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From the National Institute of Public Health,
University of Southern Denmark

Ida Høgstedt Danquah

"Oh-oh, the others are standing up… I better do the same!"

Results from the randomised controlled trial of the multi-component sitting time intervention among office workers, 'Take a Stand!'

PhD thesis

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Preface and acknowledgements

This thesis is based on the 'Take a Stand!'-study, which was carried out by the National Institute of Public Health at University of Southern Denmark. 'Take a Stand!' was funded by TrygFonden.

In the end of 2012, I returned from maternity leave to work on a new sitting time intervention. Since then, it has been an amazing journey with 'Take a Stand!' from the very first decisions on target groups and intervention components, through the hectic intervention phase, to a final PhD-thesis now, seven and a half years later. This has only been possible in corporation with and with support from a number of important people.

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This thesis is based on the following five papers:

Paper I: Danquah IH, Kloster S, Holtermann A, Aadahl M, Bauman A, Ersbøll AK, Tolstrup JS. **Take a Stand!—a multi-component intervention aimed at reducing sitting time among office workers: a cluster randomized trial**. International Journal of Epidemiology. 2017;46(1):128-140.

Paper II: Danquah IH, Kloster S, Holtermann A, Aadahl M, Tolstrup JS. **Effects on musculoskeletal pain from "Take a Stand!" - a cluster-randomized controlled trial reducing sitting time among office workers.** Scandinavian Journal of Work, Environment & Health. 2017;43(4):350-357.

Paper III: Danquah IH, Tolstrup JS. **Does It Work For Everyone? The Effect of The Take A Stand! Sitting-Intervention In Subgroups Defined By Socio-Demographic, Health-Related, Work-Related And Psychosocial Factors**. Journal of occupational and environmental medicine. 2020 jan;62(1):30-36.

Paper IV: Danquah IH, Kloster S, Tolstrup JS. **"Oh-oh, the others are standing up... I better do the same". Mixed-method evaluation of the implementation process of Take a Stand!—a cluster randomized controlled trial of a multicomponent intervention to reduce sitting time among office workers**. Under 2nd review at BMC Public Health, March 2020.

Paper V: Danquah IH, Tolstrup JS. **Standing Meetings Are Feasible and Effective in Reducing Sitting Time among Office Workers—Walking Meetings Are Not: Mixed-Methods Results on the Feasibility and Effectiveness of Active Meetings Based on Data from the "Take a Stand!" Study.** Int. J. Environ. Res. Public Health 2020, 17(5), 1713.

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List of abbreviations

BMI – Body mass index

CI95% – 95% Confidence interval

CVD – Cardiovascular disease

HR – Hazard ratio

LBP – Low back pain

LPA – light physical activity

MET – Metabolic equivalent

MI – Multiple imputation

MVPA – Moderate-to-vigorous physical activity

OR – Odds ratio

RCT – Randomised controlled trial

SD – Standard deviation

SE – Standard error

WHO – World Health Organisation

YLD – Years lived with disability

1 Introduction

During the late 2000s and early 2010s an increasing focus on sedentary behaviour emerged, with a rising number of studies focusing on the health consequences of a sedentary lifestyle and testing potential interventions to reduce sitting time.

Early studies revealed a link between excess sitting time and metabolic health; for example cardiovascular disease and risk of type 2 diabetes independent of time spent on physical activity [1-3]. Though estimates were associated with great uncertainty (related to measurement methods, potential confounding factors and the exact physiological mechanism), researchers agreed that sitting too much was associated with some health risks [3].

Regarding sedentary behaviour interventions, focus has been on the large occupational group of office workers whose job is mainly sedentary, and therefore contributes many hours of sitting each day [4]. This places these workers in the excess risk categories with regard to the health consequences of sitting time.

In the early 2010s, therefore, a number of single-component interventions aimed at office workers (for example the introduction of sit-stand desks or computer prompts to break sitting) were tested in small-scale studies. These yielded promising results on reducing sitting time [5, 6]. However, no large-scale randomised controlled studies had yet been conducted of multi-component sitting time interventions with office workers. In this space, we designed the intervention 'Take a Stand!' and tested it in a cluster randomised controlled trial (RCT) in four office workplaces in Denmark and Greenland.

As part of my PhD, I have been involved in all aspects of the project. Together with a group of experienced researchers, I took part in decisions on primary and secondary outcome measures and the design of the intervention. I was in charge of the preparation of the randomised controlled trial, including planning and collection of data (anthropometrics, questionnaires, activity measures and interviews). Finally, I did much of the data management and analysis of the different data sources.

This thesis is based on five papers. Results on sitting time and health effects are published in **paper I** and **paper II** of this thesis, while **paper III** considers the results of sub-group analysis of the sitting time effect. **Paper IV** is a mixed methods study considering factors during the implementation period impacting the implementation and the sitting time effect of the intervention. **Paper V** evaluates the implementation and effects of a single element of the intervention, namely standing and walking meetings.

The thesis is structured as follows. First, the background is presented along with the main aim and specific objectives. Next, the development and final components of 'Take a Stand!' are described, followed by a summary of data sources and analysis methods. Results from **papers I-V** are then summarised briefly, before the main findings and methodological considerations are discussed. Finally, conclusions are presented, together with a short discussion of the implications of the thesis for future research and practice.

2 Background

This section starts with a definition of sitting time, and an overview of how much time adults (and especially office workers) spend sitting. Then the health consequences of sitting are summarised; overall, the physiological mechanisms, the health consequences of the different aspects of sitting time (amount, accumulation and domain), and finally, the consequences for musculoskeletal health. The context of the workplace is then described, and previous research on the reduction of sitting time among office workers is reviewed, before the aim and objectives of this thesis are listed.

2.1 What is sitting time?

Sedentary behaviour is defined as any waking behaviour characterised by an energy expenditure <= 1.5 metabolic equivalent (METs), while in a sitting, reclining or lying posture [7, 8]. Hence, sedentary behaviour, often called 'sitting time' or simply 'sitting', is to be differentiated from physical inactivity, which is defined as not fulfilling the official recommendation for physical activity [8]. It is therefore possible for one person to have a high level of sitting time and still be physically active (i.e. fulfilling physical activity recommendations, for example from World Health Organisation (WHO)-specified 150 minutes moderate-to-vigorous physical activity per week [9]). Throughout this thesis the term 'sitting time' will be used to cover all types of sedentary behaviour (sitting, reclining and lying), since it is assumed that most sedentary time among office workers, and adults at large, constitutes sitting. The term 'physical activity' will be used to cover physical activity of moderate and vigorous intensity (MET-values of 3.0-5.9 and >6 respectively [9]) .

2.2 Sitting time levels of adults – and office workers

Results from a Eurobarometer study of 27,919 people in 28 European countries showed a median self-reported sitting time of 300 minutes per day, with 18.5% reporting sitting 7.5 hours/day or more [10]. Denmark was at the top of the ranking, with 32% sitting >7.5 hours/day [10]. A review of 132 studies from 16 countries charting accelerometer-measured activity found that working adults were sitting for 60% of the day (equivalent to about 9.5 hours) [11]. Comparing occupational groups, office workers were found to have the highest amount of sitting, the lowest amount of light physical activity (LPA), and the highest amount of moderate-to-vigorous physical activity (MVPA) [11].

Globally, and especially in developed countries, there has been a transition from high physical activity levels (obtained during manual work, transportation and domestic work) to high levels of sitting time, due

to an increase in sedentary occupations, the use of motorised transport, and involvement in sedentary leisure activities, such as watching television [12]. In 2010, 46% of Danish adults had a job characterised as mainly involving sitting [13]. The increase in sedentary occupations includes an increase in the proportion of adults in office-based jobs [14].

Office work is often characterised by working with a computer and mainly being seated [15]. Studies of office workers from the United Kingdom (UK), Australia and the United States (US) agree on sitting times of around 11 hours/day [4, 16-18], of which the major portion is accumulated at work [16, 19, 20], where it is estimated that office workers sit for 65-82% of the workday [4, 11, 15, 18-23]. Studies have also found that office workers with high sitting levels at work also had high levels of sitting during their leisure time [21, 22]. Sitting time could be interrupted (for example by getting up to fetch coffee or to print out a document, going to a meeting or talking to a colleague), but it could also be accumulated in prolonged sitting periods (>30 minutes uninterrupted sitting). Among office workers 80% of breaks from sitting have been found to occur before 20 minutes of continual sitting [23]. However, others have found that 33-42% of the workday is spend in prolonged sitting periods [19, 20]. Therefore, the potential to reduce overall sitting time among adults is considerable when targeting office workers, since they are a large group with high amounts of sitting.

In Denmark, almost all office workers have sit-stand desks. This has been the case for several years. The purpose of this is often to ensure that workers are able to adjust their desks in accordance with different working tasks, and in cases where several workers share one desk [24]. However, the general impression is that the sit-stand-function is not used during regular daily work. This was confirmed by initial observations in the very start of the design phase for 'Take a Stand!': at all offices everyone had sit-stand-desks, but they were always in the low position.

2.3 Sitting time and health

During the past 20 years, physical activity research has increased focus on the health risks associated with too much sitting, either on its own or in relation to the risks of insufficient exercise [3]. Sitting time has been associated with an increased risk of all-cause mortality [25-31], cardiovascular mortality [27, 29, 31, 32], cardiovascular disease (CVD) [31-33], diabetes [29, 31, 33, 34] and mortality of some types of cancer [27].

Sitting more than 10 hours each day has been associated with higher all-cause mortality of Hazard Ratio (HR) 1.48 (CI95% 1.22-1.79) compared to sitting for 7.5 h/day – this was the result of a meta-analysis of 39 studies, including a total of 36,383 adults with accelerometer-measured sitting time and physical activity [28]. Regarding CVD, a meta-analysis of 720,425 participants showed an increased risk of CVD of

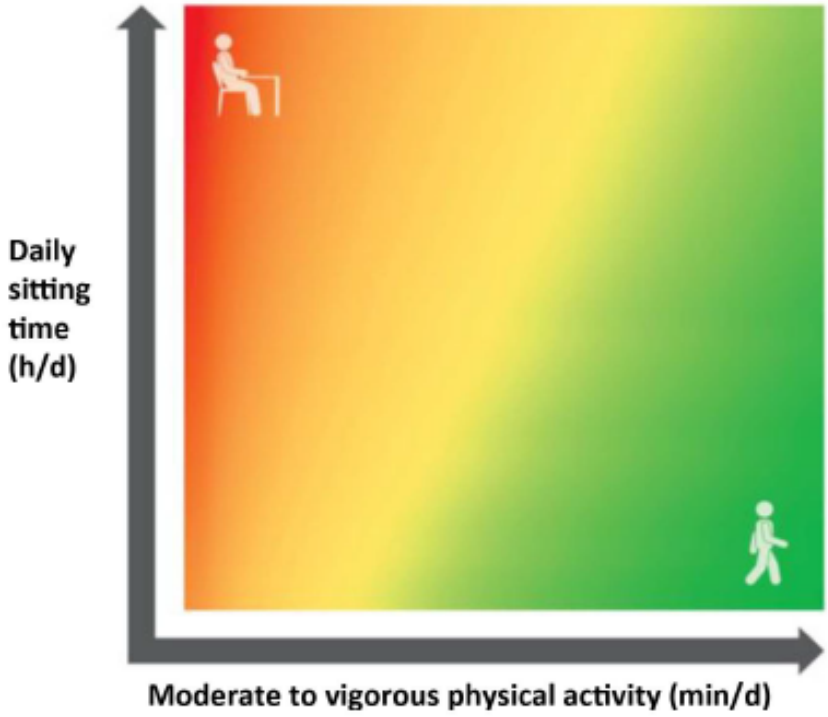
HR 1.14 (CI95% 1.09-1.19) in participants in the highest sitting time category compared to the lowest (median sitting 12.5 h/day compared to 2.5 h/day) [32].

Physical activity is an important confounder when considering the adverse effects of sitting time. So, most studies controlled for physical activity and, in general, associations between sitting time and health outcomes were persistent. However, in some studies the results were attenuated [26, 33, for example] or only persisted among the inactive [34]. This implies effect modification, as physical activity modifies the effect of sitting time on health.

This effect modification was described in a meta-analysis of data from one million participants, which assessed the association between sitting time and mortality, stratified by physical activity [27]. The result was a strong correlation between daily sitting and all-cause mortality but varying across physical activity levels. As a result, in the least active groups (below 25-35 minutes of moderate intensity activity per day) there was a pronounced increase in mortality, with increasing sitting time from <4 hours sitting/day to >8 hours sitting/day. However, in the group being active 60-75 minutes per day of moderate intensity, there was no difference in mortality across different sitting time levels.

The relationship between sitting time, physical activity and mortality can be illustrated usefully by a heat map (figure 1). In this map, red designates the highest mortality risk and green the lowest. In this case, the risk of mortality is reduced either by replacing sitting time with light-intensity activity (moving down the y-axis) or by adding physical activity (moving right on the x-axis) [35].

Figure 1: Heat map showing the relationship between sitting time, moderate-to-vigorous physical activity (MVPA) and risk of all-cause mortality. Red defines the highest mortality (high sitting and low MVPA) while green defines the lowest mortality (low sitting and high MVPA). Source: Powell *et al* (35) based on data from Ekelund *et al* (27).



2.3.1 How does sitting harm health?

It has been suggested that sedentary physiology (that is, the bodily responses to sitting) is something distinct from exercise physiology (bodily responses to exercise), with a set of independent physiological mechanisms as described below [1, 3, 36, 37]. However, it has also been proposed that because sitting time, physical activity and light-intensity activity (for example standing and low-intensity walking) are all parts of the same 24-hour day (together with sleep), these behaviours are too interdependent to be totally disentangled [38].

The proposed physiological relation between sitting time and health consists of adverse effects in the circulatory system as a result of long periods of sitting with no activity in the large skeletal muscles of the back, legs and trunk [3, 36, 37]. This results in negative effects on vascular health and metabolism and consequently negative health outcomes like cardiovascular disease and type 2 diabetes [3, 36, 37]. However, the exact physiological path is yet to be fully elucidated [38].

2.3.2 Amount, accumulation and domains of sitting

Sitting time has several aspects to be taken into consideration. These are the actual amount of sitting time (how many minutes), the way sitting is accumulated (duration of sitting bouts and frequency of interruptions from sitting), and the domain of sitting (occupation, transport, leisure time, household) [37, 39].

Regarding the amount of sitting, studies have indicated that the relation between sitting and health outcomes is non-linear. Studies of all-cause mortality have found an increased risk at around 6-9 hours of sitting per day, with sitting times above 9.5 hours associated with a significantly higher risk of death [28, 29]. Studies of CVD mortality have found increased risk above 6-8 hours of daily sitting [29], while risk of incident CVD increased only above 10 hours of sitting per day [32].

Regarding the accumulation of sitting time, studies have found a positive effect on metabolic risk factors when breaking up sitting every 30 minutes [40-42, for example]. However, the exact frequency, intensity and length of breaks varies between studies [43]. In addition, sitting for prolonged periods (>30 minutes) has been associated with increased waist circumference and BMI [44]. It is therefore highly relevant to consider intervention effects on these accumulation parameters (**paper I**) in addition to the actual amount of sitting time.

Regarding the domain of sitting, Owen *et al* [39] have suggested an ecologic model of sedentary behaviour that includes four domains: occupation, transport, leisure time and household. Most studies have considered the health effects of total sitting time; however, some studies have separated different domains [45, 46, for example]. When comparing occupational and leisure-time sitting, a cross-sectional study found fewer and weaker associations of occupational sitting and metabolic risk compared to leisure-time sitting [46]. However, occupational sitting is considered the largest single contributor to the quantity of overall sitting time among adults, and it therefore constitutes a relevant risk factor for health consequences of sitting time [45, 47].

In summary, all three aspects of sitting – the amount, the accumulation and the domain – are associated with health consequences. However, there is not enough evidence to settle on the exact sitting time pattern necessary to avoid premature mortality [38, 48].

2.3.3 Musculoskeletal pain

In addition to metabolic health consequences, sitting time has been associated with impacts on musculoskeletal health, especially among office workers.

Low back pain (LBP), neck pain and other musculoskeletal disorders were among the six most common causes of years lived with disability (YLDs) among adults worldwide in 2010 [49]. Among the working

population, musculoskeletal pain is found to be a risk factor for future long-term sickness absence [50]. In a Danish cohort study, around 80% of office workers reported neck or shoulder pain during the past year, making office workers the group with the highest prevalence; while LBP had the lowest prevalence among office workers, but it was still reported by 50% during the past year [51].

Regarding the association between sitting time and musculoskeletal health, sitting at work has been found to be a risk factor for neck pain [52-54], but not – or only to a limited degree – for LBP [55-58]. Finally, introducing shifts between sitting and standing work [59, 60] or increasing breaks from sitting [61] have been found effective in reducing pain among office workers.

In summary, musculoskeletal pain is prevalent among office workers and reduced sitting time might reduce or prevent pain. It is therefore of relevance and interest to explore the effects of sitting time interventions on musculoskeletal pain (**paper II**).

2.4 The workplace as a setting for health promotion

The workplace is recognised internationally as a key setting for health promotion – mainly because the majority of the population spend large proportions of their time at work each day, making the workplace a common setting with a common culture [62-64].

The WHO has defined a healthy workplace as one that both prevents work-related injuries *and* promotes health and well-being of workers [65]. Through health promotion, the workplace has the potential not only to improve the health of the individual worker, but also achieve health benefits for the workplace and society as a whole. At the workplace, health promotion could increase wellbeing, job satisfaction and productivity, as well as reduce sick-leave. In wider society, workplace health promotion could help prevent noncommunicable diseases, which are a major burden on society due to the health costs and increased mortality [62, 66, 67].

The workplace as a health-promotion setting has several inherent advantages, in addition to being a way to reach large groups: 1) The individual is affected in several ways (physical, social, organisational and psychosocial), making it possible to improve health through a number of different mechanisms; for example, changing the built environment or organisational structures to be more health promoting in themselves [63, 68, 69]). 2) A workplace population is often quite constant, making possible long term programmes with high levels of participation [68]). 3) There is a build-in social support network at the workplace, in the form of co-workers, which makes interventions more sustainable [62, 64, 68, 69]. 4) Much office work is based on routines, making it easier for new practices to become habitual [70]. 5) Finally, the workplace has well-established infrastructure and communication channels, which could be used for the dissemination of relevant interventions [64, 69].

On the other hand, there are a number of issues to be aware of when implementing workplace health promotion programmes. First of all, health is often seen as an individual and personal matter, and there is a risk that workers will feel intruded upon by the employer if the focus on the personal aspects of health and a healthy lifestyle becomes too strong [63, 64, 71]. Second, the main focus for workers at any workplace is productive work, making health programmes a secondary project, which risk to be underprioritised as a result of limited resources, lack of organisational commitment, insufficient management support, or an unsupportive workplace culture [63, 64, 72, 73]. It has therefore been pointed out that workplace health promotion projects need to be easy to implement, matching both the needs of employees and the local culture at the workplace [64, 67, 71].

2.5 Interventions to reduce sitting at the workplace

Workplace health promotion programmes have been found effective in enhancing physical activity by addressing and changing individual health behaviours [62, 63]. Often these interventions have been implemented as physical activity during work hours, but not as part of the productive work itself [72, 73]. This means that health interventions can cause a loss of productive time and become particularly vulnerable in case of time constraints during busy periods. However, focusing on reducing sitting might be more feasible, as this could be integrated more easily into regular productive work [69, 72, 73].

During the 2000s, interventions to increase workplace physical activity (for example through counselling, walking groups or web-based information) started to include results on sitting time, mainly as a secondary outcome [74-80, for example].

During the 2010s, an increasing number of interventions were tested, aiming specifically to reduce sitting time among office workers. Studies included a number of small-scale studies or pilot studies, and interventions included just one component, such as sit-stand-desks [5, 6, 81, 82], active breaks [83], prompts to reduce sitting [84] or counselling [85]. Not all studies reduced sitting, but those which did found reductions of 28-137 minutes per day [5, 6, 82, 85], a reduction of prolonged sitting periods [84], and increased breaks from sitting [5].

In 2012, a review of 11 studies attempting to reduce workplace sitting concluded that evidence in the area was weak and highlighted a need for high quality studies of interventions with multiple strategies, assessing multiple outcomes (such as health, economic and social ones) with validated, ideally objective, measurement methods [86].

At the beginning of 2013, the first results of a multi-component intervention (interventions including strategies at individual, organisational and environmental level) were published from a small scale (n=43)

non-randomised controlled trial in Australia resulting in reduced sitting of 125 minutes/8-hour workday after four weeks [87].

Apart from effects on sitting time, these studies assessed how sitting time interventions were perceived among office workers through qualitative evaluations of potential intervention strategies [88], or actual interventions — for example the installation of sit-stand-desks [6] or the implementation of active breaks [83]. Altogether, these studies highlighted the need for interventions to be tailored to specific occupational roles; that both the individual and the organisation were responsible for changes; that management support towards the project was important; that perceived or experienced health effects were a main promoter; and that the main barrier was potentially compromised productivity [6, 83, 88]. Finally, studies on workplace health interventions highlighted the need for process evaluations, exploring how and why the interventions worked [71, 89].

To summarise, the scientific context in 2013, when we designed 'Take a Stand!' was a field in rapid development, with an increased focus on sitting time, a number of effective single-component interventions, the first small-scale results of multi-component interventions, and preliminary knowledge on both promoters and barriers for implementation. Furthermore, there was an explicit need for trials of multi-component sitting time interventions towards office workers. More specifically, 1) large 2) cluster randomised controlled trials with 3) objectively measured sitting time and 4) thorough process evaluations.

Since then, several other multi-component randomised controlled trials have reported reduced sitting [90-92, for example]. Results of process evaluations have also been published [93-97, for instance], and several reviews have been conducted of both single- and multi-component sitting time interventions, as well as process evaluation results [see 72, 98-105].

2.6 Aims of thesis

The overall aim of the thesis was to assess the effects and conduct process evaluation of the multi-component sitting time intervention, 'Take a Stand!'

In addition to the main effect on actual sitting time at work, effects of interest included the accumulation of sitting time and effects on activity both at work and during leisure. The concern was to assess how sitting time changed, what sitting time was possibly replaced by, and whether changes during work hours impacted leisure time. Effects on health parameters included both parameters associated with cardiometabolic health (for example, body fat and waist circumference) as well as musculoskeletal pain. To know more about how effective the intervention was in different groups, subgroup analyses were performed in relation to the effect on workplace sitting time.

The process evaluation included a description of the implementation regarding fidelity of intervention delivery (that is, the dose delivered and the dose received). In addition, the implementation process was explored in terms of how factors from the context, the organisation of the intervention and the mental models of participants were related to the effect of 'Take a Stand!' Finally, one of the specific elements of the intervention, namely standing and walking meetings, was assessed both with regard to its implementation level, participants' perception of this element, and its association with the effect on sitting time.

The specific objectives were:

To assess the effects of 'Take a Stand!', and more specifically:

- To examine the effects of 'Take a Stand!' on workplace sitting among office workers, both regarding actual sitting time and the accumulation of sitting (sit-to-stand transitions and prolonged sitting periods) (**paper I**).
- To assess the effects of 'Take a Stand!' on other activity variables, such as workplace standing and steps, and leisure time sitting, steps and physical activity (**paper I**).
- To examine the health effects of 'Take a Stand!' on body-composition (body fat percentage, fat mass and fat-free mass), waist circumference and the prevalence of musculoskeletal pain (neck-shoulder, back and extremities) (**papers I** and **II**).
- To assess how the sitting time effect of 'Take a Stand!' differed across subgroups (**paper III**).

To conduct a process evaluation of 'Take a Stand!', including:

- To assess the fidelity of 'Take a Stand!' regarding dose delivered and dose received (**paper I**).
- To explore how factors related to the context, the organisation of the intervention, and the mental models of the participants (for example, motivation) impacted the implementation and the effect of the 'Take a Stand!' (**paper IV**).
- To explore feasibility and effectiveness of one sub-element of 'Take a Stand!' i.e. active meetings (**paper V**).

3 Materials and methods

This chapter gives an overview of the data and methods applied in the thesis. All papers are based on data collected in relation to the cluster randomised controlled trial, evaluating the multi-component intervention 'Take a Stand!'. Table 1 gives an overview of the aims, design, data material and methods in each of the five papers. In the following the intervention, the different data sources and the methods are described in further details.

Table 1: Overview of aims, design, materials and methods in the five papers of the thesis.

	Paper I	Paper II	Paper III	Paper IV	Paper V
Aim	To test if 'Take a Stand!' reduced sitting time and prolonged sitting periods, increased the number of sit-to-stand transitions and decreased waist circumference and body fat percentage	To examine the effects of 'Take a Stand!' on musculoskeletal pain	To test whether the effects size of 'Take a Stand!' differed across subgroups defined by socio-demographic, health-related and psychosocial factors	To explore, which factors during the implementation impacted the implementation process and the sitting time intervention 'Take a Stand!'	To explore the feasibility and efficacy of the 'Take a Stand!' element on standing and walking meetings.
Design	Randomised controlled trial	Randomised controlled trial	Randomised controlled trial	Mixed methods	Mixed methods
Data material	Questionnaires Anthropometrics Activity data	Questionnaires Activity data	Questionnaires Activity data	Questionnaires Activity data Interviews	Questionnaires Activity data Interviews
Study population	Intervention group: N=173 (10 offices) Control group: N=144 (9 offices)	Intervention group: N=173 (10 offices) Control group: N=144 (9 offices)	Intervention group: N=173 (10 offices) Control group: N=144 (9 offices)	Intervention group: (N=173) Interviews: 58 participants, ambassadors and managers from 10 intervention offices	Intervention group: (N=173) Interviews: 58 participants, ambassadors and managers from 10 intervention offices
Methods	Multilevel mixed-effects linear regression	Multilevel mixed-effects logistic regression and negative binomial regression	Multilevel mixed-effects linear regression	Multilevel mixed-effects linear regression Directed content analysis	Multilevel mixed-effects linear regression Directed content analysis
Exposure	'Take a Stand!' intervention	'Take a Stand!' intervention	'Take a Stand!' intervention	Implementation variables	Participation in active meetings
Outcomes	Workplace: sitting, sit-to-stand transitions, prolonged sitting periods, standing and steps Leisure time: sitting, steps and physical activity Waist circumference, body fat percentage, fat mass and fat-free mass	Pain in neck-shoulders, back and extremities Total pain score	Sitting time at work	Sitting time at work	Sitting time at work
Follow-up	1 and 3 months	1 and 3 months	1 and 3 months	3 months	3 months

3.1 The intervention 'Take a Stand!'

The overall goal of 'Take a Stand!' was to reduce workplace sitting time while maintaining the same level of productivity, which implies that all intervention activities should be compatible with normal work tasks. The development of the intervention, the pilot study, and the final intervention contents are described below.

3.1.1 Development of 'Take a Stand!'

The intervention was developed using Intervention Mapping, which includes six steps for planning an intervention [106]. Below, and in table 2, there follows a simplified example of how one programme outcome, 'to reduce sitting time at work', was developed through the six steps.

Table 2: Example of the Intervention Mapping process regarding the programme outcome 'To reduce sitting time at work'. Only selected results are shown.

Intervention Mapping Step	Outcome	Environmental factors
Step 1: Needs assessment	Programme outcome: reduce sitting time at work	Interpersonal and organisational factors
Step 2: Matrices	Behavioural goal: increase use of sit-stand desks	Environmental goal: ensure accept from others
Step 3: Theory-based methods and practical strategies	Goal setting theory: personal goals	Social Cognitive Theory on observational learning and reinforcement: Ambassadors
Step 4: Development of programme materials	Workshop programme with goal-setting sessions	Meeting with ambassadors and managers
Step 5: Adoption and implementation plan	Final plan for implementation	
Step 6: Evaluation plan	Questionnaires (e.g. number of goals) Interviews (e.g. social aspects) Accelerometers (e.g. sitting time)	

First, programme outcomes were decided, in this case 'reducing sitting time at work', and relevant environmental factors were identified to be for example co-workers and managers (interpersonal), and norms and facilities (organisational).

In order to reduce sitting time, 'increase the use of sit-stand desks' was determined as a behavioural goal, while 'ensure that co-workers and managers accept the new practice' was an environmental goal (step 2).

Then, in step 3, each goal was addressed with different strategies and activities using relevant theory: social cognitive theory; Rogers' diffusion of innovation theory; goal-setting theory; and literature from similar studies [64, 77, 84, 85, 88, 107-111]. In the example, 'habits and skills' was found to be one of the determinants of the increased use of sit-stand desks. So, we duly combined this with goal setting theory and decided that participants should set personal goals at a workshop. Related to the environmental goal of acceptance by others, we needed to change norms, and in relation to this, we employed components

from social cognitive theory: namely, observational learning and reinforcement. These components were applied for example by identifying ambassadors who could be frontrunners during the intervention period.

As a consequence of these activities, programme materials included a workshop programme with goal-setting sessions, and an agenda for a meeting with ambassadors and managers. These were developed and then tested in a pilot study (step 4).

Next, a plan for the final implementation was made (step 5) and evaluation measures were settled upon (step 6). These were to evaluate the goal-setting session and the role of the ambassadors, ensuring that the final questionnaire included questions about the number of goals set and the perceived level of ambassador support. In addition, the ambassador role and social aspects of the intervention were discussed during interviews. Finally, the accelerometer was decided to be the evaluation measure for assessing the sitting time effect.

3.1.2 Pilot study

The purpose of the pilot study was to test both the intervention content and the method for evaluating effect (i.e. the accelerometer). In addition, the pilot study should provide knowledge about the workplace and work routines in order further to qualify intervention content and expected effects.

The pilot study took place in an office with 15 participants (13 women) from June to October 2013. After an introductory meeting, observations were made for one day registering conditions in the workplace, namely facilities, work routines and meetings. The intervention content was then developed and adjusted through focus group interviews and meetings with ambassadors and managers. Data collection procedures were tested through collecting questionnaires and activity data (ActiGraph for five days). The intervention was tested during a two-week period. This was initiated at a workshop and evaluated continuously with ambassadors, and also through a focus group with participants at the end. Finally, five participants volunteered to repeat their activity measure following the intervention period (six weeks later).

The evaluation of the pilot study was generally positive; participants reduced sitting, primarily by using their sit-stand-desk; they liked the workshop and the materials; and they enjoyed participating together at the office. The pilot study resulted in a number of small changes to the intervention among others: the length of the different parts of workshop programme was adjusted; the planned training programme was discarded; and it was emphasised that facilities for standing meetings should be in place and that ambassadors should do follow-up during the intervention period. Data from the pilot study was not included in the final trial.

3.1.3 The final intervention

The final intervention included five components: the appointment of ambassadors and management support, environmental changes, a lecture, a workshop, and e-mails and text messages. Each component is described in further detail below, and figure 2 displays an overview of the specific activities and their timing, together with timing of data collection.

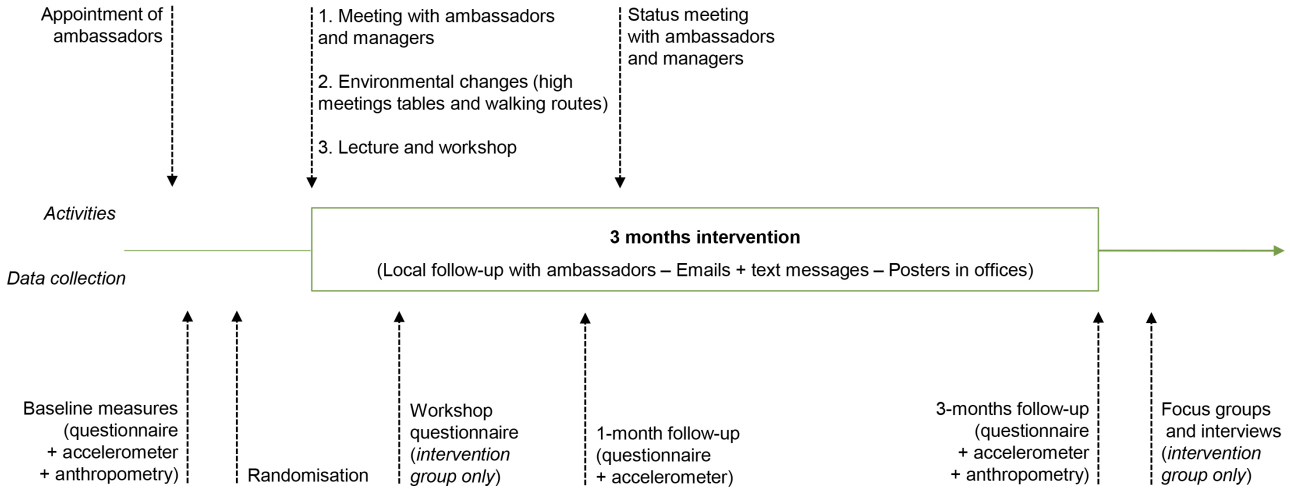


Figure 2: Overview of the timing of intervention activities (above timeline) and data collection activities (below timeline) in 'Take a Stand!'

Appointment of ambassadors and management support: At each office one or two local ambassadors were appointed. Their role was to be in charge of the project locally, by providing social support, motivating colleagues, and ensuring regular follow-up at the office. In addition, managers at all offices agreed to act as role models. At the beginning of the intervention period, a meeting was held with managers, ambassadors and researchers to discuss practical issues related to the project. This included facilities for standing meetings, personal expectations about the project and roles during the intervention period. After one month a follow-up meeting was held with ambassadors and managers to discuss progress, successes and difficulties.

Environmental changes: All intervention offices installed high meeting tables in some of their official meeting rooms. They also ensured adequate facilities for informal standing meetings, such as high tables in corridors and offices. In addition, ambassadors identified suitable routes for walking meetings of various length, and directions for these were placed centrally at the office and e-mailed to participants.

Lecture on sitting time and health: The lecture lasted around 15 minutes and was given by one of the researchers at the beginning of the workshop. Themes included recommendations on physical activity and sitting time, data on sitting time, and evidence on sitting time and health outcomes. At the end there was

time for questions. The content of the lecture was as well communicated in a leaflet distributed to all participants at the workshop and on the project website.

Workshop: The workshop was held once at each workplace during normal working hours. It was conducted by two of the researchers and lasted approximately two hours. The aim was to ensure local adaptation at individual, office and workplace level. During the workshop, participants were guided through the four main themes of the intervention: using a sit-stand desk, breaking up prolonged sitting periods, having standing and walking meetings, and setting common goals at office level.

All themes were introduced by a short motivational talk including relevant evidence. Then several possible strategies in relation to the theme were described, participants discussed these in smaller groups, and each individual decided on one or more individual goals in relation to the theme. For the last theme, which was about setting common goals, all participants from the same office agreed on their common goals. Individual goals were noted on a personal card and common goals on posters to be put up in the office. Examples of individual goals included raising the table in the morning or moving the waste bin away from the table. Examples of common goals included standing office meetings or raising the table at a specific time or signal.

In addition, themes were supported by general posters listing the strategies proposed at the workshop. Each participant also received a post-it notes block and a postcard with project graphics, to remind them about the project.

This structure of the workshop was the same for each workplace, but appropriate local adaptation was ensured by participants and offices selecting different goals or different variations of the same goal (such as standing meetings at different frequency and length).

E-mails and text messages: During the three months intervention period, participants could sign up for weekly e-mails and/or biweekly text messages. The content repeated some of the suggested strategies from the workshop and also provided tips related to the four themes.

3.2 The randomised controlled trial

'Take a Stand!' was evaluated in a randomised controlled trial taking place from November 2013 to June 2014.

The trial was prospectively registered at Clinicaltrials.gov (NCT01996176) with the following primary outcomes: reducing sitting at work, increasing sit-to-stand transitions, and reducing prolonged sitting periods (>30 minutes) after 1 month (**paper I**). The secondary outcomes were sitting outcomes after 3 months (**paper I**), reducing waist circumference and body fat percentage after 3 months (**paper I**), and

reducing musculoskeletal pain after 1 month (**paper II**). In addition, a number of exploratory outcomes were assessed, including effects on: sitting and activity parameters after 1 and 3 months (that is, standing at work, steps at work, total time spent in prolonged sitting periods and leisure time sitting, steps and moderate-to-vigorous physical activity) (**paper I**); fat mass and fat-free mass after 3 months (**paper I**); and musculoskeletal pain after 3 months (**paper II**).

Furthermore, process evaluation of the trial included fidelity (**paper I**), the implementation process (**paper IV**) and the sub-element on active meetings (**paper V**).

Below are the details about participants, randomisation, ethics, the choice of accelerometers for sitting time measurement, and the framework for process evaluation.

3.2.1 Participants

Sample size calculations were made in collaboration with a statistician based on principles for cluster randomised trials [112]. Calculations were based on the primary outcome, sitting time at work after 1 month, where we expected a reduction of 60 minutes. Assuming 80% power, a significance level of 5%, a standard deviation of 100 minutes and an intra-class coefficient of 0.2, calculations showed that a least 12 offices with 25 employees per office were required (totally 300 participants).

Eligible workplaces were office-based with workers mainly sitting during the working day, with at least four well-separated offices (separated by walls, floors or geographic locations and not collaborating) and with management agreement to participate actively in intervention activities and, if necessary, invest in facilities for standing meetings.

Eligible individuals were >18 years old, understood Danish, worked >4 days a week, were not pregnant, and did not have any sickness or disability affecting the ability to stand or walk.

Fulfilling these criteria, the final study population constituted 317 office workers from 19 clusters at four different workplaces in Denmark and Greenland. From Denmark three public workplaces participated and from Greenland one private workplace. From each workplace 4-6 clusters participated with a cluster size of 6-33 participants.

3.2.2 Randomisation

Clusters were randomised within each workplace for intervention or control at a ratio of 1:1, using the random number sequence in Stata. At three of the workplaces, offices were of about the same size; however, in the last workplace, offices were different sizes and therefore they were randomised in blocks defined by size. Randomisation took place before baseline measures, but was not disclosed to participants, researchers or data collectors until all the baseline measures had been completed. Randomisation resulted

in 173 participants from 10 clusters in the intervention group and 144 participants from 9 clusters in the control group (see the flowchart in figure 3). The uneven size of intervention and control group was by chance because of small differences in office sizes.

The control group was offered the intervention after completion of follow-up data collection.

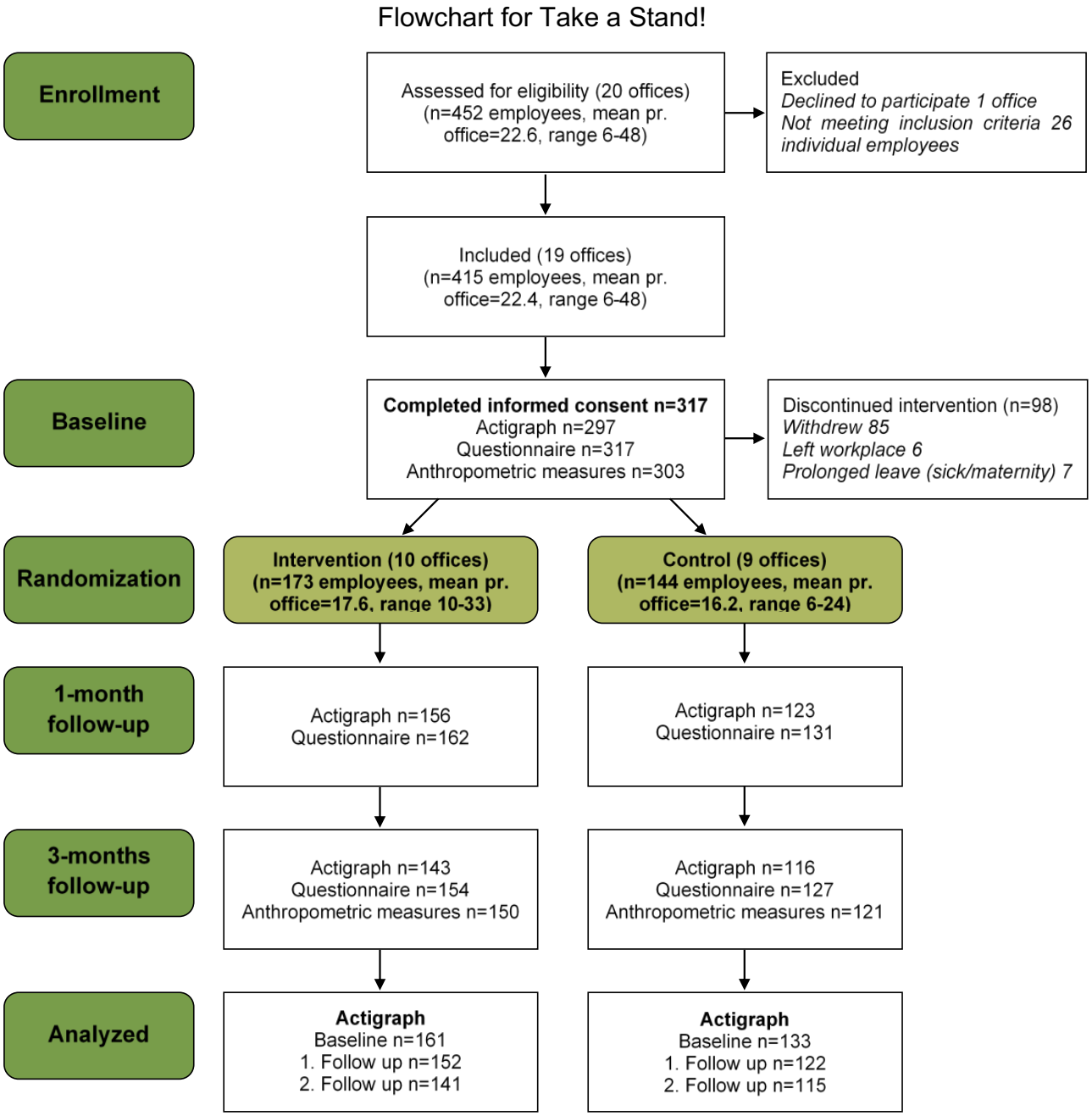


Figure 3: Flowchart of the participants in 'Take a Stand!' from enrollment to analysis. At 1-month follow-up 8 participants discontinued the intervention (5 in control group, 3 in intervention) and at 3-months follow-up 6 participants discontinued the intervention (2 in control group, 4 in intervention group). For analysis, only Actigraph data is shows as the remaining data depended on the specific variables.

3.2.3 Ethics

The trial was approved by the Ethics Committee in Denmark (H-6-2013-005) and in Greenland (project 20914-3, id: 2014-095402).

At participating offices, all employees received oral and written information about the project and decided individually whether they wanted to participate. All participants then signed informed consent forms. Participants were told that they could withdraw from the project at any time, and that their data would be treated confidentially and not shared with the workplace except in a final report on workplace results, which would be totally anonymised.

Participants received no incentive for participation but, after the trial, they received an individual feedback report with their own measurement results from the baseline, together with follow-up measures concerning anthropometry and activity.

3.2.4 The choice of accelerometers for sitting time measurement

Sitting time was the main outcome measure of the intervention, and therefore the choice of measurement method (accelerometer on the thigh) is substantiated in the following. At large, sitting time is measured in two ways: subjective measures (questionnaires) and objective measures (accelerometers) [113].

Questionnaires have the strength of being relatively easy to administer, with a low participant-burden, cost little, and there is no or very little subsequent data processing [113, 114]. However, the available questionnaires measuring sitting time also have quite low validity, and are designed to monitor sitting time in populations, why the ability to measure changes as a consequence of an intervention is unknown [113-116].

Accelerometers have traditionally been used to measure physical activity as counts per minute expressing intensity. With this method, values below 100 counts per minutes have been defined as sedentary [114]. However, when used to measure sitting time, counts may be misleading, because they only express intensity, and the definition of sedentary time includes both intensity (low MET-value) and posture (sitting, reclining or lying), so by using counts alone it might not be possible to distinguish sitting from standing [113]. This is crucial to sitting time research, especially in interventions like ‘Take a Stand!’, which aim to turn sitting time into standing time. Instead, by placing the accelerometer on the thigh and using the inclinometer function, a distinction can be made between sitting and standing. Combining this information with data on acceleration, it is possible to identify different activity types with high levels of validity [113, 117-119].

When using accelerometers, it is relevant to consider when participants should wear the instrument, how long the measurement period should be, and which criteria should be set for a measurement day to be valid and for a break to count as a break [114, 120]. Regarding when to wear the instrument, it is important to consider whether the domains in focus (work, leisure and sleep) influence each other and it might therefore be relevant to measure a full 24-hour day in order to capture all the changes [121, 122]. Regarding the measurement period, studies have shown that at least 6-9 days were required in order to estimate sitting time adequately across working hours and leisure time, weekday and weekend days [123]. On the other hand, a study of weekdays only estimated that 4 days were adequate to estimate total sitting time and 4.7 days to estimate workplace sitting time [124]. Additionally, regarding the time the instrument should be worn for a valid day, studies have typically used 8-12 hours a day as a criterion, with more hours per day resulting in fewer days of measurement [123]. Finally, the exact definition of break length to interrupt sitting time might affect the number of breaks and the prolonged periods of sitting, while total sitting time is not influenced considerably by varying the break length [125].

3.2.5 Framework for process evaluation

The Framework for Evaluating Organizational-level Interventions, by Nielsen & Randall [126] was used to structure the process evaluation. This framework consists of factors at three levels influencing the outcome of organisational interventions. A modified version of the framework is displayed in figure 4, showing only the factors included: a) the intervention context considers events at the workplace level hindering or facilitating the intervention; b) the organisation of the intervention comprises how the intervention is initiated and implemented, including the role of managers and ambassadors as drivers of change; and

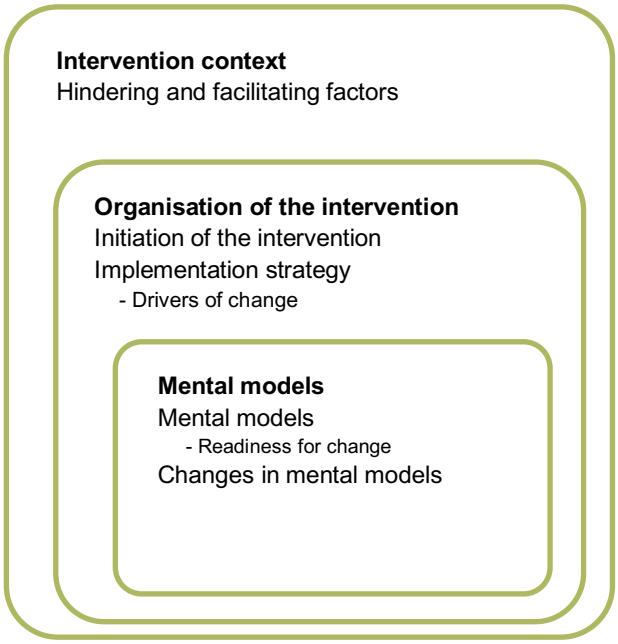


Figure 4: The model used for process evaluation in 'Take a Stand!' At each level – intervention context, organisation of the intervention, and mental models – a number of potential factors were explored in the process evaluation regarding how they affected implementation and sitting time effect. The model is a modified version *of The Framework for Evaluating Organizational-level Interventions,* by Nielsen & Randall (126).

finally c) the mental models include participant's mental models, considering their readiness for changing the specific behaviour, and changes in their shared mental models in relation to intervention activities.

3.3 Data

Data were collected at baseline, with follow-up after 1 month and 3 months including questionnaire data, anthropometric measures and activity data (figure 2). In addition, interviews took place after finishing the final data collection at 3 months. Each data source is described below.

3.3.1 Questionnaire data

Questionnaires were web-based and were answered at baseline, after the workshop (intervention group only), and at both follow-up points.

At baseline, questions included those on the office environment, working conditions, tenure, health and illness, health behaviour, educational level, and motivation for the project. Immediately after the workshop, participants in the intervention group received a short questionnaire considering their experience of participation in the workshop and an evaluation of the different activities.

At both 1- and 3-month follow-up, some of the baseline questions were repeated. The intervention group also answered additional questions about the implementation of the intervention, covering management support, the motivation towards the project, the sense of community around the project, and participation in (and facilities for) standing and walking meetings. At 3-months follow-up, additional questions were added to the intervention group. These covered mutual support, negative consequences, and the atmosphere at the office during the project period.

3.3.2 Anthropometric measurements

Weight, fat mass, fat-free mass and bodyfat percentage were measured using a scale type BC-418 MA (Tanita Corp., Tokyo, Japan). Height was measured using a Seca Leicester height measure. Waist circumference was measured midway between the lower rib and the iliac crest with a non-stretchable measuring tape.

3.3.3 Activity data

Activity outcomes were measured with an ActiGraph GT3X+ accelerometer recording tri-axial accelerations. The waterproof accelerometer was worn on the front of the thigh 24 hours a day from Monday to Friday, and it was only removed in case of prolonged water activities, contact sport, or skin irritation. During the accelerometer period, participants kept a log in which they recorded their bed times, work hours and any irregularities (such as days off).

Data from the accelerometer were processed using Acti4 software, which has been developed specifically for thigh mounted accelerometers. Acti4 uses information on accelerometry and inclinometry to compile total number of minutes spent sitting/reclining, standing, walking, climbing stairs, running, cycling and rowing. Acti4 has been validated in different settings and has been found to have high sensitivity and specificity, particularly for distinguishing sitting from standing [117-119].

Work, leisure and sleep were distinguished using information from the log, adjusted by visual inspection of activity graphs. Work hours included working both at the workplace and at home. Leisure time included both time before and after work. Non-workdays were discarded, and eligible workdays had to include a minimum of 4 hours work and 4 hours leisure. Moderate-to-vigorous physical activity included all minutes spent walking fast (>100 steps/minute), climbing stairs, running, cycling and rowing. Work and leisure time were each standardised to 8-hour days.

3.3.4 Interviews

After finalizing the 3-months follow-up, interviews were conducted with participants, ambassadors and managers from all intervention offices. Most interviews (31 in total) took place during work hours and at the workplace, except the 11 which were conducted by phone as a result of practical circumstances.

At each office, participants were interviewed in focus groups of two to five participants (33 participants in total), using a semi-structured format. This included, among other things, an evaluation of the different elements of 'Take a Stand!', concurrent projects, the atmosphere at the office in relation to the intervention, and thoughts about the future retention of intervention activities. All 15 ambassadors were interviewed either alone, or together with the other ambassador at the office. These interviews considered some of the same themes as the focus groups, but additionally focused on the role of the ambassador during the project. Finally, ten managers were interviewed, with additional questions on their role in the project.

3.4 Methods

Papers I-III were based on statistical methods, while **papers IV** and **V** used mixed methods. First statistical analysis and then interview analysis are described below, followed by a description of how the methods were integrated in the two mixed method papers.

3.4.1 Statistical analysis

An overview of the statistical methods, exposure, outcomes, the study population, and follow-up times for each paper is displayed in table 1. Methodology is described briefly below. Please refer to individual papers for more detailed information.

Multilevel mixed-effects linear regression was used to analyse the effects of the trial in **papers I, III, IV** and **V**. In **paper II**, on musculoskeletal pain, outcomes on specific pain sites were binary, and thus analysed with multilevel mixed-effects logistic regression; while negative binomial regression was used for the total pain score.

Models in **papers I-III** all included an interaction between randomisation (intervention or control) and time (baseline, 1 and 3 months) in order to assess different intervention effects at different follow-up time points, as compared with the control group. Thus, the interaction term expresses the counterfactual situation — that is, whether the outcome in the intervention group differed from what would have been expected if there had been no intervention.

Models in **papers IV** and **V** only included the intervention group and data from the 3-months follow-up, taking baseline values into account.

Missing information was handled slightly different in the different papers. In **paper I**, primary analyses used multiple imputation, while complete case analyses were performed as sensitivity analyses. The multiple imputation procedure was based on variables pre-hypothesized to potentially predict missing information (age, gender, tenure at workplace and motivation towards the project); however, none of these were systematically associated with missing values, indicating that values were missing completely at random [127]. In **paper II**, primary analyses were complete case, while sensitivity analyses included handling missing with last observation carried forward. **Papers III-V** were complete case analyses only.

3.4.2 Interview data analysis

Interviews were transcribed verbatim and imported into NVivo12 for analysis. Directed content analysis [128] was used to analyse data based on categories from *The Framework for Evaluating Organizational-level Interventions,* by Nielsen & Randall [126]. Findings were grouped according to nodes based on the framework, and nodes were summarised into a short text describing each theme.

Paper IV used interview data related to all three levels of the framework (context, organisation of the intervention, and mental models), while **paper V** used data related to intervention activities (part of the level specified as ‘organisation of the intervention’ in the original framework).

3.4.3 Mixed methods

Papers IV and **V** used mixed methods, but integrated methods differently, since **paper IV** integrated methods at several stages of the study, while **paper V** used different methods to answer sub-aims of the same paper.

In **paper IV**, three forms of integration [129] took place: a) theoretical integration, where all methods were used to describe the same theoretical model, namely *The Framework for Evaluating Organizational-level Interventions*, by Nielsen & Randall [126]; b) data integration, in that the interview data were used to generate variables included in the statistical analysis; and c) method integration in the analysis phase, where interview data were used to elaborate on statistical findings and elucidate differences between materials, as inspired by the processes described by Moran-Ellis [130] and Kelle [131].

In **paper V**, different methods were used to answer different parts of the overall objective of the paper [132]. More specifically, data were collected, analysed and reported separately, to address the two sub-aims on feasibility and efficacy of active meetings.

4 Results

This chapter summarises the results of the five papers in the thesis. After a short introduction to the study population, results are summarised in two parts: effect-results (**papers I-III**) and process evaluation results (implementation results from **paper I**, as well as **papers IV** and **V**). Detailed results and original detailed tables are to be found in the respective papers.

4.1 Study population

The 317 participants in 'Take a Stand!' had a mean age of 46 years, 66% were women and 67% had tertiary education (table 3). Regarding health, mean BMI was 26, 14% were smokers and 91% rated their health as excellent, very good or good. Managers constituted 16% in total. Office size was divided according to four types: alone (19%), small (33%), medium (25%) and large (23%).

Table 3: Baseline characteristics regarding demography, health, working conditions and activity for participants in 'Take a Stand!', in total, and divided by intervention and control group (n=317). All characteristics were self-reported from questionnaire data; except BMI, which was calculated based on anthropometric measures; and activity, which was measured with accelerometer.

	Intervention (n=173)		Control (n=144)		All (n=317)	
	N	**N (%)**	**N**	**N (%)**	**N**	**N (%)**
Demographic factors						
Age (years, mean [SD[a]])	173	46 (10)	144	45 (11)	317	46 (10)
Females	173	105 (61)	144	105 (73)	317	210 (66)
Tertiary education	172	130 (76)	143	85 (57)	315	212 (67)
Health and health behaviour						
BMI[b] (mean [SD])	162	26 (5.0)	136	27 (4.8)	298	26 (4.9)
Smoker	171	18 (11)	142	25 (18)	313	43 (14)
Self-rated health, excellent/very good/good	171	154 (90)	142	131 (92)	313	285 (91)
Musculoskeletal pain						
Neck-shoulder	171	87 (51)	142	73 (51)	313	160 (51)
Back/lower back	171	68 (40)	142	61 (43)	313	129 (42)
Extremities[c]	171	60 (35)	142	60 (42)	313	120 (38)
Motivated to change workplace sitting	171	137 (80)	142	122 (86)	313	259 (83)
Working conditions						
Manager	172	30 (17)	139	20 (14)	311	50 (16)
Office size	172		143		315	
Alone		32 (19)		29 (20)		61 (19)
Small (2-4 p)		69 (40)		35 (25)		104 (33)
Medium (5-11 p)		43 (25)		36 (25)		79 (25)
Large (>11 p)		28 (16)		43 (30)		71 (23)

Sitting and physical activity[d]		Mean (SD)		Mean (SD)		Mean (SD)
Sitting time, min/8h workday	161	345 (54)	133	335 (59)	294	340 (57)
Sit-to-stand transitions, n/hour work-place sitting	161	6.2 (2.8)	133	6.4 (2.8)	294	6.3 (2.8)
Prolonged sitting periods, n/8h workday	161	3.0 (1.3)	133	2.7 (1.1)	294	2.8 (1.3)
Standing time, min/8h workday	161	82 (45)	133	96 (52)	294	88 (48)
Steps, n/h work	161	482 (172)	133	442 (144)	294	464 (161)
Sitting time, min/8h leisure	162	291 (53)	133	289 (49)	295	290 (51)
MVPA[e] in leisure, min/8h leisure	162	45 (22)	133	44 (19)	295	45 (21)
Steps, n/h leisure	162	709 (312)	133	702 (278)	295	706 (297)

[a] SD=Standard Deviation
[b] BMI=Body Mass Index
[c] Arms, hands, legs, knees, hips or joints
[d] Measured with Actigraph attached on thigh (n=162)
[e] MVPA=Moderate-to-Vigorous Physical Activity (total time spent walking fast (>100 steps/minute), running, climbing stairs, rowing and cycling)

4.2 Effects of the intervention (papers I-III)

Effects of the interventions on sitting time, activity and health, and in different subgroups, were reported in **papers I-III.** Below results are summarised across the papers.

4.2.1 Effects on sitting and activity variables during work and leisure (paper I)

At baseline, sitting per 8-hour workday was 340 minutes, and standing was 88 minutes (table 3). Participants had a mean of 6.3 sit-to-stand transitions per hour of workplace sitting, and 2.8 prolonged sitting periods per 8-hour workday. During leisure, participants sat for 290 minutes per 8-hour leisure and were physically active for 45 minutes.

Sitting time during working hours was reduced in the intervention group compared to the control group —after 1 month by -71 minutes/8-hour workday (CI95% -85;-57, p<0.001) and after 3 months by -48 minutes/8-hour workday (CI95% -62;-34, p<0.001) (figure 5). Sit-to-stand transitions increased in the intervention group compared to the control group, at 1 month by +14%/hour workplace sitting (CI95% 6;23%, p<0.001) and at 3 months by +3%/hour workplace sitting (CI95% -5;11%, p=0.46). Finally, number of prolonged sitting periods (>30 minutes) decreased at 1 month by -0.79/8-hour workday (CI95% -1.08;-0.50, p<0.001) and at 3 months -0.41/8-hour workday (CI95% -0.70;-0.12, p=0.006). This resulted in a drop in total time in prolonged sitting periods at 1 month of -38 minutes/8-hour workday (CI95% -53;-22, p<0.001) and at 3 months of -16 minutes/8-hour workday (CI95% -31;-0.66, p=0.03), while the length of prolonged sitting periods remained stable (about 50 minutes/prolonged period).

Sitting time was primarily replaced by an increase in standing time, of +64 minutes/8-hour workday after 1 month (CI95% 51;77, p<0.001) and +43 minutes/8-hour workday after 3 months (CI95% 30;56, p<0.001). But the intervention group also increased the number of steps by +7% after 1 month (CI95% -0.2;14%, p<0.06) and +8% after 3 months (CI95% 1;14%, p<0.02).

All leisure time variables (sitting, steps and moderate-to-vigourous physical activity) remained at the same level in the intervention group compared the control group, at both 1- and 3-month follow-up (figure 5).

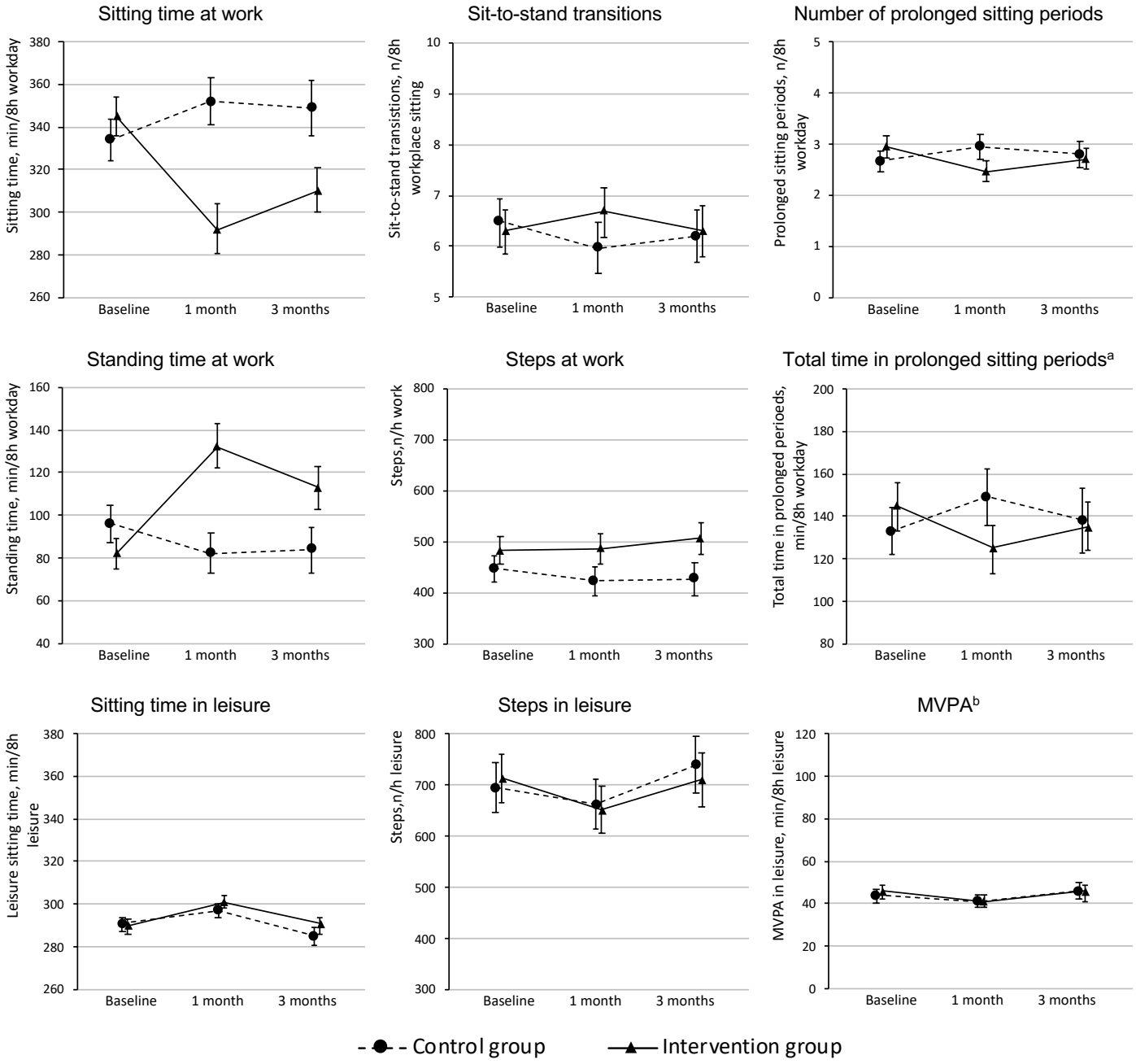


Figure 5: Mean of sitting time and activity variables in the 'Take a Stand!' intervention group and control group at baseline, 1-month follow-up and 3-months follow-up. Multiple imputation results (n=317). Bars represent 95% confidence intervals. Primary outcomes were sitting at work, sit-to-stand transitions and prolonged sitting periods (>30 minutes) after 1 month. Secondary outcomes were sitting outcomes after 3 months. Exploratory outcomes were: total time spent sitting in prolonged sitting periods, standing at work, steps at work, steps during leisure and moderate-to-vigorous physical activity during leisure after 1 and 3 months. [a]>30 minutes [b]MVPA: Moderate-to-Vigorous Physical Activity.

4.2.2 Effects on health variables (papers I and II)

Results on body composition were reported in **paper I**. After 3 months, body fat percentage in the intervention group was lower, compared to the control group, by -0.61 percentage points (CI95% -1.09;-0.14 p=0.011), reflecting an increase in fat-free mass of +0.79kg (CI95% 0.44;1.13, p<0.001). There were no changes in waist circumference and fat mass (table 4).

Table 4: Baseline and 3-months follow-up of body composition measures in intervention and control group; and between-group differences in changes from baseline to 3-months follow-up.

	Intervention group Mean (SE)		Control group Mean (SE)		Mean difference[a] (95% CI)	
	Baseline	3-months follow-up	Baseline	3-months follow-up	Baseline to 3-months follow-up	P-value
N (MI)	173	173	144	144	317	
Waist circumference (cm)	92.4 (1.12)	91.7 (1.12)	90.8 (1.06)	90.0 (1.07)	0.15 (-0.55;0.85)	0.68
Body fat percentage	29.3 (0.72)	29.0 (0.73)	31.1 (0.84)	31.4 (0.83)	-0.61 (-1.09;-0.14)	0.011
Fat mass (kg)	23.4 (0.83)	23.3 (0.84)	24.5 (0.94)	24.5 (0.92)	-0.34 (-0.75;0.08)	0.11
Fat-free mass (kg)	54.3 (0.87)	54.8 (0.87)	52.3 (0.89)	52.0 (0.90)	0.79 (0.44;1.13)	<0.001

MI – Multiple Imputation
SE – Standard Error
[a]Between-group difference from baseline, adjusted for baseline values.

Regarding musculoskeletal pain (**paper II**), the prevalence of pain in the neck-shoulder, back and extremities was 51%, 48% and 38% respectively (table 3).

After 3 months, odds for neck shoulder pain was lower in the intervention group compared to the control group (figure 6a). In the intervention group compared to the control group, taking baseline into account, Odds Ratio (OR) for pain in the neck-shoulder was 0.52 after 3 months (CI95% 0.30;0.92 p=0.02). There were no differences in pain in the back or the extremities at any time point, nor in neck-shoulder pain after 1 month (figure 6b and 6c).

In addition, we calculated a pain score ranging from 0-6, combining the degree of pain (0-2) and the number of pain sites (0-3). For this score (figure 6d), we found a slight reduction in the intervention group compared to the control group when taking baseline levels into account at 1 month (β=-0.13 CI95% -0.23;-0.03 p=0.01) and 3 months (β=-0.17 CI95% -0.32;-0.01 p=0.04).

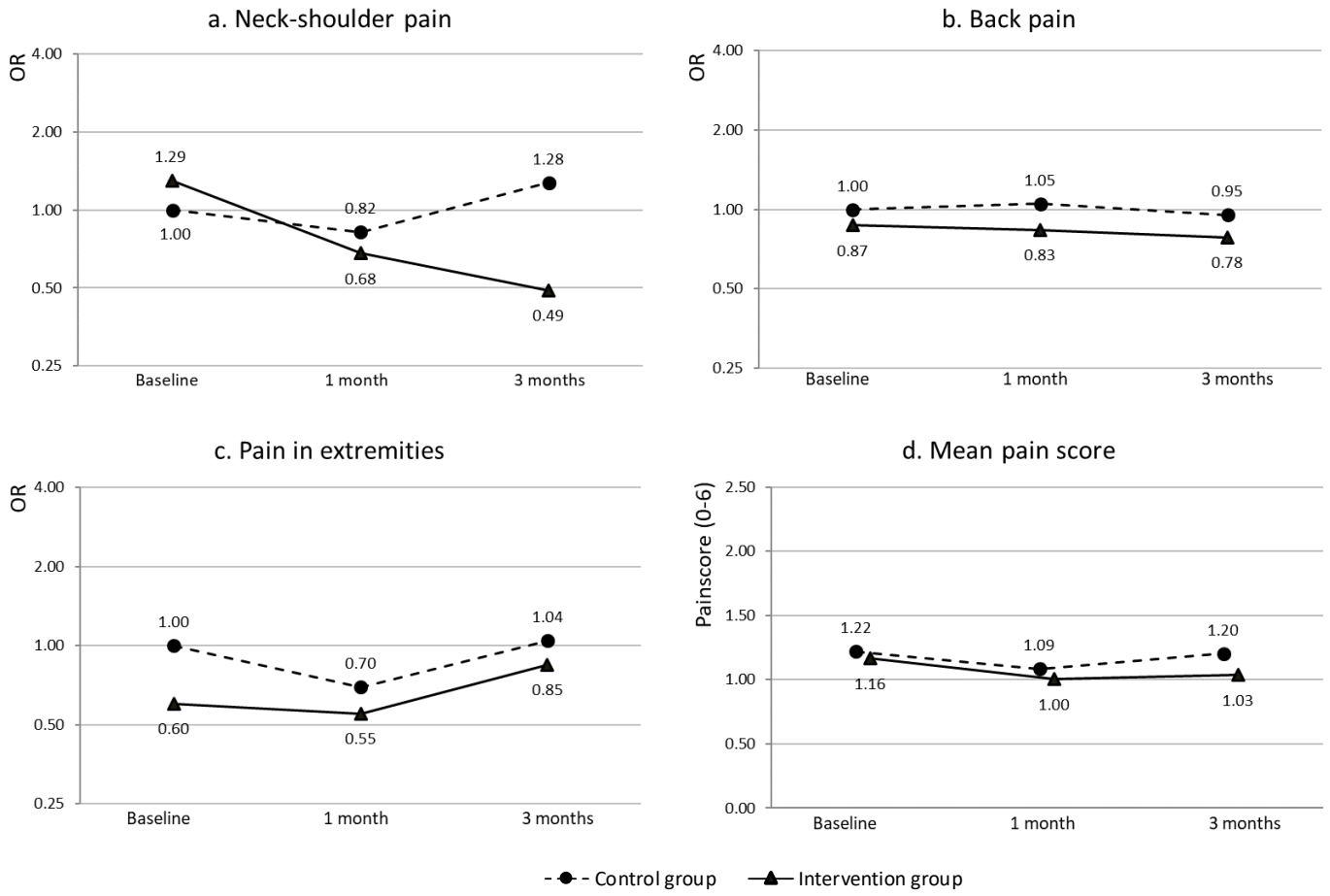


Figure 6: Odds Ratio (OR) for pain in neck-shoulder (a), back (b) and extremities (c); and mean pain score (d) during 'Take a Stand!' for the intervention group and control group at baseline, 1-month follow-up and 3-months follow-up (n=279).

4.2.3 Subgroup analysis of the main effect on sitting time (paper III)

Subgroup analyses (**paper III)** were performed for subgroups defined by socio-demographic, health and work-related, as well as psychosocial factors. The socio-demographic variables assessed were sex, age, education and marital status, and across all strata we found a similar effect on sitting at work in the intervention group compared to the control group (figure 7).

This result was repeated for the other subgroups, reproducing the overall picture of sitting time effect (**paper I)** with a large decrease in sitting time in the intervention group compared to the control group at 1 month followed by a slight increase at 3 months.

The tested health-related factors were smoking, obesity, self-rated health, sickness absence, stress, leisure time sitting, and self-reported and measured leisure time physical activity. The tested work-related factors were tenure, meeting frequency, work hours, office size, tiredness after work and being a manager. Finally, the tested psychosocial factors were baseline recordings about whether participants wanted to change workplace sitting, or felt a need for a project considering sitting time.

Socio-demographic factors

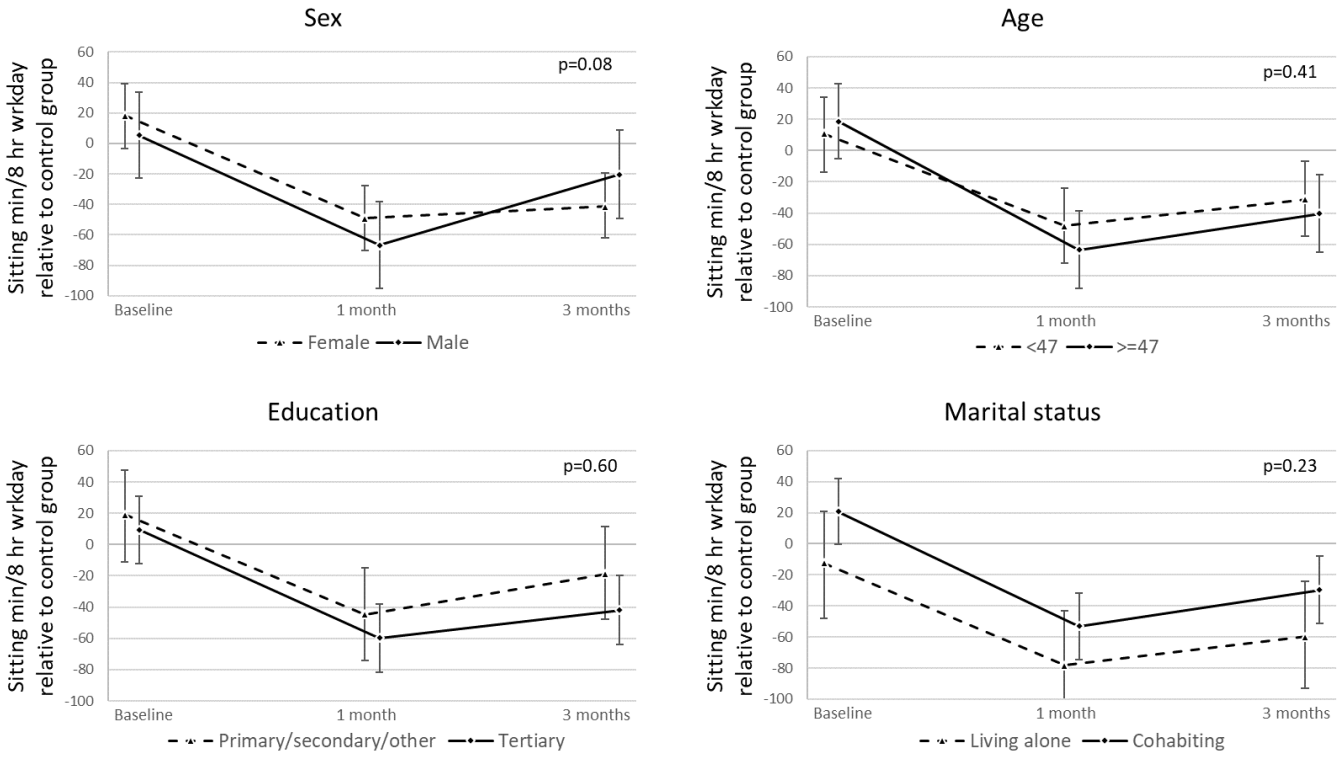


Figure 7: Selected results of subgroup analysis of the effect on workplace sitting in the intervention group compared to the control group (n=256). P-values for maximum likelihood ratio comparing the full model including three-factor interaction (randomisation*time*assessed factor) with the same model including only two-factor interaction (randomisation*time).

4.3 Process evaluation results (papers I, IV and V)

This part includes results on fidelity, factors influencing the implementation process, and the evaluation of the intervention-element on active meetings.

4.3.1 Fidelity of intervention delivery (paper I)

The fidelity of the intervention was reported as the dose delivered and the dose received in **paper I**.

At all four workplaces, all components of the intervention were delivered as planned: all planned meetings were held with the ambassadors and the managers; all offices provided facilities for standing meetings; lectures and workshops were held at all offices; and common goals were set in every office. E-mails and text messages were sent as planned; and ambassadors followed up on the project at regular meetings, varying from weekly to monthly.

Dose received was assessed by a number of indicators relating to each of the five main components of the intervention. A summary of these indicators is displayed in table 5. As can be seen, the main portion of participants received all five components of the intervention. For example, 76% participated in both the lecture and the subsequent workshop, and 86% felt that management had supported the project.

Table 5: Indicators of dose received for the five intervention components. Intervention group only. The table displays only selected indicators, for a display of all indicators, please refer to **paper I** directly.

Intervention component	Indicator	Dose received % (n)
Ambassadors and management support	Management supported 'Take a Stand!'[a]	86% (135)
Environmental changes	Know where to have standing meetings[a]	79% (124)
	Know where to have walking meetings[a]	89% (138)
Lecture	Participation rate[b]	76% (132)
Workshop	Participation rate[b]	76% (132)
	Set personal goals[b]	83% (111)
E-mails and text messages	Signed up for e-mails[c]	73% (127)
	Signed up for text messages[c]	42% (72)

[a] at 3-months follow-up
[b] information from workshop questionnaire
[c] information from distribution list. No-one signed off during the intervention period

4.3.2 Factors influencing the implementation process (paper IV)

Factors influencing the implementation process were divided into three levels: the context, the organisation of the intervention, and the mental models of participants (**paper IV**). In what follows, the main results regarding each of the three levels are described.

Context: The contextual level considered the influence of specific events at the workplace during the intervention period. Concurrent institutional changes were found to be both a potential hindrance and also a facilitating factor. So, ambassadors often found that these changes took time and focus from the project, while participants found the project to be a welcome common feature during a turbulent time. One participant in a focus group expressed this as follows:

> "*I think the project was good for us in our situation, with a whole new management and new departments; so we had some kind of a joint project."*

Organisation of the intervention: Regarding the organisation of the intervention, the themes covered initiation and drivers of change (management support and the role of ambassadors). At initiation, how the intervention was sold by the manager was important. It was this that enabled participants to feel able to participate, and not imposed upon. Management support was a major theme and was perceived to be crucial to the participants. The manager had a central role as a good example, and also because participants felt a need for the manager to allow them to participate in intervention activities. This was described in by one ambassador as follows:

> "*It's really important that management thinks it is OK to spend time on it. That they're motivated and think that it's in our best interest."*

Finally, the ambassador role had a potential to enhance the outcome of the intervention, but this was often not explored fully. In some offices, ambassadors were very active (reminding participants of the project), while in other offices participants called for a more active ambassador. However, we found no relation between having an active ambassador and sitting time effects after 3 months. Barriers to being more active, as described by the ambassadors, were time constraints and a fear of violating the privacy of co-workers.

Mental models: The concept of mental models considered the motivation and the development of shared mental mindsets during the intervention. In the statistical analysis, a strong desire to reduce sitting time, a high motivation towards the intervention, and a strong sense of collective engagement were each significantly related to decreased sitting time after 3 months of about 30 minutes/8-hour workday, compared to participants with low scores on these variables.

The social part of the project was highlighted as very important and, across factors related to mental models, several themes came up during interviews, all considering social aspects of the intervention. These included mutual influence between participants, humour, and the ability of the project to create a feeling of community at the office. Participants influenced each other in the office, so that one person raising his/her desk could inspire others to do the same. This was described by a participant in one of the focus groups as follows:

> "*There's a bit of a domino effect. Oh-oh, the others are standing up... I better do the same!"*

Lastly, non-participants at the office were described in mixed terms, being both a potential barrier and a potential promoter of the intervention.

Altogether, individual factors like motivation might influence the actual effect on sitting time, but the organisational culture in the office was found to be very important for implementation of the intervention, as illustrated by this quotation:

> "*I really think that the single most important aspect has been that management and colleagues backed the project."*

4.3.3 Feasibility and effectiveness of active meetings (paper V)

Active meetings (that is, meetings beeing standing or walking) was a sub-element of 'Take a Stand!' To evaluate this element (**paper V**), we assessed the feasibility as the implementation of active meetings, and the views of participants regarding barriers and enablers for these meetings; and the effectiveness as the relation between participation in standing and walking meetings and sitting time at work at 3 months.

It was found that it was highly feasible to organise standing meetings in the office setting. At 3-months follow-up almost all participants (94%) knew where to have standing meetings, 92% found facilities for those satisfactory, and in most offices standing meetings were now part of the general meeting-routine.

Facilities in the form of high meetings tables were key for meetings to be standing, as one participant noted: "*As long as the desks are in the up position, so are we*."

In addition, standing meetings were found to be more effective, with participants being more focused, attentive and participative, compared to sitting meetings. This was explained by one participant as follows:

> *"In addition, you avoid one or two of your colleagues leaning back and zoning out, like they do when everybody's seated."*

On the other hand, walking meetings were not implemented on regular basis at any office, even though several ambassadors tried to implement the concept. Barriers were mainly practical issues like the weather and lack of discretion. Furthermore, participants found it hard to keep focus while walking and some feared that leaving the office would be perceived as 'skipping work'.

Regarding effectiveness, workers participating in standing meetings on a regular basis sat 59 minutes/8-hour workday less after 3 months compared to workers with no participation in standing meetings. Participation in walking meetings was not associated with reduced sitting time, probably due to the very low implementation level (figure 8).

	N (%)	Sitting at 3 mo[a] (CI 95%)
Participation in standing meetings		
No	9 (7)	
Yes, occasionally	66 (52)	-23 (-63;18)
Yes, regularly	52 (41)	**-59 (-101;-17)**
Participation in walking meetings		
No	69 (55)	
Yes, occasionally	55 (44)	-15 (-37;7)
Yes, regularly	2 (2)	-55 (-141,30)

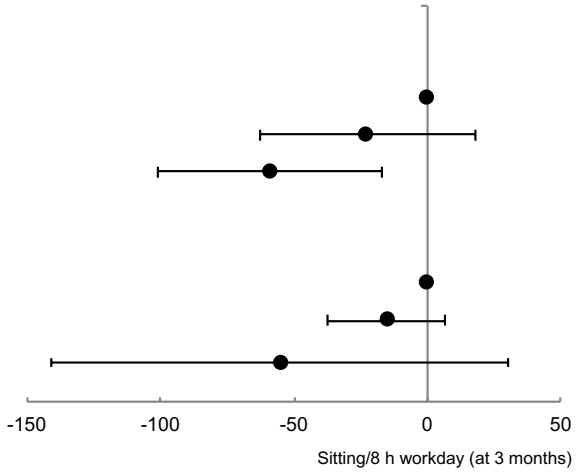


Figure 8: Participation in standing and walking meetings and association with sitting time at 3-months follow-up. Intervention group only (n=127). Boldface indicates statistical significance (p=0.017). [a]Sitting/8-hour workday at 3-months follow-up compared to baseline.

5 Discussion

5.1 Main findings

The main effects of 'Take a Stand!' were:

- *Effects on sitting time* (**paper I**): The main goal of reducing sitting time among office workers was achieved, as sitting time at work was reduced by 71 minutes/8-hour workday after 1 month and 48 minutes/8-hour workday after 3 months. Prolonged sitting periods decreased and sit-to-stand transitions increased.
- *Effects on activity* (**paper I**): Sitting time was mainly replaced by standing, but the number of steps during work hours increased as well. There were no changes in leisure time sitting, steps or physical activity.
- *Health effects of the intervention* (**papers I** and **II**): Body fat percentage reduced slightly reflecting an increase in fat-free mass. Additionally, pain in the neck-shoulders and the total pain score were reduced. There were no changes in waist circumference, BMI or pain in the back and the extremities.
- *Sitting time effects across subgroups* (**paper III**): The effect on sitting time seemed not to differ across the tested subgroups.

The main results of the process evaluation were:

- *Fidelity* (**paper I**): Overall the intervention had high fidelity, both regarding the dose delivered, where all components were delivered as planned; and the dose received, where most participants reported positively on indicators for receiving each of the five intervention components.
- *Implementation process* (**paper IV**): Being part of the context, concurrent institutional changes were perceived both as a barrier and a promoter of implementation. Relating to the organisation of the intervention, management support was found to be very important, and ambassadors had great potential as drivers of change. Finally, regarding the mental models of the participants, desire to change sitting habits, motivation, and sense of collective engagement were related to decreased sitting time. Additionally, the social aspects were very important during implementation of the intervention; for example, through the mutual influence between participants reminding and supporting each other.
- *Feasibility and effectiveness of the sub-element of active meetings* (**paper V**): Standing meetings were feasible to implement, and frequent standing meetings were associated with reduced sitting time.

Standing meetings were perceived to be more productive compared to sitting meetings; however, the right facilities were needed. Walking meetings were difficult to implement and rarely used. The main barriers included practical issues, like the weather, and organisational barriers, like perceived lack of acceptance of walking meetings as part of productive work.

5.2 Is it possible to reduce sitting time among office workers?

As described in the background section, 'Take a Stand!' was developed when the field of research in sitting time interventions among office workers was still evolving. Since then, workplace interventions have been tested in large RCT studies [90, 91], and results of these intervention studies have been summarised in reviews [72, 98, 102-105]. In the following section, the sitting time effects of 'Take a Stand!' are compared to these studies.

We found that 'Take a Stand!' effectively reduced sitting time by 71 minutes after 1 month and 48 minutes after 3 months. These effects are comparable to the findings of two large RCT studies of multi-component interventions, conducted in England and Australia, with follow-up after 3 to 12 months [90, 91]: Edwardson *et al* [90] found a reduction in sitting time of -51 minutes/workday at 3 months, -64 minutes/workday at 6 months, and -83 minutes/workday at 12 months; while Healy *et al* [91] found a reduction of -99 minutes/8-hour workday at 3 months, and -45 minutes/8-hour workday at 12 months. The interventions in these studies were similar to 'Take a Stand!', in that they included an organisational component in the form of management support, an environmental component of sit-stand desks, and an individual component involving education and individual goal-setting. In addition, these interventions included an element of individual coaching and feedback. Regarding the environmental component of sit-stand-desks, there was a difference between interventions which might influence the effect; the English and Australian studies introduced new (and expensive [133]) sit-stand desks to participants, which might enhance motivation [134], while Danish workers already had sit-stand desks but needed change their behaviour and start to use the sit-stand function.

These results from multi-component interventions are supported by similar reductions in sitting time from reviews and meta-analysis of workplace interventions. For example, meta-analysis of interventions with activity-permissive workstations found pooled effects of -77 minutes sitting/8-hour workday [102], while interventions focusing on computer, mobile and wearable technology yielded an effect of -42 minutes sitting/day [105] (the analysis here included 'Take a Stand!'). Regarding multi-component interventions, one review of smaller studies (<50 participants) found a pooled effect of -89 minutes/8-hour workday [98], while a Cochrane review [104] concluded that multi-component interventions seemed effective in reducing sitting time. However, they were not able to calculate the pooled effect size because of the small

number of studies, and they called for more large-scale RCT studies with follow-up times above 12 months [104].

Altogether, it seems feasible to reduce sitting time among office workers by about one hour a day, especially by introducing multi-component interventions, like 'Take a Stand!'.

5.2.1 Sustainability of sitting time effects

Even though it is initially feasible to reduce sitting time, there might be an issue on how to retain effects in the long term. In 'Take a Stand!' this was seen from the reduced effect size between 1 and 3 months (**paper I**), and described by participants as decreased motivation (**paper IV**). The two RCT studies mentioned above showed opposing results in this regard: in the study by Healy *et al* [91], there was a reduced effect over time, which the authors suggested might be due to the fact that the individual component ceased after 3 months. This was supported by Edwardson *et al* [90], who contributed their increased effect from 3 to 12 months to ongoing coaching and sustained contact with the research team. In 'Take a Stand!', contact with the research team was brief at 1 month and there was no contact between the 1- and 3-month follow-up, which supports the hypothesis that ongoing coaching and contact is necessary to sustain the effect. That notion is as well substantiated by findings that interventions might lose momentum over time [93], and by participants in 'Take a Stand!', who called for more active ambassadors and more reminders during the intervention period (**paper IV**). Furthermore, participants attributed decreased motivation to the fact that the main focus at the workplace is productive work. This suggests the need to incorporate changes within the organisational culture and workplace structure in order to ensure ongoing focus and support; something which is discussed further in the section on the workplace as context below.

5.3 Is the change in sitting time enough to influence health?

At the moment, there is no international agreement on exactly how much sitting time is too much [38], or about how much of a reduction is needed to see a clinically relevant health effect. Given that, what are the clinical perspectives of reducing sitting time at work by 48-71 minutes, as we did in 'Take a Stand!'?

Considering workplace sitting, analysis of cohort data from 50,277 women concluded that every two hours/day increment in workplace sitting was related to a 5% increase in obesity and a 7% increase in diabetes [135], while an intervention study found cardiometabolic effects after 12 months with reduction in workplace sitting of -99 minutes after 3 months and -45 minutes after 12 months [136]. A systematic review of workplace sitting time interventions (including 'Take a Stand!', **paper I**) concluded that, in general, interventions are able to improve cardiometabolic health by reducing sitting time [137]. Most of the studies included found sitting time reductions between one and two hours; however, the minimum change required to yield benefits, and the dose-response relation, remains unknown [137].

Looking at total sitting time, a reduction like the one found in **paper I** might be related to lower all-cause mortality, when the reduction is in the high end of sitting time. So meta-analysis of accelerometer-measured sitting time has found increased risk of all-cause mortality above 9.5 hours of daily sitting [28]. More specifically, reducing sitting time from 11 hours/day to 10 hours/day corresponded to a reduction in all-cause mortality with HR from 2.2 to 1.5 compared to sitting 7.5 hours/day [28].

Altogether it seems reasonable to conclude that reducing sitting time by 48-71 minutes, as we did in 'Take a Stand!', could have a positive health impact. However, the health effect is small, and changes in sitting time might influence other health behaviours — which could again affect the total health impact, both positively and negatively. On the positive side, one could speculate that an intervention like 'Take a Stand!' might lead to improvement in other health behaviours as a result of an increased focus on health and the experienced ability to change one's health behaviour [138]. On the negative side, changing sitting time might have negative consequences on other behaviours, such as diet. This has been suggested in studies on time spent watching television: these find that some of the negative health consequences of a high quantity of TV-time might be due to increased snacking [139]. To my knowledge, no studies have assessed the relation between occupational sitting, energy intake and health; however, it might be a relevant factor to consider in relation to the total health impact of sitting time interventions. Hypothetical effects might be similar to those for TV-time, with increased sitting resulting in increased energy intake. However, the opposite could also be the case: office workers reducing sitting time might increase calorie intake because, they think, they should compensate for the increased energy expenditure from standing.

In a wider perspective, office workers are a relatively healthy population. This was also shown to be the case in the present study, where levels of smoking and physical inactivity were low and educational level high. It might, therefore, be harder to detect health effects of sitting time interventions among office workers, than when intervening in groups with less favourable health profiles [40]. On the other hand, workplace health promotion, like reducing sitting time, is categorised as primary prevention. That is, it involves targeting a healthy population in order to prevent or delay the occurrence of disease [64]. Thus, through primary prevention intervention like 'Take a Stand!' reaching large groups of the population, such as all office workers, even small changes at the individual level might have substantial consequences at a larger population level in the long run by preventing or delaying disease in large groups [48, 64, 136].

5.3.1 Could reduced sitting time affect musculoskeletal pain among office workers?

We examined the association of 'Take a Stand!' with the prevalence of musculoskeletal pain, and found positive effects on neck-shoulder pain after 3 months (**paper II**). More specifically, we found an increase

in pain in the control group, together with a reduction in the intervention group, which indicates that the intervention both reduced and prevented neck-shoulder pain.

A review from 2019 [140], which included results from 'Take a Stand!', found that evidence was not adequate to conclude that reducing sitting time is able to reduce musculoskeletal pain. Other reviews on the prevention of musculoskeletal pain among office workers have found that an increased number of breaks might be able to prevent musculoskeletal pain, while introducing sit-stand desks alone might not be effective [141, 142]. However, the studies were found to be of low quality and with mixed results, and there is a need in the future for high quality studies on whether reducing sitting time or increasing breaks from sitting can help prevent or reduce musculoskeletal pain among office workers [140, 141]. Finally, a time-lag has been proposed, requiring a minimum duration of the changes involved before effects on musculoskeletal pain are seen [143]. However, no studies have looked at long-term associations between reduced sitting time and musculoskeletal pain [140, 144].

A number of other strategies, like exercise regimes, resistance training or stretching have been found effective to prevent or reduce musculoskeletal pain [142, 145]. However, these strategies are likely to take up time during the workday and therefore, reducing musculoskeletal pain without affecting productivity, e.g. through the reduction of sitting time, might be more attractive to employers.

5.4 Should we target specific groups of workers?

When implementing a workplace-based health promotion project focusing on sitting, it might seem relevant to focus on specific groups e.g. those least active during leisure time, as they are not able to compensate for the many hours of sitting by doing physical activity, and they will be at increased risk of health consequences [27]. The project could also be structured individually, so that only the people most motivated to change would take part.

However, our results from subgroup analysis (**paper III**), which are support by results from other studies [90], suggest that the effect seem similar across subgroups of these factors. In addition, our results from the process evaluation highlighted organisational support from managers and colleagues as important for the intervention to succeed (**papers IV** and **V**). As a result, an all-office approach seems to be the most feasible and yield the potentially best effect.

This is in line with workplace health-promotion literature, suggesting a shift from individual programmes towards broader programmes including both the physical and social environment at the workplace [66, 146]. Future interventions to reduce sitting time should, therefore, target the whole office. The implications of the workplace as a context are discussed in the following section.

5.5 The workplace as a context for health promotion

As described in the introduction of this thesis, the workplace is a relevant place to conduct health interventions, partly because large groups of adults spend many hours there. However, there are also several aspects to consider when implementing sitting time interventions in the workplace; how the distinct context of the workplace affects implementation, how the intervention appeals to the employer, and, finally, ethical aspects of workplace health promotion. In this section, these are discussed in relation to 'Take a Stand!' and similar interventions.

5.5.1 How does the workplace context influence implementation of interventions?

When introducing a sitting time intervention in the workplace, it is important to be aware that the intervention is implemented in an organisation with a specific organisational culture, social norms and ways of working [64, 147, 148]. This means that, for interventions to succeed, especially in the long run, this organisational context needs to be actively addressed.

An important element in the organisation of most workplaces is the managers, and, as supported by **paper IV**, management support is often found to be key for behavioural changes to take place [100, 101, 148, 149]. From the very start of the project it is important, therefore, to ensure management support e.g. by engaging with managers, understanding barriers and facilitators, and communicating potential benefits and costs [101]. Furthermore, during the intervention period, it is important that management support is visible and communicated effectively [149, 150].

Another aspect of the workplace is the social climate, norms and support system between colleagues [101]. Especially support from peers and a supportive social climate has been highlighted by employees in several studies and reviews, including **papers IV** and **V**, as important for changes in sitting time to take place [97, 99, 100, 151-154]. However, changing the organisational culture takes time, with a continuous focus, in order to be implemented and yield the full effect [87, 93, 96, 155]. In this regard studies have found changes in sitting time after 4 weeks to 3 months; however, others suggest that the optimal effect might take up to 12 months to achieve [87, 96, 155]. Thus, with an intervention period of 3 months, 'Take a Stand!' might not have succeeded in changing the organisational culture around workplace sitting, and this failure might explain some of the problems with maintaining the sitting time effect, as described above (section 5.2.1).

Finally, interventions need to be fully integrated into the productive work to yield their full potential [72, 101]. In this way, over time, reduced sitting would be an integrated part of the workplace culture, and the design of the productive work would naturally and inherently support and promote alternatives to sitting [14, 73].

Altogether, interventions yield success by actively addressing and maintaining focus on the organisational context of the workplace, including managers, the social climate and the nature of the work involved. Using elements from 'Take a Stand!', this would result in an organisational culture where management supported standing work and standing meetings; where colleagues encouraged each other to stand; and where facilities were right for both standing meetings and standing work. With these changes, interventions effects would be more likely to be retained over time, even without the involvement of researchers.

5.5.2 What could motivate employers to implement sitting time interventions?

In order to ensure management and organisational support for an intervention in this area, it is necessary to motivate employers to implement it. According to the WHO definition [65], a healthy workplace promotes workers' safety, health and wellbeing, and as such reducing sitting time fits well into workplace health promotion.

As found in 'Take a Stand!', sitting time interventions might have positive effects on musculoskeletal health (**paper II**), something which is costly to employers, however, as discussed above (5.3.1), evidence in this area is still sparse. Other short-term consequences, relevant to the employer, could be reduced stress-levels [101] and the social benefits afforded by providing employees with a sense of community (**paper IV**). However, the main health effects on cardiovascular disease and diabetes, particularly, are obtained at a later time. Sitting time interventions are therefore considered to be primary prevention, which pays off in many years, making them less attractive to employers, who have to consider returns in the short run [64]. Hence, the health effects of sitting time interventions might not be enough to motivate employers, and it is necessary to consider how they could impact productivity and whether they are cost-effective.

Regarding productivity, this is often difficult to measure objectively among office workers. However, self-reported productivity has been assessed in a number of studies, including 'Take a Stand!'. In 'Take a Stand!' we found no effects on productivity (results not published), but studies of similar interventions have actually found improved productivity [156-158].

Regarding cost-effectiveness, one study has taken the employer perspective (considering productivity, absenteeism and presenteeism) and concluded that increased productivity compensated for intervention costs, resulting in savings over a 12 months period [156]. Another study has considered a wider perspective and concluded that reducing sitting was associated with a greater cost; however, over the lifetime of the cohort, the intervention was found to be cost-effective when scaled up to the national level [159].

Summing up, to convince employers, it is necessary to highlight the way that sitting time interventions could positively affect musculoskeletal pain and productivity in the short run, and that they are cost-effective in the long run when health effects on lifestyle diseases are achieved.

5.5.3 Ethical aspects

Implementing sitting time interventions, like 'Take a Stand!', at a broader scale, and as all-office interventions, has some ethical implications, which are important to consider.

By law, work should not harm employees, and as previously mentioned, the WHO proposes healthy workplaces to promote the health and wellbeing of workers [65]. However, health is often considered an individual matter and workplace health promotion projects are therefore subject to concerns about the individual autonomy and privacy [64, 160, 161].

In 'Take a Stand!', non-participants in the office were found potentially to reduce the motivation of participants (**paper IV**), either because they expressed negative opinions towards the project, or because they were not part of the social support system around the intervention. However, in order to respect individual autonomy, it is hard to make participation mandatory. A study on non-participation in a workplace health promotion project has shown that some employees did not participate due to moral considerations; for example that the employer might violate privacy by interfering in health behaviour [161]. Thus, in order to accommodate issues of non-participation, moral issues and respect for individual decision-making need to be addressed when initiating interventions at the workplace [161, 162].

Another proposed solution to the dilemma posed by a tension between autonomy and workplace health promotion is that the employer should ensure a healthy environment through promoting the right organisational factors for healthy work. By making the healthy work set-up easy and the default situation, individuals would be in a position to decide themselves whether and how to make use of these possibilities [73, 160, 163, 164]. Regarding sitting time interventions, this would imply that managers should support standing work and meetings and provide sit-stand desks and high meeting tables, while individual employees decide when to raise the desk, when to break from sitting, and exactly which meetings should be standing ones. In this way, interventions become all-office interventions. This approach is also supported by the results in **paper IV,** and by other studies highlighting the need for social support for interventions to succeed.

5.6 Could intervention elements be effective on their own?

In **paper V**, we explored the feasibility and effectiveness of one sub-element of the intervention: namely, active meetings. We found that standing meetings, especially, could be implemented successfully, and that participation in these was related to a reduction in sitting time.

However, looking at one sub-element of the intervention, and finding it effective in reducing sitting time, might not be enough to warrant this element being implemented on its own [48]. For example, in 'Take a Stand!' we found that the right facilities were key for standing meetings to take place (**paper V**). Other studies have highlighted that participants need organisational support in order not to feel odd when standing [148, 165, 166]. In 'Take a Stand!', facilities were in place (**paper I**) and organisational support for standing meetings was most likely obtained through the common goal setting at the workshop, where standing meetings were included as a goal in most offices.

In 'Take a Stand!', standing meetings were well-implemented and popular, but only because this intervention element was supported at several levels; environmental (high meetings tables), organisational (common goal setting towards regular standing meetings) and probably individual, too (for instance, individual goalsetting and the provision of information on health consequences). In addition, we do not know how much of the reduced sitting time was during meetings, how standing during meetings influenced activity for the rest of the workday, or how standing meetings impacted the implementation of other elements of the intervention.

This finding, that it is hard to isolate elements or strategies from a multi-component intervention, is supported by an Australian study from Stephens *et al* [167], who analysed participant-selected strategies from a multi-component workplace intervention, which successfully reduced sitting. They identified over 80 strategies (including standing during/before or after a phone call, removing bins, and standing during meetings) and concluded that workers chose several different strategies. Moreover, both the specific strategy and the number of strategies affected the reduction in sitting time.

In addition, Shrestha *et al* [104], in their review of sitting time interventions among office workers, used the ecological model by Sallis *et al* [168] to argue that interventions should include the following to be effective: infrastructure for reducing sitting (that is, environmental changes); increasing awareness and understanding of why and how (that is, individual support); and making use of social networks (that is, organisational changes).

Altogether, this supports the view that successful interventions should include multiple components, including organisational support (as supported by **paper IV**), and provide various strategies (for example

standing meetings, using sit-stand desks and breaking sitting time), enabling the individual to choose which strategies fit their daily work best, as supported by the ethical considerations set out above.

5.7 Methodological considerations

The main strength of the present study is the randomised controlled design (**papers I** and **II**), which is placed at top of the hierarchy of evidence and which is considered the gold standard for evaluating health interventions [169, 170] . Other strengths include the multi-component intervention developed with Intervention Mapping; the objectively measured sitting time; the large number of participants; the long follow-up compared to previous studies on sitting time interventions; and the high fidelity of intervention delivery.

The mixed methods design of **papers IV** and **V,** combining questionnaire data and interview data also has several advantages: information from interviews was used to generate variables for statistical analysis (**paper IV**); results from statistical analysis were better understood by following them in the interview material (**paper IV**); and different parts of the research question were addressed with the most suitable methods (as in **paper V**).

However, there are of course a number of methodological considerations and potential limitations, of which the most important will be discussed in the following section.

5.7.1 Measuring sitting time – potential drawbacks of thigh-born accelerometers

Measuring sitting time with accelerometers placed on the thigh is highly recommended [120, 171] and widely used in workplace sitting time interventions [e.g. 91, 155, 172, 173]. That said, there are a number of potential drawbacks to be aware of: firstly, one could question the actual objectivity of this objective measurement method; and secondly, there is a lack of information on energy expenditure. This will be discussed in the following section, and finally, alternative measurement methods will be touched upon.

The objectivity of measurements can be questioned because wearing the accelerometer can itself influence activity patterns. For example, in ‘Take a Stand!’ – and most likely in other intervention studies – it might be speculated that participants in the intervention group might be especially keen on sitting less during the accelerometer wearing period, but not so much during the rest of the intervention period. This might impact the control group too, but not to the same degree because they have not received the intervention and accompanying suggestions on how to change behaviour. In this case, the sitting time effect of the intervention would be over-estimated; however, this is hard to avoid, or measure, since participants might not be fully conscious of it.

As mentioned previously, the definition of sedentary time includes both energy expenditure (MET-value) and posture (sitting, reclining or lying) [8]. When measuring sitting time with an accelerometer on the thigh, we get information on posture: that is, when the thigh is horizontal and not moving, the person is sitting, reclining or lying. In the case of office workers, and especially during working hours, this is assumed to be equivalent to sitting time; however, we do not get accurate information on the energy expenditure involved. But as office work mostly involves no or low upper body activity, and as no stand-alone system exists for assessing both posture and energy expenditure, assessing both would increase the participant burden, the researcher resources and the costs, and for this reason a postural measure of sitting time is considered the most adequate [120].

New measurement methods resulting from technological advances, or from new uses of existing data from mobile phones and smart watches, might offer alternatives or supplementary information to data acquired from thigh-born accelerometers [120]. For example, a study from 2018 by Clark *et al* [174] tested the use of Bluetooth monitors (on the thigh/wrist of participants, and in different locations in the office) to determine the position of participants in the workplace and the results were promising. In ways like this it is possible to obtain information on where workers spend their time, and which types of activity are prevalent at different locations, for example, whether they are standing in meetings rooms, at their desk, or in the hallway. This makes it possible to obtain more knowledge about participants' behaviour, and possibly about the effectiveness of different strategies in interventions.

5.7.2 Analysing activity data – why consider the 24-hour nature of a day?

The day has a finite amount of time in it (24 hours). When reducing one type of activity (for example, sitting time), another type of activity (for example, standing or walking) has to increase. In 'Take a Stand!' we found a decrease in sitting time in the intervention group, an increase in standing and the number of steps taken, a reduction in prolonged sitting periods, and an increase in breaks from sitting (**paper I**). Altogether this gives a picture of a more varied and active workday, as one would assume that sitting was replaced by several different activity types. Moreover, when we assessed sitting, physical activity and steps taken during leisure, we found no changes as a result of the intervention. This allowed us to assume that activity patterns during leisure time were quite stable, regardless of the intervention. However, we have not assessed all-workday or all-day activity patterns, which means that changes might cover up very different patterns between workers.

Recently, greater focus has been directed towards the possible weaknesses of traditional one-activity analysis, as performed in 'Take a Stand!' (**paper I**) when analysing time use data. For example, it may be that these analyses are not able to decide which activities replace the activity in focus, and how these

substituting activities affect health outcomes [175]. In addition, the health consequences of physical activity depend upon whether the activity is performed at work or during leisure time [176, 177], and studies have indicated that the same applies to sitting time [46]. Finally, it has been suggested that there is a need to achieve a balance between different activities across a 24-hour day [178].

All this calls for alternatives to one-activity analysis, for example isotemporal substitution analysis, which considers the fact that one activity is *per se* replaced by another [48, 179], or compositional data analysis, which takes into account the finite 24-hour time period in any day [48, 175, 180-182]. An example of this would be the compositional data analysis of data from an Australian sitting time intervention in the workplace, which concluded that replacing sitting with walking was associated with greater health benefits than when it was replaced by standing [180].

Altogether, when analysing data from workplace sitting time interventions, it is relevant to consider what activities replace sitting time, how sitting in different domains effect each other, and what health consequences this has. This can of course be achieved by traditional one-activity analysis, as in 'Take a Stand!' but more information could be obtained by taking the 24-hour nature of the day into account in analysis.

5.7.3 What is the problem with traditional subgroup analysis?

For the traditional subgroup analysis related to the main effect of the intervention (**paper III**), we pre-hypothesised 20 factors potentially related to sitting time and intervention effect, and tested them one by one. This procedure is commonly used; however, it is associated with a number of limitations [183, 184] such as power, because the survey was not scaled to measure subgroups. Another potential problem is related to the application of the results; we tested only one variable at a time; however each person will belong to several groups and therefore it might be hard to draw a settled conclusion on the basis of the results [184]. We did not find any group differences, making conclusions in this regard straightforward; however, we cannot rule out differences, which could not be detected due to lack of power. Alternatives to a traditional subgroup analysis are found in more advanced methods, for example predicted outcome risk or treatment effect modelling, making it possible to identify subgroups by several variables at a time [183, 184].

5.7.4 Self-selection and social-desirability bias in interview data

Participants for the focus groups were recruited through the ambassadors as a convenience sample [185], including participants from intervention clusters who had the time and willingness to participate in a focus group during working hours. Within this process it was emphasised that we aimed to include participants with both a positive and a negative view of the intervention. Overall, it was our perception that this intention was fulfilled, since several focus groups revealed both positive and negative opinions. However, we

cannot rule out self-selection bias. Self-selection bias occurs when participants who volunteer for interviews are different from those who do not [185]. As such, it might be that participants in interviews were those having the most radical thoughts (positive or negative) towards the project, or that they were only those who were not otherwise busy, or that they were those who always volunteered at the workplace. If this was the case, then it might impact the generalisability of the results [185].

Another type of bias that might pose an issue in our interview data is social desirability bias. In other words, that the person interviewed is trying to present their account of reality in a way that is socially desirable to the researchers [186]. In the case of 'Take a Stand!', participants in interviews might, therefore, tend to be too positive about their level of participation and implementation of the intervention, in order to please the interviewer, who was representing the research project and thus the intervention. To account for this, most of the interviews were conducted by a student assistant who was not part of the implementation of the intervention. However, we cannot rule out social desirability bias, and the consequence of this is that intervention components and effects might be presented more positively than was actually the case.

5.7.5 Challenges of mixed methods

By using mixed methods, in **papers IV** and **V,** we obtain results, which could not be obtained by one of the methods separately. This is one of the potential strengths of mixed methods; that the end product is more than the sum of the individual parts [187]. However, combining methods also has its challenges. For example, in **paper IV**, regression analysis found no association between management support and sitting time effect, while interview results identified management support as crucial for change to take place. This was explained as due to lack of power in the statistical analysis or because the methods used considered different aspects of management support. However, it might be an example of giving the more interesting finding (that management support is important) focus in reporting the results, which is a common problem when integrating quantitative and qualitative research [187]. Other relevant barriers mentioned by Bryman [187] are the structure of the research project and the role of timeliness in it. In the case of the present project, questionnaire data and interview data were collected at different timepoints, and were thus not able to feed into each other. For example, it would be interesting to be able to include the interview-finding that standing meetings were perceived to be more effective (**paper V**) into questionnaires, in order to reveal the frequency of this experience.

6 Conclusions

‘Take a Stand!’ was a multi-component intervention implemented among office workers. It effectively reduced sitting time at work after 1 and 3 months. The intervention group also increased breaks from sitting, reduced prolonged sitting periods, and increased standing and the number of steps taken at work. Leisure time sitting, number of steps and physical activity did not change. The effect on sitting time did not differ between any of the tested subgroups, indicating that the intervention was effective across all groups.

Health consequences of the intervention were a reduction in body fat percentage, reflecting an increase in fat-free mass, and a reduced prevalence of pain in the neck-shoulders. There were no effects on waist circumference, BMI or pain in the back or the extremities.

Process evaluation showed high intervention fidelity and identified several factors that had an impact on the implementation of ‘Take a Stand!’ These included individual factors, like motivation; but even more importantly, organisational factors such as management support and the social aspects of the project, where participants influenced and supported each other. Explorative analysis of the sub-element concerning active meetings showed that standing meetings were both feasible and effective in reducing sitting time, while walking meetings were associated with several barriers, making them difficult to implement.

On the whole, this thesis indicates that multi-component interventions like ‘Take a Stand!’ are able to reduce sitting and improve health among office workers. However, attention must be paid to the organisational context of the workplace, in order for implementation to be successful.

Future studies should consider long-term retention of intervention activities and intervention effects, along with the opportunities to scale up successful interventions to suit other workplaces.

7 Implications

7.1 Implications for research

The findings in this thesis, together with concurrent research, contribute to the growing evidence base on sitting time among office workers. This evidence is quite comprehensive now, compared to the time when we developed 'Take a Stand!'. However, there are still areas lacking evidence, and new areas calling for more research. Some of these are described below.

First of all, successful multi-component interventions should be scaled up and adjusted to fit real-life settings as well as possible. Effects should be assessed at long-term (>12 months), in order to evaluate both sustainability of sitting time effects and the full health and organisational consequences [48, 136, 188]. Furthermore, these studies should assess implementation procedures, focusing on how to prepare for dissemination outside research projects [48]. Examples of large, long-term and translational studies are currently taking place [133, 189, 190], and the results of these will inform the future implementation of sitting time interventions at workplaces.

Interventions like 'Take a Stand!' could be moderated to respond to findings about greater health effects from replacing sitting with stepping compared to standing [180] for example, as suggested by Owen *et al.* [48], this could be done by assessing the effects of short exercise activities at the desk, for example squats. Specific elements of interventions, like standing and walking meetings, could also be deliberately assessed in the context of a full intervention, focusing on how specific elements could be incorporated into every-day work. Moreover, new interventions should take the 24-hour nature of the day into account [133], together with the need for a balance between activities across the day [178] — for example by intervening towards passive commuting and leisure time sitting [48].

Finally, future interventions could assess the health effects and implementation aspects of the proposed guidelines for sitting in the office workplace [191], in order to offer further guidance to office workers on the desirable amount of sitting and standing. These guidelines, proposed by an expert committee of sitting time-researchers from UK, USA and Australia in 2015, suggested at least two hours a day of standing or light walking during working hours, gradually increasing to four hours a day. In addition, they proposed regular breaks from sitting, the use of sit-stand desks, the avoidance of prolonged seating and prolonged static standing, and they recommended the inclusion of sitting time in general workplace health-promotion activities. However, they were based on existing evidence, while actual implementation effects had not been assessed.

Methodologically, musculoskeletal pain should be examined with detailed questionnaires — for example, the Nordic Musculoskeletal Questionnaire, which considers symptoms and pain intensity in nine body areas [144]. This should be done in order to obtain greater knowledge on causal pathways, long-term intervention effects, and the secondary consequences on sick leave and productivity. Analyses should also make use of compositional data methods, which could contribute to increased knowledge about both activity and health effects [180].

Finally, instead of only targeting office workers, future studies could consider specific target groups in different sectors, doing different types of work, or in different office layouts. Alternatively, new target groups of workers with a high level of sitting time could be explored, for example cashiers, drivers or receptionists.

7.2 Implications for practice

The results of this PhD could have several implications for practice: at the national level, between sectors, within workplaces, and for the individual office worker. These implications are expanded upon in this section.

Although the debate is ongoing, there are currently no international guidelines on sitting time and no agreements on the exact quantity to recommend [192-194]. However, several countries, such as Australia, the USA, Norway and the UK [193, 195-197], have included recommendations on sitting time in their national physical activity guidelines. For example, from the UK [195]: “All adults should minimise the amount of time spent being sedentary (sitting) for extended periods”, moreover the UK is the only country to have a work-related reference in this regard, as the extension to the recommendation includes “taking regular breaks at work”. Regarding occupational health and safety policies, no country has specifically included sitting time [198], and as the evidence base is still evolving it might be hard to give specific directions as to the exact amount of sitting to recommend [38]. However, policies could make use of the above-mentioned guidelines from 2015 [191], or they could include recommendations similar to the national recommendations on limiting sedentary time, maybe with the additional provision that employers should provide facilities and organisational support for alternatives to sitting.

Additionally, partnerships between sectors and institutions (for example, between business and industry sectors, along with governmental institutions on both public health and occupational health and safety) have been suggested as a way to develop and implement evidence-based strategies for reducing sitting time [48]. Initiatives like ‘Take a Stand!’, for example, could be adjusted and promoted at national level.

Furthermore, workplaces should try to incorporate standing work, standing meetings and breaks into the productive work, finding inspiration in existing programmes such as BeUpstanding from Australia,

delivered by workplace champions [190], or the Danish practitioner-oriented publication on ‘Take a Stand!’ [199].

Finally, as many office workers sit for large parts of their day, especially during working hours, the individual office worker could consider reducing their sitting time at work, preferably along with colleagues, in order to obtain organisational support. The individual office worker could also use their membership of a trade union to call for focus on, and initiatives towards, reduced sitting time.

8 Summary

Background

High amount of sitting time is found to be related to all-cause mortality and metabolic health (for example cardiovascular disease and risk of type 2 diabetes). Sitting more than 6-10 hours/day is related to increased health risks and office workers, whose job is primarily sedentary, are sitting 10-11 hours/day.

Internationally, during the early 2010s, small-scale studies assessed the effects of single-component interventions aiming at reduced sitting time for example by introducing sit-stand desks. These studies yielded promising results, which was also the case for the few multi-component interventions tested in pilot studies. However, when we designed 'Take a Stand!' in 2013, no large-scale randomised controlled trials had been conducted testing multi-component sitting time interventions among office workers.

'Take a Stand!' was such an intervention, designed to make office workers sit less during working hours, break up sitting time and reduce prolonged sitting periods; and tested in a larger cluster randomised controlled trial design.

Aim

The overall aim of the thesis was to assess the effects and describe the implementation of the multi-component sitting time intervention 'Take a Stand!'. More specifically, this was translated into seven objectives, which were answered by five papers as follows:

- Examine the effects of 'Take a Stand!' on workplace sitting, both regarding actual sitting time, sit-to-stand transitions and prolonged sitting periods (**paper I**).
- Assess the effects of 'Take a Stand!' on other activity variables, such as workplace standing and steps, and leisure time sitting, steps and physical activity (**paper I**).
- Examine the health effects of 'Take a Stand!' on body-composition, waist circumference and prevalence of musculoskeletal pain (**papers I** and **II**).
- Assess how the sitting time effect of 'Take a Stand!' differed across subgroups (**paper III**).
- Assess fidelity of the intervention regarding dose delivered and dose received (**paper I**)
- Explore how factors during implementation impacted the implementation process and the effect of 'Take a Stand!' (**paper IV**)
- Explore feasibility and effectiveness of active meetings (**paper V**)

Methods

Intervention: 'Take a Stand!' was a multi-component intervention developed using Intervention Mapping. The final intervention included five components: 1. appointment of ambassadors and management support; 2. environmental changes; 3. lecture; 4. workshop aimed at ensuring local adaptation at individual, office and workplace level; and 5. e-mails and text messages.

Design: 'Take a Stand!' was evaluated in a cluster randomised controlled trial taking place from November 2013 to June 2014 including 317 participants from 19 offices at 4 workplaces in Denmark and Greenland. All participants had sit-stand desks prior to the intervention. Clusters were randomised for intervention or control at a ratio of 1:1.

Data: Data was collected at baseline, and after 1 and 3 months and included questionnaire data, anthropometric measures, activity data and interviews. Questionnaires were web-based. Activity data was collected with ActiGraph GT3X+ accelerometers placed on the thigh. Interviews were conducted after finishing the 3-months data-collection.

Analysis: Statistical analyses were multilevel mixed-effects linear regression, multilevel mixed-effects logistic regression and negative binomial regression. Interviews were transcribed and analysed in NVivo with directed content analysis based on categories from *The Framework for Evaluating Organizational-level Interventions,* by Nielsen & Randall.

Results

The main effect of the intervention was a reduction in sitting time during workhours in the intervention group compared to the control group of -71 minutes/8-hour workday after 1 month (CI95% -85;-57, $p<0.001$) and -48 minutes/8-hour workday after 3 months (CI95% -62;-34, $p<0.001$). Sit-to-stand transitions increased, and number of prolonged sitting periods decreased. Sitting time was replaced by an increase in standing time and a slight increase in number of steps. There were no changes in any leisure time variables, i.e. sitting, steps and moderate-to-vigorous physical activity (**paper I**). Body fat percentage in the intervention group was lower by 0.61 percentage points (CI95% -1.09;-0.14, $p=0.011$) at 3 months compared to the control group reflecting an increase in fat-free mass of 0.79 kg (CI95% 0.44;1.13, $p<0.001$). There were no changes in waist circumference and fat mass (**paper I**). After 3 months OR for pain in the neck-shoulders was 0.52 (CI95% 0.30;0.92, $p=0.02$) in the intervention group compared to the control group. There was a reduction in total pain score, reflecting both the number of pain sites and the degree of pain, after 1 and 3 months. There were no differences in pain in the back or the extremities at any time point, nor in pain in the neck-shoulders after 1 month (**paper II**). The effect on sitting time at

work was similar across all tested subgroups defined by socio-demographic, health- and work-related, as well as psychosocial factors (**paper III)**.

Regarding implementation, we found high levels of both dose delivered and dose received (**paper I**). During the implementation process, concurrent institutional changes were found to be both a potential hindering and facilitating factor. Management support was found to be crucial both at initiation and during the intervention period. Furthermore, the social part of the project was highlighted as very important e.g. because of the ability of the project to create a community at the office. Finally, strong desire to reduce sitting time, high motivation and a strong sense of collective engagement were related to decreased sitting time after 3 months of about 30 minutes/8-hour workday compared to participants with low scores on these variables (**paper IV**). Standing meetings were found to be highly feasible to implement in the office setting and workers participating in standing meetings on a regular basis sat 59 minutes less after 3 months (CI95% -101;-17, p=0.017) compared to office workers with no participation in standing meetings. Walking meetings were associated with many barriers, like the weather, thus, they were rarely used at any office (**paper V**).

Conclusion

The multi-component sitting time intervention 'Take a Stand!' was able to reduce sitting time, increase sit-to-stand transitions and reduce prolonged sitting. Furthermore, 'Take a Stand!' had a positive impact on health parameters like body fat and musculoskeletal health. Sitting time effects were consistent across all tested subgroups.

Fidelity of the intervention was high, and during implementation individual factors like motivation influenced the effect on sitting time, but even more important was the organisational culture ensuring general participation, management and peer support, and a positive atmosphere at the office during the intervention period. Finally, standing meetings were found to be feasible and effectively reducing sitting time, while walking meetings were difficult to implement.

9 Dansk resumé

Baggrund

Høj siddetid er relateret til højere dødelighed og sygdomme som hjertekarsygdom og type 2 diabetes. Disse konsekvenser ses især ved en daglig siddetid over 6-10 timer og kan kun i kompenseres for ved store mængder fysisk aktivitet (>60 minutter om dagen). Kontoransatte sidder omkring 11 timer om dagen på kontoret og i fritiden.

I løbet af '00-erne og '10-erne blev der gennemført en række mindre studier, der fandt at fx introduktion af hæve-sænkeborde eller påmindelser på computeren kunne reducere siddetiden blandt kontoransatte. Desuden blev der lavet pilotstudier, hvor flere af disse indsatser blev kombineret til multi-komponente indsatser, også med reduceret siddetid til følge. Da vi påbegyndte udviklingen af 'Take a Stand!', i 2013, var der endnu ikke lavet større kontrollerede studier af effekten af multi-komponente indsatser på kontoransattes siddetid.

Derfor udviklede vi 'Take a Stand!' – en multikomponent indsats blandt kontoransatte, der skulle reducere siddetid i arbejdstiden, øge antallet af afbrydelser og reducere længere stillesiddende perioder (>30 minutter). Denne indsats afprøvede vi i et cluster-randomiseret kontrolleret studie.

Formål

Formålet med denne afhandling var at afdække effekterne af 'Take a Stand!', samt at undersøge, hvilke faktorer, der var betydende under implementeringen af indsatsen. Dette formål blev udmøntet i følgende syv underformål besvaret i fem artikler:

- Måle effekten af 'Take a Stand!' på siddetid, afbrydelser og længere stillesiddende perioder (**artikel I**).
- Måle effekten på andre aktivitets-mål bl.a. stå-tid, skridt og fysisk aktivitet i fritiden (**artikel I**).
- Måle sundhedseffekter af indsatsen f.eks. på fedtprocent og muskelskeletbesvær (**artikel I** og **II**).
- Undersøge hvordan effekten på siddetid varierede på tværs af sub-grupper (**artikel III**).
- Beskrive implementeringsniveauet i form af leveret indsats og modtaget indsats (**artikel I**).
- Undersøge faktorer under implementeringen, der havde betydning for implementeringsprocessen og effekten af 'Take a Stand!' (**artikel IV**).
- Undersøge implementering og effekt af et del-element; de gående og stående møder (**artikel V**).

Metoder

Indsatsen: 'Take a Stand!' var en multikomponent indsats bestående af fem dele: 1. ledelsesopbakning og identifikation af ambassadører, 2. fysiske forandringer på kontoret, 3. oplæg om siddetid og helbred, 4. workshop med fokus på lokale tilpasninger, og 5. mulighed for e-mails og sms'er.

Design: 'Take a Stand!' blev afprøvet i et cluster-randomiseret kontrolleret studie med 317 deltagere fra 19 kontorer på 4 arbejdspladser i Danmark og Grønland. Alle deltagere havde hæve-sænkebord ved projektets start. Kontorerne blev randomiseret 1:1 til indsats eller kontrolgruppe.

Data og analyser: Data blev indsamlet ved baseline, samt efter 1 og 3 måneder og bestod af spørgeskemadata, antropometriske mål, aktivitetsdata samt interviews. Aktivitet blev mål med et accelerometer sat fast på låret. Interviews blev gennemført efter sidste måling. Statistiske analyser var regressionsanalyser og interviews blev analyseret efter metoden 'directed content analysis'.

Resultater

Efter 1 måned var siddetiden i indsatsgruppen i forhold til kontrolgruppen reduceret med 71 minutter/8 timers arbejdsdag, efter 1 måned var denne reduktion 48 minutter. Antallet af skift fra siddende til stående steg, og der var et fald i antallet af længere stillesiddende perioder. Siddetiden blev primært erstattet af stå-tid, men deltagerne gik også lidt flere skidt. Vi fandt ingen ændringer i aktiviteten i fritiden (**artikel I**). I forhold til sundhedseffekterne fandt vi et lille fald i fedtprocenten efter 3 måneder, hvilket afspejlede en øget fedtfri masse. Der var ingen ændringer i taljemål og fedtmasse (**artikel I**). Efter 3 måneder rapporterede indsatsgruppen færre smerter i nakke og skuldre, men der var ingen ændringer i smerter i ryg/lænd og arme/ben (**artikel II**). Subgruppeanalyser viste en ensartet effekt af interventionen på tværs af alle testede faktorer (**artikel III**).

Implementeringsniveauet var generelt højt (**artikel I**). Sideløbende forandringer på arbejdspladsen i projektperioden kunne både fremme og hindre implementeringen, mens ledelsesopbakning generelt var essentiel for implementeringssucces. Derudover blev de sociale dele af projektet fremhævet, blandt andet på grund af det fællesskab, der blev skabt på kontoret omkring projektet. Endelig fandt vi en lavere siddetid blandt deltagere, der havde et stort ønske om at reducere siddetid, var motiverede for projektet og følte et stærkt fællesskab omkring projektet i forhold til deltagere med lave værdier for disse (**artikel IV**). Stående møder blev implementeret med succes og regelmæssige stående møder var associeret med 59 minutters lavere siddetid efter 3 måneder. Der var en række barrierer forbundet med afholdelse af gående møder, de blev derfor ikke implementeret regelmæssigt (**artikel V**).

Konklusion

‘Take a Stand!’ havde succes med at reducere siddetiden blandt kontoransatte og havde positive effekter på helbredet f.eks. fedtprocent og nakke-skulder-smerter. Effekten var konsistent på tværs af subgrupper.

‘Take a Stand!’ blev implementeret tilfredsstillende og vi fandt at implementeringen blev påvirket af både individuelle faktorer, f.eks. motivationen for projektet, og organisatoriske faktorer f.eks. ledelsesopbakning og fællesskab omkring projektet. Stående møder blev implementeret på alle kontorer og bidrog til reduceret siddetid, mens gående møder var svære at implementere.

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