

Associations of changes in diet and leisure-time physical activity with employer's direct cost of short-term sickness absence

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Author contributions

NK and JL contributed to the design of the study, assisted with data analysis and participated in critical revision of the manuscript. JS performed the data analyses and drafted the manuscript. EM, OP and OR were involved in interpreting results and critically reviewed the manuscript. All authors read and approved the final manuscript as submitted.

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4

5 **Abstract**

6 Several unhealthy lifestyles are associated with increased sickness absence (SA). This study examined the
7 associations of changes in diet and leisure-time physical activity (LTPA) with employer's direct cost of subsequent
8 short-term (< 10 working days) SA. The survey data from phases 1 (2000–02) and 2 (2007) of the Helsinki Health
9 Study (HHS), a longitudinal cohort study of initially 40–60-year-old employees of the City of Helsinki, Finland,
10 were linked with SA register data. Final data consisted of 4157 employees. Dietary habits were inquired with a
11 short food frequency questionnaire. Consumption of fruits (F) and vegetables (V) was used to indicate healthiness
12 of diet. LTPA was measured with a series of questions on the intensity and the amount of LTPA. Data on short-
13 term SA and salaries (2008–12) were received from the employers' registers. A two-part model was used to
14 analyse the associations. Those who improved their F&V consumption from non-daily to daily and persevered
15 physically active got 620 € (95% CI -1194, -47) lower cost than those remaining non-daily F&V consumers and
16 physically inactive. When examining LTPA only, those who persevered physically active or improved from
17 moderately active to active got 19% less cost for the employer than those remaining inactive. Dietary changes
18 were not independently associated with the cost. Improving employees' diet and LTPA may reduce employer's
19 direct cost of SA. Although the associations of diet with SA cost were not statistically significant, improvements
20 in diet may contribute to the beneficial associations of LTPA and employer's cost of SA.

21

22 **Keywords**

23 Cost, Diet, Employees, Leisure-time Physical Activity, Sickness Absence, Worksites

24 **Introduction**

25 Unhealthy diet and physical inactivity contribute to chronic diseases, thus causing economic
26 burden in societies (Candari, Cylus, & Nolte, 2017). The estimated annual healthcare cost range
27 for unhealthy diets is 3–148 € and for physical activity (PA) 3–181 € per capita (Candari et al.,
28 2017). On average, unhealthy diet and physical inactivity are attributable to approximately 2%
29 of the total healthcare costs (Proper & van Mechelen, 2008). In addition, unhealthy lifestyles
30 and lifestyle-related common diseases are associated with weakened work ability and
31 productivity, and increased sickness absence (SA) (van den Berg, Burdof, & Robroek, 2017;
32 Leijten et al., 2014; Robroek, van den Berg, Plat, & Burdof, 2011), which lead to additional
33 cost also for the employers. Our previous study (Kanerva, Pietiläinen, Lallukka, Rahkonen, &
34 Lahti, 2018) found that several unhealthy lifestyles may increase the direct cost of short-term
35 SA to the employer by up to 30%.

36

37 Previous studies have shown that physical inactivity is associated with increased SA (Kerner,
38 Rakovac, & Lazinica, 2017) and their cost (Tolonen, Rahkonen, & Lahti, 2017), but the role of
39 diet in SA is still unclear. Some diet-related factors, including obesity, high blood glucose and
40 blood pressure, have been shown to increase SA cost (Kowlessar, Goetzal, Carls, Tabrizi, &
41 Guindon, 2011). There may also be joint associations of diet and PA with SA as diet and PA
42 have both separately and together several positive effects on health (G.A. Kelley & Kelley,
43 2012; Walker, O’Dea, Gomez, Girgis, & Colagiuri, 2010; Davies, Batehup, & Thomas, 2011).
44 Improving employees’ diet and PA may prevent SA cost, but studies on the effects of lifestyle
45 changes on SA are lacking. The estimated cost of SA in the European countries is 2.5% of GDP
46 (Edwards & Greasley, 2010).

47

48 In general, costs are divided into direct, including salary and replacement cost, and indirect
49 cost, including decreased production and management cost. Data on short-term SA are not often
50 available due to lack of comprehensive registers, which is one reason for the lacking evidence.
51 Short-term SA have been shown to predict subsequent SA due to ill-health they reflect (Hultin,
52 Lindholm, Malfert, & Möller, 2012). Thus, early recognition of the risk factors beyond short-
53 term SA may have significant, far-reaching health and economic consequences.

54

55 This study aimed to investigate the associations of changes in diet and leisure-time physical
56 activity (LTPA) with employer's direct cost of subsequent short-term (< 10 working days) SA.
57 Employer's comprehensive register of SA data and individual salaries were used to estimate
58 the real cost of SA among midlife and ageing employees of the City of Helsinki.

59

60 **Materials and Methods**

61 *Study Design, Setting and Participants*

62 The Helsinki Health Study (HHS) invited all 40–60-year-old employees of the City of Helsinki,
63 Finland, to participate the survey of 2000–02 (phase 1) (Lahelma et al., 2013). The sample
64 consisted of 13 346 employees, with 67% responding ($n= 8960$). Phase 1 respondents received
65 a similar follow-up questionnaire in phase 2 (2007), with 83% responding ($n= 7332$). Data from
66 2000 to 2007 were used to examine the changes in diet and LTPA. The survey data were linked
67 with employer's personnel registers providing the information on short-term SA, salaries and
68 employment time (2008–12), by using unique personal identification number given to each
69 Finnish citizen. Those not consenting to linkage ($n= 1449$) and those no longer employed by
70 the City of Helsinki ($n= 1726$) were excluded. The final data consisted of 4157 employees. The
71 HHS protocol was approved by the ethics committees of the Department of Public Health,
72 University of Helsinki and the health authorities of the City of Helsinki.

73

74 ***Measures***75 *Cost of Sickness Absence*

76 Individual annual gross salary data from the employers' personnel register were used to
77 calculate the cost of short-term SA (< 10 working days). Salaries were first converted to 2012
78 earnings level using local government wage and salary indices (Statistics Finland, 2018). Then,
79 participant's average daily earnings for each follow-up year were calculated: the individual
80 annual salary was divided by participant's employment months, and then divided by 21. The
81 number of annual short-term SA days was multiplied with the daily salary of the particular year.
82 For total SA cost per individual, annual costs between 2008 and 2012 were summed.

83

84 *Diet*

85 Food frequency questionnaire (FFQ) included 20 questions about different foods consumed
86 during the past four weeks. There were seven frequency alternatives to choose from, varying
87 from "not at all during the past 4 weeks" to "twice a day or more". Participants' fruit and
88 vegetable (F&V) consumption was classified into three groups based on the Finnish nutrition
89 recommendations (The National Nutrition Council of Finland, 2014): consuming neither F nor
90 V daily, consuming either F or V daily and consuming both F and V daily. F&V consumption
91 variables from phases 1 and 2 were combined into a 9-group variable reflecting change. Dark
92 bread consumption was dichotomised into non-daily (5–6 times a week or less) and daily (once
93 a day or more) and thus, the change variable consisted of four groups. Meat consumption was
94 dichotomised into participants consuming meat or meat products moderately (2–4 times a week
95 or less) and frequently (5–6 times a week or more). The combined change variable in meat
96 consumption consisted of four groups.

97

98 In addition to FFQ, there were two questions about the fat products used as bread spread (6
99 alternatives) and in cooking (10 alternatives). Each alternative was categorised either into
100 vegetable-oil-based or animal-based fats. Participants choosing vegetable oil-based fats both
101 for spread and cooking formed a group of “vegetable oils”, participants choosing animal-based
102 fat either for spread or cooking formed a group of “mixed fats” and participants choosing
103 animal-based fat both for spread and cooking formed a group of “animal fats”. Consequently,
104 the change variable consisted of nine groups. If the responder had missing data or more than
105 one chosen alternative concerning a food habit in question (F&V $n=71$, dark bread $n=56$, meat
106 $n=63$ and fat $n=441$), the answer was marked as zero, corresponding to not meeting the
107 recommendations.

108

109 *Physical Activity*

110 Leisure-time physical activity (LTPA) was measured with a question on the frequency and
111 intensity of exercise in leisure-time or commuting during the past 12 months. The intensity of
112 exercise included four grades: walking, brisk walking, jogging and running or equivalent
113 activities. In addition, average weekly hours in each intensity grade were asked with five
114 alternatives from “not at all” to “four hours or more”. From these questions, metabolic
115 equivalent (MET) index was constructed. The total weekly MET-hours were calculated by
116 multiplying the estimated MET value of each intensity grade (Kujala, Kaprio, Sarna, &
117 Koskenvuo, 1998) by the time used and combining the MET-hours of four intensity grades
118 (Lahti, Lahelma, & Rahkonen, 2012). Then, respondents were classified into three groups both
119 in phases 1 and 2: inactive (< 14 MET-hours week⁻¹), moderately active (≥ 14 MET-hours week⁻¹
120 ¹ including the two lowest intensity grades) and active (≥ 14 MET-hours week⁻¹ the two highest
121 intensity grades) (Lahti et al., 2012). Consequently, the change variable consisted of nine

122 groups. If the responder had missing data ($n= 54$), the response was marked as zero,
123 corresponding to the lowest activity level.

124

125 *Joint – Diet and Physical Activity*

126 The joint variable of diet and PA consisted of changes in F&V consumption and LTPA. F&V
127 consumption was chosen to the joint variable to indicate the healthiness of participants' diet.
128 Changes in dark bread and meat consumption and in quality of fat, and their associations with
129 employer's direct cost of SA were also investigated, but their independent associations were
130 more inconsistent than the associations of changes in F&V consumption and cost. Instead of 9-
131 group change variables, in order to get a reasonable number of groups to the joint variable, we
132 used 4-group change variables for both F&V consumption and LTPA. In F&V consumption,
133 this means that only those who consumed both F&V daily were included in the group of daily
134 consumers, and the rest into the non-daily consumers. LTPA was estimated as described above,
135 though combining the groups of moderately active and active. Consequently, the joint variable
136 consisted of 16 groups.

137

138 *Covariates*

139 To control for confounding, information on participants' age, gender, work years, prior SA days
140 during the year before 5-year SA follow-up period, occupational position, marital status,
141 smoking, binge drinking, sleeping hours and occupational physical workload were used. Data
142 on participants' work years, prior SA days and occupational position were received from the
143 employers' registers whereas other covariates were derived from the phase 2 questionnaires.
144 Occupational position included four classes: professionals or managers, semi-professionals,
145 routine non-manuals and manual workers. Marital status was classified into those in
146 relationship and those not in relationship. Smoking status was classified into non-smokers and

147 current smokers. Alcohol use was classified into no binge drinking (those answering “never”)
148 and binge drinking (all others). Sleeping hours were classified into 7–8 hours and < 7 or > 8
149 hours a day. Occupational physical workload was classified into heavy or light according to the
150 response to a question on how physically strenuous the respondent found their work.

151

152 *Statistical Analysis*

153 Descriptive analyses by different background, dietary and LTPA groups were performed among
154 all participants and separately among those who had SA (Tables 1 and 2). To estimate
155 participants’ short-term SA and their cost, mean and standard deviation (SD) were calculated.

156 A two-part model was used to analyse the associations of changes in diet and LTPA with the
157 cost. Each dietary and LTPA variable was investigated separately from each other. The
158 probability of having short-term SA among all participants was analysed first using generalised
159 linear model with binomial regression. Then, the associations of changes in diet and LTPA with
160 the SA cost were analysed among employees who had short-term SA during 2008–12, using
161 generalised linear model with gamma distribution and log-link function. To control for
162 confounding, both analyses were first adjusted for age, gender and work years (Model 1) and
163 then additionally, for other covariates (Model 2). Finally, marginal effects were evaluated at
164 covariate means to estimate the cost in euros. As a sensitivity analysis, all statistical tests were
165 redone by excluding those with missing information in F&V or LTPA variables. The results of
166 the sensitivity analysis did not differ from the main results. Also, the associations of changes in
167 diet and LTPA with short-term SA days were examined, and the results were similar with the
168 results concerning SA cost. All analyses were performed using IBM SPSS Statistics version 22
169 and STATA version 15.

170

171 **Results**

172 Of all participants, 84% ($n= 3510$) had at least one short-term SA spell during the 5-year follow-
173 up (Table 1). Participants who had unhealthier lifestyles in terms of smoking, alcohol use and
174 sleeping had more SA days and got higher cost for the employer than those with healthier
175 lifestyles. Table 2 shows the descriptive statistics of short-term SA and their direct cost in
176 dietary and LTPA change variables among all participants and among those who had short-
177 term SA during the follow-up (see Table S1 for fat, bread and meat variables). Concerning
178 change in F&V consumption, the most SA days and the highest cost were among those who did
179 not consume F&V daily over the 5-year follow-up. Concerning change in LTPA, the most SA
180 days and the highest cost were among those who decreased their LTPA from moderately active
181 to inactive (Table 2).

182

183 [Table 1 and 2 near here].

184

185 Cost estimates for the contribution of changes in diet and LTPA on employer's direct cost of
186 short-term SA, based on two-part model are shown in Table 3. Supplementary table 2, with the
187 complete results of the two-part model, shows that changes in F&V consumption and LTPA
188 were not associated with having short-term SA among all participants (Model 2, logistic
189 regression). In dietary changes, statistically significant associations with SA cost were found
190 only for change of F&V consumption, when adjusting for gender, age and work years (Table
191 3, Model 1), whereas changes in fat quality, dark bread and meat consumption were not
192 statistically significantly associated with the cost (see Table S3). In general, increasing F&V
193 consumption or persevering frequent F&V consumption got lower cost of short-term SA
194 compared to those who did not report daily F&V consumption over the follow-up (Table 3,
195 Model 1). After adjusting for more covariates (Table 3, Model 2), however, no statistically

196 significant results were found. Concerning change in LTPA, persevering physically active got
197 898 € (95% CI -1331, -464, $p < 0.001$) and improving from moderately active to active got 857
198 € (95% CI -1345, -369, $p = 0.001$) lower cost compared to those who persevered inactive
199 (reference group) (Table 3, Model 1). The mean cost among reference group was 3609 € (95%
200 CI 3226, 3992). The results attenuated but remained statistically significant after adjusting for
201 more covariates (Table 3, Model 2).

202

203 [Table 3 near here].

204

205 The joint associations of changes in diet and LTPA with the SA cost have been illustrated in
206 Figure 1. The figure shows the estimated cost in different joint groups compared to those who
207 remained non-daily F&V consumers and physically inactive (reference group) over the follow-
208 up. Changing from non-daily to daily F&V consumer and persevering physically active was
209 associated with 620 € (95% CI -1194, -47, $p = 0.034$) lower cost compared to the reference
210 group (mean cost 3479 €, 95% CI 2989, 3969). Furthermore, those persevering in daily F&V
211 consumption and physically active got 507 € (95% CI = -1036, 21, $p = 0.060$) lower cost than
212 the reference group. The highest cost for the employer got those who decreased their F&V
213 consumption from daily to non-daily and remained inactive, but the association was not
214 statistically significant.

215

216 [Figure 1 near here].

217

218 **Discussion**

219 This study showed that maintaining a healthy diet and a physically active lifestyle as well as
220 improvements in these may decrease employer's direct cost of short-term (< 10 working days)

221 SA. F&V consumption was used to indicate the healthiness of participant's diet in general.
222 Employees who increased their F&V consumption from non-daily to daily and persevered
223 physically active got 620 € less cost than those remaining non-daily F&V consumers and
224 physically inactive. When examining only LTPA, the lowest cost for the employer got those
225 who either persevered physically active or increased their activity level from moderate to active,
226 both with 19% reduction of cost compared to those remaining inactive. Also, in dietary changes,
227 there was a tendency that those who increased their F&V consumption or maintained a greater
228 F&V consumption got the lowest cost, but no statistically significant results were found after
229 adjusting for several background factors.

230

231 Studies on changes in diet and LTPA and their associations with SA cost has been very limited.
232 Our study showed that not only having healthy lifestyles but also improving them may decrease
233 SA cost for the employer. The associations were clearer and stronger when the employee shifted
234 from semi-healthy to the healthiest group of diet or LTPA, compared to those with slighter
235 improvements. For example, improving from non-daily F&V consumption to consume F or V
236 daily, as well as increasing LTPA level from inactive to moderate, did not get significantly
237 lower cost compared to those with continuously unhealthy lifestyles. Similarly, in a previous
238 study using the same data (Lahti et al., 2012), employees who raised their LTPA level from
239 inactive to vigorous had a significantly lower risk for both shorter and longer SA compared to
240 those remaining inactive, whereas increasing LTPA level from inactive to moderate did not
241 decrease the risk significantly. In our study, being physically active in phase 1 seemed to protect
242 from further SA cost despite of decreases in LTPA. The results may reflect participant's earlier,
243 possibly long-term good fitness status rather than the effect of change, as we do not know
244 participant's LTPA status before phase 1.

245

246 Previous studies have shown that being physically active may decrease employee's SA (Kerner
247 et al., 2017) and their cost for the employer (Tolonen et al., 2017) compared to those who are
248 less active, whereas the associations of diet with SA are still unclear (Robroek et al., 2011;
249 Fitzgerald, Kirby, Murphy, & Geaney, 2016). Our results are in line with these findings. The
250 beneficial effect of PA on SA may be partly explained by the preventive impact of PA on
251 musculoskeletal disorders which are one of the major causes of SA (Haukka et al., 2013; van
252 Amelsvoort, Spigt, Swaen, & Kant, 2006). PA, especially moderate activity, may also enhance
253 immune function (Romeo, Wärnberg, Pozo, & Marcos, 2010), which could lead to decreased
254 short-term SA. Short-term SA has been shown to be associated especially with minor and
255 common illnesses such as respiratory disorders, headache and gastroenteritis (Feeney, North,
256 Head, Canner, & Marmot, 1998). The potential effect of diet on short-term SA may relate to
257 the capacity of F&V to modify antioxidant pathways and immune system (Lampe, 1999).

258
259 Although the changes in diet were not independently associated with the cost, the joint
260 associations of healthy diet and PA may produce cost savings for the employer. The joint
261 associations may be partly explained by weight changes as the beneficial effects of diet and PA
262 changes on health are often related to that. For example, the beneficial effects of improvements
263 in diet and PA on blood lipid metabolism (GA Kelley & Kelley, 2012) and some cancers
264 (Davies et al., 2011) have been perceived to be explained by weight change. Moreover, previous
265 studies have shown that obesity is strongly associated with SA (K Neovius, Johansson, Kark,
266 & Neovious, 2009). Nevertheless, in addition to weight control, improving diet and PA have
267 several other beneficial effects on individual's health, e.g. through decreased blood pressure
268 and blood glucose, which may further decrease employer's cost (Kowlessar et al., 2011).

269

270 ***Strengths and Limitations***

271 The strength of this study is the large data set with identical questions on LTPA and diet in
272 phases 1 and 2. The response rates in phases 1 (67%) and 2 (83%) were at least satisfactory,
273 and the characteristic differences between responders and non-responders were relatively minor
274 (Lahelma et al., 2013). Thus, the HHS cohort participants represent well the target population,
275 middle-aged municipal employees in Finland (Laaksonen et al., 2008). Participants who were
276 older, in higher occupational classes and with shorter SA tended to be more likely to respond
277 in phase 1. The cohort is not representative of the Finnish general population, e.g. as women's
278 proportion in the cohort is large (Lahelma et al., 2013). Comparison between countries may be
279 challenging because of differences in legislation, different methods of measurements and
280 definitions of short-term SA. However, the average number of short-term SA days an employee
281 takes in Finland is at the average level among EU countries (Parent-Thirion, Macías, Hurley,
282 & Vermeulen, 2007).

283
284 Employer's comprehensive registers on employees' short-term SA and individual annual gross
285 salaries enabled us to estimate the associations of diet and LTPA with employer's real cost,
286 which are rarely investigated. Data of short-term SA are not often available because of lack of
287 the registers, or the data are derived from employees' self-reporting health questionnaires which
288 may be inaccurate. In addition, we were able to control for several covariates that associate with
289 SA, F&V consumption and LTPA. The design of our study was prospective, looking first at
290 changes in diet and LTPA in approximately 5-year interval (phase 1–2007) and examining the
291 association of these changes with cost of short-term SA occurring during the next 5-year
292 interval (2008–12). This design gives some suggestion about the direction of the association
293 between F&V consumption, LTPA and SA. As changes in F&V consumption and LTPA may

294 be indicative of participant's health status, we aimed to control this confounding at least
295 partially by adjusting for SA that occurred during one year before the SA follow-up (2008–12).

296

297 It needs to be acknowledged, however, that the direct salary cost form only a part of the total
298 cost of short-term SA that changes in diet and LTPA may provide to the employer. Unhealthy
299 diet and physical inactivity may increase also other direct and indirect cost for the employer,
300 e.g. through reduced productivity at work, hiring substitutes and medical care cost. Insufficient
301 F&V consumption has been associated with a degree of productivity loss at work (Robroek et
302 al., 2011) and inadequate PA with increased medical care cost and presenteeism (Kowlessar et
303 al., 2011; Walker, Tullar, Diamond, Kohl, & Amick, 2017). To evaluate the effect of changes
304 in diet and LTPA on the total cost for the employer, all the direct and indirect costs should be
305 estimated.

306

307 There are several challenges in investigating changes in diet and PA. First, the information of
308 changes in participants' diet and LTPA is based on participants' self-reports only in two
309 different time points and may therefore not represent real change. Secondly, we cannot know
310 when and in which timespan the changes of diet and LTPA have occurred. The effect of change
311 in diet or LTPA may be different, if the employee has changed his/her lifestyle habits gradually
312 over the 5-year follow-up compared to sudden change in the beginning or in the end of the
313 follow-up. In addition, we do not know participants' background before phase 1 concerning
314 diet and LTPA, which may have a remarkable effect on participant's current health and the
315 impact of change. Changes in diet and PA may also yield such longitudinal effects on health
316 and cost, e.g. through weight loss, which appear after a longer timespan than we had in our
317 study.

318

319 F&V consumption and LTPA are derived from self-reports, which potentially results in
320 reporting bias, especially as F&V consumption and PA are often overestimated. We used
321 frequency of F&V consumption to indicate the healthiness of diet, which may only partly
322 represent the real healthiness of diet. Firstly, participants with daily F&V consumption do not
323 necessarily meet the nutrition recommendations, if F&V portion sizes are small. Participants'
324 diet could be estimated more precisely if we had information on the amount of F&V
325 consumption in addition to frequency. That could yield also stronger estimates of SA cost for
326 diet. Secondly, the healthiness of diet consists of adequate F&V consumption together with
327 other healthy dietary choices. On the other hand, in previous studies concerning SA, both F&V
328 consumption and dietary indices are used to measure the healthiness of employee's diet, and
329 the results vary in both cases (Robroek et al. 2011; Fitzgerald et al., 2016). In addition, self-
330 report PA questionnaires have demonstrated good reliability while no single type of PA
331 questionnaire has proven superior (Silsbury, Goldsmith, & Rushton, 2015; van Poppel,
332 Chinapaw, Mokkink, van Mechelen, & Terwee, 2010).

333

334 *Conclusions*

335 Improving employees' diet and LTPA may reduce employer's direct cost of SA. We found that
336 employees who improved their F&V consumption from non-daily to daily and persevered
337 physically active caused significantly lower cost of short-term (< 10 working days) SA spells
338 to the employer than those remaining non-daily F&V consumers and physically inactive
339 through the 5-year follow-up. Furthermore, employees who persisted physically active or
340 improved their activity from moderate to active got one-fifth lower cost for the employer than
341 those remaining inactive. To estimate the total cost savings which improvements in diet and
342 LTPA may produce for the employer, the effect of other direct and indirect cost should also be
343 evaluated.

344

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352

353 Declaration of Interest Statement

354 The authors declare that they have no competing interests.

355

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448 **Appendices**

449 Table 1. Short-term sickness absence and their direct cost (€) of short-term sickness absence
 450 for the employer over the 5-year follow-up by participants' background characteristics.

	All participants (<i>n</i> = 4157)			Those who have short-term SA (<i>n</i> = 3510)		
	Mean (SD) or <i>n</i> (%)	SA days (mean, SD)	SA cost (mean, SD)	Mean (SD) or <i>n</i> (%)	SA days (mean, SD)	SA cost (mean, SD)
Age (mean, SD)	53.9 (5.7)			53.3 (5.4)		
Gender (<i>n</i> , %)						
Women	3477 (83.6)	28 (0.6)	3645 (73)	3009 (85.7)	32 (0.6)	4210 (79)
Men	680 (16.4)	17 (0.9)	2757 (138)	501 (14.3)	23 (1.1)	3762 (167)
Occupational position (<i>n</i> , %)						
Professionals/managers	1300 (31.3)	16 (0.6)	3051 (118)	984 (28.0)	21 (0.8)	4030 (142)
Semi-professionals	876 (21.1)	24 (0.9)	3501 (135)	761 (21.7)	28 (1.0)	4037 (146)
Routine non-manuals	1470 (35.4)	33 (1.0)	3886 (112)	1322 (37.7)	37 (1.0)	4320 (118)
Manual workers	511 (12.3)	33 (1.7)	3538 (176)	443 (12.6)	38 (1.8)	4076 (189)
Marital status (<i>n</i> , %)						
In relationship	2917 (70.2)	24 (0.6)	3344 (75)	2452 (70.2)	29 (0.6)	3982 (84)
Not in relationship	1221 (29.4)	30 (1.0)	3869 (127)	1042 (29.8)	35 (1.1)	4530 (138)
Smoking (<i>n</i> , %)						
Non-smoker	3189 (76.7)	23 (0.5)	3219 (70)	2643 (75.8)	28 (0.6)	3883 (78)
Current smoker	942 (22.7)	36 (1.3)	4453 (158)	843 (24.2)	40 (1.4)	4977 (167)
Alcohol use (<i>n</i> , %)						
No binge drinking	1751 (42.1)	23 (0.7)	3120 (92)	1449 (41.3)	28 (0.8)	3776 (103)
Binge drinking	2406 (57.9)	28 (0.7)	3777 (90)	2061 (58.7)	33 (0.8)	4408 (98)
Sleeping hours (<i>n</i> , %)						
7-8h	3045 (73.2)	26 (0.6)	3483 (73)	2598 (75.3)	30 (0.6)	4084 (80)
<7h or >8h	1045 (25.1)	27 (1.1)	3546 (140)	854 (24.7)	33 (1.2)	4335 (159)
Occupational physical work load (<i>n</i> , %)						
Light	2741 (65.9)	22 (0.5)	3282 (77)	2272 (65.2)	27 (0.6)	3959 (87)
Heavy	1384 (33.3)	33 (1.0)	3931 (118)	1212 (34.8)	38 (1.1)	4498 (127)

451 Abbreviations: SA; sickness absence, SD; standard deviation.

452 Table 2. Short-term sickness absence and their direct cost (€) of short-term sickness absence
 453 over the 5-year follow-up by changes in diet and physical activity.

	All participants (<i>n</i> = 4157)			Those who have short-term SA (<i>n</i> = 3510)		
	<i>N</i> (%)	SA days (mean, SD)	SA cost (mean, SD)	<i>N</i> (%)	SA days (mean, SD)	SA cost (mean, SD)
Change in F&V consumption						
Continuously neither daily	445 (10.7)	30 (2.0)	3983 (229)	382 (10.9)	35 (2.1)	4640 (252)
Neither daily to other daily	306 (7.4)	28 (2.1)	3800 (261)	261 (7.4)	33 (2.4)	4455 (287)
Neither daily to both daily	203 (4.9)	28 (2.1)	3442 (241)	174 (5.0)	33 (2.3)	4016 (256)
Other daily to neither daily	265 (6.4)	30 (2.0)	3926 (257)	227 (6.5)	35 (2.2)	4583 (227)
Continuously other daily	511 (12.3)	27 (1.4)	3668 (203)	420 (12.0)	33 (1.6)	4462 (229)
Other daily to both daily	492 (11.8)	23 (1.3)	3235 (181)	421 (12.0)	27 (1.5)	3780 (199)
Both daily to neither daily	130 (3.1)	26 (2.3)	3599 (325)	110 (3.1)	31 (1.5)	4253 (350)
Both daily to other daily	378 (9.1)	23 (1.5)	3235 (214)	308 (8.8)	28 (1.6)	3970 (244)
Continuously both daily	1427 (34.3)	25 (0.8)	3290 (98)	1207 (34.4)	29 (0.8)	3890 (107)
Change in LTPA						
Continuously inactive	418 (10.1)	28 (1.7)	3723 (238)	346 (9.9)	34 (1.9)	4497 (269)
Inactive to moderately active	362 (8.7)	28 (1.9)	3669 (226)	304 (8.7)	34 (2.1)	4369 (250)
Inactive to active	173 (4.2)	25 (2.5)	3815 (329)	149 (4.2)	30 (2.7)	4429 (357)
Moderately active to inactive	336 (8.1)	31 (2.1)	3877 (246)	288 (8.2)	36 (2.3)	4523 (268)
Continuously moderately active	993 (23.9)	27 (1.0)	3485 (127)	850 (24.2)	32 (1.1)	4071 (138)
Moderately active to active	389 (9.4)	23 (1.3)	3177 (175)	331 (9.4)	27 (1.4)	3734 (190)
Active to inactive	169 (4.1)	25 (2.1)	3520 (301)	145 (4.1)	30 (2.3)	4103 (326)
Active to moderately active	395 (9.5)	26 (1.6)	3608 (211)	335 (9.5)	31 (1.7)	4254 (232)
Continuously active	922 (22.2)	22 (0.9)	3213 (128)	762 (21.7)	26 (1.0)	3887 (144)

454 Abbreviations: F&V; fruit and vegetable, LTPA; leisure-time physical activity, SA; sickness absence, SD; standard
 455 deviation.

456 Table 3. Cost estimates^a of changing patterns compared to continuously unhealthy diet and
 457 inactive lifestyle.

	Model 1 ^b				Model 2 ^c			
	dy/dx ^d	<i>p</i>	95% CI		dy/dx ^d	<i>p</i>	95% CI	
Change in F&V consumption								
Neither daily to other daily	-247	0.393	-813	319	-59	0.818	-562	444
Neither daily to both daily	-740	0.015	-1335	-145	-305	0.286	-866	256
Other daily to neither daily	-250	0.409	-844	344	-18	0.948	-552	516
Continuously other daily	-521	0.037	-1012	-30	-199	0.374	-637	239
Other daily to both daily	-805	0.001	-1278	-331	-235	0.297	-678	207
Both daily to neither daily	-183	0.638	-946	579	234	0.522	-482	951
Both daily to other daily	-589	0.026	-1108	-71	-256	0.285	-726	213
Continuously both daily	-675	0.002	-1097	-254	-194	0.318	-576	187
Change in LTPA								
Inactive to moderately active	-117	0.674	-665	431	52	0.843	-466	571
Inactive to active	-414	0.214	-1066	239	-46	0.887	-682	589
Moderately active to inactive	39	0.893	-530	608	-14	0.959	-535	508
Continuously moderately active	-301	0.182	-742	141	-276	0.183	-682	130
Moderately active to active	-857	0.001	-1345	-369	-542	0.022	-1005	-78
Active to inactive	-431	0.191	-1076	214	-294	0.340	-897	310
Active to moderately active	-374	0.159	-895	146	-295	0.228	-773	185
Continuously active	-898	<0.001	-1331	-464	-546	0.009	-954	-137

458 Abbreviations: CI; confidence interval, F&V; fruit and vegetable, LTPA; leisure-time physical activity.

459 ^a Employer's direct cost of short-term SA over the 5-year follow-up.

460 ^b Adjusted for gender, age and work years. The two-part model was used for the analysis. Associations of changes
 461 in F&V consumption and SA cost and associations of changes in LTPA with SA cost were examined separately.

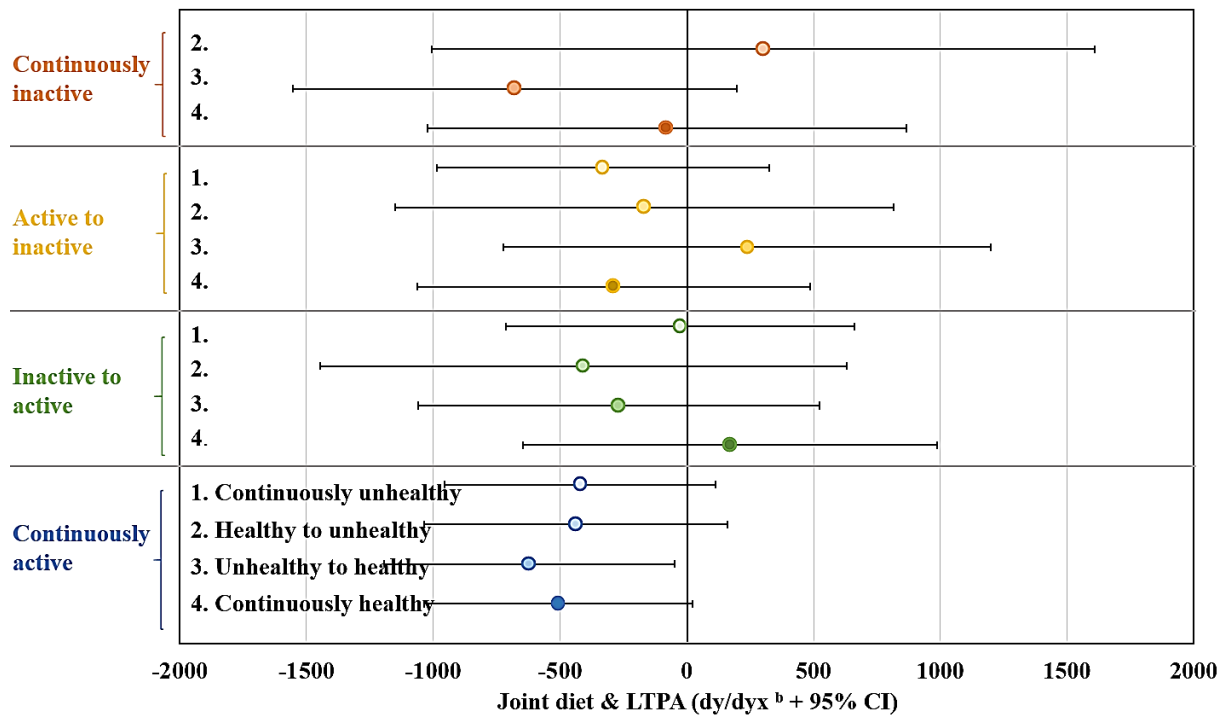
462 ^c Model 1 + SA days during the year before 5-year follow-up period, occupational position, marital status, smoking,
 463 binge drinking, sleeping hours and occupational physical work load.

464 ^d Marginal effects at covariate means are derived from the two-part model which consists of generalized linear
 465 model with binomial regression, and generalized linear model with gamma distribution and log-link function.

466 Estimates in euros of consistently healthier or changing patterns over the follow-up compared to continuously
 467 unhealthy diet and inactive lifestyle.

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469



470

471 Figure 1. Joint associations of changes in diet^a and leisure-time physical activity with
 472 employer's direct cost (€) of short-term sickness absence over the 5-year follow-up.

473

474 Abbreviations: F&V; fruit and vegetable, LTPA; leisure-time physical activity, SA; sickness absence.

475

476 ^a F&V consumption is used as an indicator of healthiness of participant's diet, where non-daily F&V consumption
 477 represents unhealthy diet and daily F&V consumption healthy diet.

478 ^b Marginal effects in euros in different joint groups compared to those with continuously unhealthy diet and
 479 physical inactivity. Vertical line at zero represents the reference group. Joint variable adjusted for gender, age and
 480 work years, SA days during the year before 5-year follow-up period, occupational position, marital status,
 481 smoking, binge drinking, sleeping hours and occupational physical work load. The two-part model was used for
 482 the analysis.