
<td>17.36</td>
</tr>
<tr>
<td><strong>Age, mean(SD)</strong></td>
<td>59±17</td>
<td>57±18</td>
<td>5.11</td>
</tr>
<tr>
<td><strong>Age, % ≥65 years at follow-up</strong></td>
<td>60</td>
<td>52</td>
<td>50.21</td>
</tr>
<tr>
<td><strong>Socioeconomic position, % highly educated</strong></td>
<td>37</td>
<td>33</td>
<td>8.93</td>
</tr>
<tr>
<td><strong>Lifestyle behaviours, % unfavourable</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alcohol drinking</td>
<td>32</td>
<td>28</td>
<td>16.55</td>
</tr>
<tr>
<td>Smoking</td>
<td>13</td>
<td>13</td>
<td>0.75</td>
</tr>
<tr>
<td>Vegetables/fruit</td>
<td>76</td>
<td>75</td>
<td>0.84</td>
</tr>
<tr>
<td>Fish</td>
<td>53</td>
<td>52</td>
<td>0.24</td>
</tr>
<tr>
<td>Candy/Cakes</td>
<td>50</td>
<td>47</td>
<td>9.77</td>
</tr>
<tr>
<td>Sweetened beverages</td>
<td>23</td>
<td>23</td>
<td>0.01</td>
</tr>
<tr>
<td>Home physical activity</td>
<td>35</td>
<td>31</td>
<td>14.25</td>
</tr>
<tr>
<td>Walking/Cycling</td>
<td>69</td>
<td>66</td>
<td>8.81</td>
</tr>
<tr>
<td>Exercise</td>
<td>53</td>
<td>47</td>
<td>32.97</td>
</tr>
</tbody>
</table>

Significant between-group differences were found for gender, age, and socioeconomic position, and for unfavourable alcohol drinking, candy- and cakes consumption, and physical activity in all contexts.

Odd ratios (OR) of sustained leisure time sedentary behaviour according to other unfavourable lifestyle are shown in Table 2. Adjustment for most potential confounders did not lead to an appreciable modification of the estimates, which are therefore presented as unadjusted. Only age turned out as an actual confounder of the association between home physical activity and sustained sedentary time, therefore retained in the corresponding adjusted model. The associations presented in bivariate analyses in table 1 were substantially confirmed.

Sensitivity analyses based on different cut-off points for the definition of sedentary behaviour; 2-3 hours a day resulted in an analytical sample of n=20136 in the sustained sedentary group and of n=4194 in the reduced sedentary group. Only candy- and cakes consumption was found to be a stronger predictor compared to the original cut-off: 1.28 (1.20-1.37) vs 1.13...
(1.05-1.25). With a cut-off set at 4-5 hours a day the analytical sample was n=1672 for the sustained sedentary and n=1434 for the reduced sedentary group. Employing this cut-off resulted in the association with smoking to be stronger than in the main analysis and statistically significant (1.34 (1.10-1.63) vs 1.06 (0.93-1.20)). In addition, ORs were higher for home activity: 1.54 (1.32-1.80) vs 1.35 (1.22-1.49), and for walking/cycling: 1.34 (1.15-1.57) vs 1.15 (1.05-1.26).
Table 2. Odds ratios and 95% Confidence Intervals of sustained sedentary behaviour during leisure time according to lifestyle

<table>
<thead>
<tr>
<th>Unfavourable lifestyle</th>
<th>OR</th>
<th>CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alcohol drinking</td>
<td>1.22</td>
<td>1.11-1.34</td>
</tr>
<tr>
<td>Smoking</td>
<td>1.06</td>
<td>0.93-1.20</td>
</tr>
<tr>
<td>Vegetables/fruit</td>
<td>1.05</td>
<td>0.95-1.16</td>
</tr>
<tr>
<td>Fish</td>
<td>1.02</td>
<td>0.94-1.11</td>
</tr>
<tr>
<td>Candy/Cakes</td>
<td>1.15</td>
<td>1.05-1.25</td>
</tr>
<tr>
<td>Sweetened beverages</td>
<td>1.01</td>
<td>0.91-1.11</td>
</tr>
<tr>
<td>Home physical activity</td>
<td>1.35a</td>
<td>1.22-1.49</td>
</tr>
<tr>
<td>Walking/Cycling</td>
<td>1.15</td>
<td>1.05-1.26</td>
</tr>
<tr>
<td>Exercise</td>
<td>1.29</td>
<td>1.18-1.40</td>
</tr>
</tbody>
</table>

*a adjusted for age (continuous)

OR= Odds ratio, CI= Confidence interval

Table 3 shows the same associations stratified by gender, age and socioeconomic position. All tests for multiplicative interaction showed that subgroup differences in the associations were not significant: gender differences for home physical activity (p=0.58) and exercise (p=0.11), age differences for alcohol drinking (p=0.15) and socioeconomic position differences for home physical activity (p=0.50).
### Table 3. Predictors of sustained leisure time sedentary behaviour, stratified by gender, age, and socioeconomic position

<table>
<thead>
<tr>
<th>Unfavourable Behaviours</th>
<th>Gender</th>
<th>Age</th>
<th>Socioeconomic position</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>OR 95% CI</td>
<td>OR 95% CI</td>
<td>OR 95% CI</td>
</tr>
<tr>
<td>Alcohol</td>
<td>1.28 1.12-1.46</td>
<td>1.14 0.99-1.30</td>
<td>1.31 1.13-1.51</td>
</tr>
<tr>
<td>Smoking</td>
<td>1.08 0.91-1.28</td>
<td>1.04 0.86-1.27</td>
<td>1.14 0.96-1.36</td>
</tr>
<tr>
<td>Vegetables/fruit</td>
<td>1.01 0.89-1.15</td>
<td>1.00 0.84-1.19</td>
<td>1.14 0.98-1.33</td>
</tr>
<tr>
<td>Fish</td>
<td>1.03a 0.91-1.16</td>
<td>1.09 0.96-1.24</td>
<td>0.97 0.85-1.11</td>
</tr>
<tr>
<td>Candy/Cakes</td>
<td>1.19 1.06-1.34</td>
<td>1.13 0.99-1.28</td>
<td>1.07 0.94-1.22</td>
</tr>
<tr>
<td>Sweetened beverages</td>
<td>1.05a 0.89-1.23</td>
<td>1.01 0.88-1.16</td>
<td>1.15 1.00-1.32</td>
</tr>
<tr>
<td>Home activity</td>
<td>1.40a 1.20-1.62</td>
<td>1.18 1.04-1.34</td>
<td>1.44 1.27-1.64</td>
</tr>
<tr>
<td>Walking/Cycling</td>
<td>1.15 1.02-1.30</td>
<td>1.12 0.98-1.29</td>
<td>1.16 1.01-1.33</td>
</tr>
<tr>
<td>Exercise</td>
<td>1.37 1.22-1.55</td>
<td>1.19 1.05-1.35</td>
<td>1.32 1.16-1.50</td>
</tr>
</tbody>
</table>

*a adjusted for age (continuous). OR= Odds ratio, CI= Confidence interval*
Table 4. Predictors of sustained leisure time sedentary behaviour, for the working-age population, stratified by work- or occupational sedentary behaviour

<table>
<thead>
<tr>
<th>Unfavourable Behaviours</th>
<th>SEDENTARY Work/Occupation n=2616 OR (95% CI)</th>
<th>NON-SEDENTARY Work/Occupation n=1431 OR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alcohol</td>
<td>1.29 (1.08-1.55)</td>
<td>1.34 (1.06-1.69)</td>
</tr>
<tr>
<td>Smoking</td>
<td>1.26 (0.99-1.60)</td>
<td>1.06 (0.81-1.39)</td>
</tr>
<tr>
<td>Vegetables/fruit</td>
<td>1.10 (0.90-1.33)</td>
<td>1.19 (0.92-1.53)</td>
</tr>
<tr>
<td>Fish</td>
<td>0.94 (0.79-1.11)</td>
<td>1.04 (0.84-1.30)</td>
</tr>
<tr>
<td>Candy/Cakes</td>
<td>1.05 (0.89-1.24)</td>
<td>1.10 (0.88-1.36)</td>
</tr>
<tr>
<td>Sweetened beverages</td>
<td>1.16 (0.97-1.38)</td>
<td>1.20 (0.96-1.49)</td>
</tr>
<tr>
<td>Home activity</td>
<td>1.36 (1.15-1.60)</td>
<td>1.49 (1.20-1.84)</td>
</tr>
<tr>
<td>Walking/Cycling</td>
<td>1.10 (0.90-1.32)</td>
<td>1.08 (0.87-1.33)</td>
</tr>
<tr>
<td>Exercise</td>
<td>1.35 (1.15-1.59)</td>
<td>1.23 (1.00-1.52)</td>
</tr>
</tbody>
</table>

OR= Odds ratio, CI= Confidence interval
Table 4 presents stratified separate sub-group analysis of occupational sedentary behaviour for the working-age population. Predictors of leisure time sedentary behaviour did not differ according to occupational- or work sedentary behaviour.

Discussion
Compared to a reduction in leisure time sedentary behaviour, sustained sedentary behaviour was predicted by unfavourable lifestyle behaviours related to alcohol consumption, consumption of sweets and physical activity. These predictors were not dependent on gender, age, socioeconomic position, and work- or occupational sedentary behaviour.

Although these associations were expected according to the alternative hypotheses in this study not all of them are in line with previous studies. For instance, a previous systematic review reported no evidence of a relation between alcohol drinking and sedentary behaviour. [4] However, of the 15 studies included in this review, the majority assessed the association of alcohol consumption with TV viewing only, while the measurement of leisure time sedentary behaviour in our study also included other typical sedentary leisure time activities. For smoking, the same systematic review reported on different results dependent on if sedentary behaviour was measured in general or in a specific context. [4] The review did not support an association between smoking and general sedentary behaviour, however, for the associations with leisure time sedentary behaviour mixed results were found. [4] Future longitudinal studies with large sample sizes and a more refined assessment of the context of sedentary behaviour are needed to clarify these associations.

A recent systematic review on the associations of sedentary behaviour with nutrition reported only on three studies among adults. [7] All these studies had cross-sectional designs and reported only associations with the healthy food index score or with total energy intake. To gain more insight in this behaviour it is of importance to separately report on consumption of different types of food such as vegetables, fruit and energy-dense snacks as we did in this study. [7] Seemingly, consumption of vegetables and fruit, fish, and sugar-sweetened beverages did not predict sustained leisure time sedentary behaviour, while candy- or cake consumption was a significant predictor, particularly among individuals with low socioeconomic position and presumably low health literacy. Further research in diverse social
and cultural contexts is needed to gain deeper insight on this association, and on the benefits of its use in health promotion programs.[21]

Sensitivity analyses were performed to explore whether the associations were robust to the choice of the cut-offs for the definition of sedentary behaviour. These showed results in line with those of the main analysis. Expectedly, most associations were stronger when the cut-off was set to a higher level (4-5 hours per day of sedentary behaviour). However, choosing this cut-off also entailed a much smaller analytical sample. Therefore, those results must be interpreted with caution.

Although this study enhances the currently limited evidence base due to its longitudinal design and large sample size, limitations of our study were possible bias due to retention at follow-up, non-differential misclassification and to self-reported outcomes. All these instances may have most likely caused an underestimation of the associations under study. Differential retention of participants according to their joint lifestyle, for instance, may have concealed an association between smoking and sustained sedentary behaviour if the sedentary participants retained at follow-up would be most likely to be non-smokers. A further limitation of this study is the availability of information at only two points in time during four years, making it impossible to study behavioural changes in the in between period. Self-reported information is a recognized limitation of studies with behavioural end-points. The use of objective measures to study sedentary behaviour in different contexts, such as accelerometers combined with diary, wearable cameras or GPS (Global positioning system) is an important development of future studies, though less feasible for large population-based samples.[22] An interesting direction for future research is to assess whether reducing sedentary behaviour is accompanied by favourable changes in other lifestyle behaviours, or vice versa. Unfortunately, our study had limited statistical power to assess such associations since few individuals in our sedentary population changed other lifestyle.

Potentially, the identified predictors can be used in the development of interventions by combining strategies to reduce leisure time sedentary behaviour with interventions on other unfavourable lifestyle, such as alcohol drinking, candy-or cake consumption and low levels of physical activity. There is some rationale for multiple-behaviour interventions, specifically the motivation-enhancing effect that successfully changing one behaviour will have on other behavioural changes.[23] Moreover, combining interventions can be time- and cost-
These advantages should be weighed against the risk of failure due to “overload” of health messages, or the risk that interventions might not address any specific behaviour with sufficient depth. In fact, previous studies lend support to both these possibilities. In a study from Fleig et al. in 2015, combining changes in nutrition and physical activity simultaneously was found to facilitate rather than hinder favourable changes. Furthermore, results from a quasi-experimental study in a rehabilitation setting showed that a behavioural intervention targeting exercise also facilitated engagement in fruit and vegetable consumption. However, a systematic review concluded that addressing multiple health behaviours yielded mixed results. Therefore, experimental studies are necessary to determine whether interventions to reduce leisure time sedentary behaviour can be effectively combined with interventions aiming at other lifestyle changes. An example of such intervention could be behavioural counselling applying a motivational approach in order to achieve changes in different lifestyle either simultaneously or sequentially.

Combining strategies to reduce sedentary behaviour with the promotion of physical activity has shown to be effective by causing a reallocation of sedentary time to physical activity. This reallocation can lead to clinically meaningful gains in metabolic health even if only concerning light physical activity. It is important to note that for larger impact on improving both behaviours, increased focus on sedentary behaviour in interventions is essential. Only in older adults, known to be the most sedentary segment of the population, physical activity interventions might be sufficient to see meaningful reductions in sedentary time. However, further studies are necessary to understand if solely targeting physical activity in this group is the most effective strategy for improving health.

**Conclusion**

Individuals with unfavourable profiles of alcohol drinking, sweet consumption or physical activity are more likely to stay sedentary over a 4-year period compared to sedentary persons with healthier lifestyles. Age, gender, socioeconomic position and work- or occupational sedentary behaviour do not importantly moderate the association between lifestyle and leisure time sedentary behaviour. The impact of combining interventions to reduce leisure time sedentary behaviour with interventions to reduce alcohol drinking, sweet consumption and/or to increase physical activity should be tested as a promising strategy for lifestyle modification.
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Competing interests
The authors declare that they have no competing interests.

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