Effectiveness of the multi-component dynamic work intervention to reduce sitting time in office workers – Results from a pragmatic cluster randomised controlled trial

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ABSTRACT

Objective: Prolonged sitting, which is highly prevalent in office workers, has been associated with several health risks. The aim of this study was to evaluate the Dynamic Work intervention by determining its effect on total sitting time at the 8-month follow-up in comparison to the control.

Methods: This two-arm pragmatic cluster randomised controlled trial included 244 office workers from 14 different departments of a large, Dutch insurance company. The Dynamic Work intervention was a real-life, worksite intervention that included environmental components (i.e. sit-stand workstations), organisational components (i.e. group sessions), and individual components (e.g. activity/sitting trackers). Outcomes were assessed at baseline, 4-month follow-up, and 8-month follow-up. The primary outcome was total sitting time per day, objectively assessed using the activPAL activity monitor at 8-month follow-up. Secondary outcomes included other total and occupational movement behaviour outcomes, health-related outcomes, and work-related outcomes. Data analyses were performed using linear and logistic mixed models.

Results: Total sitting time did not differ between the intervention and control group at the 8-month follow-up. Secondary outcomes also showed no difference between the intervention and control group at either the 4-month or at 8-month follow-up, with the exception of number of occupational steps, which showed a statistically significant effect at 4-month follow-up (but not at 8-month follow-up) of 913 (95% CI = 381–1445) steps/8-h working day.

Conclusions: This study evaluated the effectiveness of a real-life worksite intervention to reduce sitting time and showed little to no effect. This may be due to the relatively low intensity of the intervention, i.e. that it only involved the replacement of 25% of sitting workstations with sit-stand workstations. Future research should focus on the evaluation of more intensive real-life worksite interventions that are still feasible for implementation in daily practice.

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1. Introduction

Sitting for long periods of time has been associated with multiple health risks, including type 2 diabetes, cardiovascular disease, and premature death (Biswas et al., 2015; Ekelund et al., 2016, 2019; Biddle et al., 2016). Recent public health guidelines have stressed the importance of reducing sedentary time in addition to increasing physical activity (Committee, 2018; Weggemans et al., 2018). Over the past several decades, occupations have become more sedentary (Church et al., 2011). Office workers, in particular, tend to accumulate long bouts of sitting during working days (Ryde et al., 2014). This highlights the need for employers to focus on occupational health and safety from a broader, public health perspective (Sakowski and Marcinkiewicz, 2018), and increases the need to implement worksite interventions to reduce sedentary behaviour in high sitting occupations (Straker et al., 2014).

Worksite interventions to reduce sitting typically include environmental components (e.g. placement of sit-stand workstations); organisational components (e.g. motivating role of management); and/or individual components (e.g. coaching). Systematic reviews have shown that these interventions may result in a decrease in (occupational) sitting time (Commissaris et al., 2016; Neuhaus et al., 2014). However, these studies have generally included only one component to reduce sitting, were conducted in rather small populations and relied on experimental designs; included only short follow-up periods of up to three months; and were limited in terms of generalisability to the wider population of office workers (Commissaris et al., 2016; Neuhaus et al., 2014; Zhu et al., 2018; Chambers et al., 2019). Implementing a multi-component intervention, combining environmental, organisational and individual components, has been shown to be more effective in terms of reducing occupational sitting time than the introduction of sit-stand workstations alone, for example (Chu et al., 2016). A recent Cochrane review has emphasised the need for high-quality studies, including cluster randomised trials in larger office populations, to evaluate long-term effectiveness (Shrestha et al., 2018). Over the past few years, this need has been acknowledged by several large-scale studies implementing multi-component interventions (Danquah et al., 2017), and evaluating longer-term effectiveness (Buman et al., 2017; Edwardson et al., 2018; Healy et al., 2016). However, these studies were all researcher-initiated interventions rather than reflecting real-life worksite practice, implementing company-initiated interventions.

Worksite interventions aimed at reducing sitting time have also been evaluated in terms of a variety of secondary outcomes other than sitting time. With regard to experiencing musculoskeletal symptoms, there seemed to be ambiguous effects on total body discomfort (Karakolis and Callaghan, 2014) and on low back pain (Agarwal et al., 2018) when using sit-stand workstations compared to sitting workstations. Despite the heterogeneity of measurement methods used across studies, work performance seemed to be unaffected by the use of sit-stand workstations, but seemed to decrease when desk bikes (Ojo et al., 2018) and treadmill desks (Dupont et al., 2019) are used. Effects of interventions on sickness absenteeism and presenteeism have been rarely evaluated, but are of high importance for employers. As such, it has been recommended to include this outcome in future studies (Shrestha et al., 2018).

The Dynamic Work intervention was specifically designed to reduce sitting time among office workers at a Dutch insurance company. This multi-component intervention was initiated by the company itself and included the partial replacement of sitting workstations with sit-stand workstations in an open-plan office. Furthermore, the intervention included the provision of an activity/sitting tracker to employees and the deployment of internal occupational physiotherapists. The Dynamic Work intervention was implemented following company procedures, reflecting real-life worksite practice.

The primary aim of this study was to examine whether the Dynamic Work intervention was effective in reducing total sitting time in office workers, at 8 month follow-up, as compared to the control group. Additionally, we examined whether employees who participated in the Dynamic Work intervention improved on other movement behaviour outcomes (e.g. occupational sitting time, standing time, steps); health-related outcomes (e.g. BMI, vitality, musculoskeletal symptoms); and work-related outcomes (e.g. work performance, sickness absenteeism and presenteeism), as compared to the control group at 4-month and 8-month follow-up. This study is one of the first evaluations of a multi-component real-life worksite intervention, in a relatively large office population that also focuses on long-term effectiveness.

2. Methods

We used the CONSORT checklist (http://www.consort-statement.org/) to report on this cluster randomised controlled trial, see Appendix 1. This study is registered at ClinicalTrials.gov (registration number: NCT03115645), and the published study protocol describes the study methods in full detail (Jelsma et al., 2019). The study protocol is also summarised below.

2.1. Design

The study was conducted in a matched-pair, pragmatic cluster randomised controlled trial among employees of a large insurance company in the Netherlands. Employees of 14 departments were invited to participate in the study. Data were collected at baseline and at 4-month and at 8-month follow-up between February 2017 and April 2018. Initially, follow-up measurements were planned at three and 12 months; however, the inclusion period took longer than planned as a result of the inclusion of six additional departments due to low participation rates in the departments that were initially invited to participate. Due to logistical problems, the roll-out of the intervention also took longer than anticipated. This led to an average unplanned delay of four months in the randomisation of departments and implementation of the Dynamic Work intervention. As a consequence, the first follow-up measurements took place four months after the start of the intervention (which was eight months after the start of the baseline measurements). The next follow-up measurement was eight months after the start of the intervention (which was 12 months after the start of the baseline measurements).

This study has been approved by the Medical Ethics Review Committee of the VU University Medical Center Amsterdam (2016.533). Study requirements and procedures were explained in a letter to all participants and written informed consent was obtained from all participants prior to any measurements being taken.

2.1.1. Participants

Department managers who had not been involved in any previous implementation of sit-stand workstations and cycling workstations at the company were invited by the head of the internal occupational health department to volunteer their department for participation. Fourteen departments participated in the study, with a total of 607 office employees working in open-plan, shared office spaces. The participating departments differed in size (mean N = 43; min N = 7, max N = 110) and were based in five different office locations throughout the Netherlands. All employees in the participating departments received an invitation email from the research team. Interested employees were asked to reply by email and answer eligibility questions. Inclusion criteria were: a permanent or a temporary employment contract lasting for at least the 12-month duration of the study. Exclusion criteria were: a contract for less than 0.6 full time equivalents (FTE); a condition that could affect adherence to the intervention protocol (e.g. being wheelchair bound); or being pregnant.

2.2. Intervention

We used the TIDieR (Template for Intervention Description and Replication) checklist to report on this intervention (Hoffmann et al.,
The initial plan was to place electrically adjustable sit-stand workstations (VEPA, Hoogeveen, The Netherlands) in the open-plan, shared office spaces of participating departments in a one-to-three ratio with regular, sitting workstations. Because of the extra departments included, the actual ratio changed to one-to-four, on average, as a fixed number of workstations had to be shared between more employees (due to financial constraints). Furthermore, desk bikes (Work trainer, Harmelen, The Netherlands) were provided for every second sit-stand workstation, and at least two office sit balls were provided per intervention department (Vluvstuf, Breda, The Netherlands).

2.2.2. Organisational components
Managers of each participating department had an initial face-to-face meeting with the internal occupational physiotherapist. During this meeting, the potential motivating role of the manager (e.g. leading by example) in the context of the Dynamic Work intervention was discussed. Two team meetings were planned with the occupational physiotherapist. These meetings lasted 30 min and were scheduled approximately four weeks apart. In the first team meeting, the health risks associated with prolonged sitting and correct (ergonomic) usage of the new furniture and other components were explained. During the second team meeting, experiences with the sit-stand workstations, the desk bikes, the sit balls and the individual activity/sitting tracker (see below) were discussed with a focus on overcoming any barriers to decreased sitting time, increased standing time or steps that were experienced.

2.2.3. Individual components
During the intervention period, the occupational physiotherapists proactively approached participants to inquire about their experience during on-site consultations (at least two per department). These consultations took place on the open-plan office floors, were generally of short duration, had an ad hoc nature, and were intended to provide tips and reflect on individual questions of participants about the Dynamic Work intervention (e.g. questions regarding ergonomic position, personal goals, and dealing with barriers). In collaboration with the researchers the Activator, a novel, individual activity/sitting tracker (PAL technologies, Glasgow, UK) was provided to all participants in the intervention group. This tracker provided users with feedback on step count, time spent upright and percentage of time spent sitting via a smartphone app. The device had an option to set haptic vibration feedback after 15 or 30 min of uninterrupted sitting. Additionally, participants received a 12-week, self-help ‘sit less, move more’ programme booklet, in which personal goals could be set. Use of the Activator and the booklet were explained during the first group meeting with the occupational physiotherapist.

2.2.4. Usual practice
Both the intervention and the control groups received usual practice. The company relied on an active approach to engage their employees in a physically active lifestyle at work. This included promotion of walking meetings, taking the stairs and mapped walking routes. Also, at the entrance of company buildings, shared (short-stay) work zones included sit-stand workstations and desk bikes.

2.3. Outcomes
Measurements were conducted at the office locations by trained researchers. Data collection included: 1) movement behaviour outcomes, assessed using an activity tracker and self-reported measures; 2) health-related outcomes, including physical measurements and self-reported outcomes; 3) work-related outcomes and demographic characteristics. Self-reported outcomes were assessed using an online questionnaire (Survalyzer B.V., Utrecht, the Netherlands) provided on a tablet, or in hard copy, upon request. The study project also included extensive process and economic evaluations, which will be reported elsewhere.

2.3.1. Movement behaviour outcomes
Sitting, standing and stepping time and step count were objectively assessed using the activPAL micro (PAL Technologies Ltd, Glasgow, UK) activity monitor. The activPAL has been shown to provide valid and reliable measures of sitting, standing and stepping in adults (Grant et al., 2006). The activPAL was worn continuously on the front of the right mid-thigh, with only temporary removal of the device (e.g. for prolonged water contact like bathing). We used a nine-day protocol, in which the first day (attachment) and the last day (de-attachment) were excluded from analyses, resulting in data sets covering seven full days. In a short diary log, participants indicated sleep time (e.g. time went to bed and time got up); occupational time; and non-wearing time. The activPAL devices were initialised with default settings and downloads were carried out using the PALconnect software version 8.7.6.32 (PAL Technologies limited, Glasgow, UK). If the activPAL recorded data fewer than four days, participants were asked to wear the activPAL for another week.

The ProcessingPAL tool V1.1.16112018, developed by Charlotte Edwardson and Shashidar Ette, was used to analyse the daily activPAL data (i.e. across all waking hours) and can be downloaded at https://github.com/UOL-COLS/ProcessingPAL/releases/tag/V1.1. The ProcessingPAL tool uses the automated sleep and non-wear algorithm developed by Winkler et al. (2016) to isolate waking hours from sleeping, prolonged periods of non-wear and invalid data. Days with <500 steps, >95% in any one activity or ≤10 h of waking wear data were considered invalid by the algorithm and were excluded. We deleted all data with more than 20 h waking time, assuming the algorithm did not correctly distinguish between sleep and waking behaviour. The PAL tool v8.9.9.33 (PAL Technologies Ltd, Glasgow, UK) created Event.csv files and indicated valid first days. Data needed to include at least four valid days to be included in the analyses. Data on total movement outcomes were averaged across valid days and standardised to 16 h waking time.

Occupational data was processed using the HSC analyses program v.2.21 (developed by Dr. Philippa Dall and Professor Malcolm Granat, School of Health and Life Sciences, Glasgow Caledonian University) using self-reported occupational time from participants’ diary logs. Occupational time included all specified working hours (i.e. at the office, at home or elsewhere, including lunch time, overtime or occupational transportation time). Data for occupational movement outcomes were considered valid if the activPAL was worn for more than 80% of the self-reported occupational time. All occupational data were averaged and standardised to an 8-h working day.

Additionally, numbers of accumulated bouts of sitting (>30 min, >60 min) and sit-to-stand transitions were calculated for total and occupational time. Non-occupational movement behaviour outcomes were calculated by subtracting the occupational from the total movement behaviour outcome.

Self-reported sedentary behaviour was assessed using the Workforce...
Sitting Questionnaire (WSQ). The WSQ includes different sitting domains and has shown acceptable validity compared to objectively measured total sitting time and sitting at work (Chau et al., 2011). Self-reported means of transportation to work was assessed, providing different sitting do.

2.3.2. Health-related outcomes

Anthropometric measures included body height (assessed at baseline) in centimetres (SECA 206 stadiometer, SECA, Birmingham, UK, measured to the nearest 0.1 cm) and body weight in kilograms (SECA 877 flat scale, 274 SECA, Birmingham, UK, accurate to the nearest 0.1 kg), assessed after participants removed heavy items of clothing and their shoes. Body mass index (BMI) score was calculated in kg·m⁻². Waist circumference was assessed in millimetres (SECA 201 non-expandable tape, SECA, Birmingham, UK) and the average of two measurements was used.

Self-reported, health-related outcomes included a Vitality-score (Vita16©), which was found to be valid and reliable in a Dutch adult population (Strijk et al., 2015). The Vita16© contains three dimensions (energy, motivation and resilience), represented by 16 items with a 7-point Likert answering scale (Hardly (1) to Always (7)). Experience of musculoskeletal symptoms in the past three months was assessed using the modified Nordic questionnaire (Kuorinka et al., 1987) with four answering categories, which were dichotomised into experiencing complaints (Frequently; For a longer period of time) or not (Never; Once in a while). The complaints were assessed in four different body regions (neck, shoulders or upper back; arms, wrists or hands; lower back; hips, thighs, knees, ankles or feet). With a visual analogue scale (VAS) score, severity of complaints could be further indicated in case of any complaints. Sleeping time was measured using a single-item question, inquiring average time spent sleeping per night over the past seven days. Smoking status was assessed as being a current smoker or a non-smoker.

2.3.3. Work-related outcomes

Work-related outcomes included work performance, assessed using two scales; task performance (5 items); and contextual performance (8 items) of the Individual Work Performance Questionnaire (IWPQ). The IWPQ has shown to be a valid and reliable instrument (Koopmans et al., 2014a; Koopmans et al., 2014b). Recovery from work-related exertion was assessed using the Need For Recovery (NFR) scale (van Veldhoven and Broersen, 2003). A score was calculated by adding up the scores for all 11 items with a dichotomous answering scale (yes/no) and transformed into a scale from 0 to 100. The outcome was dichotomised and higher (>54) scores indicated a greater need for recovery after work. The NFR showed sufficient test-retest reliability and sensitivity to detect change (de Cron et al., 2006). Imbalance of occupational effort and reward was measured with the short Effort-Reward Imbalance (ERI) questionnaire (Siegrist et al., 2004), which consisted of 16 items with a four-point Likert answering scale (strongly disagree to strongly agree). The ERI-short contained three psychometric scales: effort (three items), reward (seven items), and over-commitment (six items). Scores were dichotomised and higher scores (>1.0) on the effort-reward ratio scale reflected a greater imbalance between effort and reward. High over-commitment scores (upper tertile) indicated higher over-commitment. Average time spent at a desk during a working day was assessed using one item with four answering categories (from <4 h to >8 h). Longest uninterrupted period spent sitting behind the desk was assessed using one item with five answering categories (ranging from <30 min to >2 h). Additionally, self-reported sickness absenteeism and presenteeism were assessed using the Productivity Cost Questionnaire (iPCQ) (Bouwmans et al., 2013). Both outcomes were dichotomised into reported or unreported sickness absenteeism or presenteeism.

2.3.4. Socio-demographic characteristics

Age, gender, marital status, parity, education level, income per household, duration of work experience with current employer, contract hours per week, overtime hours per week, days worked from home and work content were assessed at baseline using online questionnaires.

2.4. Sample size

For the primary outcome, a minimal difference of 45 min of total sitting was chosen as smallest detectable change. We used a standard deviation of 80.7 in line with a similar study (Healy et al., 2016). With an intra-class correlation (ICC) of 0.021 (design effect of 1.40), we corrected for clustering effects within departments. Alpha was set to 0.05, power to 90% and drop-out at 25%. This resulted in a projected total sample size of 250 participants.

2.5. Randomisation and blinding

After baseline measurements, departments (clusters) were matched in pairs, based on number of participants and work content (which resulted in combining three smaller departments into one). After matching, pairs were randomly allocated to either the control or intervention group, using a list randomiser (www.random.org), performed by an independent researcher (neither involved in recruitment or data collection). By randomising at the department level, possible contamination of departments and individual participants in the control group was minimised. Moreover, departments were matched so that they were not physically close to each other (e.g. the departments were on different floors at a minimum). Managers of participating departments were informed of group allocation by the head of the occupational health department. Staff and researchers involved in 4-month and 8-month follow-up data collection and data analyses were blinded for group allocation.

2.6. Statistical methods

For general descriptive analyses, SPSS 22.0 was used on non-imputed data. Analyses were performed according to the intention-to-treat principle (using group allocation, regardless of degree of participation in the intervention) on non-imputed data, as drop-out was less than the anticipated 25%. Differences between participants that dropped out of the study and those that remained were assessed using a t-test (normally distributed, continuous variables) or a Chi-square test (categorical variables). StataSE14 was used for linear mixed (maximum likelihood) and logistic mixed regression models for primary and secondary outcome analyses, including random effects for cluster and fixed effects for group allocation. The outcome (e.g. total sitting time) was used as the dependent variable, while study group allocation was modelled as the independent variable and all outcomes were adjusted for their baseline measurement. A two-level structure for department and participant, and an interaction effect with group allocation and time (two follow-up measurements) were included in the multilevel models. Outcomes are presented in means (SD) or count (percentage) including the β (adjusted difference between control and intervention group), or odds ratio (OR) with 95% confidence intervals, respectively. P-values of 0.05 were considered to be statistically significant. We tested for effect modification of age, gender and BMI in the model for total sitting time, standing time, stepping time and step count.

We conducted sensitivity analyses for total sitting time (primary outcome), standing time, stepping time and step count. Sensitivity analyses included complete case analyses (including only participants with movement outcome data at baseline, and at 4-month and 8-month follow-up) and multiple imputations using 10 imputed datasets and several baseline descriptive outcomes (i.e. gender, age, marital status, parity, education level, work experience, working hours, self-reported sitting at baseline) as predictors. Both analyses were conducted to
check whether drop-out was creating bias in the outcomes. We also conducted a sensitivity analysis in which we did not correct for 16 h total awake time, but used the raw movement behaviour times instead. We included these analyses because a recent, similar study (Edwardson et al., 2018) showed large differences in outcomes between corrected and uncorrected data.

3. Results

3.1. Participant flow and recruitment

The study flow diagram is presented in Fig. 1. Of the 607 invited office employees at baseline, 304 showed interest and were assessed for eligibility. In total, we included 244 (40.2%) participants at baseline (see Appendix 3 for an overview of participants per matched cluster). At four month follow-up, 21 (17.4%) and 19 (15.4%) participants dropped out of the intervention and control group, respectively. The main reported reason for withdrawal was lack of time to attend measurements. At eight month follow-up, 26 (21.5%) and 28 (22.8%) participants dropped out of the intervention and control group, respectively. For the primary outcome, total sitting time, 92 (74.8%) participants from the control group and 92 (76.0%) from the intervention group were included in the analyses. Participants who dropped out at eight month follow-up measurement were lower educated and had fewer bouts of occupational sitting of >30 min at baseline (Appendix 4).

3.2. Baseline data

Table 1 shows the baseline characteristics of the control group and the intervention group. Almost 60% of the study office population were women and the mean age was 42.3 years. The majority (65.1%) was highly educated and 42.6% had high household income. The participants spent most of their working time at the computer (61.5%) and in meetings (23.8%). Additional information on the population (e.g. time being desk based and means of transportation to and from work) can be found in Appendix 5.

3.3. Outcomes and estimations

In Table 2, the baseline, 4-month and 8-month follow-up results are presented for movement behaviour outcomes, health-related outcomes and work-related outcomes, including outcome estimates (β or OR) with 95% CI’s. For the primary outcome, total sitting time at eight month follow-up, no statistically significant difference (β = −0.27; 95% CI = −0.60 – 0.06 h/16-h day) was found between the control and intervention group. Similarly, non-significant results were found for total standing and stepping time and total step count at both follow-up measurements. For movement behaviour outcomes during working hours, participants in the intervention group spent more time standing (β = 0.26; 95% CI = 0.06 – 0.46 h/16-h day) and had a higher total step count (β = 73; 95% CI = 43 – 106 steps/h/16-h day) compared to the control group. Moreover, participants in the intervention group showed a trend towards a lower total sitting time (β = −0.16; 95% CI = −0.35 – 0.04 h/16-h day) and higher total step count (β = 39; 95% CI = 20 – 59 steps/h/16-h day).
follow-up (awake time, total sitting, standing and stepping time, and total step count). Effects on the outcomes remained unchanged and were not statistically significant. All sensitivity analyses are presented in Appendix 5. The outcomes of the Dynamic Work study were not in line with previous studies on the effectiveness of worksite interventions, containing activity-permissive workstations, aimed at reducing sitting time. A meta-analysis has shown a pooled reduction of 77 min in (occupational) sitting time in the short-term after introducing activity-permissive workstations (Neuhaus et al., 2014). Furthermore, our outcomes were also not in line with comparable, recent, large-scale randomised controlled trials evaluating the long-term effectiveness of multi-component interventions in office workers in which sitting time was assessed with the activPAL (Edwardson et al., 2018; Healy et al., 2016). With regard to total sitting time, Edwardson and colleagues found a decrease of 82.4 min/day (not standardised to 16-h wake time) after 12 months (Edwardson et al., 2018), while Healy and colleagues reported a reduction in total sitting time of 36.3 min/day (standardised to 16-h wake time) 12 months after baseline (Healy et al., 2016). For occupational sitting time, both studies found a similar effect of about 45 min/working day (both standardised to an 8-h working day). These studies had a reasonably similar set-up to ours, with all interventions providing sit-stand workstations or other activity-permissive furniture, some form of coaching, as well as self-monitoring tools. However, there were also important differences between the interventions, specifically in terms of intensity and potential exposure, that might explain the differences in the observed results. In the Edwardson and Healy studies, the coaching of individual participants was more intensive (one-on-one sessions and/or multiple telephone calls), which resulted in relatively high intervention costs (Gao et al., 2018). The Dynamic Work intervention included a more modest time-investment of coaching professionals, including group meetings and individual counselling during two on-site visits. This accurately reflected the real-life setting but likely resulted in lower exposure to this component due to non-attendance of individual participants. However, it has been shown that adding a digital (relatively low-cost) individual component was also effective in increasing the use of sit-stand workstations at the long-term (Garrett et al., 2019; Sharma et al., 2019). On average, the Dynamic Work intervention only replaced one in every four sitting workstations with a sit-stand workstation in the open-plan, shared office spaces, which was less than the intended one-to-three ratio due to the additional departments that were included. In both other studies (Edwardson et al., 2018; Healy et al., 2016), all personal workstations were replaced with activity-permissive workstations, aimed at reducing sitting time. A meta-analysis has shown a pooled reduction of 77 min in (occupational) sitting time in the short-term after introducing activity-permissive workstations (Neuhaus et al., 2014). Furthermore, our outcomes were also not in line with comparable, recent, large-scale randomised controlled trials evaluating the long-term effectiveness of multi-component interventions in office workers in which sitting time was assessed with the activPAL (Edwardson et al., 2018; Healy et al., 2016). 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On average, the Dynamic Work intervention only replaced one in every four sitting workstations with a sit-stand workstation in the open-plan, shared office spaces, which was less than the intended one-to-three ratio due to the additional departments that were included. In both other studies (Edwardson et al., 2018; Healy et al., 2016), all personal workstations were replaced with sit-stand workstations. The partial replacement of furniture may have limited the availability of sit-stand workstations, thereby limiting the availability of sit-stand workstations and/or desk bikes to other participants. Preliminary results from our process evaluation show 41.4% and 46.2% of participants experienced skin irritation during the follow-up measurements. 4. Discussion We evaluated the effectiveness of the Dynamic Work intervention on total sitting time at an 8-month follow-up, for which we did not find a statistically significant difference (−16.2; 95% CI = −36.0–3.6 min/16-h day) between the intervention and control group. Secondary movement behaviour outcomes (total daily sitting and stepping time, as well as step count) revealed no significant differences at both follow-up measurements. For occupational movement behaviour outcomes, there were also no relevant differences in time spent sitting and standing. However, there was a significant improvement of approximately 25% in steps taken during working hours at the 4-month follow-up, but this improvement disappeared at the 8-month follow-up.

The outcomes of the Dynamic Work study were not in line with previous studies on the effectiveness of worksite interventions, containing activity-permissive workstations, aimed at reducing sitting time. A meta-analysis has shown a pooled reduction of 77 min in (occupational) sitting time in the short-term after introducing activity-permissive workstations (Neuhaus et al., 2014). Furthermore, our outcomes were also not in line with comparable, recent, large-scale randomised controlled trials evaluating the long-term effectiveness of multi-component interventions in office workers in which sitting time was assessed with the activPAL (Edwardson et al., 2018; Healy et al., 2016). With regard to total sitting time, Edwardson and colleagues found a decrease of 82.4 min/day (not standardised to 16-h wake time) after 12 months (Edwardson et al., 2018), while Healy and colleagues reported a reduction in total sitting time of 36.3 min/day (standardised to 16-h wake time) 12 months after baseline (Healy et al., 2016). For occupational sitting time, both studies found a similar effect of about 45 min/working day (both standardised to an 8-h working day). These studies had a reasonably similar set-up to ours, with all interventions providing sit-stand workstations or other activity-permissive furniture, some form of coaching, as well as self-monitoring tools. However, there were also important differences between the interventions, specifically in terms of intensity and potential exposure, that might explain the differences in the observed results. In the Edwardson and Healy studies, the coaching of individual participants was more intensive (one-on-one sessions and/or multiple telephone calls), which resulted in relatively high intervention costs (Gao et al., 2018). The Dynamic Work intervention included a more modest time-investment of coaching professionals, including group meetings and individual counselling during two on-site visits. This accurately reflected the real-life setting but likely resulted in lower exposure to this component due to non-attendance of individual participants. However, it has been shown that adding a digital (relatively low-cost) individual component was also effective in increasing the use of sit-stand workstations at the long-term (Garrett et al., 2019; Sharma et al., 2019). On average, the Dynamic Work intervention only replaced one in every four sitting workstations with a sit-stand workstation in the open-plan, shared office spaces, which was less than the intended one-to-three ratio due to the additional departments that were included. In both other studies (Edwardson et al., 2018; Healy et al., 2016), all personal workstations were replaced with sit-stand workstations. The partial replacement of furniture may have limited the availability of sit-stand workstations, thereby limiting the availability of sit-stand workstations and/or desk bikes to other participants. Preliminary results from our process evaluation show 41.4% and 46.2% of participants in the intervention group indicated they never made use of the standing workstations and/or desk bikes to other participants. Preliminary results from our process evaluation show 41.4% and 46.2% of participants in the intervention group indicated they never made use of the standing workstations and/or desk bikes to other participants. Preliminary results from our process evaluation show 41.4% and 46.2% of participants in the intervention group indicated they never made use of the standing workstations and/or desk bikes to other participants. Preliminary results from our process evaluation show 41.4% and 46.2% of participants in the intervention group indicated they never made use of the standing workstations and/or desk bikes to other participants. Preliminary results from our process evaluation show 41.4% and 46.2% of participants in the intervention group indicated they never made use of the standing workstations and/or desk bikes to other participants. 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option at 4-month and 8-month follow-up respectively. This suggests that the sitting culture that is norm in most offices, is hard to change with only a partial introduction of activity-permissive workstations, especially when workstations are shared. Given that open-plan office spaces with shared desks are becoming more common than the traditional, enclosed work spaces with personal desks (Ted Moudis Associates, 2018), this is an important consideration for the design of future interventions. Especially, since it is often more appealing from an employer’s perspective to implement shared, activity-permissive workstations due to the lower cost and the likely lack of willingness to use these workstations by a part of the office-worker population (Renaud et al., 2018). Nonetheless, the effects of partial introduction of activity-permissive workstations have not yet been studied extensively. A small study (N = 11) showed no reduction in occupational sitting time when a few, standing ‘hot desks’ were introduced in an office (Gilson et al., 2012). Moving to an activity-permissive workplace, including sit-stand workstations on faculty basis, also showed a limited reduction in sitting time (19.7 min/8-h working day) across a small population (N = 24), though statistically significant changes in standing time were observed (Gorman et al., 2013). Also at long-term follow-up (18 months), moving to an active office design showed no effect on objectively measured sitting time (Wahlstrom et al., 2019).

In the Dynamic Work study, many participants worked from home about one day a week or at other locations, further reducing the opportunities for actual exposure to the organisational (group meetings), environmental (furniture) and individual (coaching) components. Working from home regularly has shown to be prevalent in populations in which new ways of working, such as open-plan, shared offices are common (Nijp et al., 2016). As sitting times tend to be higher on days that employees work from home (Olsen et al., 2018), this is also an important consideration when developing future workplace interventions.

Another explanation for the lack of effect in our study might be the dilution of intervention messages. The intervention was aimed at reducing a single behaviour (sitting) and increasing another (standing and steps). This may have resulted in some participants aiming to reduce sitting, while others sought to increase (occupational) steps and still others focused on improving both. However, substantial increases in steps tend to result in only small changes in sitting time as these be

Table 2
Primary (total sitting time) and secondary (other movement behaviour, health-related and work-related) outcomes.

<table>
<thead>
<tr>
<th>Outcome mean (SD)</th>
<th>Baseline Control</th>
<th>4-month follow-up Control</th>
<th>4-month follow-up Interv</th>
<th>8-month follow-up Control</th>
<th>8-month follow-up Interv</th>
<th>p (95% CI)</th>
<th>p (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Movement behaviour outcomes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Sitting time, h/16 h</td>
<td>10.0 (1.2)</td>
<td>10.1 (1.3)</td>
<td>10.2 (1.2)</td>
<td>10.2 (1.3)</td>
<td>10.2 (1.2)</td>
<td>10.2 (1.4)</td>
<td>-0.11 (0.43-0.22)</td>
</tr>
<tr>
<td>- Standing time, h/16 h</td>
<td>4.1 (1.0)</td>
<td>4.1 (1.1)</td>
<td>3.9 (1.0)</td>
<td>3.9 (1.0)</td>
<td>4.0 (1.0)</td>
<td>3.9 (1.1)</td>
<td>-0.04 (0.27-0.18)</td>
</tr>
<tr>
<td>- Stepping time, h/16 h</td>
<td>1.9 (0.6)</td>
<td>1.9 (0.4)</td>
<td>1.8 (0.5)</td>
<td>1.9 (0.5)</td>
<td>1.8 (0.5)</td>
<td>1.9 (0.5)</td>
<td>0.09 (0.043-0.22)</td>
</tr>
<tr>
<td>- Steps/16 h</td>
<td>9685</td>
<td>9462</td>
<td>9065</td>
<td>9616</td>
<td>583 (190-1355)</td>
<td>8904</td>
<td>9459</td>
</tr>
<tr>
<td>- Sit-stand transitions/16 h</td>
<td>55.5 (13.7)</td>
<td>55.7 (13.8)</td>
<td>53.4 (11.9)</td>
<td>54.0 (14.0)</td>
<td>54.2 (13.1)</td>
<td>56.1 (13.3)</td>
<td>-0.12 (0.60-1.10)</td>
</tr>
<tr>
<td>- Sitting bouts &gt;30 min/16 h</td>
<td>5.6 (1.6)</td>
<td>5.6 (1.5)</td>
<td>5.9 (1.6)</td>
<td>5.8 (1.4)</td>
<td>5.9 (1.5)</td>
<td>5.5 (1.6)</td>
<td>-0.11 (0.4-0.22)</td>
</tr>
<tr>
<td>Occupational</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>- Sitting time, h/8 h</td>
<td>5.7 (0.9)</td>
<td>5.6 (1.0)</td>
<td>5.9 (0.9)</td>
<td>5.6 (1.0)</td>
<td>5.8 (1.0)</td>
<td>5.6 (1.0)</td>
<td>-0.27 (0.58-0.03)</td>
</tr>
<tr>
<td>- Standing time, h/8 h</td>
<td>1.7 (0.9)</td>
<td>1.8 (0.9)</td>
<td>1.5 (0.8)</td>
<td>1.7 (0.8)</td>
<td>1.6 (0.9)</td>
<td>1.7 (0.9)</td>
<td>0.12 (0.14-0.37)</td>
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<tr>
<td>- Stepping time, h/8 h</td>
<td>0.6 (0.2)</td>
<td>0.7 (0.3)</td>
<td>0.6 (0.2)</td>
<td>0.7 (0.4)</td>
<td>0.6 (0.2)</td>
<td>0.7 (0.3)</td>
<td>0.15 (0.06-0.24)</td>
</tr>
<tr>
<td>- Steps/8 h</td>
<td>3470</td>
<td>3556</td>
<td>3060</td>
<td>4060</td>
<td>913 (381-1445)</td>
<td>3043</td>
<td>3023</td>
</tr>
<tr>
<td>- Sit-stand transitions/8 h</td>
<td>28.3 (12.1)</td>
<td>29.3 (10.7)</td>
<td>26.9 (9.2)</td>
<td>27.3 (10.4)</td>
<td>26.7 (10.5)</td>
<td>27.7 (9.5)</td>
<td>-0.16 (0.16-0.64)</td>
</tr>
<tr>
<td>- Sitting bouts &gt;30 min/8 h</td>
<td>3.3 (1.5)</td>
<td>3.0 (1.4)</td>
<td>3.5 (1.4)</td>
<td>3.1 (1.3)</td>
<td>3.4 (1.4)</td>
<td>3.1 (1.3)</td>
<td>-0.15 (0.54-0.24)</td>
</tr>
<tr>
<td>Health-related outcomes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- BMI, kg m⁻²</td>
<td>25.8 (4.3)</td>
<td>25.5 (4.5)</td>
<td>26.1 (4.2)</td>
<td>25.3 (4.9)</td>
<td>26.0 (4.2)</td>
<td>25.3 (4.5)</td>
<td>0.07 (0.25-0.38)</td>
</tr>
<tr>
<td>Musculoskeletal complaints</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Upper back, neck, shoulders, n (%)</td>
<td>23 (18.7)</td>
<td>21 (17.4)</td>
<td>15 (15.2)</td>
<td>18 (18.4)</td>
<td>15 (16.1)</td>
<td>13 (13.8)</td>
<td>0.17 (0.39-7.69)</td>
</tr>
<tr>
<td>- Arms, wrists, hands, n (%)</td>
<td>11 (8.9)</td>
<td>11 (9.1)</td>
<td>5 (5.0)</td>
<td>8 (8.2)</td>
<td>5 (5.4)</td>
<td>6 (6.4)</td>
<td>2.13 (0.50-8.97)</td>
</tr>
<tr>
<td>- Lower back, n (%)</td>
<td>19 (15.4)</td>
<td>15 (12.4)</td>
<td>15 (15.0)</td>
<td>13 (13.3)</td>
<td>13 (14.0)</td>
<td>8 (8.5)</td>
<td>0.97 (0.40-2.38)</td>
</tr>
<tr>
<td>- Legs, hips, knees, feet, n (%)</td>
<td>26 (21.1)</td>
<td>10 (8.3)</td>
<td>13 (13.0)</td>
<td>6 (6.1)</td>
<td>12 (12.9)</td>
<td>4 (4.3)</td>
<td>0.44 (0.07-3.00)</td>
</tr>
<tr>
<td>Work-related outcomes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Sickness absenteeism, n (%)</td>
<td>26 (21.1)</td>
<td>35 (28.9)</td>
<td>21 (21.0)</td>
<td>9 (9.2)</td>
<td>41 (44.1)</td>
<td>33 (35.5)</td>
<td>0.31 (0.12-0.83)</td>
</tr>
<tr>
<td>Work presenteeism, n (%)</td>
<td>53 (43.1)</td>
<td>43 (35.5)</td>
<td>45 (45.0)</td>
<td>42 (43.3)</td>
<td>36 (38.7)</td>
<td>45 (47.9)</td>
<td>1.17 (0.48-2.81)</td>
</tr>
<tr>
<td>Work performance score</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Task performance, mean (SD)</td>
<td>2.6 (0.6)</td>
<td>2.8 (0.6)</td>
<td>2.6 (0.7)</td>
<td>2.8 (0.6)</td>
<td>2.6 (0.8)</td>
<td>2.8 (0.5)</td>
<td>0.11 (0.05-0.27)</td>
</tr>
<tr>
<td>- Contextual performance, mean (SD)</td>
<td>2.2 (0.7)</td>
<td>2.4 (0.8)</td>
<td>2.3 (0.8)</td>
<td>2.4 (0.8)</td>
<td>2.2 (0.8)</td>
<td>2.4 (0.7)</td>
<td>-0.03 (0.22-0.16)</td>
</tr>
</tbody>
</table>
suggested that interventions that focused both on physical activity and sedentary behaviour reduced daily sitting time to a lesser extent than interventions solely focusing on reducing sedentary behaviour (Prince et al., 2014; Martin et al., 2015; Gardner et al., 2016). Future interventions should attempt to ensure that participants understand the distinction, and appreciate the benefits of decreasing sedentary time, as well as increasing physical activity.

4.1. Strengths and limitations

Major strengths of this study were the randomised controlled design and the objectively measured primary outcome. Another strength was the relatively large number of participants included, providing adequate statistical power to evaluate the effect of the intervention on the main outcome. However, for some secondary outcomes, such as the experience of musculoskeletal complaints, the study might have been underpowered. Furthermore, the Dynamic Work intervention was developed and implemented in large part by the participating insurance company. It included relatively low-cost components, reflecting the real-life worksite practice. This made the feasibility of large scale implementation of this intervention, if effective, greater than other more intensive and expensive multi-component interventions studied in this field.

Delays in inclusion and intervention roll-out were limitations of this study that resulted in a shorter-than-intended, long-term follow-up period. However, given the lack of effectiveness at both follow-up measurements, a longer follow-up period is not expected to affect the study outcomes. Nevertheless, the delay in roll-out of the intervention due to these logistical problems may have taken away some of the momentum that would have otherwise increased commitment to the intervention in the participating departments.

Furthermore a possible lack of generalisability might have occurred due to an expressed interest of about only half of the potential participants. As a result the included participants represented a population that was already fairly active at baseline (i.e. almost 10,000 steps/day), leaving little room for improvement. Our ongoing extensive process evaluation will further explore reasons for the lack of effectiveness, including adherence to the intervention.

Lastly, we saw a high dropout rate (24.6%), but this was something that we had anticipated in our sample size calculation (<25%) and that is similar to comparable Dutch occupational health studies (Coffeng et al., 2014). Sensitivity analyses on complete cases, as well as multiple imputed data sets, showed our outcomes to be robust.

4.2. Conclusion

In conclusion, the Dynamic Work intervention was not effective in reducing total sitting time at the long-term. Secondary total and occupational movement behaviour outcomes, as well as health and work-related outcomes, showed only marginal effects. This lack of effect may have been caused by the relatively low intensity of our intervention. This suggests that a certain level of intervention exposure needs to be reached in order to achieve meaningful effects. Specifically, the partial replacement of sitting workstations with activity-permissive workstations and the frequency and form of the counselling sessions by the occupational physical therapist in our study, might have been insufficient to achieve substantial reductions in sitting time. These findings have important implications, as partial replacement of sitting workstations and restricted time (and cost) investments of coaching professionals are common in daily worksite practice. Future research should focus on the intervention intensity required to achieve meaningful change with real-life worksite interventions that can be easily implemented in daily practice.

Authors’ contributions


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Data availability statement

Data can be made available for non-commercial purposes upon request to the authors.

Declaration of competing interests

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: The authors declare no conflicts of interest. This work was supported by Achmea, Interne Diensten N.V. (Handelsweg 2 Zeist, The Netherlands), which also provided the study population and co-developed the Dynamic Work intervention with the research team. Achmea had no influence on or role in the study design, data collection, analyses and interpretation of the data, the writing of this paper, and the decision to submit the paper for publication.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.apergo.2019.103027.

References

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