BMJ Open

Concurrent changes in physical activity and body mass index among 66 852 public sector employees over a 16-year follow-up: multitrajectory analysis of a cohort study in Finland

Roosa Tiusanen ,[1] Mikhail Saltychev ,[1] Jenni Ervasti ,[2] Mika Kivimäki,[2,3,4] Jaana Pentti,[3,5,6] Sari Stenholm ,[5,6] Jussi Vahtera [5,6]

To cite: Tiusanen R, Saltychev M, Ervasti J, *et al*. Concurrent changes in physical activity and body mass index among 66 852 public sector employees over a 16-year follow-up: multitrajectory analysis of a cohort study in Finland. *BMJ Open* 2022;**12**:e057692. doi:10.1136/bmjopen-2021-057692

► Prepublication history and additional supplemental material for this paper are available online. To view these files, please visit the journal online (http://dx.doi.org/10.1136/bmjopen-2021-057692).

SS and JV are joint senior authors.

Received 27 September 2021
Accepted 26 January 2022

For numbered affiliations see end of article.

Correspondence to
Dr Roosa Tiusanen;
roemti@utu.fi

ABSTRACT

Objectives To identify concurrent developmental trajectories of physical activity and body mass index (BMI) over time.

Design Prospective cohort study, repeated survey.

Setting Cohort study in Finland.

Participants 66 852 public sector employees, who have been followed up for 16 years.

Outcome measures Shapes of trajectories of changes in physical activity and BMI.

Results At baseline, mean age was 44.7 (SD 9.4) years, BMI 25.1 (SD 4.1) kg/m^2 and physical activity 27.7 (SD 24.8) MET hours/week. Four clusters of concurrent BMI and physical activity trajectories were identified: (1) normal weight (BMI <25 kg/m^2) and high level of physical activity (30–35 MET hours/week), (2) overweight (BMI 25–30 kg/m^2) and moderately high level of physical activity (25–30 MET hours/week), (3) obesity (BMI 30–35 kg/m^2) and moderately low level of physical activity (20–25 MET hours/week) and (4) severe obesity (BMI >35 kg/m^2) and low level of physical activity (<20 MET hours/week). In general, BMI increased and physical activity decreased during the follow-up. Decline in physical activity and increase in BMI were steeper among obese respondents with low level of physical activity.

Conclusions Changes in BMI and physical activity might be interconnected. The results may be of interest for both clinicians and other stakeholders with respect to informing measures targeting increasing physical activity and controlling weight, especially among middle-aged people. Additionally, the information on the established trajectories may give individuals motivation to change their health behaviour.

Strengths and limitations of this study

- ► Large cohort of 66 852 participants.
- ► Repeated measures of physical activity and body mass index (BMI) over 16 years.
- ► Only leisure time physical activity was taken into account, leaving out work-related activity.
- ► The self-reported nature of estimates of BMI and physical activity might lead to information bias.

INTRODUCTION

Both obesity and physical inactivity have negative impact on multiple aspects of health and they increase the risk of mortality.[1–3] Ageing is associated with gaining weight and decreasing physical activity,[4–6] but less is known whether these changes occur simultaneously and how much heterogeneity there is in the developmental trajectories of body weight and physical activity.

Few studies have examined heterogeneity in weight development over time more closely. A study among 30-year-old US war veterans identified five different, but all increasing, trajectories of body mass index (BMI) over 6-year follow-up.[6] However, the steepness of trajectories varied: while the participants without obesity showed only a small increase in BMI, the increase was much steeper among the participants with obesity. Another study from the USA conducted on overweight participants aged 60 years identified seven weight trajectories of which most showed either stable overweight, continuously increasing BMI or relapse after weight loss. Even in the two trajectory groups showing decrease in BMI, the participants remained overweight.[7]

Physical activity has also been reported to change over time. Leisure time physical activity among women has previously been reported to increase until age of 50 years and start to decrease after that.[4] For men, the change in leisure time physical activity has been reported to vary between different types of activity—while moderate physical activity increased, low and high levels decreased.[5] Studies concerning trajectories of physical activity have found variation in development of activity. A 22-year follow-up study from Canada among those aged 18–60-years has identified trajectories of consistently inactive, increasing, consistently active and decreasing leisure time physical activity.[8] Another study conducted in the USA among 120 initially overweight people aged 54 (±9) years has measured activity with pedometers and identified 'sedentary' and 'low active' groups (decreasing daily count of steps), 'somewhat active' group (persistent daily count of steps) and 'active' group (increased daily count of steps) in 18-month follow-up.[9]

The association between higher levels of physical activity and lower BMI has been established in adults,[10 11] and there has been some evidence that this association might be most pronounced when physical activity exceeds 150 min/week.[10] There is, however, limited knowledge on simultaneous changes in these two factors. In short-term follow-up (18 months) among overweight Canadians aged 54 years, a trajectory with increasing activity has been associated with a trajectory of greater weight loss.[9] There is yet little knowledge on these two factors over longer follow-up. It is also unknown whether developmental patterns of BMI and physical activity differ by age or by gender.

To address the gap in the literature, the objective of this study was to examine concurrent changes in BMI and physical activity over 16-year follow-up by using a group-based multitrajectory analysis. While conventional statistics show a trajectory of average change of outcome over time, group-based trajectory modelling can distinguish and describe subpopulations (clusters), which may differ substantially from each other and from the average trajectory seen in the entire population. The aim was also to examine, whether the distinguished trajectories are different for those aged <50 years and those aged >50 years and whether the results are different when the study population is stratified by gender.

METHODS

Study population

Participants were drawn from the Finnish Public Sector (FPS) cohort study, a dynamic cohort with follow-up intervals 2–4 years initiated from 1998/2000. It consists of employees in the municipal services of 10 Finnish towns and 21 public hospitals, who had a job contract for a minimum of 6 months. In year 2000, the most common occupations of the respondents were registered nurse (23%), teacher (19%), practical nurse (13%) and cleaner (10%). The FPS has been described in more detail elsewhere.[12 13] Data in the current study included responses to five questionnaire surveys administered in 2000–2002, 2004–2005, 2008–2009, 2012-2013 and 2016-2017 (average response rate 70%). The baseline was the response given in 2000–2002 or 2004–2005. Participants who had reported their BMI and physical activity in at least two waves were included in the analysis.

Physical activity was assessed with a questionnaire at all survey waves. The respondents were asked to estimate their average weekly hours of leisure time physical activity/exercise and commuting activity within the previous year. The time spent on activity at each intensity level in hours per week was multiplied by the average energy expenditure of each activity, expressed in metabolic equivalent of task (MET).[14] The MET is a ratio of rate of energy expenditure reflecting the amount of consumed energy compared with resting. One MET unit of 3.5 mL of oxygen per kg per min corresponds to oxygen consumption when calmly sitting down. Weekly physical activity was expressed as MET hours/week and categorised as low (<14 MET hours/week), moderate (14 to <30 MET hours/week) or high (≥30 MET hours/week) physical activity levels.[15 16] This categorisation was chosen since physical activity >14 MET hours/week has been reported to be associated with cardiovascular disease[17] and the activity level of 30 MET hours/week has been shown to be needed for weight management.[18] 14 MET hours/week is approximately the equivalent of 140 min of brisk walking weekly. The definition of physical activity in the survey is presented in online supplemental table E1.

The BMI was defined as weight/height^2 (kg/m^2) based on self-reported body weight and height. The interpretation of the mean level of BMI trajectories was based on the following categorisation: normal weight (<25 kg/m^2), overweight (25–29.9 kg/m^2), obese (30–34.9 kg/m^2) and severely obese (≥35 kg/m^2). Of the respondents, only 934 (1%) had BMI ≤18.5 kg/m^2, and thus, for the matter of clarity, BMI <25 kg/m^2 was considered 'normal'. Age was defined in full years. The cohort was divided in two approximately even age groups: ≤50 (n=31 797, 48%) and >50 years (n=35 055, 52%).

Statistical analysis

The characteristics of participants were reported as means and SD or as absolute numbers and percentage when appropriate.

Group-based multitrajectory analysis was used to distinguish different developmental trajectories for physical activity and BMI, both treated as continuous variables. This method is a form of finite mixture modelling for analysing longitudinal repeated measures data. While conventional statistics show a trajectory of average change of outcome over time, group-based trajectory modelling is able to distinguish and describe subpopulations (clusters) existing within a studied population. A censored (known also as 'regular') normal model of group-based multitrajectory analysis was used. The goodness of model fit was judged by running the procedure several times with a number of trajectory clusters starting from one up to five, until the smallest group was below the pre-agreed cut-off at ≥5%. The Bayesian Information Criterion, Akaike Information Criterion and average posterior probability were used as criteria to confirm the goodness of fit. A cubic regression was applied. The trajectory analysis was conducted on two age groups <50 and >50 years as previous studies have suggested that changes in BMI and physical activity may vary depending on the age.[19 20] The sensitivity analysis was conducted by dividing both age groups by gender. No adjustments for co-variables were made.

All the analyses were performed using Stata/IC Statistical Software: Release 16 (StataCorp, College Station, Texas, USA). The additional Stata module 'traj' was required to conduct group-based trajectory analysis. The module is freely available for both SAS and Stata software (Jones and Nagin 1999; 2013).

Patient and public involvement

Participants of research were not involved in setting the study question and outcome measures and were not involved in the design and implementation of the study or writing the manuscript.

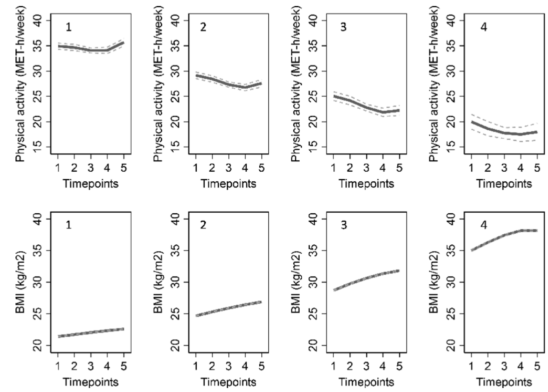

Figure 1 Trajectories of physical activity and body mass index (BMI) among respondents <50 years; 95% confidence limits are shown as dotted lines. For BMI, very narrow 95% CIs are poorly separable in the figure. Time between responses is approximately 4 years.

RESULTS

During the 16-year follow-up, the 66 852 participants had reported body weight and height on average in 3.5 (SD 1.3) study waves and physical activity in 3.6 (SD 1.3) study waves. The sample was predominated by 53 468 women (80%). In the younger group (aged ≤50 years), mean age was 39.8 (SD 7.2), BMI at baseline was 24.6 (SD 4.0) kg/m^2 and average physical activity was 28.8. (SD 25.5) MET hours/week. In the older group (aged >50 years), age was 55.0 (SD 2.9), BMI was 25.6 (SD 4.2) kg/m^2 and physical activity was 26.7 (SD 24.1) MET hours/week.

A four-trajectory model was chosen as the five-trajectory model had resulted in a smallest group below a pre-agreed cut-off of 5% (table 1). Four concurrent trajectories of BMI and physical activity were identified for both age groups (figures 1 and 2):

1. Group 1 (38% among ≤50 years, 32% among >50 years): individuals with normal weight (BMI <25 kg/m^2) and high level of physical activity (30–35 MET hours/week).
2. Group 2 (39% among ≤50 years, 42% among >50 years): individuals with overweight (BMI 25–30 kg/m^2) and moderately high level of physical activity (25–30 MET hours/week).
3. Group 3 (18% among ≤50 years, 21% among >50 years): individuals with obesity (BMI 30–35 kg/m^2) and moderately low level of physical activity (20–25 MET hours/week).
4. Group 4 (5% among ≤50 years, 5% among >50 years): individuals with severe obesity (BMI >35 kg/m^2) and low level of physical activity (<20 MET hours/week).

Table 1 Goodness of fit of group-based trajectory analysis models

Model	Smallest group N	Smallest group %	BIC	AIC	APP
≤50 years					
1-cluster model	31 797	100	–905 561	–905 509	
2-cluster model	8234	26	–869 531	–869 432	0.94
3-cluster model	3331	10	–851 542	–851 397	0.92
4-cluster model	1490	**5**	**–841 703**	**–841 510**	**0.89**
5-cluster model	898	3	–835 396	–835 157	0.87
>50 years					
1-cluster model	35 055	100	–869 200	–869 148	
2-cluster model	9690	28	–836 174	–836 076	0.93
3-cluster model	3845	11	–819 600	–819 454	0.91
4-cluster model	1888	**5**	**–809 601**	**–809 409**	**0.89**
5-cluster model	999	3	–803 977	–803 738	0.87

The chosen models are shown in bold.
AIC, Akaike Information Criterion; APP, average posterior probability; BIC, Bayesian Information Criterion.

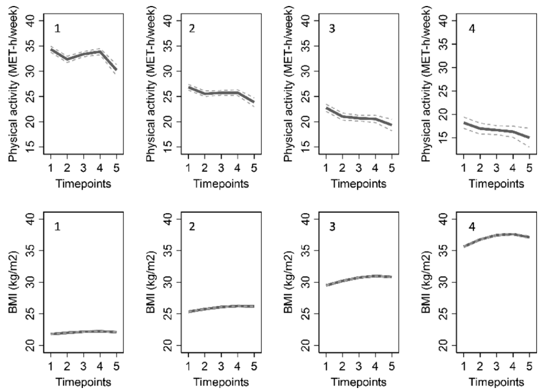

Figure 2 Trajectories of physical activity and body mass index (BMI) among respondents >50 years; 95% confidence limits are shown as dotted lines. For BMI, very narrow 95% CIs are poorly separable in the figure. Time between responses is approximately 4 years.

Group 1: individuals with normal weight and high level of physical activity

In this group, the younger respondents demonstrated a stable high level of physical activity with a slight rise towards the end of follow-up and their BMI increased slightly throughout the follow-up. For the older respondents, the level of physical activity decreased markedly during the follow-up, even if there was a slight rising pattern in the middle of follow-up. At the same time, the trajectory of BMI remained flat.

Group 2: individuals with overweight and moderately high level of physical activity

In this group, the level of physical activity declined in both age groups, but the decline was steeper among the older respondents. In younger respondents, the decrease of physical activity slowed down slightly towards the end of follow-up. Simultaneously, BMI was steadily growing among younger respondents, while remaining relatively flat in older group.

Group 3: individuals with obesity and moderately low level of physical activity

The physical activity and BMI trajectories were similar to the trajectories observed in group of overweight individuals with moderately high level of physical activity (group #2), but with a slightly steeper decline in physical activity and steeper increase in BMI.

Group 4: individuals with severe obesity and low level of physical activity

Also in this group, physical activity decreased and BMI increased. In younger respondents, this development slowed down at the end follow-up for both physical activity and BMI. Instead, in older respondents, the decrease in physical activity accelerated towards the end of follow-up with simultaneous slight decline in BMI.

Sensitivity analysis

Stratifying the respondents by gender in addition to age resulted in similar findings with few exceptions (online supplemental figures E1–E4 and online supplemental table E2). Among normal weight or overweight respondents, the decline in physical activity was steeper among men compared with women.

DISCUSSION

This prospective cohort study in 66 852 public sector employees followed repeatedly by 4-year intervals investigated trajectories of concurrent changes in BMI and physical activity over 16 years. Four trajectory clusters were identified for both participants aged ≤50 years and for those >50 years: (1) individuals with normal weight and high level of physical activity; (2) individuals with overweight and moderately high level of physical activity; (3) individuals with obesity and moderately low level of physical activity and (4) individuals with severe obesity and low level of physical activity. On average, BMI increased and physical activity decreased during the follow-up. Some trajectories demonstrated, however, distinctive features. Over time, the respondents with normal weight or overweight gained only a little weight while preserved a high or moderately high level of physical activity, even if the intensity of physical activity mildly decreased especially in older respondents. The decrease in physical activity and increase in BMI were steeper among the respondents with obesity or severe obesity, who had moderately low or low level of physical activity already at the start of the follow-up. Among the normal weight or overweight respondents, decline in physical activity was steeper among men compared with women.

The observed age-related weight gain is in line with previous studies,[4–6 21] as well as the decline in physical activity.[4 22 23] Previous studies have also shown that an increase in BMI slows down with advancing age, and this was also supported by the present findings—the rise in BMI was steeper in the younger respondents.[24 25] During the follow-up, the decline in physical activity mirrored the increase in BMI. Similar findings have been reported before—several studies conducted among middle-aged adults have observed an association between physical activity and weight gain.[10 11 26 27] This association has been described to be dose-dependent—physically active individuals gain less weight than inactive peers.[11] Current results support this finding, since the increase in BMI was less steep in the more active groups. The amount of activity needed to prevent weight gain has been debated. Some studies have concluded that current activity recommendations are not sufficient enough to prevent weight gain and that there is a need for higher activity to remain in the normally weighted category.[10 11 26] This is in line with the current findings—only high physical activity was associated with normal weight.

The strengths of the study were long follow-up of 16 years, repeated measurements on physical activity and BMI and a large sample size. For our knowledge, there are no previous multitrajectory analyses of the relation between physical activity and BMI conducted in adults.

Tiusanen R, *et al*. *BMJ Open* 2022;**12**:e057692. doi:10.1136/bmjopen-2021-057692

The study has also some limitations. Physical activity was self-reported and only leisure time and commuting activity were inquired. Thus, physical activity at work was not considered. The distribution of physical activity intensity was skewed—most of the participants were at least somewhat active, and even in the least active group the mean activity level was approximately 18 MET hours/week, which is approximately the equivalent of 3 hours of brisk walking weekly. BMI was also based on self-reported weight and height, which may cause recall and information bias, possibly resulting in under-reporting of body weight.[28] Most of the participants had BMI >25 kg/m^2 indicating overweight or obesity (62% in the age group of ≤50 years and 68% in the older), which may reflect the current overweight and obesity pandemic. The cohort included predominantly working-age women employed in public sector. Therefore, the results might not be directly reflected on the entire population, since there might be variation in behaviour, for instance, among unemployed people or entrepreneurs. Moreover, a public sector often employs people with higher socioeconomic status, who might have more knowledge and financial resources to healthy lifestyle choices compared with manual workers.

The results may be of interest for both clinicians and other stakeholders with respect to informing measures targeting increasing physical activity and controlling weight, especially among middle-aged people. Additionally, the information on the established trajectories may give people more motivation to change their health behaviour. Further research may reveal risk factors that affect developmental trajectories seen in this study. Such factors may be, for example, gender, socioeconomic status, smoking, alcohol consumption and concurrent health disorders among others.

CONCLUSIONS

Changes in BMI and physical activity might be interconnected. The normal weight or overweight respondents gained only a little weight while preserved a high or moderately high level of physical activity. Compared with normal weight trajectories, the decrease of physical activity and increase in BMI were markedly steeper among the obese or severely obese trajectories, who also had moderately low or low level of physical activity. The findings were similar for both age groups. Among the normal weight and overweight trajectories, decline in physical activity was steeper among men compared with women. Since physical inactivity and overweight are both risk factors for many diseases, more research is needed to develop interventions that could simultaneously affect both.

Author affiliations

[1]Department of Physical and Rehabilitation Medicine, TYKS Turku University Hospital, Turku, Finland
[2]Finnish Institute of Occupational Health, Helsinki, Finland
[3]Clinicum, University of Helsinki Faculty of Medicine, Helsinki, Finland
[4]Department of Epidemiology and Public Health, University College London, London, UK
[5]Department of Public Health, University of Turku, Turku, Finland
[6]Centre for Population Health Research, University of Turku, Turku, Finland

Twitter Jenni Ervasti @JenniErvasti1

Contributors All the authors substantially contributed to the conception and design of the work, the interpretation of the results and revising it critically for important intellectual content. JE, JV and MK were responsible for the acquisition of data for the work. MS and JP were responsible for the statistical analysis. RT and MS were responsible for drafting the work. All the authors have finally approved the version to be published and they are agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. JV was a guarantor accepting full responsibility for the work, having access to the data, and controlling the decision to publish.

Funding This study was supported by funding granted by the Academy of Finland (Grants 332030 to SS; 633666 to MK; 321409 and 329240 to JV); NordForsk (to MK and JV); the UK MRC (Grant K013351 to MK); Hospital District of Southwest Finland (to SS).

Competing interests None declared.

Patient consent for publication Not applicable.

Ethics approval The ethics committee of the Hospital District of Helsinki and Uusimaa approved the study (registration number HUS/1210/2016). Participants gave informed consent to participate in the study before taking part.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available on reasonable request. Data may be obtained from a third party and are not publicly available. We are allowed to share anonymised questionnaire data of the Finnish Public Sector Study by application for with bona fide researchers with an established scientific record and bona fide organisations. For information about the Finnish Public Sector Study, contact Professor Mika Kivimaki (mika.kivimaki@helsinki.fi)/Dr Jenni Ervasti (jenni.ervasti@ttl.fi).

ORCID iDs

Roosa Tiusanen http://orcid.org/0000-0002-7781-8922
Mikhail Saltychev http://orcid.org/0000-0003-1269-4743
Jenni Ervasti http://orcid.org/0000-0001-9113-2428
Sari Stenholm http://orcid.org/0000-0001-7560-0930
Jussi Vahtera http://orcid.org/0000-0002-6036-061X

REFERENCES

1 Bull F, Goenka S, Lambert V. Physical Activity for the Prevention of Cardiometabolic Disease. In: Prabhakaran D, Anand S, eds. *Cardiovascular, respiratory, and related disorders*. Washington, DC, 2017.
2 Bigaard J, Frederiksen K, Tjønneland A, *et al*. Waist circumference and body composition in relation to all-cause mortality in middle-aged men and women. *Int J Obes* 2005;29:778–84.
3 Anon. Obesity: preventing and managing the global epidemic. Report of a who consultation. *World Health Organ Tech Rep Ser* 2000;894:i–xii.

4 Sui X, Zhang J, Lee D-C, *et al*. Physical activity/fitness peaks during perimenopause and BMI change patterns are not associated with baseline activity/fitness in women: a longitudinal study with a median 7-year follow-up. *Br J Sports Med* 2013;47:77–82.
5 Drøyvold WB, Holmen J, Midthjell K, *et al*. Bmi change and leisure time physical activity (LTPA): an 11-y follow-up study in apparently healthy men aged 20-69 Y with normal weight at baseline. *Int J Obes Relat Metab Disord* 2004;28:410–7.
6 Rosenberger PH, Ning Y, Brandt C, *et al*. Bmi trajectory groups in veterans of the Iraq and Afghanistan wars. *Prev Med* 2011;53:149–54.
7 Fitzpatrick SL, Rosales AG, Brown SD, *et al*. Behavioural and psychosocial factors associated with 5-year weight trajectories within the portal Overweight/Obesity cohort. *Obes Sci Pract* 2020;6:272–81.
8 Barnett TA, Gauvin L, Craig CL, *et al*. Distinct trajectories of leisure time physical activity and predictors of trajectory class membership: a 22 year cohort study. *Int J Behav Nutr Phys Act* 2008;5:57.
9 Imes CC, Zheng Y, Mendez DD, *et al*. Group-Based trajectory analysis of physical activity change in a US weight loss intervention. *J Phys Act Health* 2018;15:840–6.
10 Jakicic JM, Powell KE, Campbell WW, *et al*. Physical activity and the prevention of weight gain in adults: a systematic review. *Med Sci Sports Exerc* 2019;51:1262–9.
11 Moholdt T, Wisløff U, Lydersen S, *et al*. Current physical activity guidelines for health are insufficient to mitigate long-term weight gain: more data in the fitness versus fatness debate (the HUNT study, Norway). *Br J Sports Med* 2014;48:1489–96.
12 Kouvonen A, Kivimäki M, Elovainio M, *et al*. Effort/reward imbalance and sedentary lifestyle: an observational study in a large occupational cohort. *Occup Environ Med* 2006;63:422–7.
13 Kouvonen A, Kivimäki M, Virtanen M, *et al*. Effort-reward imbalance at work and the co-occurrence of lifestyle risk factors: cross-sectional survey in a sample of 36,127 public sector employees. *BMC Public Health* 2006;6:24.
14 Leskinen T, Stenholm S, Aalto V, *et al*. Physical activity level as a predictor of healthy and chronic disease-free life expectancy between ages 50 and 75. *Age Ageing* 2018;47:423–9.
15 Kujala UM, Kaprio J, Sarna S, *et al*. Relationship of leisure-time physical activity and mortality: the Finnish twin cohort. *JAMA* 1998;279:440–4.
16 Ainsworth BE, Haskell WL, Leon AS, *et al*. Compendium of physical activities: classification of energy costs of human physical activities. *Med Sci Sports Exerc* 1993;25:71–80.
17 Tanasescu M, Leitzmann MF, Rimm EB, *et al*. Exercise type and intensity in relation to coronary heart disease in men. *JAMA* 2002;288:1994–2000.
18 Fogelholm M, Suni J, Rinne M, *et al*. Physical activity pie: a graphical presentation integrating recommendations for fitness and health. *Journal of Physical Activity and Health* 2005;2:391–6.
19 Stenholm S, Pulakka A, Kawachi I, *et al*. Changes in physical activity during transition to retirement: a cohort study. *Int J Behav Nutr Phys Act* 2016;13:51.
20 Stenholm S, Solovieva S, Viikari-Juntura E, *et al*. Change in body mass index during transition to statutory retirement: an occupational cohort study. *Int J Behav Nutr Phys Act* 2017;14:85.
21 Yang Y, Dugué P-A, Lynch BM, *et al*. Trajectories of body mass index in adulthood and all-cause and cause-specific mortality in the Melbourne Collaborative cohort study. *BMJ Open* 2019;9:e030078.
22 Achttien RJ, van Lieshout J, Wensing M, *et al*. The decline in physical activity in aging people is not modified by gender or the presence of cardiovascular disease. *Eur J Public Health* 2020;30:333–9.
23 McAuley E, Hall KS, Motl RW, *et al*. Trajectory of declines in physical activity in community-dwelling older women: social cognitive influences. *J Gerontol B Psychol Sci Soc Sci* 2009;64:543–50.
24 Brown WJ, Kabir E, Clark BK, *et al*. Maintaining a healthy BMI: data from a 16-year study of young Australian women. *Am J Prev Med* 2016;51:e165–78.
25 Lewis CE, Jacobs DR, McCreath H, *et al*. Weight gain continues in the 1990s: 10-year trends in weight and overweight from the cardia study. coronary artery risk development in young adults. *Am J Epidemiol* 2000;151:1172–81.
26 Erlichman J, Kerbey AL, James WPT. Physical activity and its impact on health outcomes. paper 2: prevention of unhealthy weight gain and obesity by physical activity: an analysis of the evidence. *Obes Rev* 2002;3:273–87.
27 Hankinson AL, Daviglus ML, Bouchard C, *et al*. Maintaining a high physical activity level over 20 years and weight gain. *JAMA* 2010;304:2603–10.
28 Connor Gorber S, Tremblay M, Moher D, *et al*. A comparison of direct vs. self-report measures for assessing height, weight and body mass index: a systematic review. *Obes Rev* 2007;8:307–26.

Table E1. Defining the level of physical activity in the survey.

What was the intensity and frequency of your average physical activity (leisure or commuting) during the past year (or since the onset of your disease if the disease had begun less than a year ago)?					
Intensity (Mark all four options)	Amount per week				
	None	<½ hour	1 hour	2 – 3 hours	≥ 4 hours
Normal walking or respective					
Brisk walking or respective					
Light jogging or respective					
Brisk jogging or respective					
The responses were converted into MET units according to a following scheme.					
Intensity (Mark all four options)	MET minutes per week				
	None	<½ hour	1 hour	2 – 3 hours	≥ 4 hours
Normal walking or respective	0	69	138	345	550
Brisk walking or respective	0	99	198	495	792
Light jogging or respective	0	210	420	1050	1680
Brisk jogging or respective	0	240	480	1200	1920

Table E2. Goodness of fit of group-based trajectory analysis models. The chosen models are shown in bold.

Model	Smallest group		BIC[1]	AIC[2]	APP[3]
	n	%			
Men <51 years					
1-cluster	5,894	100%	-156,412	-156,369	1
2-cluster	1,469	25%	-151,020	-150,938	0.93
3-cluster	509	9%	-148,201	-148,080	0.91
4-cluster	**292**	**5%**	**-146,715**	**-146,555**	**0.88**
5-cluster	147	2%	-145,799	-145,600	0.86
Men >50 years					
1-cluster	7,490	100%	-177,574	-177,530	1
2-cluster	1,894	25%	-171,451	-171,368	0.92
3-cluster	622	8%	-168,332	-168,209	0.90
4-cluster	**334**	**4%**	**-166,442**	**-166,280**	**0.88**
5-cluster	174	2%	-165,267	-165,066	0.87
Women <51 years					
1-cluster	25,903	100%	-746,837	-746,786	1
2-cluster	6,530	25%	-715,572	-715,475	0.95
3-cluster	2,773	11%	-700,393	-700,250	0.92
4-cluster	**1,173**	**5%**	**-692,029**	**-691,840**	**0.90**
5-cluster	745	3%	-686,684	-686,449	0.87
Women >50 years					
1-cluster	27,565	100%	-690,012	-689,961	1
2-cluster	7,608	28%	-662,602	-662,506	0.94
3-cluster	3,164	11%	-649,085	-648,944	0.91
4-cluster	**1,536**	**6%**	**-641,136**	**-640,949**	**0.89**
5-cluster	842	3%	-636,666	-636,433	0.86

[1] BIC = Bayesian Information Criterion, [2] AIC = Akaike information criterion, [3] APP = Smallest average posterior probability

Tiusanen R, *et al. BMJ Open* 2022; 12:e057692. doi: 10.1136/bmjopen-2021-057692

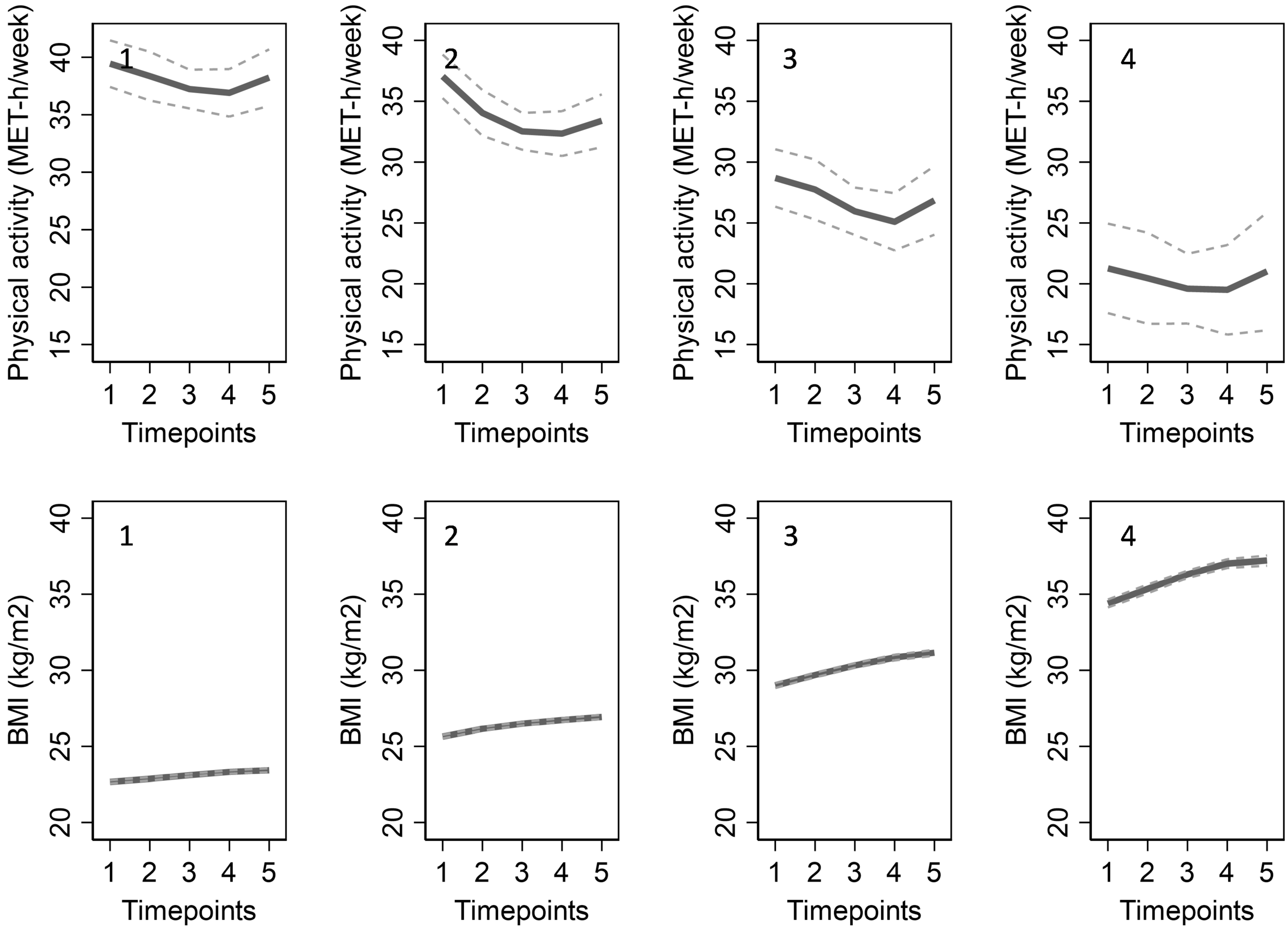

Figure E1. Trajectories of physical activity and body mass index (BMI) amongst men < 50 years
95% confidence limits are shown as dot-lines. For BMI, very narrow 95% CIs are poorly separable in the figure. Time between responses is approximately four years.

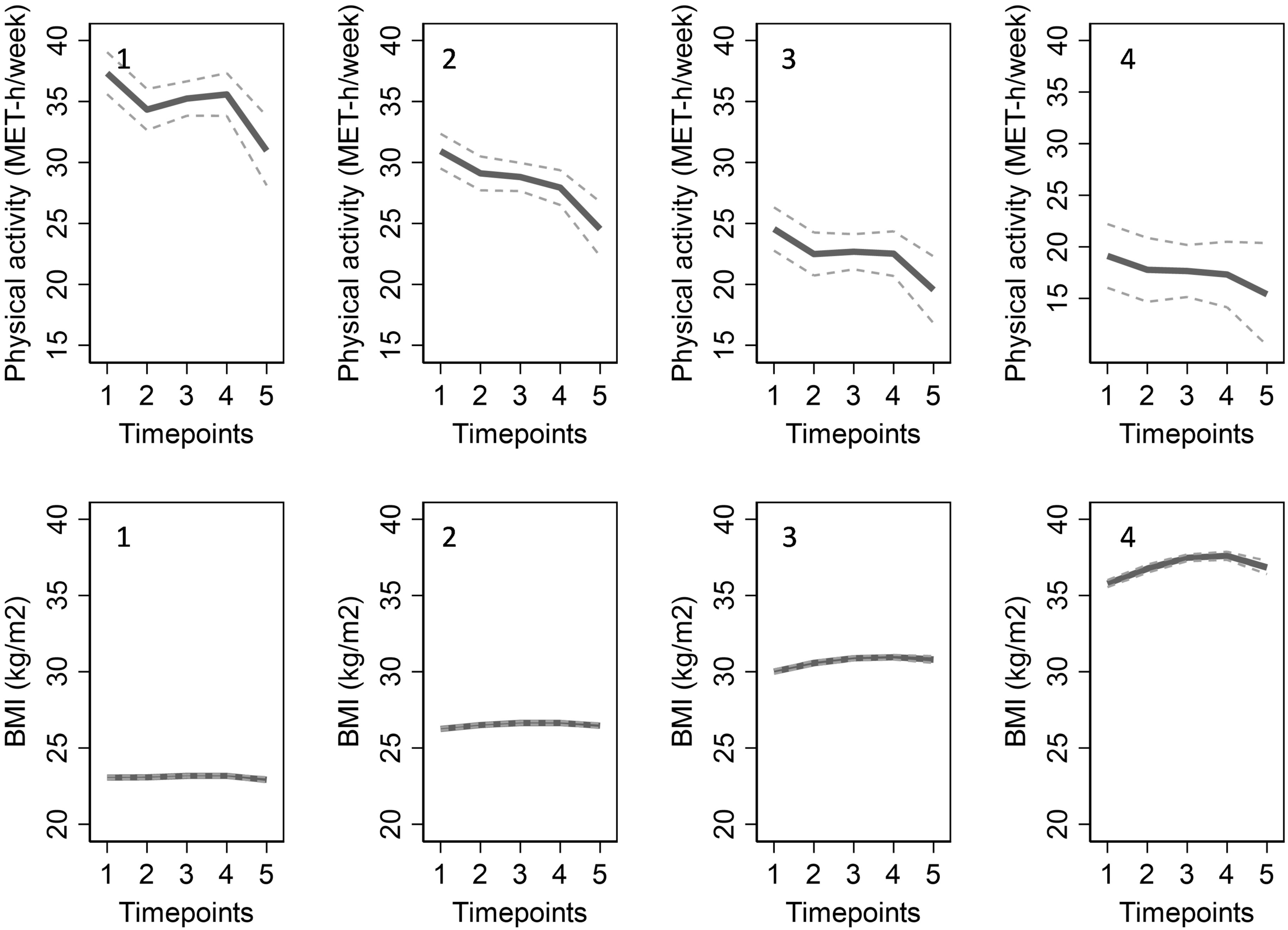

Figure E2. Trajectories of physical activity and body mass index amongst men > 50 years
95% confidence limits are shown as dot-lines. For BMI, very narrow 95% CIs are poorly separable in the figure. Time between responses is approximately four years.

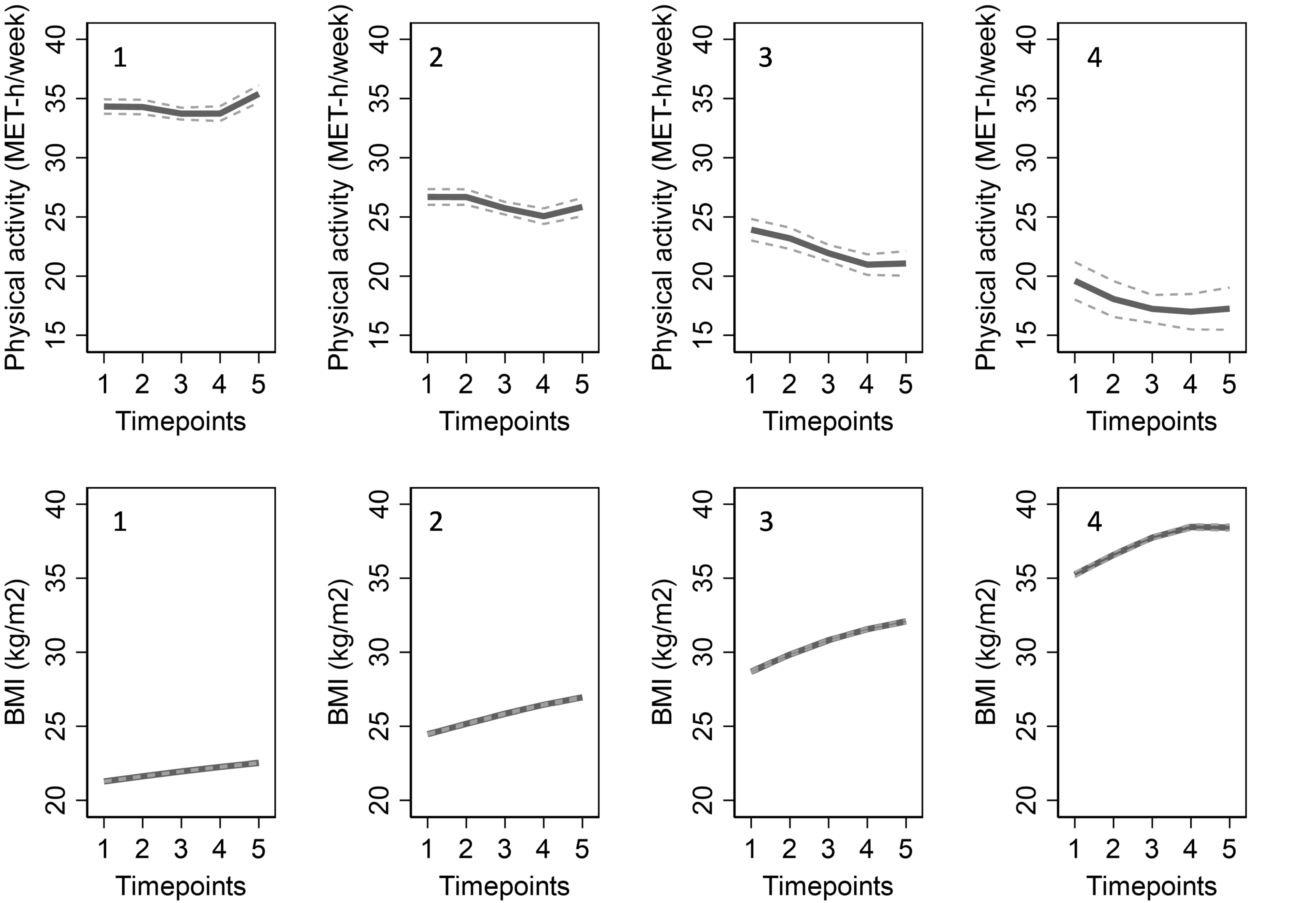

Figure E3. Trajectories of physical activity and body mass index amongst women < 50 years
95% confidence limits are shown as dot-lines. For BMI, very narrow 95% CIs are poorly separable in the figure. Time between responses is approximately four years.

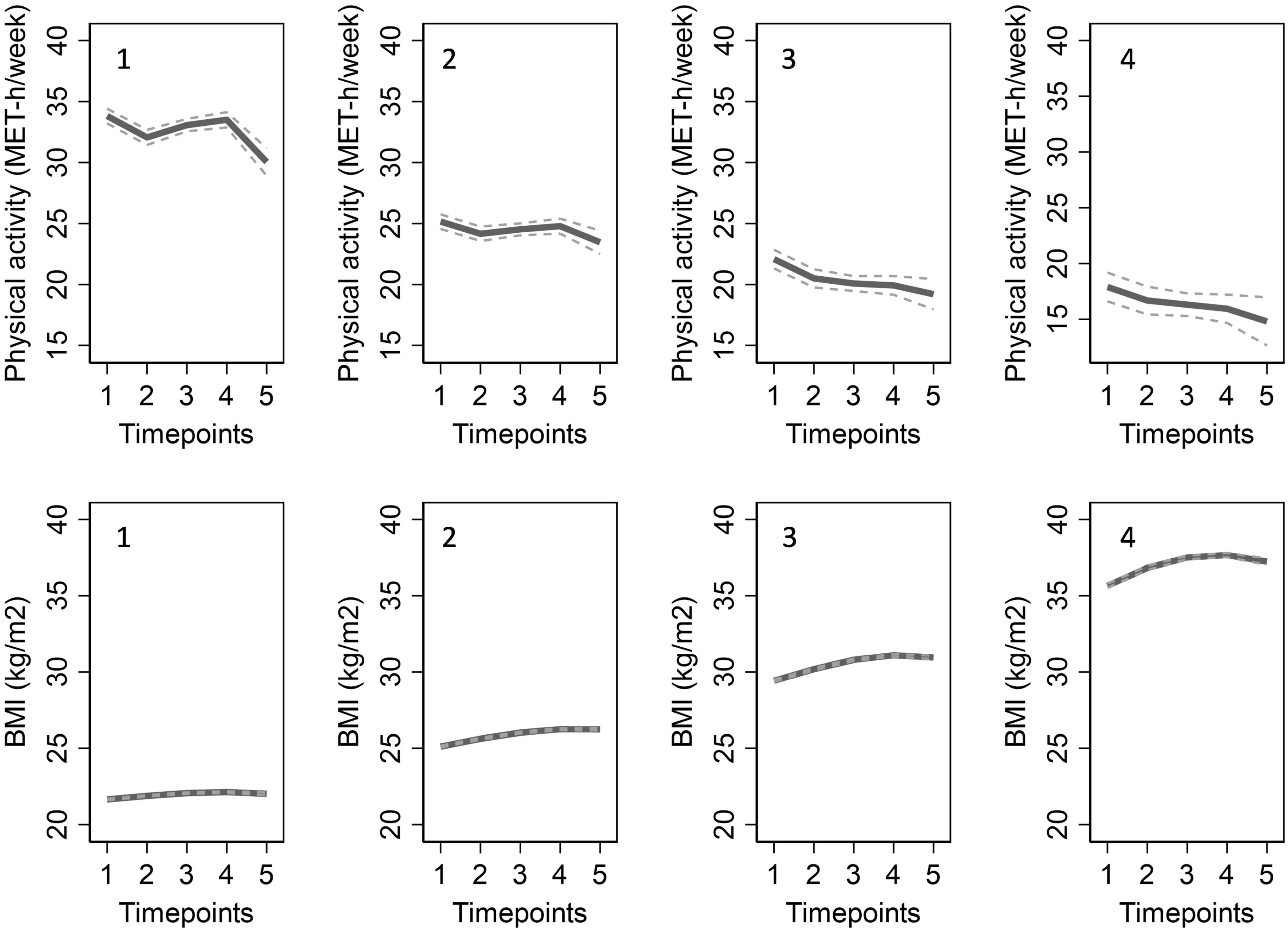

Figure E4. Trajectories of physical activity and body mass index amongst women > 50 years
95% confidence limits are shown as dot-lines. For BMI, very narrow 95% CIs are poorly separable in the figure. Time between responses is approximately four years.