Motivational counseling for reduction of sitting time.

A community-based randomized controlled trial in sedentary adults

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ABSTRACT

Background: Sedentary behavior is regarded as a distinct risk factor for cardio metabolic morbidity and mortality, but knowledge of the efficacy of interventions targeting reductions in sedentary behavior is limited. **Purpose:** To investigate the effect of an individualized face to face motivational counseling intervention aimed at reducing sitting time. **Design:** A randomized, controlled, observer-blinded community-based trial with two parallel groups using open-end randomization with 1:1 allocation. **Setting/participants:** A total of 166 sedentary adults were consecutively recruited from a population-based study 'The Health2010 Study'. **Intervention**: Participants were randomized to a control (usual lifestyle) or an intervention group with 4 individual theory-based counseling sessions. **Main outcome**: Objectively measured overall sitting time (ActivPAL 3TM, 7 days); secondary measures were breaks in sitting time, anthropometric measures and cardio metabolic biomarkers, assessed at baseline and after six months. **Analysis**: Repeated measures multiple regression analyses. **Results**: N=93 were randomized to the intervention group, n=73 to the control group, n=149 completed the study. The intervention group had a mean sitting time decrease of -0.27 h/day, corresponding to 2.9% of baseline sitting time (h/day), the control group increased mean sitting time by 0.06 h/day. The between-group difference in change, -0.32 h/day (95% CI -0.87 to 0.24, p=0.26) was not statistically significant. Significant differences in change in fasting serum insulin of -5.9 pmol/l (95% CI -11.4 to -0.5, p=0.03), in HOMA-IR of -0.28 (95% CI -0.53 to -0.03, p=0.03) and in waist circumference of -1.42 cm (95% CI -2.54 to -0.29, p=0.01) were observed in favor of the intervention group. **Conclusion:** Although the observed decrease in sitting time was not significant, a community-based individually tailored theory-based intervention program aimed at reducing sitting time may be effective for increasing standing and improving cardio metabolic health in sedentary adults. Trial registration at ClinicalTrial.gov (NCT00289237). Data were collected 2010-2012, and analyzed 2013-2014.

INTRODUCTION

Recent evidence suggests that sedentary behavior may be a distinct risk factor for cardiovascular morbidity and mortality, independent of leisure-time moderate and vigorous physical activity (MVPA).[1-9] The detrimental health effects of sedentary behaviors, (e.g. during TV-viewing) [1;3-5;10;11] and overall sitting during the day [2;6-8;12;13] have been shown in observational studies. Additionally, the number of breaks in sitting time may be inversely associated with the cardio metabolic risk profile.[14] It has been proposed that targeting increased participation in MVPA may not be sufficient to offset the health hazards associated with excessive sitting. In a group of healthy middle-aged and elderly women, participation in sustained 10-minute bouts of objectively measured MVPA was unrelated to objectively measured duration of daily sitting time.[15] Recent experimental studies also suggest that neither recommended levels of MVPA [16] or restricted energy intake [17] can fully compensate the negative cardio metabolic health effects of sitting.

Sedentary behavior is defined as 'any waking behavior characterized by an energy expenditure ≤1.5 Metabolic Equivalents while in a sitting or reclining position'.[18] Adults in western societies spend 45-60% of their waking hours in sedentary pursuits, a stark contrast to the small proportion of total time spent in MVPA (5%).[19-22] Reduction of sitting time therefore represents a potential target for promotion of health and prevention of chronic disease.

Recently, a number of studies have reported on the effects of interventions aimed at reducing and breaking up sedentary time in different settings and populations.[23-29] Generally, studies have been small scale feasibility studies with theory-based behavioral interventions,[26;27] short-term experimental studies [24;28] or work-site intervention studies conducted in small convenience samples.[23;25;29] Those studies have shown that reduction of sitting time is possible [23;25-29] with reductions ranging from 3-4% of total daily sitting time [26;27] up to approximately 25% of working

hours.[23;25;29] Additionally, positive cardio metabolic effects have been observed in some studies.[23;24] However, there is a need for randomized trials conducted in population-based study samples in order to confirm that the possible beneficial effects of reducing sitting time are achievable in community settings, and to obtain un-biased estimates of the effects on various health outcomes.

Therefore the aim of the present study was to investigate the efficacy of an individually tailored theory-based, motivational counseling intervention on objectively measured sitting time, number of breaks in sitting time, anthropometric measures and cardio metabolic biomarkers, in a population-based sample of sedentary adult men and women. We hypothesized that daily sitting time could be reduced, that number of breaks in sitting time could be increased and that cardio metabolic biomarkers and anthropometric measures could be improved.

METHODS

Setting and Participants

Participants for the present randomized controlled trial (RCT), 'Sedentary Intervention Trial' (SIT) were consecutively recruited from 'The Health2010' study, a population-based epidemiological study carried out at The Research Centre for Prevention and Health (RCPH). A random sample of 3,762 men and women between 18 and 69 years of age and living in ten municipalities in the Western part of the Capital Region of Denmark was initially drawn through the Danish Civil Registration Office. The Health 2010 participants (N=1,522, response rate 40.5 %), who self-reported at least 3.5 hours of daily leisure time sedentary behaviors were eligible and approached to participate in the present sedentary behavior trial ('SIT'). The 3.5 h/day corresponded to the median daily leisure time sitting in a previous population study with similar age and gender distribution.[30] Additional eligibility criteria included: comprehension of the Danish language, self-report of

maximum 8 hours of vigorous physical activity per week [31], not having a handicap or a functional limitation that prevented reduction of sedentary behavior (e.g. being wheel-chair bound).

All eligible participants, approached in the period November 23rd 2010 – August 24th 2011, were given thorough oral and written information about participation in the 'SIT' study by one of two research nurses and written informed consent was obtained from all interested participants before formal inclusion in the 'SIT'. The six month follow-up examinations were concluded on the 1st of March 2012. Ethical approval was obtained from the Ethics Committee of the Capital Region of Denmark (H-1-2010-072) and the study was registered at ClinicalTrial.gov (NCT00289237).

Randomization and blinding

After inclusion, participants were instructed to wear an ActivPAL 3TM® inclinometer [32;33] for a 7-day period. The ActivPAL data were processed by a 'blinded' investigator and the data was not shown to the participant. Participants were then allocated to the control or intervention group by 'open end' randomization using computer-generated random numbers (Microsoft® Access, 'Random' function), operated by a blinded data manager.

Participants returned to the centre after six months to initiate a follow-up 7-day ActivPAL measurement followed by a health examination. Although this was an open trial whereby participants and some of the researchers were aware of randomization group, the research staff conducting the objective measurements and data processing was blinded to the randomization.

Intervention and control group

The behavior change intervention program consisted of four individual theory-based face to face sessions conducted by one of two research nurses. The sessions took place with approximately six-week intervals during a six month period, with the first session taking place on the day the

participants were randomized and notified about their allocation status. Each session lasted between 30 and 45 minutes. The behavior change intervention program was based on behavioral choice theory,[34] incorporating individual behavior goal setting, self-efficacy,[35] and motivational interviewing techniques.[36;37] Participants set specific individual goals for change in sedentary behavior by identifying adequate behavior substitutes or choices and by initiating small changes in availability and access to sedentary behavior in their daily lives [34] (e.g. 'I will go to the kitchen for coffee refill when watching TV instead of leaving the coffee pot on in the table in front of me', 'I'll raise my desk to a standing position at the end of a work day, when going to lunch or for a meeting during the day'). At each of the following sessions (sessions 2-4), behavior goals were reviewed and evaluated. Together with the research nurse goals were modified and new goals were set.

The intervention program focused on 4 key messages or themes:

1. Reduce daily TV-viewing

2. Substitute sitting with standing when possible – at work and/or at home. (No time restrictions)

3. Break up prolonged sitting – by standing up frequently

4. Maximum 30 minutes of sitting per episode

Written materials containing these key messages, including strategies and suggestions for reduction of sitting time, were handed out to participants at each session in purposefully developed booklets and on postcards and stickers. One key message was introduced at each session along with the corresponding written material. No specific messages were directed at MVPA.

Participants randomized to the control group were instructed to maintain their usual lifestyle from randomization to the end of the 6 month follow-up period. After the follow-up assessments were completed at the end of the study, participants in the control group were given a single 45-minute

session with individual counseling on reduction of daily sitting time – corresponding to a shortened or compact version of intervention group program.

Primary outcome

The outcomes were assessed by identical methods in all participants at baseline and after six months. The primary outcome, total volume of daily sitting, and the secondary outcome, number of breaks in sitting time, were assessed by objective measurement over 7 days after inclusion in the study, the *baseline period,* and again the last 7 days before the follow-up health examination, the *follow-up period*. Measurements were obtained using an ActivPAL 3TM® Activity Monitor (PAL Technologies, Glasgow, Scotland, UK). This is a small (2.0 x 1.4 x 0.3 inches) and light (20.1 grams) triaxial accelerometer-based device which is worn on the anterior upper right thigh and kept in place by an adhesive pad, a Palstickie®, supplied with the monitor. The monitor uses accelerometer-derived information about thigh position to estimate time spent in different body positions (i.e. sitting/lying, standing and stepping). Data were processed using the ActivPAL software (version 6.4.1) as 0.05 second events.[38] The ActivPAL monitor has previously been validated against direct observation[32;33] and is currently considered the best choice for objective measurement of sitting/lying. The ActivPAL has also been found to be sensitive to change in sitting time.[32]

During the ActivPAL measurement period, participants kept a log sheet, reporting when they went to bed at night, when they awoke in the morning, and any other time they were lying down sleeping or resting in bed during the day. The ActivPAL was to be removed for showering, bathing, or swimming, which was also reported.

Secondary outcomes

Self-reported sitting time at work and during leisure on an average weekday was measured by a questionnaire, the Physical Activity Scale 2.1.,[31] a modified version of the Physical Activity Scale.[39;40] Construct validity of PAS 2.1. has previously been established by cognitive interviewing.[31] Information on weekly MVPA, sociodemographic characteristics, and other lifestyle variables was also reported by questionnaire.

Anthropometric measures: Height was measured without shoes to the nearest centimeter; weight was measured in light clothing without shoes to the nearest 0.1 kg along with body fat % by bioelectrical impedance (Tanita BC-420MA), and BMI was calculated as kg/m^2. Waist circumference was measured midway between the lower rib margin and the iliac crest to the nearest 0.5 centimeter with a non-elastic tape measure.

Cardio metabolic biomarkers: Venous blood samples were drawn after an overnight fast (≥ 8 hours). Fasting serum insulin levels were analyzed using fluoro-immunoassay (Auto-Delfia; Perkin Elmer, Waltham, MA, USA) and fasting plasma glucose levels were enzymatically analyzed by the hexokinase/glucose-6-phosphate dehydrogenase (G6PDH) method (Hitachi 912; Roche diagnostics, Indianapolis, IN, USA). Using the homeostasis model assessment (HOMA), hepatic insulin resistance (HOMA-IR) and basal insulin secretion (HOMA %B) were estimated from fasting glucose and insulin levels.[41] The proportion of HbA_{1c} was assessed using high-pressure liquid chromatography (HPLC, Tosoh G7, Roche Diagnostics). Total cholesterol, high-density lipoprotein cholesterol (HDL), and triglycerides were measured by enzymatic procedures (BoeringerMannhein, Germany). Low-density lipoprotein cholesterol (LDL) was calculated by Friedewald's formula.

Statistical analysis

Data are presented as mean (standard deviation) or as frequencies (%). General linear mixed models for repeated measures ANCOVA (SAS proc mixed) were performed to determine the effect of the intervention on the primary and secondary outcomes by including an interaction term between randomization group (intervention vs. control) and time from baseline to 6 months follow-up. Selection of co-variates was based on being differently distributed between intervention and control group at baseline and results are presented in an unadjusted model and a model adjusted for sex and work status. Loss to follow-up was assumed to be missing at random.

All data processing and analyses were performed in SAS (version 9.3) and mixed model analyses were performed using SAS Proc Mixed procedure. A significance level of 0.05 was chosen.

Sample size

Power calculations were performed before the initiation of the study. In a previous population-based study of a similar age and gender distribution,[30] participants with ≥3.5 hours of self-reported leisure time sitting per day had a mean self-reported leisure time sitting duration of 4.96 (1.64) hours per day. We expected an intervention effect of approximately 45 minutes of reduction in sitting time per day, based on findings in a feasibility study by Kozey-Keadle et al.[27] Assuming an alpha and beta of 0.05 and 0.2, respectively, we calculated that 150 participants should be included in the study. Moreover, we expected approximately 10% attrition, and hence, included 166 participants for randomization in the present study.

RESULTS

Participant flow and baseline characteristics

During the inclusion period, 689 Health2010 participants were assessed for eligibility. Among these, 299 (43% of participants assessed for eligibility) met eligibility criteria (Figure 1), and 171 (57% of eligible participants) initially consented to participate and started the 7-day baseline ActivPAL monitoring period. Five participants withdrew after initially accepting participation, but before randomization; one due to skin reaction to the adhesive ActivPAL 'Palstickie', whereas four withdrew for undisclosed reasons. Recruitment and inclusion was terminated when 166 participants were consecutively randomized after completion of the pre-randomisation ActivPAL measurements. Randomization resulted in 73 participants being assigned to the control group and 93 to the intervention group. Between randomization and the six month follow-up, five participants (6.8%) withdrew from the control group and 12 participants (12.9%) withdrew from the intervention group. The most frequently reported reason for withdrawal was lack of time (Figure 1).

There was a similar gender distribution (53% women) in participants (n=166) and non-participants from the H2010 Study sample (n=523), whereas mean age in participants was slightly higher (51.3 (14.2)) than in non-participants (47.3 (13.7)).

Despite the rather uneven number of participants, the two randomized groups appeared relatively well balanced (table 1) with the exception of an uneven gender distribution with 63 % women in the intervention group vs. 49 % in the control group. Likewise, 60 % of participants in the intervention group were not working, as opposed to only 47% in the control group. Median sitting time was 9.49 h/day (interquartile range: 8.19 – 10.50) in the intervention group and 9.64 h/day (interquartile range 8.61 – 10.69) in the control group.

Data quality and attendance

The minimum number of valid days accepted for inclusion of ActivPAL data were 2 full days of measurement. Measurements were only considered valid, if the monitor had been removed less than

2 hours per day for showering, bathing or swimming. At baseline, three participants had missing ActivPAL data because of defective recording with the ActivPAL monitors or corrupt files. Two participants had two full days of measurement only, 5 participants had 4 days of measurement, and all others (n=156) had 5-7 days of measurement. At the six month follow-up, two participants had incomplete and missing data due to monitor problems, two participants had 3 full days of measurement only, 4 participants had 4 days of measurement, whereas all others (n=141) had 5-7 days of measurement. One of the participants with missing ActivPal data at baseline later dropped out of the study leaving ActivPal data from n=79 and n= 66 participants in the intervention and the control group, respectively.

Attendance to the counseling sessions in the intervention group was nearly complete. Only two participants were unable to meet at the Centre for counseling session number four, but the intervention material was sent by mail instead.

Effectiveness of the intervention

Objectively measured daily sitting time decreased in the intervention group and increased in the control group, however, the difference in change between groups in favor of the intervention group was not statistically significant -0.32 h/day (95% CI -0.87 to 0.24, p=0.26) (Table 2) With further adjustment for sex and work status, the significance level was unchanged (table 2). In the intervention group, the reduction in objectively measured sitting time was -0.27 h/day, corresponding to a 2.9% reduction in daily sitting time compared to baseline. In the intervention group the median change in sitting time was -0.14 h/day (interquartile range -1.09 to 0.72). In the control group median change in sitting time was -0.07 h/day (interquartile range -0.7 to 0.68). In the intervention group, 32% (n=25) reduced their daily sitting time at least 0.75 h/day, whereas a similar reduction in sitting time was found in 24% (n=16) of the control group.

For objectively measured standing time, there was a significant difference in change in favor of the intervention group of 0.44 h/day (95% CI 0.08 to 0.80, p=0.02). Results in favor of the intervention group were also seen for objectively measured stepping time, however this was not statistically significant (p=0.11). No significant differences in change in number of breaks were found (Table 2).

Change in self-reported leisure time sitting was significantly more pronounced in the intervention than in the control group: mean difference in change from baseline to 6 months was -0.81 h/day (95% CI -1.36;-0.27, p=0.004). In contrast, there were no significant differences in change in self-reported sitting at work, (Table 2). For the other secondary outcomes, anthropometric and cardio metabolic biomarkers, there was a mean difference in change in waist circumference from baseline to 6 months of -1.42 cm (95% CI -2.54 to -0.29, p=0.01) in favor of the intervention group (Table 3). When adjusted for sex and work status, this finding remained statistically significant (p=0.01). For weight and body fat, there were small differences in change in favor of the intervention group, but differences were not statistically significant (Table 3). Finally, the difference in change in serum insulin was -5.9 pmol/l (95% CI -11.4 to-0.50, p=0.03), and -0.28 (95% CI -0.53 to-0.03, p=0.03) in insulin resistance, estimated by HOMA-IR, in favor of the intervention group. There was no statistically significant effect of the intervention on serum lipids, fasting glucose, HOMA-%B or HbA_{1c} (Table 3).

Analyses were also performed with sitting time expressed as percentage of waking hours (non-sleep wear-time) and with break-rate (breaks per hour of sitting time), as suggested by Lyden et al.[42] However, results were essentially unchanged (data not shown).

DISCUSSION

In this population-based study sample of community-dwelling adults, a six month individually tailored theory-based intervention program aimed at reducing daily sitting time was effective for improving cardio-metabolic biomarkers. The overall sitting time was reduced by 2.9% in the intervention group, but this reduction was not statistically different when compared to the control group. However, standing time significantly increased in the intervention group and fasting serum insulin level, HOMA-IR and waist circumference were reduced. To our knowledge this is the first randomized trial to investigate the effects of a behavioral intervention targeted at reducing overall sedentary behavior in a population-based sample of sedentary adults.

Recent non-worksite intervention studies have employed strategies aimed at reducing sedentary behavior in older adults [26] or in overweight and obese adults.[27;28] Only one of these studies had a randomized control group and applied a TV-lockout intervention (usual daily TV-viewing time was reduced to half by using a TV-lockout device),[28] whereas two studies used behavioral interventions.[26;27] Generally, these studies found reductions in objectively measured sitting time from 3.2% to 4.3%.[26-28] In comparison, the reduction in objectively measured sitting time in the intervention group in our study was 2.9%.

Previous intervention studies have targeted the reduction in sitting time at the work site, either through point-of-choice prompts to reduce sitting time at work,[25] installation of Sit-Stand workstations,[23] or a multicomponent intervention comprising organizational, environmental and individual elements.[29] One study found no effect on total sitting time, but a significant effect on the number of and duration of sitting events.[25]Another study found a decrease in overall daily ActivPAL measured sitting time of 97 minutes and an increase in HDL cholesterol of 0.26 mmol/l in the intervention group, whereas no other significant biomarker differences were found.[23] A recent study found a workplace sitting time reduction of 125 minutes per day following a four-week intervention period, but no statistically significant effects on anthropometric or cardio-metabolic

309 health outcomes.[29] In comparison, in the present study a mean decrease of 16 minutes per day was
310 found in the intervention group, but no effect of the intervention on lipid parameters. However, the
311 present study differed markedly from the work site studies in several ways. The worksite studies
312 included - presumably rather homogeneous – samples of employees from academic institutions or
313 government agencies, whereas participants in this study were a relatively heterogeneous group of
314 adults recruited from a population-based study sample. The interventions in the occupational studies
315 included specific work site installations, thus the physical environment was altered to be more
316 conducive to standing during the work day, whereas the intervention in this study was behavioral,
317 individualized, and addressed all domains of daily life. Furthermore, the present study had a longer
318 intervention period.

319 The finding of significant differences in fasting serum insulin of 5.9 pmol/l and in HOMA-IR of
320 -0.28 in favor of the intervention group is consistent with results from the recent experimental study
321 by Stephens et al.[17] The acute response of 1 day of prolonged sitting was a sizeable reduction (18%)
322 in insulin action over 24 hours compared to a condition where sitting was minimized. Likewise, in
323 another experimental crossover trial in overweight or obese adults,[24] Dunstan and colleagues found
324 an acute lowering effect of breaking up prolonged sitting time by light or moderate intensity
325 physical activity breaks on postprandial glucose and insulin responses, when compared to a day of
326 prolonged sitting. A study by Duvivier and colleagues found a beneficial effect of adding periods of
327 light intensity activity or MVPA to a 14 hour a day sitting regime on insulin sensitivity and fasting
328 triglycerides and non-HDL cholesterol.[16] Another recent randomized crossover study by Peddie et
329 al found a beneficial effect on insulin and glucose levels of interrupting prolonged sitting by regular
330 short activity breaks (vigorous treadmill exercise (7.4 METs)), but no effect on triglyceride level.[43]

331 The intervention effects in the present study appear modest from a clinical or individual
332 perspective. From a public health perspective, however, the magnitude of the improved fasting

serum insulin and the reduction in waist circumference, if sustained in the longer term, could potentially have a significant impact at population level.[44]

The present study has some strengths and limitations. Strengths include the objective measurement of sedentary behavior and cardio-metabolic biomarkers, the relatively large population-based study population, and the fact that the study was undertaken in a community setting under free-living conditions. The latter two makes generalizability relatively high and findings can most likely be generalized to other adult, populations with moderate to high sitting time. A limitation is that outcome assessors were not fully blinded. The two nurses who conducted the motivational counseling sessions also performed the six month follow-up examination. However, the primary outcome, objectively measured sitting time, and cardio metabolic biomarkers were processed by blinded investigators and are hence unlikely to have been affected by the nurses' knowledge of participants' allocation status. Ideally, sitting time should have been measured continuously throughout the intervention period, as the 7-day baseline and follow-up measurement periods are not necessarily representative of sedentary behavior in the remaining 23 weeks. Consequently adherence to the intervention program cannot be evaluated by objective measures. Another possible limitation of the study is the uneven number of participants allocated to intervention and control group. This risk exists when using 'open ended' randomization, which is, however, also considered the optimal form of randomization, as it renders an equal chance of group allocation to every participant. Finally, no detailed measurement of dietary habits was included in the present study. It therefore cannot be ruled out that intervention group participants were generally made conscious of lifestyle health issues and improved their dietary habits as a result of the intervention. This possible spill-over effect of the intervention may potentially have contributed to the positive changes, for example the reduction in waist circumference in the intervention group. Likewise, it cannot be fully ascertained whether the observed changes in cardio metabolic markers have in fact occurred as a

result of reduction in sitting time or whether increases in MVPA have contributed. Although results indicate that standing time increased significantly in the intervention group compared to the control group, the intervention may have affected cardio metabolic biomarkers via various pathways.

The rate of drop-out was relatively low (10.2%), but it was still twice as high in the intervention group relative to the control group. This indicates that the time commitment for the intervention group participants may have been an obstacle to some participants.

The study population in the present study was rather heterogeneous with a large variation in baseline sitting time, baseline MVPA level and change in sitting time. Future studies should therefore aim to identify subgroups with high/low responsiveness. Maintenance of reduction in sitting time and improvement of cardio metabolic biomarkers is another aspect that should be further investigated in future studies with longer follow-up time.

In conclusion, our findings suggest that a six month individually tailored theory-based intervention program may increase standing time, improve fasting serum insulin and reduce waist circumference in sedentary men and women recruited from a population-based study sample. Future studies should investigate different types of interventions targeted at reduction and break up of sitting time in order to provide further directions for public health action against the detrimental health effects of sedentary behavior.

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The authors declare that there was no racial or gender bias in the selection of participants.

Contributorship

TJ, DRW, DWD, AL and MA were responsible for the conception and design of the study. TJ, AL MA, TR and SR were involved in the design of the study and development of the intervention. MA analysed data and wrote first draft of the manuscript. DRW, DWD, TJ, AL and MA discussed data analyses and interpretation and contributed to subsequent versions of the manuscript. DRW, DWD, TJ, AL, TM, SR and MA critically revised the manuscript and approved the final version of the manuscript.

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534 **Figure Legend**

535 **Figure 1:** Consolidated Standards of Reporting Trials (CONSORT) diagram of participants' flow
536 through the trial.

Figure 1: Consolidated Standards of Reporting Trials (CONSORT) diagram of participant's flow through the trial.

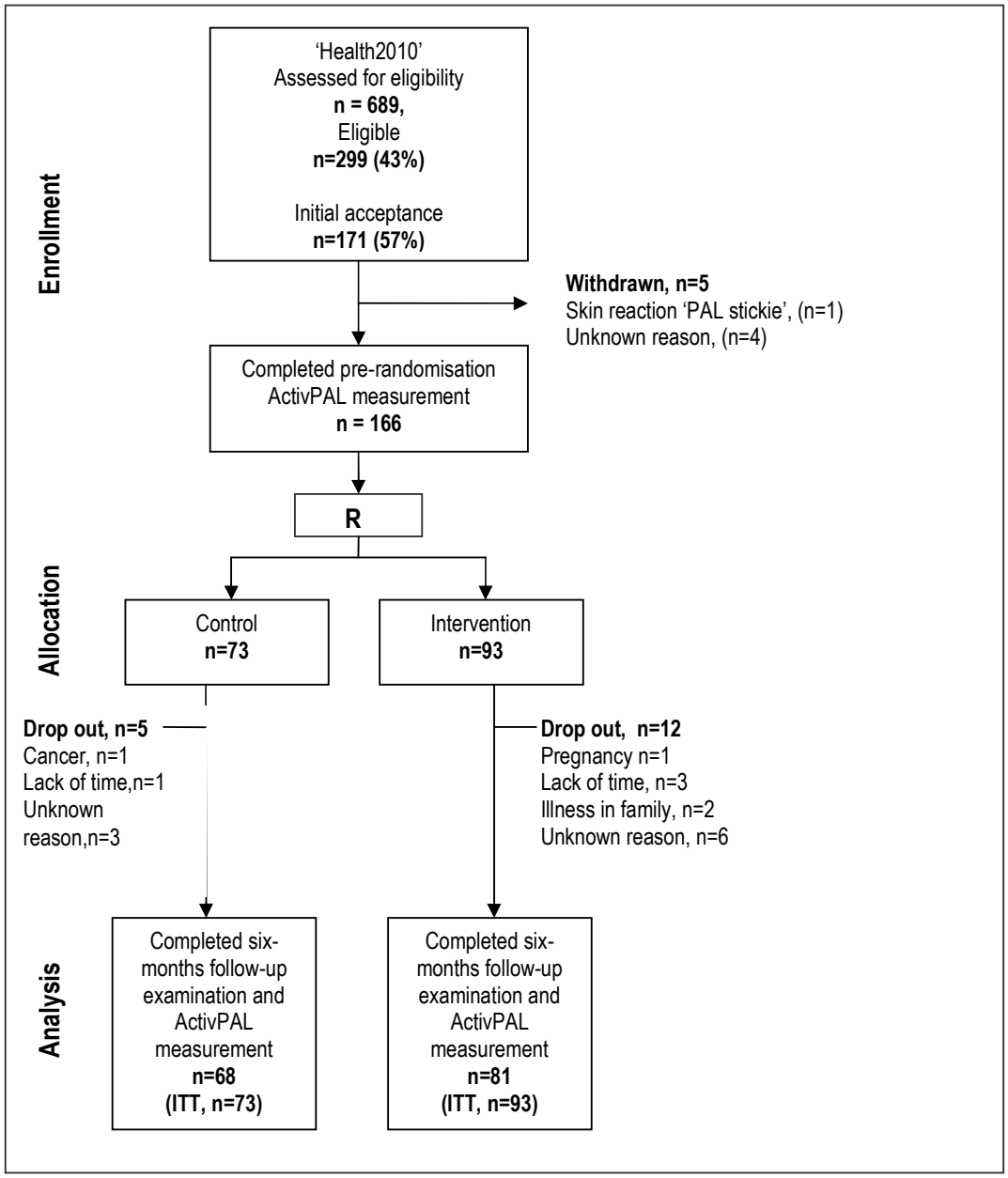

Table 1. Baseline characteristics of participants by randomisation group.
Data are presented as mean (SD), unless otherwise stated.

Characteristic	Intervention N=93	Control N=73
Women (%)	63%	49%
Age (years)	52.2 (13.8)	51.8 (14.3)
Seasonal variation, *(included winter, (%))*	51%	53%
Daily smokers (%)	16%	15%
Employment status (*not working (%)*)	60%	47%
Sitting time (ActivPAL) [a] *h/day*	9.29 (2.0)	9.78 (1.8)
Standing time (ActivPAL) [a] *h/day*	4.15 (1.1)	4.10 (1.2)
Stepping time (ActivPAL) [a] *h/day*	1.78 (0.6)	1.74 (0.7)
Number of breaks (ActivPAL)[a] *per day*	60.2 (17.8)	59.6 (19.2)
Total non-sleep wear time (ActivPAL) [a] *h/day*	15.3 (1.2)	15.7 (1.0)
Self-reported vigorous physical activity *h/week* [b]	0.5 (0.0-2.0)	0.0 (0.0-1.0)
Self-reported moderate physical activity *h/week* [b]	2 (0.5-5.0)	2 (1-4.0)
BMI, kg/m^2	27.1 (5.1)	27.5 (4.9)
Weight, *kg*	79.0 (15.7)	82.1 (17.0)
Waist circumference, *cm*	92.7 (12.9)	95.2 (14.3)
Body fat (%)	32.8 (9.0)	32.1 (9.7)
Cholesterol, *mmol/l*	5.30 (0.9)	5.31 (1.1)
HDL cholesterol, *mmol/l*	1.57 (1.5)	1.51 (1.4)
LDL cholesterol, *mmol/l*	3.18 (3.0)	3.20 (3.0)
Triglycerides, *mmol/l*	1.17 (1.0)	1.32 (1.2)
Fasting plasma glucose, *mmol/l*	5.48 (0.9)	5.71 (1.1)
Fasting serum insulin, *pmol/l*	50.26 (43.4)	54.55 (46.9)
Fasting HbA_{1c}, %	5.57 (0.5)	5.59 (0.6)
Fasting HbA_{1c}, mmol/mol	37.5 (5.6)	37.6 (6.7)
HOMA-IR (insulin resistance)[b, c]	1.41 (0.9-2.1)	1.63 (1.1-2.6)
HOMA-%B (basal insulin secretion)[b, c]	68.3 (44.8-93.4)	73.0 (44.9-97.9)

[a] ActivPAL baseline data for n=91 intervention group participants and n=72 control group participants only.
[b] Median and interquartile range.
[c] Homeostatis Model Assessment

Table 2: Change in sitting time, physical activity & wear time from baseline to 6 month follow-up.

	Intervention group mean (SD)			Control group mean (SD)			Intervention vs. control group Mixed models [#]		
Outcome (*intervention n; control n)*	**Baseline**	**6 months**	**Within particip. change**	**Baseline**	**6 months**	**Within particip. change**	**Difference in change, between groups mean (95%CI)**	**p**	**p[§]**
Objective measures by ActivPAL									
Sitting, ActivPAL, h/day (79;66)	9.3 (1.8)	9.0 (1.7)	-0.27 (1.7)	9.8 (1.8)	9.9 (1.8)	0.06 (1.7)	-0.32 (-0.87;0.24)	0.26	0.31
Breaks (sitting), ActivPAL, no/day (79/66)	59.9 (15)	60.3 (15)	0.5 (14.8)	59.2 (19)	59.7 (18)	0.4 (12.2)	-0.74 (-5.8; 4.4)	0.77	0.69
Standing, ActivPAL, h/day (79;66)	4.2 (1.1)	4.4 (1.3)	0.21 (1.0)	4.1 (1.2)	3.9 (1.3)	-0.22 (1.2)	0.44 (0.8; 0.80)	**0.02**	**0.02**
Stepping, ActivPAL, h/day (79;66)	1.8 (0.6)	1.9 (0.6)	0.1 (0.5)	1.7 (0.7)	1.7 (0.7)	-0.04 (0.6)	0.15(-0.04;0.33)	0.11	0.13
Non-sleep wear time, h/day (79/66)	15.2 (1.3)	15.3 (0.9)	0.04 (1.0)	15.6 (0.9)	15.4 (1.1)	-0.21 (0.9)	0.27 (-0.05;0.60)	0.09	0.09
Self-report measures									
Self-report sitting, (leisure) ,h/day (76;65)	5.3 (1.8)	4.4 (1.7)	-0.93 (1.6)	5.0 (1.7)	4.9 (2.2)	-0.03 (1.7)	-0.81 (-1.36;-0.27)	**0.004**	**0.004**
Self-report sitting (work), h/day (33;34)	4.4 (2.4)	4.0 (2.4)	-0.41 (1.3)	4.4 (2.4)	4.3 (2.4)	-0.05 (1.2)	-0.47 (-1.06;0.12)	0.12	0.11
Self-report vigorous PA, h/week (76;65)	1.3 (1.6)	1.3 (2.2)	0.07 (1.5)	0.8 (1.4)	0.8 (2.1)	0.05 (2.0)	0.29 (-0.20;0.78)	0.25	0.23

Analyses performed by linear mixed models with a treatment x time interaction term characterizing the intervention effect of interest.
§ p values adjusted for sex and work status.

Table 2: Change in anthropometric measures and biomarkers from baseline to 6 month follow-up.

	Intervention group mean (SD)			Control group mean (SD)			Intervention vs. control group Mixed models [#]		
Outcome (*intervention n; control n)*	**Baseline**	**6 months**	**Within particip. change**	**Baseline**	**6 months**	**Within Particip change**	**Difference in change, between groups mean (95%CI)**	**p**	**p[§]**
Anthropometrics									
Waist circumference cm (81;68)	93.5 (12.9)	92.3 (12.9)	-1.18 (4.0)	95.5 (14.5)	95.7 (15.0)	0.24 (2.7)	-1.42 (-2.54;-0.29)	**0.01**	**0.01**
Weight kg (81;68)	79.7 (15.7)	78.8 (15.2)	-0.84 (3.1)	82.1 (17.6)	82.1 (17.7)	0.007 (2.2)	-0.83 (-1.73;0.06)	0.07	0.07
Body Fat % (81;67)	32.9(8.9)	32.4 (9.2)	-0.5 (2.6)	31.4 (9.7)	31.6 (9.6)	0.2 (2.3)	-0.74 (-1.55;0.07)	0.07	0.08
Biomarkers									
Fasting plasma glucose, mmol/l (81;68)	5.5 (0.9)	5.3 (0.7)	-0.2 (0.5)	5.8 (1.1)	5.6 (0.9)	-0.2 (0.7)	0.003 (-0.20;0.19)	0.98	0.98
Fasting serum insulin, pmol/l (80;68)	49.4 (31.3)	43.2 (28.0)	-6.2 (16.1)	54.9 (33.2)	54.5 (35.2)	-0.4 (17.3)	-5.9 (-11.4;-0.50)	**0.03**	**0.03**
HbA_{1c}, % (81;66)	5.6 (0.5)	5.7 (0.5)	0.08 (0.3)	5.6 (0.6)	5.7 (0.6)	0.07 (0.2)	0.01 (-0.07;0.09)	0.73	0.73
HbA_{1c}, mmol/mol (81;66)	37.6 (5.8)	38.6 (5.5)	1.0 (3.3)	37.8 (6.9)	38.6 (6.2)	0.8 (2.3)	0.16 (-0.79;1.12)	0.74	0.74
HOMA-IR (80;68)	1.8 (1.4)	1.5 (1.1)	-0.3 (0.7)	2.1 (1.5)	2.1 (1.6)	-0.03 (0.8)	-0.28 (-0.53;-0.03)	**0.03**	**0.03**
HOMA-%B (80;68)	72.5 (42.1)	67.4 (36.9)	-5.1 (28.8)	77.1 (45.9)	80.2 (42.6)	3.0 (33.6)	-9.33 (-19.50;0.83)	0.07	0.08
Total cholesterol mmol/l (81;68)	5.3 (0.9)	5.1 (0.8)	-0.26 (0.7)	5.3 (1.1)	5.3 (0.9)	-0.08 (0.6)	-0.18 (-0.39;0.31)	0.09	0.12
HDL cholesterol mmol/l (81;68)	1.6 (0.4)	1.6 (0.4)	-0.03 (0.2)	1.5 (0.4)	1.5 (0.4)	-0.02 (0.2)	-0.0004 (-.077;.076)	0.99	0.89
LDL cholesterol mmol/l (81;68)	3.2 (0.9)	3.0 (0.8)	-0.21 (0.6)	3.2 (1.0)	3.2 (0.9)	-0.06 (0.5)	-0.15 (-0.33;0.04)	0.11	0.15
Triglycerides mmol/l (81;68)	1.13 (0.5)	1.07 (0.6)	-0.06 (0.4)	1.34 (0.7)	1.32 (-0.7)	-0.02 (0.6)	-0.06 (-0.23;0.10)	0.45	0.43

Analyses performed by linear mixed models with a treatment x time interaction term characterizing the intervention effect of interest.
§ p values adjusted for sex and work status.