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Title: Displacing sedentary time: Association with cardiovascular disease prevalence

Authors: Wellburn S[1], Ryan CG[1], Azevedo LB[1], Ells L[1], Martin DJ[1], Atkinson G[1], Batterham, AM[1].

Affiliations: [1]Health and Social Care Institute, Teesside University, Middlesbrough, UK

Corresponding Author

Dr. Cormac G Ryan,

Health and Social Care Institute

Teesside University,

TS1 3BA, UK.

Email: c.ryan@tees.ac.uk

Tel: 0044 (0)1642 738253

Fax: 0044 (0)1642 732983

ABSTRACT

Purpose: Isotemporal substitution analysis offers new insights for public health, but has only recently been applied to sedentary behavior research. We aimed to quantify associations between the substitution of 10 minutes of sedentary behavior with 10 minutes of light physical activity (LPA) or moderate-to-vigorous physical activity (MVPA) and the prevalence of cardiovascular disease (CVD). Age was also explored as a potential effect modifier.

Methods: We completed a secondary analysis of data from 1477 adults from the Health Survey for England (2008). Sedentary time, LPA and MVPA were measured using accelerometry. We applied isotemporal models to quantify the relationship with CVD prevalence of replacing 10 minutes of sedentary time with equivalent amounts of LPA or MVPA. Prevalence risk ratios (RR) with 95% confidence intervals (CI) are presented, adjusted for covariates. The role of age as an effect modifier was explored via age × MVPA and age × LPA interactions. CVD was defined as per the International Classification of Diseases.

Results: The prevalence of CVD was 24%. The RR was 0.97 (95% CI: 0.96 to 0.99) for LPA and 0.88 (0.81 to 0.96) for MVPA. Substitution of approximately 50 minutes of LPA would be required for an association equivalent to 10 minutes of MVPA. The beneficial association of MVPA was attenuated with age, with a decrease in the relative risk reduction of ~7% per decade.

Conclusions: Isotemporal substitution of sedentary time with LPA was associated with a trivial relative risk reduction for CVD, whereas the equivalent replacement with MVPA had a small beneficial relationship. With respect to CVD prevalence, MVPA might become decreasingly important in older individuals. Prospective studies are needed to investigate causality.

Key words: Isotemporal substitution; public health; prevalence risk ratio; physical activity

INTRODUCTION

In 2008 17.3 million deaths were attributable to cardiovascular disease (CVD) and this is expected to increase to 23.3 million by 2030 (24, 39). There is a growing body of literature suggesting that sedentary behavior is an important risk factor for CVD (11, 20, 21, 25, 28, 30, 31, 36). Such findings have resulted in recommendations (35) that individuals of all ages should minimize their sedentary time (sitting) and an increasing number of controlled trials of interventions explicitly attempting to reduce sedentary behavior (6, 9, 33).

The amount of time in the day is fixed. Reducing one form of behavior for a period of time will result in another form of behavior taking its place for an equivalent period. The beneficial health effects of reducing a potentially negative behavior, like sedentary time, might be dependent on the behavior with which it is replaced (14, 26). It has been argued that the positive effects of reducing sedentary behavior might be largely attributed to the resultant increase in time spent being active (17). A relatively new method of analysis known as *isotemporal substitution* has recently been identified as an important advancement in this field (26). With this method the relative health effects of displacing a period of sedentary behavior for an equivalent period of light physical activity (LPA) or moderate-to-vigorous physical activity (MVPA) can be identified, providing useful insights for public health recommendations (26).

Two recent studies have used isotemporal substitution to investigate the associations between replacing sedentary behavior with different intensities of activity and CVD risk factors (4, 17). Both studies, using objective measures of behavior, identified that displacing sedentary behavior with MVPA was associated with a reduction in CVD risk factors such as body mass index and glucose homeostasis (4, 17). However, one study found no substantial association of displacing the sedentary behavior with LPA (17) while the other did (though a smaller association than was seen with MVPA) (4). Thus it is unclear if replacing sedentary behavior with LPA has beneficial associations in relation to CVD risk factors. Furthermore, these studies focused on CVD risk factors rather than CVD itself.

Likewise, the role of age as a moderator (effect modifier) of the relationship between sedentary behavior and CVD has not been explored using isotemporal substitution. An isotemporal substitution study replacing sedentary behaviors in older adults (mean age 75 years) with different levels of physical activity found that replacing sedentary behavior with LPA was associated with better subjectively-rated wellbeing while replacement with MVPA was not (3). Thus, it is possible that the benefits associated with reduced sedentary behavior are dependent on both the activity substituted and the age of the individual.

The aims of the current study were 1) to investigate the association between substituting 10 minutes of sedentary behavior with either LPA or MVPA and the CVD prevalence risk ratio, and 2) to explore the extent to which the association is moderated by age.

METHODS

Sample and design. This study involved a secondary analysis of data from the 2008 Health Survey for England, a population-based survey of individuals in England (8). In the survey, 16,056 addresses were selected using multistage stratified random sampling to ensure a proportionate sampling across the nine Government regions of England. Postcode sector was the primary sampling unit. Face-to-face interviews were held in 9,191 of these households with 15,102 adults. A subset of adults (n=4,507) was randomly selected to have their sedentary behavior/physical activity levels measured objectively using an accelerometer for one week. The specific details of the collection procedures have previously been described in detail (8). Participants who were confined to a bed/wheelchair, pregnant, had a latex allergy, had recent abdominal surgery or a health problem which would make wearing the accelerometer uncomfortable were excluded from selection. Furthermore, for the purpose of our analysis individuals were excluded if any of the following applied: they were <45 years of age (as younger individuals would be less likely to have CVD); their level of mobility [categorized as either: I have no problems in walking about; I have some problems in walking about; I am confined to bed] was categorized as either confined to bed or data for mobility were missing.

Measurements

Cardiovascular disease (CVD): Participants were categorized as having CVD or not according to the original 2008 Health Survey for England variable *(D) VII Heart and Circulatory condition*, which followed the definition of the International Classification of Diseases for diseases of the circulatory system. It includes the following sub-conditions: acute rheumatic fever; chronic rheumatic heart disease; hypertensive diseases; ischaemic heart disease; pulmonary heart disease and diseases of pulmonary circulation; other forms of heart disease; cerebrovascular disease; diseases of arteries, arterioles and capillaries; diseases of veins, lymphatic vessels and lymph nodes; and unspecified disorders of the circulatory system (40). This variable was calculated from a question asking individuals if they had a long-standing illness. If they replied yes, then in the second question they were asked to select, from a preordained list of conditions, up to six that they considered applicable to them.

Sedentary behavior and physical activity: Sedentary behavior and physical activity were measured using the Actigraph™ (Actigraph™ model GT1M). From the Actigraph™ counts per minute output, sedentary behavior was classified as 0-199 counts-per-minute (cpm), LPA was classified as 200-2019 cpm, and MVPA was classified as ≥2020 cpm (8). Data were only processed for participants who wore the monitor for ≥10 hours in the day (accelerometers were not worn while sleeping) for a minimum of four days.

CVD risk factors: To attempt to derive an unbiased association between sedentary time/ physical activity and CVD, the following CVD risk factors were entered as covariates within our statistical analysis: age [years], sex [male, female], socioeconomic status [quintiles of the Index of Multiple Deprivation: a measure of area deprivation based on income, employment, health deprivation and disability, education, skills and training, barriers to housing and services, and crime and living environment], diet [<2 portions of fruit and vegetables per day; 2-4 portions of fruit and vegetables per day; ≥5 portions of fruit and vegetables per day], smoking history [never smoked; used to smoke; current smoker], alcohol intake [none, ≤4 (men), ≤3 (women) units/day; >4 and ≤8 (men), >3 and ≤6 (women) units/day; >8 (men), >6 (women) units/day], anxiety/depression [I am not anxious or depressed; I am moderately anxious or depressed; I am extremely anxious or depressed] and musculoskeletal medication use [yes/no].

Statistical analysis: The design of the Health Survey for England is a multi-stage stratified random sample. We accounted for the complex survey design using a design-based approach. Survey weights, strata, and the primary sampling unit, which was postcode sector, were entered prior to the main analyses using the Stata software ‘svyset’ commands (v. 13.1; Stata Corp. College Station, Texas, USA). We adopted an 'ultimate cluster' approach, assuming that the variance between primary sampling units addresses any later stages of clustering, negating the need to specify the secondary sampling unit (household) (38). All analyses were carried out using the statistical package STATA (v. 13.1; Stata Corp. College Station, Texas, USA). In all analyses "*(D) VII Heart and Circulatory condition*" was entered as the binary dependent variable.

Similar to previous work by Hamer et al. we chose to use 10-minute time units for sedentary and physical activity behaviors (17). This bout duration is the minimum recommended time period for accumulation of activity to meet current physical activity guidelines (18, 35). An isotemporal substitution analysis (26) was performed to examine the association between replacing a 10-minute unit of sedentary activity with an equivalent unit of LPA or MVPA and CVD prevalence. Three models were analyzed. Model 1 was adjusted for age alone, Model 2 was adjusted for age and sex, and Model 3 was adjusted for all covariates. This analysis involves the inclusion of total wear time, LPA, and MVPA in the model, with sedentary time omitted. The resulting coefficients for LPA and MVPA are estimates of the association between replacing 10 minutes of sedentary time with the equivalent amount of LPA or MVPA and CVD (expressed as a prevalence risk ratio). Finally, via age × MVPA and age × LPA interaction terms, we explored the extent to which these associations were moderated by age.

In a secondary analysis, we examined the association between substituting 20 minutes of sedentary activity with 20 minutes of LPA and CVD prevalence. Our rationale here is that it is easier for people to replace sedentary time with light as opposed to moderate-vigorous activity, so a larger epoch might be more appropriate for LPA with respect to public health recommendations. For a pragmatic comparison, we also estimated the average amount of time required for substitution of sedentary behavior with LPA to observe an association with the prevalence risk ratio of CVD equivalent to that of substitution with MVPA. For all analyses we report prevalence risk ratios together with 95% confidence intervals (CI). As a generalized linear model with a binomial distribution and log link failed to converge, we derived the risk ratios using Cox regression with a constant time at risk and robust variance estimator (2). A priori, we defined the threshold for the minimum clinically important association as a prevalence risk ratio of 0.9 (a small association). This threshold implies that for every ten cases of CVD, one case is prevented due to the exposure in question. Smaller associations than this are regarded as trivial.

Of the participants with complete outcome and accelerometry data, 150 had missing covariate data comprising n=19 for anxiety/ depression and n=134 for use of musculoskeletal medications (3 participants with missing data for both variables). For the primary analysis, we used multiple imputation (MI) as a principled method of dealing with these missing data (34). Under a missing at random assumption (missing data dependent on the observed data), we imputed the 153 missing values using chained equations via the Stata MI module (37). We used 20 imputations, as the number of imputed data sets should be greater than the frequency of missing information to ensure reproducibility of results (37). Missing values were predicted using all variables in the analysis model including the interaction terms, plus the CVD outcome variable (27). We applied an ordinal logistic regression model (ologit) to impute missing values for the 3-level anxiety/depression variable, and a logistic regression model (logit) for the binary musculoskeletal medication variable. We conducted subsequent analysis for Model 3, above, using all 20 imputed data sets with results combined using Rubin's rules (32). As recommended (34), we also conducted an analysis of complete cases only (n=1327).

RESULTS

Of the subset (n = 4,507) who were randomly chosen to have their physical activity monitored, 1477 were included in our analysis (See Figure 1). The descriptive characteristics of the included and excluded participants are shown in Table 1. The descriptive characteristics of the participants with complete data, along with those with missing data, are shown in Table 2. Of the individuals eligible for this study, 24% were classified as having a CVD condition. There were no substantial differences for outcome or exposure variables between those with complete and incomplete data apart from the proportion using musculoskeletal medicines - the variable with the most missing data, imputed for the primary analysis as detailed above.

Insert figure 1 here

Insert tables 1 & 2 here

Prevalence risk ratios for adjusted and unadjusted models are shown in Table 3. In all models, replacing 10 minutes of sedentary behavior with 10 minutes of LPA was associated with a trivial risk ratio for CVD (3% relative risk reduction). Replacing 10 minutes of sedentary behavior with 10 minutes of MVPA resulted in a small beneficial effect (12% relative risk reduction).

The secondary analyses revealed a prevalence risk ratio of 0.95 (95% CI: 0.92, 0.98) for replacing 20 minutes of sedentary time with the equivalent amount of LPA. We estimated that approximately 50 minutes of sedentary time would have to be replaced with LPA to observe an association with CVD equivalent to substitution with 10 minutes of MVPA. In Table 4 we report the exploratory analysis of the observed age by MVPA interaction. The protective association on CVD prevalence of replacing sedentary behavior with MVPA decreased with age. Back-transformation of the coefficient for the interaction effect revealed that the risk ratio is attenuated by a factor of 1.083 per decade (95% CI, 1.025 to 1.146); for example, risk ratio=0.80 (age 50) multiplied by 1.083 = 0.87 (age 60). There was no substantial interaction of age with LPA, with the trivial risk ratio essentially unchanged across the age range (risk ratio changes by a factor of 0.9996 per decade: 95% CI, 0.9985 to 1.0008).

Table 5 shows the risk ratios from the analysis of complete cases. Point estimates and confidence intervals are not materially different from those derived from the multiple imputation analysis.

Insert table 3 here

Insert table 4 here

Insert table 5 here

DISCUSSION

Substituting 10 minutes of sedentary behavior with an equivalent amount of MVPA resulted in a small relative risk reduction for CVD. This relationship was affected by age with the protective association of substituting sedentary behavior with MVPA decreasing with age. The replacement of 10 minutes of sedentary time with 10 minutes of LPA had a trivial association with CVD prevalence. A longer duration of LPA (~50 minutes) would be needed to achieve the same effect as 10 minutes of MVPA.

These results show that the beneficial associations of reducing sedentary behavior are largely dependent on the intensity of physical activity that displaces it. These findings support recent moves to make recommendations regarding the reduction of sedentary behavior in public health guidelines (35). Furthermore, this study provides preliminary data on the associations with CVD prevalence of displacing different durations of sedentary behavior with physical activity of different intensities for different age groups. Such data might help to develop more specific guidelines that can be tailored to enhance adherence. For example, if an individual wanted to gain the apparent CVD-reducing benefits of replacing sedentary behavior with MVPA but was unwilling or unable to undertake MVPA, the duration of LPA required to produce the equivalent health-enhancing association is identified. Our data suggest that it requires a replacement of sedentary time with approximately 5 times as much LPA versus MVPA to derive the equivalent association.

We found that substituting sedentary behavior with both LPA and MVPA reduced the risk for CVD, although the association was trivial for LPA and small for MVPA. This finding is in keeping with the work by Buman et al. (4) who found that replacement of sedentary behavior with both LPA and MVPA activity reduced risk factors for CVD. Our findings are also consistent with those of Hamer et al. (17) who reported a protective association on cardiometabolic risk factors of replacing sedentary time with MVPA, with no substantial association of LPA.

There was a decreasing protective association of substituting sedentary behavior with MVPA with increasing age. The reason for this apparent moderation cannot be elucidated given the cross-sectional design and the data at hand. It might be that as individuals age the importance of MVPA diminishes relative to other risk factors for CVD. It could also relate to the negative association between age and MVPA (8). Further research is required to confirm and explain this finding.

The findings of this study, that substituting sedentary behavior with physical activity has a beneficial association with the CVD prevalence, support the recent increase in trials conducted of interventions which attempt to reduce sedentary behavior (6, 9, 33). However, for older adults only a small number of either non-randomized controlled trials or feasibility studies exist (5, 10, 12, 13, 22). Such work is particularly needed given that healthy older adults spend, on average (including sleep), 18 hours per day sedentary with values as high as 22 hours per day reported in care settings (15).

A key strength of this study was the use of a large nationally representative sample, with the ability to adjust for known covariates, and objective measures of sedentary time, LPA and MVPA. Furthermore, we used a principled method – multiple imputation - for addressing missing covariate data, resulting in the inclusion of an additional 150 participants versus a complete case analysis. We believe that the imputation of missing covariate values using all variables in the analysis (Model 3) together with the outcome variable (CVD) makes the missing at random assumption plausible. We note that the results from the complete case analysis (Table 5) are essentially equivalent to those from the multiple imputation analysis (Table 4). In the current study, where data were missing only in the predictors, a complete case analysis is unbiased if the missingness mechanism is unrelated to the outcome (CVD status) (34). For the covariate with the most missing data (use of musculoskeletal medications with 134/1477 missing), 9.7% of those with no CVD had missing data versus 7.2% of those with CVD. The similarity of these proportions suggests that the missingness is unrelated to the outcome, and a complete case analysis is unbiased. The only benefit of using multiple imputation in the current study, therefore, was to avoid any unnecessary loss of power and precision. However, with our relatively large sample size, there is no discernible gain in precision by including an additional 150 participants in the analysis, as indicated by the similar width of the confidence intervals for the risk ratios for complete case versus multiple imputation analyses.

It is important to acknowledge a number of limitations. First, a cross-sectional study is prone to a number of sources of bias. These include reverse causation/temporal bias, which constrains inferences to association only, and incidence-prevalence bias. Secondly, the reallocation of time in our analysis is, of course, not true isotemporal substitution (for which an experimental design would be required). Thirdly, whilst physical activity was measured objectively using the Actigraph™, distinguishing between the postures of lying/sitting and quiet standing is difficult using count-based accelerometry data (1). Therefore, posture-based objective measures (16) may provide a more sensitive measure of sedentary behavior.

It is also noteworthy that the Health Survey for England used a cut-off of 0-199 cpm to classify sedentary behavior, while evidence suggests 150 cpm to be optimal (23). As this study was constrained to the Health Survey for England cut-off points, it is possible that more activity was classified as sedentary, compared to if the empirically-based lower cut-off point had been used. Future research would benefit from assessing sedentary behavior using both cut-off points to investigate the potential impact of this data-processing decision. In addition, it could be argued that due to the physiological decline associated with ageing, a lower absolute cpm threshold for MVPA would have been more appropriate to categorize relative MVPA intensity in older adults. It has been proposed that a cut-off point as low as 1040 cpm equates to the threshold for moderate intensity activity in older adults (7, 19), which is around half the cut-off point (2020 cpm) used in the Health Survey for England for all adults. Thus, the amount of MVPA undertaken by older adults in this study might have been underestimated.

The findings from this study have a number of potential implications for future research. First, given the current limited evidence base (6) there should be a focus on the development and implementation of more randomized controlled trials of interventions specifically aimed at reducing sedentary activity and replacing it with different levels of physical activity. This research should include the continued exploration of new technology (22), and the investigation of multilevel determinants of different sedentary behaviors, tailored to the needs of specific groups (29). This issue is particularly important for older adults who are more likely to have functional limitations and a range of residential/hospital care settings, all of which may impact upon their sedentary behavior (15). Second, more research is required to further validate the findings presented in this study, using prospective study designs (observational and randomized controlled trials) to evaluate proposed causal pathways, including the potential modifying effect of age. Third, obtaining more robust answers to research questions in this field likely requires the use of new, more sensitive, objective technology for measuring sedentary behavior such as posture-based accelerometers (16).

Substituting sedentary time with MVPA has a small protective association with CVD prevalence. However, the relationship is influenced by age with MVPA becoming decreasingly important in older individuals. Prospective studies are needed to confirm and further investigate these relationships.

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CONFLICT OF INTEREST

The authors have no conflicts of interest to declare. The results of the present study do not constitute endorsement by ACSM.

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Table 1. Key Characteristics for Included and Excluded Cases.

	Included n = 1477^	Excluded n=3030*
Age (years)	62.8 (11.0)	46.1 (19.4)
Sex		
Men	45.8%	43.6%
Women	54.2%	56.4%
Socio-economic status		
1 (least deprived)	25.4%	22.4%
2	23.5%	19.1%
3	19.1%	19.1%
4	16.7%	19.7%
5 (most deprived)	15.3%	19.6%
Diet		
<2 portions of fruit and vegetables	17.3%	24.5%
2-4 portions of fruit and vegetables	50.8%	48.5%
≥5 portions of fruit and vegetables	31.9%	27.0%
Anxiety/Depression		
Not anxious/ depressed	70.2%	79.8%
Moderately anxious/ depressed	18.5%	19.2%
Extremely anxious/ depressed	1.3%	2.0%
Using musculoskeletal medicine	11.5%	6.1%
Alcohol intake		
No units/day	31.2%	38.5%
≤4 (men), ≤3 (women) units/day	36.6%	25.8%
≥4 and ≤8 (men), >3 and ≤6 (women) units/day	18.8%	16.0%
>8 (men), >6 (women) units/day	13.5%	19.7%
Smoking history		
Never smoked	44.3%	48.1%
Used to smoke	40.2%	28.5%
Current smoker	15.5%	23.4%
Endocrine and metabolic condition present	13.5%	7.8%
CVD condition present	23.6%	12.5%
Sedentary time/day (min)	592.7 (88.8)	553.6 (98.1)
Light physical activity/ day (min)	218.0 (81.5)	233.1 (77.5)
MVPA/day (min)	23.7 (23.6)	35.6 (26.1)
MVPA/day (min) [median (IQR)]	16.8 (6.7 - 34.1)	30.0 (17.0 – 47.3)

Data are mean (SD) unless stated.

CVD - cardiovascular disease, MVPA – moderate to vigorous physical activity

Median and interquartile range (IQR) is presented for MVPA as this variable was severely skewed.

^n=1477 for all variables except: Anxiety/depression n=1458, musculoskeletal medication use n=1343.

*n=3030 for all variables except: Anxiety/depression n=2831, diet n=3029, musculoskeletal medication use n=2044, alcohol intake n=2992, smoking history n=3002.

Table 2. Key Characteristics for Complete Case and Missing Data Groups.

	Complete n = 1327	Missing n = 150*
Age (years)	63.0 (11.0)	61.9 (10.7)
Sex		
Men	46.1%	42.7%
Women	53.9%	57.3%
Socio-economic status		
1 (least deprived)	25.9%	20.7%
2	23.6%	22.7%
3	18.7%	22.7%
4	17.1%	13.3%
5 (most deprived)	14.7%	20.7%
Diet		
<2 portions of fruit and vegetables	17.2%	18.0%
2-4 portions of fruit and vegetables	51.1%	48.0%
≥5 portions of fruit and vegetables	31.7%	34.0%
Anxiety/Depression		
Not anxious/ depressed	79.8%	84.0%
Moderately anxious/ depressed	18.8%	16.0%
Extremely anxious/ depressed	1.4%	0.0%
Using musculoskeletal medicine	11.6%	6.3%
Alcohol intake		
No units/day	32.1%	23.3%
≤4 (men), ≤3 (women) units/day	35.8%	43.3%
≥4 and ≤8 (men), >3 and ≤6 (women) units/day	18.5%	20.7%
>8 (men), >6 (women) units/day	13.6%	12.7%
Smoking history		
Never smoked	44.4%	43.3%
Used to smoke	40.2%	40.6%
Current smoker	15.4%	16.7%
Endocrine and metabolic condition present	13.8%	10.7%
CVD condition present	24.0%	20.0%
Sedentary time/day (min)	593.2 (88.3)	588.9 (93.7)
Light physical activity/day (min)	218.4 (81.9)	214.4 (77.9)
MVPA/day (min)	23.9 (24.0)	21.5 (19.8)
MVPA/day (min) [median (IQR)]	16.8 (6.9 – 34.3)	16.8 (6.1 – 31.8)

CVD - cardiovascular disease, MVPA – moderate to vigorous physical activity.
Data are mean (SD) unless stated.
Median and interquartile range (IQR) is presented for MVPA as this variable was severely skewed.
*n=150 for all variables except: Anxiety/depression n=131, musculoskeletal medication use n=16

Table 3. Isotemporal Substitution of a 10-Minute Unit of Sedentary Time With LPA or MVPA.

	LPA		MVPA	
Model	Risk Ratio	95% CI	Risk Ratio	95% CI
Age	0.97	0.95, 0.98	0.89	0.82, 0.96
Age/sex	0.97	0.96, 0.99	0.87	0.81, 0.94
All covariates	0.97	0.96, 0.99	0.88	0.81, 0.96

LPA - Light physical activity; MVPA - Moderate-to-vigorous physical activity, CI - confidence interval.
All covariates model adjusted for: Age, sex, smoking status, socio-economic status, diet, alcohol intake, anxiety/depression, musculoskeletal medication.

Table 4: The effect of substituting a 10-minute unit of sedentary time with Moderate-to-vigorous physical activity by age.

Age	Risk Ratio	95% CI
50	0.80	0.71, 0.91
55	0.84	0.76, 0.93
60	0.87	0.80, 0.95
65	0.91	0.84, 0.98
70	0.94	0.87, 1.02
75	0.98	0.90, 1.07
80	1.02	0.92, 1.14
85	1.06	0.94, 1.21

CI - confidence interval.
All covariates model adjusted for: Age, sex, smoking status, socio-economic status, diet, alcohol intake, anxiety/depression, musculoskeletal medication.

Table 5. Isotemporal Substitution of a 10-Minute Unit of Sedentary Time With LPA or MVPA from analysis of complete cases only (n=1327)

	LPA		MVPA	
Model	Risk Ratio	95% CI	Risk Ratio	95% CI
Age	0.97	0.95, 0.98	0.90	0.83, 0.98
Age/sex	0.97	0.95, 0.99	0.89	0.82, 0.96
All covariates	0.97	0.96, 0.99	0.89	0.82, 0.97

LPA - Light physical activity; MVPA - Moderate-to-vigorous physical activity, CI - confidence interval.
All covariates model adjusted for: Age, sex, smoking status, socio-economic status, diet, alcohol intake, anxiety/depression, musculoskeletal medication.

Figure 1: Sampling Process Flow chart