Det Nationale Forskningscenter for Arbejdsmiljø

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En risikofaktor for lænderygbesvær?

Et overblik over sammenhænge mellem siddetid og nakke-skulder- og lænderygbesvær

Mette Korshøj & Andreas Holtermann

LÆNGEREVARENDE STILLESIDDENDE ARBEJDE

EN RISIKOFAKTOR FOR NAKKE-SKULDER- OG LÆNDERYGBESVÆR?

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NFA-rapport

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FORORD

Flere og flere arbejdstagere i Danmark sidder ned i størstedelen af arbejdstiden, og en opgørelse fra 2016 viser, at 37 % af danske arbejdstagere sidder ned i mindst tre-fjerdedele af arbejdstiden (2016). Yderligere anslås det, at voksne danskere sidder i 3-6 timer om dagen i fritiden (Overgaard et al., 2012).

Viden om siddetid er primært indsamlet ved hjælp af selvrapporteret information fra spørgeskemaer. Selvrapportering af siddetid kan være vanskelig og forbundet med stor måleusikkerhed. Det anbefales derfor i forskningsmæssig sammenhæng at anvende information om siddetid indhentet via bevægelsesmålere. Tidligere studier har vist, at særligt længerevarende perioder med siddetid kan hænge sammen med forværring af helbredet, dette er dog ikke tidligere undersøgt i relation til lænderyg- og nakke-skulderbesvær. Teoretisk set kan en sammenhæng mellem siddetid og lænderyg- og nakke-skulderbesvær skyldes en mangelfuld og ensidig muskelaktivitet og manglende variation af kropsposition.

Formålet med projektet var at undersøge, hvorvidt risikoen for og intensiteten af 1: lænderygbesvær og 2: nakke-skulderbesvær øges af:

1. meget siddetid under arbejde og henover hele døgnet (total mængde af siddetid)
2. længerevarende sammenhængende arbejdsperioder med siddetid (antal perioder på 20 minutter eller mere uden afbrydelser)
3. fordelingen af perioder med siddetid under arbejde

Medarbejdere inden for brancherne: Rengøring, industri og transport har en høj forekomst af muskelskeletbesvær samt en varierende andel af siddetid i arbejdet, hvilket gjorde dem til en relevant gruppe at undersøge formålet i.

Vi ønsker at takke følgegruppen ”MSB og fysiske arbejdsbelastninger” samt de videnskabelige samarbejdspartnere: Mette Aadahl, Svend Erik Mathiassen, Marie Birk Jørgensen, Nidhi Gupta og David Hallman for deres bidrag til projektet. I tillæg ønsker vi også at takke projektgruppen bag DPhacto for indsamling og oparbejdelse af data, samt de to lektører der har givet feedback til rapporten; Mogens Theisen-Pedersen og Kristian Overgaard.

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God læselyst!

Anne Cathrine Tjellesen
Forskningschef

SAMMENFATNING

Baggrund

37 % af alle medarbejdere i Danmark sidder ned mere end 75 % af arbejdsdagen, og andelen er stigende. Ikke kun ansatte med kontorarbejde, men også ansatte i jobs der tidligere indebar mere fysisk aktivitet, fx i industri og transport, har mere og mere siddetid i arbejdstiden. Meget siddetid anses som en selvstændig risikofaktor for forringet helbred, særligt længerevarende stillesiddende perioder menes at øge risikoen. Dog er der tvivl om disse sammenhænge, grundet at de fleste studier er baseret på selvrapporteret information om siddetid. Selvrapporteret information om siddetid kan være upræcis og påvirket af blandt andet helbredsstatus og fysisk aktivitetsniveau i fritiden, derfor er direkte måling af siddetid (målt vha. bevægelsesmålere) at foretrække. En helbredsrisiko ved megen stillesiddende tid kan være ondt i ryggen (nakke-skuldre eller lænderyg). Mulige årsager til, at meget siddetid kan give ondt i ryggen, kan være en manglende brug af musklerne eller ensidig belastning.

Formål

Formålet med projektet var at undersøge, hvorvidt risikoen for og intensiteten af 1: lænderygbesvær og 2: nakke-skulderbesvær øges af:

4. meget siddetid under arbejde og henover hele døgnet (total mængde af siddetid)
5. længerevarende sammenhængende arbejdsperioder med siddetid (antal perioder på 20 minutter eller mere uden afbrydelser)
6. fordelingen af perioder med siddetid under arbejde

Metode

Formålene blev besvaret ved anvendelse af data fra DPhacto-kohorten. DPhacto omfatter data fra 704 medarbejdere fra 15 danske virksomheder og indeholder teknisk målt siddetid under arbejde og i fritid henover ca. fire døgn samt oplysning om nakke-skulder- og lænderygbesvær hver måned gennem et år.

Siddetid blev opgjort i andel af arbejdstid eller alt vågentid (arbejdstid + fritid) per døgn. Til opgørelse af længerevarende perioder med siddetid blev al siddetid per døgn adskilt på arbejdstid og vågentid og inddelt i korte (≤ 5 min), mellemlange (>5 - ≤ 20 min) og længere (> 20 min) perioder.

Nakke-skulder- og lænderygbesvær blev opgjort som intensitet af smerte på en skala fra 0 – 10, hvor 10 var den værst tænkelige smerte og 0 ingen smerte. Sammenhænge mellem siddetid og nakke-skulder- og lænderygbesvær blev estimeret ved brug af regressionsmodeller, justeret for relevante faktorer.

Resultater

De tekniske målinger viste, at der var stor variation i, hvor meget deltagerne sad ned, både henover al vågentid og i arbejdstiden. Ligeledes viste data, at mere end hver tredje af alle deltagere havde nakke-skulderbesvær (37 % angav en intensitet af nakke-skulderbesvær ≥ 5) eller lænderygbesvær (37 % angav en intensitet af lænderygbesvær ≥ 5).

Overordnet viste tværsnitsanalyserne ingen klare sammenhænge mellem siddetid, hverken henover al vågentid eller i arbejde, og nakke-skulder- og lænderygbesvær.

Body Mass Index (BMI) påvirkede sammenhængen mellem siddetid og lænderygbesvær signifikant, og derfor gennemførtes en analyse adskilt på høj (≥ 25 kg/m^2) og lav BMI (< 25 kg/m^2). Deltagere med en høj BMI havde en negativ sammenhæng mellem siddetid og lænderygbesvær, hvorimod der sås en positiv sammenhæng blandt de med en lav BMI.

Forekomsten af nakke-skulderbesvær >4, steg ved øgning af siddetid i mellemlange perioder i arbejde, hvorimod en øgning af siddetid i korte perioder i arbejde var relateret til en lavere forekomst af nakke-skulderbesvær.

Der sås en negativ sammenhæng mellem øget total siddetid i arbejde og intensitet af både nakke-skulder- og lænderygbesvær henover et år. For lænderygbesvær sås, at 5 minutter mere siddetid per arbejdsdag svarede til en lavere intensitet af lænderygbesvær henover et år på 0,05. Tilsvarende negative sammenhænge mellem forskellige varigheder af perioder med siddetid på arbejde og intensitet af lænderygbesvær henover et år sås.

Deltagere med den højeste tredjedel af siddetid under arbejde havde det hurtigste fald i intensitet af nakke-skulderbesvær henover et år blandt. Ved inddeling af deltagerne i brancherne rengøring, industri og transport sås ligeledes negative sammenhænge mellem andel siddetid i arbejde og intensitet af nakke-skulderbesvær henover et år.

Diskussion

Dette projekt havde til formål at undersøge sammenhænge mellem siddetid og ondt i ryggen. Siddetid blev opgjort ved brug af tekniske målinger henover flere arbejdsdøgn. Detaljegraden af de tekniske målinger muliggjorde undersøgelse af den samlede siddetid, opdeling af siddetiden i arbejde og fritid samt i perioder af forskellig varighed.

Overordnet viste resultaterne, at siddetid, uanset om det er i arbejde eller fritid, ikke øger hverken nakke-skulder- eller lænderygbesvær, hverken ved baseline eller henover et år, blandt arbejdstagere i brancherne rengøring, industri og transport. Dog sås, at megen siddetid, blandt de med en BMI < 25 kg/m^2, relateredes til høj forekomst af lænderygbesvær ved baseline. I tillæg, sås mest nakke-skulderbesvær ved baseline blandt de med meget siddetid i arbejde i mellemlange perioder (5–20 min). Nakke-skulderbesvær henover et år faldt hurtigere i intensitet blandt de med den højeste tredjedel af siddetid i arbejde.

At mere siddetid giver mindre ondt i ryggen kan blandt andet forklares ved, at denne undersøgelse er gennemført blandt medarbejdere i brancher, der primært har stående manuelt arbejde, og derfor kan siddetid i arbejde fungere som pause og hvile fra aktiviteter, der i højere grad end siddetid leder til ondt i ryggen.

Resultaterne fra dette projekt er nogle af de første, der anvender siddetid målt ved dagligdags aktiviteter henover flere døgn, opdelt i arbejde og fritid og i perioder af forskellig varighed. Dog giver resultaterne ingen klare indikationer på, at siddetid under arbejde udgør en betydelig risiko, men nærmere virker beskyttende, for nakke-skulder eller lænderygbesvær i disse brancher, men der er behov for flere studier til undersøgelse af sammenhænge mellem siddetid og andre fysiske arbejdskrav for at kunne give klare anbefalinger.

SUMMARY

Background

37 % of employees in Denmark sit more than 75 % of work hours and the number is increasing. Not only office workers sit a lot, also manufacturing and transport workers, who were previously exposed to higher levels of physical activity at work, tend to sit more and more. High amounts of sitting and especially prolonged sitting are thought to be hazardous for health. The majority of knowledge is based on self-reported sitting, and since self-reported sitting may be unprecise and biased by status of health and level of leisure time physical activity, these associations are questioned. Therefore, technical measures are preferred to estimate the amount of sitting. One health-risk associated with high amounts of sitting may be back pain (neck-shoulder or lower back). The associations between high amounts of sitting and back pain may be explained by lack of physical activity or long-term sustained posture.

Objective

The objective of this study was to investigate whether the risk for 1: low back pain and 2: neck-shoulder pain was increased by:

1. High amounts of sitting during work and across the entire waking time (total amount of sitting).
2. Prolonged continuous periods of sitting during work (amount of periods of ≥ 20 min without interruptions).
3. The distribution of sitting periods during work.

Methods

The Dphacto cohort was used for analysis of the objectives. DPhacto includes data from 704 employees from 15 Danish companies and holds technically measured sitting during work and leisure time across 4 continuous days as well as monthly neck-shoulder and low back pain across a year.

Sitting was calculated in relative amounts of work time or waking time during 24 hours. All periods of sitting were categorized in short (≤ 5 min), moderate (>5 - ≤ 20 min) and prolonged (> 20 min) periods and separated in work and leisure time.

Neck-shoulder and low back pain were rated on a scale from 0 – 10, where 10 was the worst possible pain and 0 was no pain. Associations between sitting and neck-shoulder or low back pain were estimated by use of regression models, adjusted for relevant confounders.

Results

The technical measurements showed a variety in relative amount of sitting time across the participants, both during all waking time and work time. Moreover, the data showed that 37 % of the participants rated their neck-shoulder pain ≥ 5, and 37 % of the participants rated their low back pain to ≥ 5. No clear associations were seen between sitting time, both during work and all waking time, and neck-shoulder pain or low back pain.

Body mass index (BMI) moderated the association between sitting time and low back pain, and therefore the analysis was stratified on high BMI ≥ 25 kg/m^2 and low BMI < 25 kg/m^2. Among those with a high BMI, a negative association between sitting time and low back pain was seen; on the contrary, a positive association was seen among those with a low BMI.

The prevalence of neck-shoulder pain >4 on a 0-10 scale, increased by increased sitting in moderate periods during work time. On the other hand, an increase of sitting in short periods during work was associated to a lowered prevalence of neck-shoulder pain.

Higher total sitting time during work was associated to lowered neck-shoulder and low back pain across a year; correspondingly, sitting 5 minutes more during work time per day would be expected to lower the low back pain by 0.05 on a 0-10 scale across a year. Similar negative associations were seen for the different durations of sitting periods and low back pain across a year.

Stratification of the sitting time in tertiles showed the higher tertile of sitting time during work time to be associated to the greatest decrease in neck-shoulder pain across a year. Stratification of the participants in the occupational groups (cleaning, manufacturing and transportation) showed similar negative associations between sitting time during work and neck-shoulder pain across a year as in the non-stratified analysis.

Discussion

This study aimed to investigate associations between sitting time and neck-shoulder pain and low back pain. Sitting time was technically measured across continuous workdays. The level of detail made investigations of total amount of sitting as well as in periods of different durations and separated in work and leisure time possible.

The results showed no increases in either baseline or across a year in neither neck-shoulder pain nor low back pain by increases in sitting time, independent of being performed during work or leisure time among employees in the cleaning, manufacturing or transportation sectors. However, among those with a BMI < 25 kg/m2, a positive association between sitting and low back pain was seen at baseline. A positive association was also seen between sitting during work time in moderate periods (5 – 20 min) and neck-shoulder pain at baseline. The higher tertile of amount of sitting during work time showed the greatest decrease in neck-shoulder pain across a year.

The more you sit, the less pain you have in neck-shoulder or low back pain; this association may be explained by the fact that this study is performed among blue-collar workers, primarily having standing manual work tasks, and therefore it may be assumed that sitting time can act as a pause from other tasks being stronger related to neck-shoulder and low back pain.

This study is one of the first to analyze technically measured free-living sitting time, separated in work and leisure and periods of different durations. These results do not indicate sitting time to be a significant risk factor for neck-shoulder pain or low back pain among blue-collar workers in the cleaning, manufacturing and transportation sectors. However, more studies investigating the associations between sitting time and other physical activities during work are needed to be able to give recommendations.

Indhold

INDLEDNING

Omkring 40 % af medarbejdere i Danmark sidder mindst tre-fjerdedele af arbejdstiden (2014), og andelen af siddetid i arbejde ser ud til at stige; i 1987 var andelen af medarbejdere med meget siddetid i arbejde 34 %, og i 2005 var det steget til 40 % (Forebyggelseskommissionen, 2009). Derudover antages det, at voksne danskere sidder i 3-6 timer dagligt i fritiden (Overgaard et al., 2012).

Meget siddetid betragtes som en selvstændig helbredsrisiko (Overgaard et al., 2012) og menes at føre til øget risiko for diabetes, hjertekarsygdom og dødelighed (Wilmot et al., 2012) samt muskelskeletbesvær. En sammenhæng mellem meget siddetid og nakke-skulder- og lænderygbesvær kan teoretisk beskrives ud fra fysiologiske betragtninger, der angiver, at en manglende muskelaktivitet (inaktivitet), ensidig biomekanisk belastning på ryggen, og/eller manglende variation i ryggens position kan lede til besvær (Beach et al., 2005; Vuori, 2001).

Dog har tidligere studier ikke kunnet vise en systematisk sammenhæng mellem siddetid og intensitet af nakke-skulder- og lænderygbesvær (Ariëns et al., 2001; Chen et al., 2009; Lis et al., 2007; Mayer et al., 2012; Roffey et al., 2010). Dette kan skyldes, at tidligere studier primært er baseret på selvrapporteret siddetid, som i forhold til teknisk målt siddetid, ex indsamlet vha. bevægelsesmålere, er en upræcis målemetode (Gupta et al., 2017), blandt andet på grund af dårlig hukommelse (Miranda et al., 2006). Yderligere kan selvrapporteret varighed af siddetid være påvirket af faktorer som selvvurderet helbred og fysisk aktivitet i fritiden (Holtermann et al., 2014). Majoriteten af de tidligere studier er baseret på data med begrænset variation i varigheden og fordelingen af siddetid i arbejdstiden, eksempelvis er nogle studier udelukkende gennemført blandt kontoransatte (Cagnie et al., 2007; Skov et al., 1996), hvilket begrænser resultaternes overførbarhed til andre brancher.

Intensitet af nakke-skulder- og lænderygbesvær varierer meget henover tid (Axén et al., 2014; Axen & Leboeuf-Yde, 2013), derfor er det nødvendigt med hyppig opfølgning for at kunne undersøge udviklingen (Gupta et al., 2015; Korshøj et al., 2017; Lunde et al., 2017). Da nakke-skulder- og lænderygbesvær er meget udbredt blandt danske arbejdstagere (Arbejde og helbred, 2014), er en af de mest betydelige helbredsudfordringer i den danske befolkning (Forebyggelseskommissionen, 2009) og derfor også har store konsekvenser for både arbejdstager, virksomhed og samfund (Andersson, 1999; Hartvigsen et al., 2004; Katz, 2006), er det relevant at undersøge, om siddetid påvirker intensiteten af besværet i nakke-skulder- og lænderyg.

Et studie af 200 medarbejdere, der både indsamlede siddetid via selvrapportering og udførte præcise tekniske målinger over flere døgn, viste en stor variation mellem individer i varighed af siddetid. Yderligere var denne selvrapportering systematisk skævvredet og betød, at den selvrapporterede siddetid, i timer per døgn, blev overestimeret med 200 minutter (3,33 time) i forhold til den teknisk målte siddetid (Gupta et al., 2017). Den anvendte metode kan med stor præcision angive de fysiske aktiviteter og kropspositioner og er efterprøvet i både laboratorie og felt, hvor den er fundet valid (Ingebrigtsen et al., 2013; Korshøj et al., 2014; Skotte et al., 2014; Stemland et al., 2015).

Da det videnskabelige grundlag for anbefalinger om varighed og fordeling af siddetid primært er baseret på selvrapporteret siddetid kan det være usikkert, hvilket kan have betydelige helbredskonsekvenser for den danske befolkning (Overgaard et al., 2012). Derfor er der et behov for studier baseret på tekniske målinger af siddetid med henblik på at undersøge sammenhænge mellem siddetid og nakke-skulder- og lænderygbesvær i pålidelige data.

Nyere studier peger på, at det særligt er de længerevarende sammenhængende perioder med siddetid, der udgør et helbredsproblem (Healy et al., 2011), dog er de længerevarende perioder med siddetid ikke undersøgt i forhold til intensitet af nakke-skulder- og lænderygbesvær. I tillæg kendes betydningen af den totale varighed og fordeling af siddetid henover hele døgnet (både i arbejde og fritid) ikke i forhold til nakke-skulder- og lænderygbesvær.

For at kunne give praktiske anbefalinger om varighed og fordeling af siddetid med henblik på reduktion af intensitet af nakke-skulder- og lænderygbesvær både til den generelle befolkning men også særligt målrettet arbejdstagere, er det nødvendigt at undersøge sammenhænge mellem siddetid og nakke-skulder- og lænderygbesvær adskilt i perioder af arbejde og fritid. Ligeledes er det relevant at undersøge, om det er den totale siddetid eller de længerevarende perioder af siddetid uden tilstrækkelige afbrydelser, der potentielt udgør en risiko for nakke-skulder- og lænderygbesvær.

Kohortestudiet DPhacto indeholder data, der giver mulighed for at undersøge sammenhænge mellem siddetid og nakke-skulder- og lænderygbesvær. I DPhacto er siddetid opdelt i arbejde og fritid og indsamlet med tekniske målinger henover flere døgn. De detaljerede målinger af siddetid muliggør, at siddetid undersøges som både total siddetid og fordeling af korte, mellemlange eller længerevarende uafbrudte perioder. Data i DPhacto er indsamlet i en population med en varierende andel af siddetid i arbejde og fritid. Yderligere er der i DPhacto indsamlet intensitet af nakke-skulder- og lænderygbesvær hver fjerde uge henover et år, og derfor er det muligt både at undersøge sammenhæng mellem siddetid og nakke-skulder- og lænderygbesvær ved start af undersøgelsen samt henover et år (Jørgensen et al., 2013). Populationen i DPhacto er medarbejdere fra brancherne rengøring, industri og transport. Disse medarbejdere er generelt kortuddannede og har forskellige former for manuelt arbejde (Arbejde og helbred, 2014). Derudover har de en høj forekomst af muskelskeletbesvær, hvilket øger risikoen for reduceret arbejdsevne, langtidssygefravær og førtidig tilbagetrækning fra arbejdsmarkedet, og de er derfor en yderst relevant population at undersøge formålet i.

Formålet med projektet var at undersøge, hvorvidt risikoen for og intensiteten af 1: lænderygbesvær og 2: nakke-skulderbesvær øges af:

1. meget siddetid under arbejde og henover hele døgnet (total mængde af siddetid)
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3. fordelingen af perioder med siddetid under arbejde

METODE

Data til besvarelse af formålet er fra DPhacto (Jørgensen et al., 2013; Jørgensen et al., 2019), der indeholder data indsamlet blandt 1.087 medarbejdere fra 15 virksomheder i rengøring-, industri- og tranportbranchen.

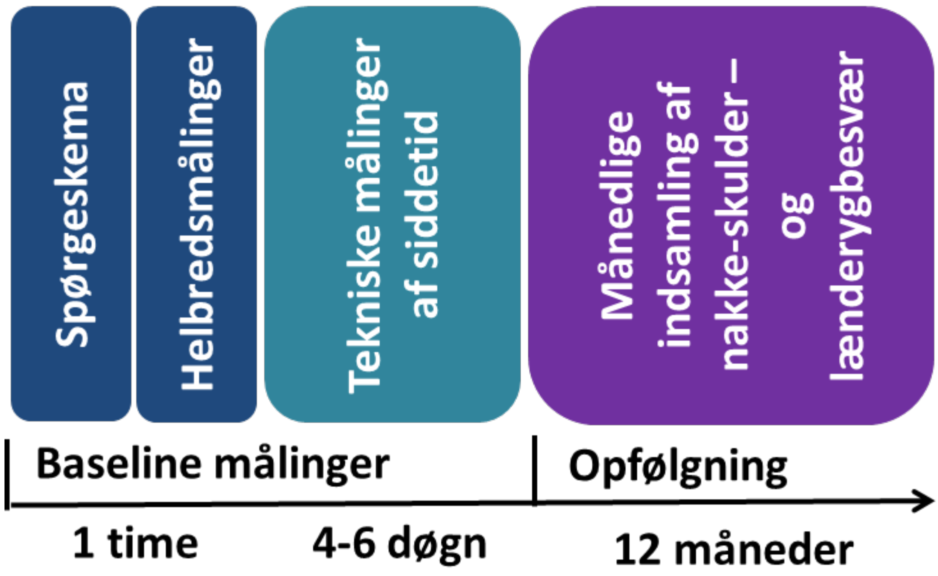
Rekruttering

Hoveddelen af virksomhederne blev rekrutteret i samarbejde med fagforeningen 3F. De deltagende medarbejdere er ikke nødvendigvis repræsentative for medarbejdere i rengøring-, industri- og transportbrancherne, både fordi deltagelse var frivillig, og fordi virksomheder, der melder sig til sådanne projekter, for det meste har en særlig interesse og et engagement i forbedring af arbejdsmiljø. Alle medarbejdere fra produktionen blev tilbudt deltagelse, hvorimod deltagere i administrative og/eller ledende stillinger kun blev tilbudt deltagelse, når det var et krav fra virksomheden.

Forud for dataindsamlingen mødtes virksomhedens ledelse, tillids-, arbejdsmiljø-, fagforenings- og medarbejderrepræsentanter med forskergruppen. Herefter blev medarbejdere inviteret til mindst et informationsmøde på hver virksomhed, typisk med tilstedeværelse af lokale 3F-formænd. Ved informationsmøderne modtog alle medarbejdere mundtlig og skriftlig information om projektet og et kort screeningsspørgeskema til udfyldelse under eller umiddelbart efter mødet. Efterfølgende kunne medarbejderne give tilsagn, om de ønskede at deltage i projektet eller ej. Deltagelse var frivillig, og tilsagn om deltagelse kunne til enhver tid trækkes tilbage uden efterfølgende konsekvenser. For at sikre bedst mulig deltagelse og lokalt ejerskab blev planlægning af dataindsamlingen på den enkelte virksomhed udført i tæt samarbejde med både 3F og virksomheden.

Dataindsamling

Dataindsamlingen forløb i perioden fra april 2012 til maj 2014 og blev udført på arbejdspladserne i arbejdstiden, med løbende opstart og afslutning på de enkelte virksomheder. Alle målinger blev udført af uddannet forsknings- og sundhedspersonale. I de indledende målinger (baseline) indgik et spørgeskema, test af fysisk kapacitet og helbred samt tekniske målinger af fysisk aktivitet og kropsposition. Efterfølgende blev deltagerne adspurgt månedligt, via sms-beskeder, angående intensitet af nakke-skulder- og lænderygbesvær henover et år.



Figur 1 Tidslinje over dataindsamling i projektet

Spørgeskema

Ved baseline udfyldte deltagerne et computerbaseret spørgeskema omhandlede alder, køn, fødeland, rygning, værste muskelskeletbesvær (Kuorinka et al., 1987) de seneste tre måneder i nakke-skulder og lænderyg, indtag af receptpligtig medicin de seneste tre måneder, diagnose med diskosprolaps, niveau af fysisk aktivitet i fritiden, jobtitel, jobanciennitet, løftebyrder i arbejde, fysisk anstrengelse under arbejde (Borg, 1990), indflydelse i arbejde (Pejtersen et al., 2010) og social støtte fra leder og kolleger (Pejtersen et al., 2010).

Efter et år blev deltagerene bedt om at besvare et computerbaseret spørgeskema omhandlede antal dage med nakke-skulder og lænderygbesvær det seneste år, og hvorvidt deres fysiske aktivitet i arbejde havde ændret sig det seneste år.

Helbredsmålinger

I forbindelse med udfyldelse af baselinespørgeskema blev alle deltagere tilbudt helbredsmålinger indeholdende: i) Blodtryk, målt med Omron M6 Comfort (Japan), tre på hinanden følgende gange efter minimum 5 minutters siddende hvile. Blodtryk over 140/90 mmHg blev evalueret som forhøjet blodtryk (Bang & Wiinberg, 2009). ii) højde, målt opretstående uden sko (Seca model 213 1721009, Tyskland); iii) vægt og fedtprocent, målt uden sko og strømper på en bioimpedansvægt (Tanita BC418, U.S.A). Body Mass Index (BMI) blev beregnet som vægt/højde^2 (kg/m^2).

Tekniske målinger af fysisk aktivitet og kropsposition

Fysiske aktivitet og kropsposition blev målt med accelerometri ved hjælp af ActiGraph GT3X+ (ActiGraph, U.S.A). Alle deltagere blev bedt om at bære 3 accelerometre placeret på den øvre del af ryggen, dominerende overarm og højre lår (figur 2). De anvendte accelerometre er små (19 g, 4,6 x 3,3 x 1,5 cm), vandtætte og ledningsfrie, de blev klistret direkte på huden for at sikre korrekt placering under hele målingen samt for at skabe mindst mulig gene.

Figur 2 Viser påsatte accelerometre til måling af fysisk aktivitet og kropsposition

Deltagerne blev bedt om at bære accelerometrene 24 timer i døgnet i 4 til 6 døgn, indeholdende minimum to arbejdsdage og om muligt også to fridage. Deltagerne blev bedt om at notere tidspunkt for påbegyndelse og afslutning af arbejde og sovetider i en dagbog. Deltagerne blev ligeledes instrueret i at tage accelerometrene af ved hudirritation, og hvordan accelerometrene skulle genmonteres, hvis de faldt af. Efter endt måling blev accelerometre og dagbøger indsamlet på arbejdspladsen.

Rå data fra accelerometrene blev downloadet i det kommercielle software (ActiLife) og blev efterfølgende behandlet i et specielt udviklet software (Acti4) designet til estimering af fysisk aktivitet og kropsposition (Korshøj et al., 2014). Estimeringen af fysisk aktivitet og kropsposition ved hjælp af Acti4 er efterprøvet både under kontrollerede forhold i laboratorie og under ikke kontrollerede forhold i felt. Acti4 har under begge forhold vist meget tilfredsstillende resultater på at kunne klassificere forskellige fysiske aktiviteter og kropspositioner. Acti4 er således en valid metode til estimering af fysiske aktiviteter (gang, løb, trappegang og cykling) og kropspositioner (ligge, sidde og stå) (Ingebrigtsen et al., 2013; Korshøj et al., 2014; Skotte et al., 2014; Stemland et al., 2015). Ved hjælp af accelerometer-målingerne var det derfor muligt at kortlægge deltagernes fysiske aktivitet og kropsposition. Dagbogsregistreringerne blev anvendt til at inddele de målte døgn i arbejdstid, fritid (henholdsvis på arbejdsdage og på fridage) og søvn. Tid med løftede arme under arbejde blev defineret ud fra det totale antal minutter med overarmen over 60° og 90° fra lodlinjen.

Kriteriet for, at en måling af arbejdstid skulle inkluderes i analyserne, var en varighed på minimum 4 timer og 75 % af en estimeret normal arbejdsdag.

Månedlig indsamling af intensitet af nakke-skulder- og lænderygbesvær

Alle deltagere blev inviteret til at deltage i opfølgning på selvvurderet intensitet af nakke-skulder- og lænderygbesvær ved hjælp af følgende spørgsmål "På en skala fra 0-10, hvad har din værste (nakke-skulder eller lænderyg) smerte været inden for den sidste måned? (0=ingen smerte, 10=værst mulig smerte)" (Kuorinka et al., 1987). Spørgsmålene blev sendt til deltagerne på sms hver fjerde søndag via det kommercielle internetbaserede software "SMS-Track" (https://sms-track.com/). Ved ubesvaret spørgsmål fik deltageren samme spørgsmål tilsendt igen den efterfølgende dag. Ved fortsat ubesvaret spørgsmål blev telefonisk kontakt forsøgt den følgende uge. Procedure for udsendelse og rykker blev udført i henhold til anbefalinger fra SMS-Track (https://sms-track.com/).

Eksklusion fra målinger

Deltagere blev ekskluderet fra alle målinger, hvis de var gravide eller havde feber på testdagen, yderligere blev deltagere ekskluderet fra accelerometer-målingerne, hvis de havde plasterallergi.

Statistiske opgørelser

Alle statistiske analyser er gennemført i SPSS (IBM SPSS Statistics 22.0 til Windows, U.S.A) eller SAS (SAS Institute, U.S.A).

Data, der indgår i analyserne, er beskrevet ud fra gennemsnit med tilhørende standardafvigelse eller som andele (%) af spørgeskemabesvarelser og helbredsmålinger.

Analyse til besvarelse af om intensiteten af lænderygbesvær ved baseline, var højere ved i) meget siddetid under arbejde og henover hele døgnet, ii) længerevarende sammenhængende arbejdsperioder med siddetid og iii) fordelingen af perioder med siddetid under arbejde, blev gennemført ved brug af en lineær regression. I analysen indgik siddetid (total og i perioder af ≤ 5 min, >5 - ≤ 20 min og > 20 min i både vågentid og arbejdstid) som timer/dag, og intensitet af lænderygbesvær blev opgjort på en skala fra 0-10. Yderligere undersøgte vi, om faktorer, der tidligere er beskrevet som udslagsgivende for denne sammenhæng, havde en effekt. Derfor blev diagnose med diskosprolaps og anstrengelse i arbejde inkluderet som konfoundere[1] og BMI som moderatorer[2]. Resultaterne afrapporteredes adskilt på BMI, inddelt i ≥ 25 kg/m^2 og < 25 kg/m^2 (Korshøj et al., 2017).

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[1] En konfounder er en faktor, der påvirker sammenhængen mellem eksponering (siddetid) og udfald (lænderygbesvær), hvis analysen ikke justeres for en konfounder, kan den lede til fejlagtige konklusioner, hvorimod justering af en konfounder vil give et resultat, der ikke er påvirket af konfounderen.

[2] En moderator er en faktor, som eksponeringen (siddetid) er påvirket af, og som derfor også påvirker sammenhængen til udfaldet (lænderygbesvær). For at kunne se sammenhængen uden påvirkning fra moderatoren kan man opdele deltagerne på baggrund af moderatoren og undersøge sammenhængen i de to undergrupper.

Undersøgelsen af, om intensiteten af lænderygbesvær henover et år øges af i) meget siddetid under arbejde og henover hele døgnet, ii) længerevarende sammenhængende arbejdsperioder med siddetid og iii) fordelingen af perioder med siddetid under arbejde, blev gennemført ved brug af en lineær mixed model. I analysen blev siddetid opgjort som ved baseline (beskrevet ovenfor). De gentagne målinger af intensitet af lænderygbesvær blev opgjort på en skala fra 0-10 fra hver enkel måling. Yderligere undersøgte vi, om tidligere beskrevne konfoundere havde en effekt. I tillæg er tid (0-12 måneder) indsat som moderator, dog uden at analysen er opdelt på månedsbasis, da man så ikke ville kunne se tidsudviklingen i intensitet af lænderygbesvær (Korshøj et al., 2018).

Sammenhæng mellem siddetid under arbejde og intensitet af nakke-skulderbesvær ved baseline er undersøgt ved brug af en korrelationsanalyse. Yderligere blev det undersøgt, om der var forskel i intensitet af nakke-skulderbesvær mellem de tre brancher ved brug af en variationsanalyse. Siddetid blev opgjort som andelen af arbejdstid brugt i siddende position (%). Nakke-skulderbesvær blev opgjort for de seneste tre måneder fra baseline på en skala fra 0-10 (Hallman et al., 2016a).

Analysen af, om forskellig varighed af siddetid i arbejde og i fritid (perioder af ≤ 5 min, >5 - ≤ 20 min og > 20 min) påvirkede risiko for at have meget nakke-skulderbesvær ved baseline, blev undersøgt i en logistisk regression. Siddetid blev opgjort som andel tid brugt i de tre perioder i både arbejde og fritid. Intensitet af nakke-skulderbesvær blev opgjort for de seneste tre måneder fra baseline på en skala fra 0-10 og derefter opdelt i høj og lav (5-10 og 0-4). Analysen blev justeret for følgende konfoundere: alder, køn, rygning, BMI, jobanciennitet, løftebyrder i arbejde, selvrapporteret fysisk aktivitet i arbejde og fritid og siddetid med løftet over skulderhøjde i både arbejde og fritid (Hallman et al., 2016b).

Til undersøgelse af, om intensiteten af nakke-skulderbesvær henover et år øges af andelen af siddetid under arbejde, blev lineær mixed models brugt. Siddetid blev opgjort som andelen af arbejdstiden brugt i siddende position (%). De gentagne målinger af intensitet af nakke-skulderbesvær blev opgjort på en skala fra 0-10 fra hver enkel måling. Tid (0-12 måneder) blev indsat som moderator, dog uden at analysen er opdelt på månedsbasis, da man så ikke ville kunne se tidsudviklingen i intensitet af nakke-skulderbesvær. Analysen blev justeret for følgende konfoundere: alder, køn, BMI, branche, løftearbejde, siddetid i fritid, selvrapporteret fysisk aktivitet i arbejde og i fritid samt andelen af arbejdstiden, hvor deltageren arbejdede med armen løftet mere end 60° i forhold til lodlinjen (Hallman et al., 2016a).

RESULTATER

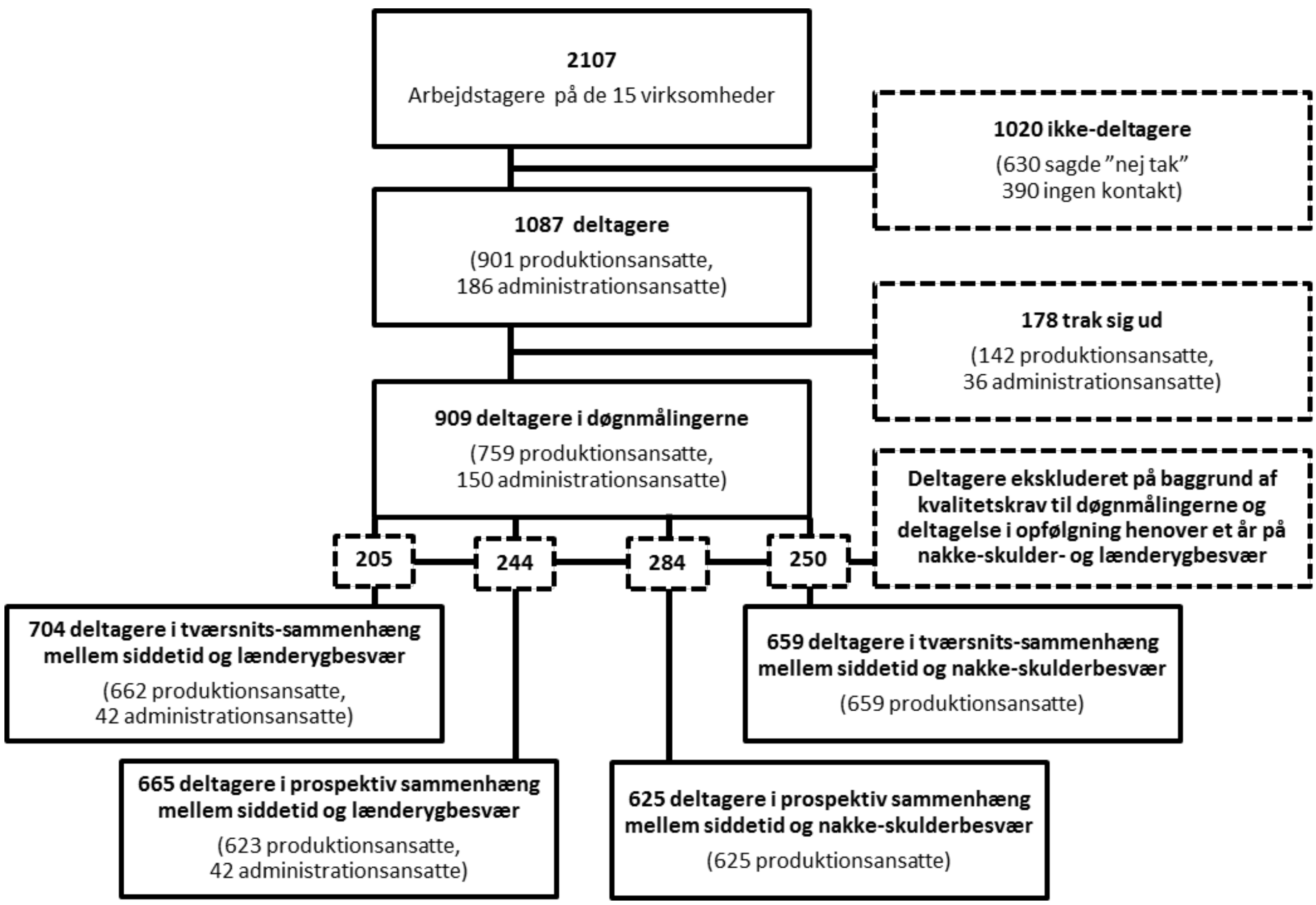
Udvælgelse og karakteristika af deltagerne

I forbindelse med dataindsamlingen til DPhacto blev 2.107 arbejdstagere præsenteret for projektet og tilbudt deltagelse, af dem meldte 1.087 sig som deltagere, og døgnmålinger blev gennemført blandt 909 deltagere, se figur 3. Alle deltagere fra produktionen blev tilbudt alle døgnmålinger, og deltagere fra administrationen blev tilbudt døgnmålinger i det omfang, virksomheden ønskede det, og der var apparatur til rådighed. Yderligere blev der anvendt forskellige kvalitetskriterier for de enkelte analyser. På grund af at ikke alle deltagerne deltog i alle undersøgelserne og fordi analyserne ikke har det samme udfald, varierer antal deltagere i de gennemførte analyser.

Ud af de 909 deltagere, der deltog i døgnmålingerne, indgik 704 deltagere i tværsnitsstudiet omkring siddetid og lænderygbesvær og i tværsnitsstudiet af sammenhæng mellem fordeling af siddetid og nakke-skulderbesvær indgik 659 deltagere udelukkende fra produktionen.

I analyserne af sammenhænge mellem siddetid og lænderygbesvær henover et år indgik 665 deltagere, og i relationen mellem siddetid og nakke-skulderbesvær henover et år indgik 625 deltagere.

Figur 3 Flow oversigt



Trods et varierende antal deltagere er inkluderet i de forskellige analyser, ses der ikke betydningsfulde forskelle i karakteristika, som alder, køn, BMI, anciennitet og andel af siddetid i arbejde og henover al vågentid mellem de inkluderede grupper af deltagere i de forskellige analyser, sandsynligt grundet at deltagerne er gengangere i alle analyserne. I tabel 1 er karakteristika af deltagerne præsenteret.

Blandt de deltagere, der er inkluderet i analyserne, viste de tekniske målinger af siddetid, at deltagerne udelukkende sad i gennemsnit 33 % af deres arbejdstid og i 44 % af al deres vågne tid henover et døgn. Yderligere viste disse opgørelser af siddetid, at ikke alle deltagerne havde den samme andel af siddetid i arbejde, da den gennemsnitlige siddetid i arbejde varierede fra 2 % til 92 % af arbejdstiden. Siddetiden henover al vågentid varierede fra 9 % til 83 %.

Ved baseline angav 30 % af deltagerne, at de ikke havde haft lænderygbesvær det seneste år, og 26 % af deltagerne angav ikke at have haft nakke-skulderbesvær det seneste år. For de med lænderygbesvær angav 33 % at have en smerteintensitet på 1-4, på en skala fra 0-10, og 37 % at have en smerteintensitet på 5 eller derover, på en skala fra 0-10. Blandt deltagere med nakke-skulderbesvær angav 63 % en smerteintensitet på 1-4, på en skala fra 0-10, og 37 % angav en smerteintensitet på 5 eller derover, på en skala fra 0-10.

Måling af nakke-skulder- og lænderygbesvær henover et år

Dataindsamlingen med sms-beskeder fungerede godt, og for nakke-skulderbesvær var der en svarfrekvens på 95 % ved baseline og 85 % ved den sidste måling 12 måneder efter. De fleste deltagere (90 %) svarede på mindst 10 ud af 14 sendte sms-beskeder for nakke-skulderbesvær.

For lænderygbesvær besvarede 65 % af deltagerne alle de 14 sendte sms-beskeder, og 85 % besvarede 12 ud af de 14 sendte sms-beskeder. Det gennemsnitlige niveau af lænderygbesvær henover et år var 2,3 (SD 2,1), på en skala fra 0-10, hvor 10 er værst tænkelige smerte.

Tabel 1 Karakteristika af deltagere inkluderet i analyserne (N=704)

	Antal	**Gennemsnit**	**SD**	**%**	**Range**
Alder (år)	704	45,0	9,9		18 – 68
Køn (kvinder)	312			44,3	
Nuværende ryger	204			29,7	
Body Mass Index (kg/m²)	688	27,4	4,9		16,2 – 45,1
Body Mass Index <25 kg/m²	448			65,1	
Body Mass Index ≥25 kg/m²	240			34,9	
Jobanciennitet (år)	674	13,0	10,1		0 – 45
Selvrapporteret fysisk anstrengelse under arbejde (skala 0-10, hvor 10 er højest)	674	5,8	2,2		1 – 10
Løfte- og bærearbejde (skala 1-6)	700	3,6	1,5		
Løfte- og bærearbejde <50 % af arbejdstid	412			58,9	

Løfte- og bærearbejde ≥50 % af arbejdstid	288			41,1	
Indflydelse i arbejde (skala 0-100, hvor 100 er mest indflydelse)	500	63,0	26,2		0 – 100
Social støtte på arbejde (skala 0-100, hvor 100 er mest støtte)	500	78,6	16,2		0 – 100
Branche					
Rengøring	128			18,2	
Industri	472			67,0	
Transport	62			8,8	
Administration	42			6,0	
Rate af oplevet anstrengelse under arbejde (skala 1 -10)	674	5,8	2,2		
Moderat og hård fysisk aktivitet i fritiden (timer/dag)	704	0,5	<0,1		0,0 – 0,5
Højeste smerte intensitet ved lænderygbesvær seneste 3 måneder*	701	3,4	3,1		0 – 10
Smerte intensitet ved lænderygbesvær = 0*	212			30,2	
Smerte intensitet ved lænderygbesvær 0-4*	228			32,5	
Smerte intensitet ved lænderygbesvær ≥5*	261			37,2	
Højeste smerte intensitet ved nakke-skulderbesvær seneste 3 måneder*	659	3,4	3,0		
Smerte intensitet ved nakke-skulderbesvær 1-4*	413			62,7	
Smerte intensitet ved nakke-skulderbesvær ≥5*	246			37,3	
Ingen dage med nakke-skulderbesvær det seneste år	172			26,1	
Diagnosticeret med diskosprolaps	56			8,0	
Antal dage med brug af smertestillende medicin de seneste 3 måneder >7 dage	69			9,8	
Samlet varighed af inkluderede tekniske malinger under arbejde (timer)	704	19,9	8,0		4,0 – 51,3
Samlet varighed af inkluderede tekniske målinger henover alt vågentid (timer)	704	42,9	15,7		10,7 – 88,7
Inkluderet varighed af tekniske målinger under arbejde (timer/dag)	704	7,7	1,6		3,3 – 14,5
Inkluderet varighed af tekniske målinger henover alt vågentid (timer/dag)	704	16,8	1,7		9,3 – 24,0
Siddetid i arbejde (% arbejdstimer)	704	33,2	21,8		1,6 – 91,6
Siddetid henover al vågentid (% af alle vågne timer)	704	43,9	12,6		9,0 – 82,6

Standard afvigelse (SD)

* Smerte intensitet er angivet på en skala fra 0 til 10, hvor 10 er højest.

Tværsnitssammenhæng mellem siddetid og lænderygbesvær

Ved baseline sås ingen sammenhæng mellem total mængde af siddetid i arbejde og i al vågentid per døgn og lænderygbesvær. Der var heller ingen sammenhæng mellem længerevarende perioder med siddetid i arbejde eller henover hele døgnet og lænderygbesvær.

De statistiske modeller viste, at BMI modererede sammenhængen mellem siddetid og lænderygbesvær signifikant (tabel 2 i Korshøj 2018, SJWEH). Derfor gennemførtes en analyse af sammenhængen mellem siddetid og lænderygbesvær adskilt på høj BMI (≥ 25 kg/m²) og lav BMI (< 25 kg/m²). Yderligere blev analysen justeret for oplevet anstrengelse under arbejde og diagnose med diskosprolaps.

De justerede analyser viste, at deltagere med høj BMI fik mindre lænderygbesvær ved mere siddetid, både når siddetiden blev opgjort som samlet varighed i arbejde og som al vågentid, samt når siddetid var opdelt i korte, mellemlange og lange perioder i både arbejdstid og i al vågentid. Blandt deltagere med en lav BMI sås at mere siddetid hang sammen med mere lænderygbesvær, både når siddetiden blev opgjort som samlet varighed i arbejde og som al vågentid samt opdelt i korte, mellemlange og lange perioder i både arbejdstid og i al vågentid (tabel 2). Trods at ikke alle sammenhængene opnår statistiks signifikans indikerer de generelt den samme retning (tabel 2).

Tabel 2 Sammenhæng mellem andel af siddetid i arbejde og henover al vågen tid samt opdelt i korte, mellemlange og lange perioder og lænderygbesvær på en skala fra 0-10, hvor 0 er ingen smerte, opdelt på BMI <25 kg/m2 (n=238) og BMI ≥ 25 kg/m2 (n=447). Signifikante sammenhænge er markeret med **fed.**

	Lav BMI <25 kg/m²			Høj BMI ≥ 25 kg/m²		
	β	**SE**	***p***	**β**	**SE**	***p***
Siddetid på arbejde						
Total siddetid	0,13	0,10	0,22	**-0,16**	**0,08**	**0,04**
Korte perioder (≤ 5 min)	**0,35**	**0,17**	**0,04**	-0,19	0,14	0,18
Mellemlange perioder (>5 - ≤ 20 min)	0,17	0,14	0,21	-0,21	0,11	0,051
Lange perioder (> 20 min)	-0,01	0,10	0,89	-0,07	0,07	0,33
Siddetid i al vågen tid						
Total siddetid	0,17	0,20	0,41	**-0,37**	**0,15**	**0,02**
Korte perioder (≤ 5 min)	**0,70**	**0,26**	**<0,01**	-0,26	0,25	0,30
Mellemlange perioder (>5 - ≤ 20 min)	**0,57**	**0,24**	**0,02**	**-0,46**	**0,19**	**0,02**
Lange perioder (> 20 min)	-0,26	0,17	0,13	-0,18	0,13	0,17

Tværsnitssammenhæng mellem korte, mellemlange og lange perioder med siddetid og forekomst af nakke-skulderbesvær

Blandt deltagere med meget siddetid i arbejde fandtes en højere forekomst af nakke-skulderbesvær. Mere specifikt fandt vi, at meget siddetid i mellemlange perioder hang sammen med en øget intensitet af nakke-skulderbesvær >4, på en skala fra 0-10. Hvorimod, meget siddetid i korte perioder var relateret til en lavere forekomst af nakke-skulderbesvær >4, på en skala fra 0-10. Der sås ingen sammenhæng mellem siddetid i lange perioder og forekomst af nakke-skulderbesvær >4, på en skala fra 0-10 (tabel 3).

Ved siddetid i fritid fandtes ingen sammenhænge med forekomst af nakke-skulderbesvær >4, uanset perioden af siddetidslængde (tabel 3). Både analyserne i arbejde og fritid var justeret for alder, køn, rygning, BMI, jobanciennitet, fysisk aktivitet i fritiden og siddetid med armene over skulderhøjde. Alle disse faktorer er angivet i tidligere studier som konfoundere og blev derfor inkluderet i den justerede analyse.

Tabel 3 Sammenhæng mellem andel af siddetid i arbejde og fritid, opdelt i korte, mellemlange og lange perioder og risiko for nakke-skulderbesvær >4, på en skala fra 0-10, hvor 0 er ingen smerte (n=595), justeret for alder, køn, rygning, BMI, jobanciennitet, løftearbejde, fysisk aktivitet i arbejde, fysisk aktivitet i fritiden, tid med overarmen løftet mere end 90° fra lodlinjen.

	OR	95 %CI	*p*
Siddetid på arbejde			
Korte perioder (≤ 5 min)	**0,68**	**0,48 – 0,98**	**0,04**
Mellemlange perioder (>5 - ≤ 20 min)	**1,32**	**1,04 – 1,69**	**0,02**
Lange perioder (> 20 min)	0,92	0,78 – 1,09	0,33
Siddetid i fritid			
Korte perioder (≤ 5 min)	1,25	0,71 – 2,21	0,44
Mellemlange perioder (>5 - ≤ 20 min)	0,76	0,52 – 1,10	0,15
Lange perioder (> 20 min)	0,90	0,71 – 1,14	0,37

Sammenhæng mellem siddetid og nakke-skulder- og lænderygbesvær henover et år

Overordnet viste analyserne negative sammenhænge mellem øget siddetid i arbejde og intensitet af både nakke-skulder- og lænderygbesvær henover et år (tabel 4 og 5).

Ved inddeling af andel af siddetid under arbejde i højeste tredjedel, midterste tredjedel og laveste tredjedel sås det største fald i intensitet af nakke-skulderbesvær henover et år blandt deltagere med den højeste tredjedel af siddetid under arbejde.

Ved inddeling af deltagerne i brancherne rengøring, industri og transport sås ligeledes negative sammenhænge mellem andel siddetid i arbejde og intensitet af nakke-skulderbesvær henover et år, og kun blandt deltagerne i transport sås en signifikant sammenhæng (tabel 4). Alle analyser med nakke-skulderbesvær som udfald blev justeret for alder, køn, BMI, branche, løftearbejde, andel af siddetid i fritiden, selvrapporteret niveau af fysisk aktivitet i arbejde og fritid og tid med overarmen løftet mere end 60° fra lodlinjen, da tidligere studier har vist, at disse faktorer kan påvirke sammenhængen mellem siddetid og nakke-skulderbesvær.

Tabel 4 Sammenhæng mellem 10 % stigning i total siddetid i arbejde blandt alle deltagere og opdelt på brancher, og nakke-skulderbesvær på en skala fra 0-10, hvor 0 er ingen smerte henover et år (n=595), justeret for alder, køn, BMI, branche, løftearbejde, andel af siddetid i fritiden, selvrapporteret niveau af fysisk aktivitet i arbejde og fritid og tid med overarmen løftet mere end 60° fra lodlinjen.

	β	95 %CI	*p*
Siddetid på arbejde			
Samlede population (n=595)	**-0,01**	**-0,01 – 0,00**	**0,03**
Rengøring (n=120)	-0,01	-0,03 – 0.01	0,40

Industri (n=448)	0,00	-0,01 – 0,00	0,35
Transport (n=57)	**-0,04**	**-0,06 - -0,01**	**<0,01**

For intensitet af lænderygbesvær henover et år viste de justerede analyser, at der var en negativ sammenhæng mellem andel af siddetid i arbejde og intensitet af lænderygbesvær henover et år (tabel 5). Denne negative sammenhæng svarer til, at for hver øgning af siddetid på arbejde med 5 min/arbejdsdag vil man kunne forvente et fald i intensitet af lænderygbesvær på 0,05 point, på en skala fra 0-10, henover et år.

Forskellig varighed af perioder med siddetid ændrede ikke den negative sammenhæng, da korte, mellemlange og lange perioder af siddetid på arbejde og intensitet af lænderygbesvær henover et år ligeledes viste negative sammenhænge (tabel 5). Ligeledes fandtes der også negative sammenhænge mellem både total, korte, mellemlange og lange perioder med andel af siddetid i al vågen tid og intensitet af lænderygbesvær.

Tabel 5 Sammenhæng mellem 10 % stigning i total siddetid på arbejde, og 10 % stigninger i siddetid på arbejde opdelt i korte, mellemlange og lange perioder, og lænderygbesvær på en skala fra 0-10, hvor 0 er ingen smerte (n=665), justeret for diagnose med diskosprolaps, højeste intensitet af lænderygbesvær de seneste tre måneder fra baseline, løftearbejde og andel af siddetid i fritiden.

	β	SE	*P*
Siddetid på arbejde			
Total siddetid	**-0,05**	**0,01**	**<0,01**
Korte perioder (≤ 5 min)	-0,12	0,02	<0,01
Mellemlange perioder (>5 - ≤ 20 min)	-0,12	0,02	<0,01
Lange perioder (> 20 min)	-0,12	0,02	<0,01

DISKUSSION

Overblik over projektet

Dette projekt havde til formål at undersøge sammenhænge mellem siddetid og ondt i ryggen (lænderyg og nakke-skuldre). Siddetid blev med accelerometre målt præcist og i en detaljegrad, der muliggjorde undersøgelse af både den samlede siddetid, men også opdelt i arbejde og fritid samt i perioder af forskellig varighed.

Overordnet viste resultaterne, at meget siddetid ikke øger forekomsten eller intensiteten af hverken nakke-skulder- eller lænderygbesvær, hverken ved baseline eller henover et år, blandt arbejdstagere i brancherne rengøring, industri og transport. Generelt viste resultaterne, at der ikke var forskel på sammenhængen mellem siddetid og nakke-skulder- og lænderygbesvær, når siddetiden var i arbejde eller i fritid eller med varierende længde af periode, på nær for siddetid i arbejde i mellemlange perioder (5 – 20 min), hvor vi fandt at meget siddetid i mellemlange perioder hang sammen med mere nakke-skulderbesvær ved baseline.

Dog fandt vi, at meget siddetid var forbundet med en højere forekomst af lænderygbesvær, blandt deltagere med en BMI < 25 kg/m^2 ved baseline, hvilket var i modsætning til sammenhængen blandt deltagere med en BMI ≥ 25 kg/m^2, hvor meget siddetid var forbundet med en reduceret forekomst af lænderygbesvær.

Henover et år sås det hurtigste fald af nakke-skulderbesvær i den tredjedel af deltagerne der havde den højeste siddetid i arbejde.

Sammenhænge mellem siddetid og lænderygbesvær ved baseline

Ved baseline sås ingen sammenhæng mellem total mængde af siddetid i arbejde og i vågentid per døgn og lænderygbesvær. Ligeledes findes der i litteraturen ikke evidens for en sammenhæng mellem siddetid og lænderygbesvær ved analyse af både selvrapporteret siddetid (Chen et al., 2009; Lis et al., 2007; Roffey et al., 2010) og siddetid målt med accelerometre, efter samme metode som i dette studie (Gupta et al., 2015; Lunde et al., 2017). Derfor virker det ikke sandsynligt, at den manglende evidens kan tilskrives eventuelle mangler i metoden til at samle information om siddetid, så som fejlestimering grundet dårlig hukommelse (Miranda et al., 2006) eller livsstilsfaktorer (Holtermann et al., 2014; Nilsen et al., 2011). En mulig forklaring på den manglende evidens kan eventuelt findes i analysemetoden, hvor studier hidtil har undersøgt en kropspositions (f.eks. at sidde) sammenhæng med lænderygbesvær uden at tage højde for, at en ændring af siddetiden vil medføre en ændring af tiden brugt på andre kropspositioner eller aktiviteter, da tiden henover et døgn er konstant (Chastin et al., 2015), hvilket understreger, at fremtidige studier af helbredseffekter af siddetid, bør tage højde for, hvad der sker, når man ikke sidder.

Tidligere studier, der undersøger sammenhængen mellem siddetid og lænderygbesvær, angiver, at særligt længerevarende perioder med siddetid er skadelige for muskel-skelet helbredet (Lis et al., 2007; Thorp et al., 2014), dog understøttes dette ikke af projektets resultater, hvor der ikke findes forskel mellem siddetid i korte, mellemlange og lange perioder og lænderygbesvær. Trods, at der ikke ses forskel mellem korte, mellemlange og lange perioder med siddetid, må det antages, at pauser fra siddende aktiviteter kan øge eksponeringen for andre aktiviteter, der i højere grad leder til lænderygbesvær, så som løft og akavede bevægelser (da Costa & Vieira, 2010; Larsson et al., 2007).

I tillæg, er det ikke tidligere undersøgt, hvilke faktorer der kan påvirke sammenhængen mellem siddetid og længerygbesvær. I dette projekt undersøgte vi dette og fandt, at BMI påvirkede sammenhængen mellem siddetid og længerygbesvær signifikant og derfor gennemførtes en analyse adskilt på høj (BMI ≥ 25 kg/m^2) og lav BMI (< 25 kg/m^2). Blandt deltagere med en høj BMI sås, at mere siddetid var forbundet med en mindre forekomst af lænderygbesvær, hvorimod at mere siddetid hang sammen med en højere forekomst af lænderygbesvær blandt deltagere med en lav BMI. Disse modsatrettede sammenhænge kan forklares ud fra, at de med en høj BMI i højere grad har brug for den pause, som siddetiden giver fra andre aktiviteter, der i højere grad giver lænderygbesvær, f.eks. løftearbejde eller arbejde i akavede positioner (da Costa & Vieira, 2010; Korshøj et al., 2017; Larsson et al., 2007). Omvendt, kan den manglende aktivitet og ændring af kropsposition eventuelt give anledning til lænderygbesvær blandt de med en lav BMI (Beach et al., 2005; Vuori, 2001).

Sammenhænge mellem siddetid og nakke-skulderbesvær ved baseline

Forekomsten af nakke-skulderbesvær >4 var forbundet med meget siddetid i mellemlange perioder i arbejde, hvorimod meget siddetid i korte perioder i arbejde var relateret til en lavere forekomst af nakke-skulderbesvær, og der sås ingen sammenhæng mellem siddetid i lange perioder i arbejde og forekomst af nakke-skulderbesvær. Uanset længden af siddetiden i fritiden sås der ingen sammenhæng mellem siddetid i fritiden og forekomst af nakke-skulderbesvær >4.

Disse resultater tydeliggør nødvendigheden af detaljerede data på siddetid og ikke kun indsamling af den totale siddetid til undersøgelse af sammenhænge med nakke-skulderbesvær. Tidligere studier, der undersøger effekten af den totale selvrapporterede siddetid i arbejde, angiver, at øget siddetid i arbejde leder til øget nakke-skulderbesvær (Ariëns et al., 2001; Cagnie et al., 2007; Yue et al., 2012). Disse modstridende resultater kan både skyldes den upræcise afrapportering af siddetid, der ikke muliggør inddeling af siddetiden i perioder med forskellig varighed, samt at studierne er gennemført på jobgrupper med forskellige eksponering for siddetid og anden fysisk aktivitet i arbejde (Celis-Morales et al., 2012; Clark et al., 2011).

I denne undersøgelse af forskellig varighed af perioder med siddetid i arbejde findes, at øget siddetid i korte perioder relateres til reduceret nakke-skulderbesvær, hvilket er i overensstemmelse med tidligere studier, der angiver, at variationen i kropsposition og aktivitet er større ved korte perioder af siddetid, hvilket beskytter mod muskelskeletbesvær generelt (Mathiassen, 2006; Toomingas et al., 2012). Omvendt kan sammenhængen mellem siddetid i mellemlange perioder og en høj forekomst af nakke-skulderbesvær forklares ud fra de længere perioder med begrænset bevægefrihed, der er en velkendt risiko for nakke-skulderbesvær (Côté et al., 2009; Mayer et al., 2012). Dog, findes ikke at megen siddetid i lange perioder relateres til en høj forekomst af nakke-skulderbesvær, hvilket ikke stemmer overens med den teoretiske antagelse om en sammenhæng mellem mellemlange perioder af siddetid og nakke-skulderbesvær. Dette kan eventuelt forklares ved at der ikke er nok deltagere der har mange lange perioder med siddetid (Hallman et al., 2016). Derfor er det nødvendigt med mere viden om hvilke aktiviteter der udføres mens man sidder, før der kan opnås viden om relationen til nakke-skulderbesvær, og til forklaring af hvorfor meget siddetid i længere perioder ikke leder til højere forekomst af nakke-skulderbesvær.

Sammenhænge mellem siddetid og lænderygbesvær henover et år

Resultaterne viste, at tid (det år som lænderygbesvær-data blev indsamlet henover) påvirkede sammenhæng mellem siddetid og lænderygbesvær, og derfor blev tid inkluderet i analysen som en modererende faktor. Der sås en negativ sammenhæng mellem total siddetid i arbejde og lænderygbesvær henover et år, svarende til, at 5 minutters mere siddetid per arbejdsdag vil sænke lænderygbesvær henover et år med 0,05, på en skala fra 0-10. Ligeledes var der tilsvarende negative sammenhænge mellem forskellig varighed af perioder med siddetid på arbejde og intensitet af lænderygbesvær henover et år.

I modsætning til disse resultater har tidligere studier med selvrapporteret siddetid vist, at øget siddetid i arbejde leder til øget lænderygbesvær (Henson et al., 2013; Larsen et al., 2014; Yates et al., 2012). Dog, viste et studie ligeledes en negativ sammenhæng mellem øget siddetid i arbejde og lænderygbesvær over tid ved brug af tekniske målinger af siddetid (Lunde et al., 2017). Både dette projekt og studiet med tekniske målinger (Lunde et al., 2017) er gennemført blandt arbejdstagere med primært manuelle jobs, og derfor kan det antages, at siddetid giver en pause fra andre aktiviteter, der leder til højere risiko for lænderygbesvær, så som løftearbejde (Coenen et al., 2014; da Costa & Vieira, 2010; Larsson et al., 2007). Studierne med selvrapporteret siddetid (Henson et al., 2013; Larsen et al., 2014; Yates et al., 2012) er gennemført blandt jobgrupper uden manuelt arbejde, hvilket ligeledes bidrager til at forklare de modstridende fund.

Resultaterne viste ligeledes, at øgning af siddetid i arbejde, uanset varigheden af perioden, var forbundet med sænket lænderygbesvær henover et år, hvilket kunne indikere, at det er pausen fra andre aktiviteter, den siddende tid giver, der er gavnlig i forhold til reduktion af lænderygbesvær, og ikke hvor længe pausen varer.

Sammenhænge mellem siddetid og nakke-skulderbesvær henover et år

Henover et år faldt nakke-skulderbesværet, når den totale siddetid i arbejde øgedes. Tidligere studier har ligeledes fundet, at øget siddetid i arbejde, målt med selvrapportering, var forbundet med mindsket nakke-skulderbesvær (Grooten et al., 2007; Picavet et al., 2016). Ligesom ved lænderygbesvær kan reduktionen af nakke-skulderbesvær forklares ved, at siddetid kan fungere som en pause fra andre aktiviteter, der i højere grad, end siddetid, leder til nakke-skulderbesvær, så som løftearbejde (Coenen et al., 2014; da Costa & Vieira, 2010; Larsson et al., 2007).

Omvendt viste et studie med videooptagelser af siddetid, at meget siddetid på arbejde var forbundet med en øget risiko for hyppige og længerevarende perioder med nakke-skulderbesvær henover en 3-årig periode (Ariëns et al., 2001), dette modstridende fund kan eventuelt tilskrives metoden til måling af siddetid samt forskelle mellem deltagerne i de to studier. I dette projekt blev siddetid målt uden afbrydelser henover ca. 2,5 døgn, hvorimod videooptagelserne blev filmet henover 4 perioder på en arbejdsdag af 10-14 minutters varighed per optagelse.

Resultaterne opdelt på branche viste at der i rengøring og industri ikke var nogen sammenhæng mellem siddetid i arbejde og nakke-skulderbesvær. I transportbranchen var der en negativ sammenhæng, så mere siddetid hang sammen med mindre nakke-skulderbesvær. Da branchegrupperne ikke er ligeligt fordelt på køn, kan disse forskelle forklares ved at der ikke er en lige fordeling af køn i de tre brancher og at dette påvirker fordeling af siddetid på arbejde (Hallman et al., 2015).

Ved inddeling af andel siddetid under arbejde i højeste tredjedel, midterste tredjedel og laveste tredjedel sås det hurtigste fald i intensitet af nakke-skulderbesvær henover et år blandt deltagere i den højeste tredjedel af siddetid under arbejde. Dermed antages det at siddetid kan fungere som en pause fra andre aktiviteter, der i højere grad leder til nakke-skulderbesvær.

Væsentlige styrker og svagheder ved projektet

En væsentlig styrke ved projektet er, at data på siddetid er indsamlet ved hjælp af teknisk måling i stedet for via selvrapport (Clark et al., 2011; Gupta et al., 2017; Lagersted-Olsen et al., 2014), der er upræcis, og derfor kan lede til fejlagtige resultater på sammenhænge med helbredsudfald (Celis-Morales et al., 2012). Derudover er metoden, der blev anvendt til opgørelse af siddetid, fundet valid i efterprøvninger i både laboratorie og felt (Ingebrigtsen et al., 2013; Korshøj et al., 2014; Skotte et al., 2014; Stemland et al., 2015). Dernæst blev siddetid opgjort henover flere sammenhængende døgn med en høj detaljeringsgrad og opdeling af arbejdstid, fritid og tid, hvor man ligger i sin seng. Denne inddeling gjorde det muligt at gennemføre analyser på siddetid i arbejde og fritid separat. I tillæg muliggjorde detaljeringsgraden af siddetidsdata inddeling af siddetid i forskellige varigheder (≤ 5 min, >5 - ≤ 20 min og > 20 min), og ligeledes inddelt i arbejdstid og fritid. Dette bidrog til, at belyse om de forskellige varigheder af siddetid påvirkede nakke-skulder eller lænderygbesvær forskelligt. En anden styrke ved siddetidsdata i dette projekt er, at det ikke kun er indsamlet i en branche, hvilket betyder, at der er en bred variation, i hvor længe deltagerne sidder henover døgnet, og også hvor lange perioder de sidder i (Jørgensen, 2019) i forhold til tidligere studier gennemført i enkelte brancher (Cagnie et al., 2007; Skov et al., 1996).

Det er dog en svaghed, at siddetid ikke er målt gentagne gange henover det år, der blev indsamlet nakke-skulder- og lænderygbesvær, da det derfor er udelukket at udetale sig om, hvor stabil siddetiden er henover et år. Dog viste analyser justeret for selvrapporterede ændringer i fysisk aktivitet på arbejde enslydende resultater med de afrapporterede. Yderligere, er der ikke indsamlet information om hvilke aktiviteter eller arbejdsopgaver der udføres i siddeperioderne og derfor kan det være vanskeligt at beskrive sammenhængen til nakke-skulder- og lænderygbesvær. Dette belyser nødvendigheden af indsamling af integreret eksponering fra flere kropsdele, kropspositioner og aktiviteter henover arbejdsdagen.

Dertil er de gentagne målinger af nakke-skulder- og lænderygbesvær, henover et år, ligeledes en styrke ved projektet. Da intensiteten af nakke-skulder- og lænderygbesvær kan variere meget henover tid (Axén et al., 2014; Axen & Leboeuf-Yde, 2013), er det en styrke at indsamle data hyppigt (Gupta et al., 2015; Korshøj et al., 2017; Lunde et al., 2017).

Da projektet kun omhandlede arbejdstagere fra rengørings-, industri- og transportbrancherne, er disse resultater ikke direkte overførbare til andre brancher, som eksempelvis kontoransatte.

Praktisk betydning af projektets resultater

Samlet set, viste resultaterne, at siddetid ikke leder til en højere forekomst af hverken nakke-skulder- eller lænderygbesvær, hverken ved baseline eller henover et år, blandt arbejdstagere i brancherne rengøring, industri og transport. Disse resultater kan blandt andet forklares ved, at dette projekt er gennemført blandt medarbejdere i brancher, der primært har manuelt arbejde, og derfor kan det antages, at siddetid i arbejde fungerer som pause fra aktiviteter, der i højere grad, end siddetid, er en risiko for at få ondt i ryggen. At variation af kropsposition under arbejde bidrager til reduktion af muskelskeletbesvær, understøttes af dette projekt, der viser at siddetid i korte perioder leder til lavere forekomst af nakke-skulder- og lænderygbesvær henover et år.

Trods disse detaljerede data tyder projektets resultater på, at nakke-skulder- og lænderygbesvær ikke kun påvirkes af enkeltstående eksponeringer, som siddetid, men i højere grad af, hvad deltagerne laver, når de ikke sidder ned. Dette kan i fremtidige projekter undersøges ved at integrere eksponering fra flere forskellige kropspositioner og aktiviteter henover hele arbejdsdagen, for dermed at kunne beskrive sammenhængen til nakke-skulder- og lænderygbesvær fyldestgørende.

Disse resultater indikerer at anbefalinger omkring reduktion af siddetid i arbejde, blandt disse brancher, potentielt kan lede til højere forekomst og intensitet af nakke-skulder- og lænderygbesvær, hvorfor reduktioner af siddetid ikke bør anbefales, før der eksisterer mere viden om disse sammenhænge. På den anden side, er denne viden ikke tilstrækkeligt til at kunne anbefale mere siddetid i arbejde i disse brancher, da meget siddetid er forbundet med risici for andre sygdomme som diabetes og hjertekarsygdom (Wilmot et al., 2012; Overgaard et al., 2012), der ikke er afdækket i dette projekt.

Derfor er der behov for mere viden om sammenhænge mellem siddetid, i kombination med andre kropspositioner og aktiviteter og ondt i ryggen, inden klare anbefalinger kan gives.

KONKLUSION

Projektets resultater giver ingen klare indikationer på, at siddetid under arbejde, eller henover hele døgnet, udgør en betydelig risiko for nakke-skulder eller lænderygbesvær blandt medarbejdere i rengørings-, industri- og transportbranchen. Ej heller fremkommer nogle klare indikationer på, at længerevarende perioder med siddetid er forbundet med øget nakke-skulder- eller lænderygbesvær. Dog ses indikationer på, at siddetid i korte perioder leder til sænket nakke-skulder- og lænderygbesvær henover et år, hvilket støtter op om den generelle anbefaling om, at variation af kropsposition under arbejde bidrager til reduktion af muskelskeletbesvær.

Derudover indikerer disse resultater, at reduktion af siddetid i arbejde blandt disse brancher potentielt kan forbindes til øget nakke-skulder- og lænderygbesvær, hvorfor reduktioner af siddetid ikke bør anbefales. Ej heller, kan disse resultater understøtte anbefalinger om mere siddetid i arbejde, før der eksisterer mere viden om disse sammenhænge.

For at kunne give klare anbefalinger er der behov for flere studier, der undersøger effekter af både siddetid og forskellige fysiske arbejdskrav i samlede analyser.

Efterskrift

Dette projekt undersøgte sammenhænge mellem siddetid og nakke-skulder- og lænderygbesvær. Projektet belyser enkelte eksponeringer i relation til et helbredsudfald uden nødvendigvis at tage højde for andre eksponeringer, der er forbundne til den undersøgte. Her kunne andre eksponeringer være tid, man står eller går på arbejde eller henover hele døgnet, forstået på den måde, at døgnets 24 timer er konstante, uanset hvordan vi vælger at fordele dem mellem eksempelvis siddetid, og tid man står og går. Derfor er den tid, man bruger på at sidde forbundet med den tid, man bruger på at gå, da man ikke kan fjerne siddetid uden at øge tid brugt på en anden aktivitet.

På baggrund af denne tankegang, der tager udgangspunkt i, at døgnets 24 timer er konstante, er der indledt et samarbejde mellem dette projekt og et sideløbende projekt omhandlende sammenhæng mellem tid brugt på at stå og gå og besvær i lænderyg, hofter og knæ. Formålet med dette samarbejde er at undersøge sammenhænge mellem forskellige sammensætninger af tid brugt på at sidde, stå og gå henover 24 timer og risiko for lænderygbesvær henover et år. Resultaterne fra dette samarbejde vil derfor supplere resultaterne fra dette projekt med viden om, hvordan fordelingen af tid brugt på at sidde, stå og gå leder til mindst muligt lænderygbesvær.

Projektet blev gennemført med støtte fra Arbejdsmiljøforskningsfonden samt med sparring fra følgegruppe og referencegruppe. Tak til alle deltagere, deltagende virksomheder, bidragsydere, samarbejdspartnere og kolleger, der har gjort dette projekt muligt at gennemføre.

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SUPPLEMENT TIL ARBEJDSMILJØFORSKNINGSFONDEN

Beskrivelse af om og hvordan projektets formål og hensigt er opnået

Det opstillede formål for projektet, angivet i ansøgningen pålydende:
Formålet med projektet er at undersøge om følgende tre forhold øger risikoen for lænderygbesvær:

1. Meget siddetid under arbejde (total mængde af siddetid under arbejde)
2. Længerevarende sammenhængende arbejdsperioder med siddetid (antal perioder på 30 minutter eller mere uden afbrydelser)
3. Meget siddetid pr døgn (total mængde af siddetid under et helt arbejdsdøgn)

Er blevet undersøgt i de to studier der vedrører lænderygbesvær, hvor der angives estimater for lænderygbesvær ved en tværsnitssammenligning og henover et år. Overordnet, viser resultaterne fra projektet at det ikke ser ud til at siddetid i arbejde, uanset om det er totalt eller delt efter varighed af den enkelte periode med siddetid, øger lænderygbesvær. Omvendt ses sammenhænge der indikerer at siddetid i arbejde, uanset varighed, leder til mindre lænderygbesvær. Ligeledes ses at siddetid pr døgn heller ikke leder til mere lænderygbesvær, nærmere omvendt. I tolkningen af disse resultater skal man have for øje at projektet er gennemført blandt arbejdstagere indenfor brancherne rengøring, industri og transport, hvilke er erhverv der har høje andele af manuelt arbejde hvor siddetid kan fungere som en pause fra andre aktiviteter der i højere grad leder til lænderygbesvær. På baggrund af denne fremkomne viden er det projektgruppens vurdering at projektets hensigt og formål er opnået.

Beskrivelse af erfaringer og konklusioner, som projektarbejdet har medført

Projektets overordnede konklusion er at siddetid i arbejde, uanset om det er totalt eller delt efter varighed af den enkelte periode med siddetid, ikke øger nakke-skulder- og lænderygbesvær. Dermed indikeres at reduktion af siddetid i arbejde potentielt kan øge nakke-skulder- og lænderygbesvær, og derfor bør reduktion af siddetid ikke anbefales før der eksisterer mere viden om disse sammenhænge.

Undervejs i projektet erfarede vi at de analyse-metoder vi anvendte havde en begrænsning i udelukkende at belyse en enkelt eksponering i relation til et helbredsudfald, uden nødvendigvis at tage højde for andreeksponeringer der er forbundne til den undersøgte. Her kunne andre eksponeringer være tid man står eller går i arbejde, forstået på den måde at siden det antal timer man arbejder om dagen ikke ændres, vil en reduktion af siddetid i arbejde medføre mere tid brugt i andre aktiviteter, som f.eks. gående arbejde. Derfor er den tid man bruger på at sidde forbundet med den tid man bruger på andre aktiviteter, som at gå og stå, da man ikke kan fjerne siddetid uden at tilføje tid brugt på en anden aktivitet. På denne baggrund, vil der igangsættes nye projekter der undersøger hvordan fordelingen af tid brugt på at sidde, stå og gå leder til mindst muligt nakke-skulder- og lænderygbesvær.

Perspektivering af projektets resultater i relation til forbedring af arbejdsmiljø

Samlet set, viste resultaterne at siddetid ikke øger hverken nakke-skulder- eller lænderygbesvær, hverken ved baseline eller henover et år, blandt arbejdstagere i brancherne rengøring, industri og transport. Disse resultater kan blandt andet forklares ved at dette projekt er gennemført blandt medarbejdere i brancher der primært har manuelt arbejde og derfor kan det antages at siddetid i arbejde fungerer som pause fra aktiviteter der i højere grad end siddetid er en risiko for at få ondt i ryggen. Dermed tyder projektets resultater på at nakke-skulder- og lænderygbesvær ikke kun påvirkes af enkeltstående eksponeringer som siddetid, men i højere grad af hvad deltagerne laver når de ikke sidder ned, hvilket påpeger nødvendigheden af at integrere eksponering fra flere forskellige kropspositioner og aktiviteter henover hele arbejdsdagen for at kunne beskrive sammenhængen til nakke-skulder- og lænderygbesvær fyldestgørende.

På kort sigt bidrager resultaterne fra dette projekt til forbedret arbejdsmiljø gennem belysningen af at anbefalinger omkring reduktion af siddetid i arbejde blandt disse brancher potentielt kan øge nakke-skulder- og lænderygbesvær, hvorfor reduktioner af siddetid ikke bør anbefales uden øje for niveauet af eksponering af andre kropspositioner og/eller aktiviteter der i højere grad leder til nakke-skulder- og lænderygbesvær og som der kan være behov for at tage pause fra. Mere klare anbefalinger kan ikke gives før der eksisterer mere viden om disse sammenhænge.

På lang sigt vil resultaterne fra dette projekt lede til undersøgelser af kombinationer af kropspositioner og aktiviteter i sammenhæng med nakke-skulder- og lænderygbesvær. Målet er at sådanne resultater vil bidrage til både en ny forståelse af det ergonomiske arbejdsmiljø, og forbedringer af arbejdsmiljøet gennem anbefalinger der i højere grad forholder sig til ikke kun enkeltstående eksponeringer, men betydningen af kombinationer af eksponeringer til forbedring af forebyggelse af muskelskeletbesvær.

PUBLIKATIONER OG PRODUKTER

Videnskabelig formidling

Peer reviewede artikler

1. Prolonged sitting at work is associated with a favorable time course of low-back pain among blue-collar workers: a prospective study in the DPhacto cohort. Korshøj M, Jørgensen MB, Hallman DM, Lagersted-Olsen J, Holtermann A, Gupta N. Scand J Work Environ Health. 2018 Sep 1;44(5):530-538. doi: 10.5271/sjweh.3726. Epub 2018 Mar 15.

2. Is objectively measured sitting at work associated with low-back pain? A cross sectional study in the DPhacto cohort. Korshøj M, Hallman DM, Mathiassen SE, Aadahl M, Holtermann A, Jørgensen MB. Scand J Work Environ Health. 2018 Jan 1;44(1):96-105. doi: 10.5271/sjweh.3680. Epub 2017 Oct 27.

3. Is prolonged sitting at work associated with the time course of neck-shoulder pain? A prospective study in Danish blue-collar workers. Hallman DM, Gupta N, Heiden M, Mathiassen SE, Korshøj M, Jørgensen MB, Holtermann A. BMJ Open. 2016 Nov 10;6(11):e012689. doi: 10.1136/bmjopen-2016-012689.

4. Temporal patterns of sitting at work are associated with neck–shoulder pain in blue-collar workers: a cross-sectional analysis of accelerometer data in the DPHACTO study. Hallman DM, Mathiassen SE, Heiden M, Gupta N, Jørgensen MB, Holtermann A. Int Arch Occup Environ Health (2016) 89:823–833

Øvrig skriftlig videnskabelig formidling

1. Is there an association between temporal patterns of sitting and low back pain? - A cross-sectional study. Korshøj M; Gupta N; Lagersted-Olsen J; Hallman DM; Jørgensen MB; Holtermann A. Abstract til 9th International Scientific Conference on the Prevention of Work-Related Musculoskeletal Disorders, Toronto, Canada, Juni 2016.

2. Prolonged occupational sitting is associated with a favorable time course of low back pain. Korshøj M, Hallman DM, Lagersted-Olsen J, Gupta N, Holtermann A, Jørgensen MB. Abstract til 20th Congress International Ergonomic Association, Firenze, Italien, August 2018.

Mundtlig videnskabelig formidling

1. Seminar om stillesiddende adfærd, Statens Institut for Folkesundhed, København September 2015. Oral præsentation, Stillesiddende arbejde.

2. 9th International Scientific Conference on the Prevention of Work-Related Musculoskeletal Disorders, Toronto, Canada, Juni 2016. Oral præsentation, Is there an association between temporal patterns of sitting and low back pain? -A cross-sectional study.

3. Arbejdsmiljøforskningsfondens årskonference 2018, poster præsentation. Siddetid på arbejde og ondt i ryggen.

4. 20th Congress International Ergonomic Association, Firenze, Italien, August 2018. Oral præsentation, Prolonged occupational sitting is associated with a favorable time course of low back pain.

Poplærformidling

Skriftlig populær formidling

1. Interview til analyse Danmark. https://analysedenmark.dk/article/bedre-ergonomi-pa-arbejdspladsen-betaler-sigfaktaboks.html

2. Interview til DJØF bladet. https://www.djoefbladet.dk/artikler/2017/9/dj-oe-ferne-sidder-for-meget-ned.aspx

3. Dansk rapport.
LÆNGEREVARENDE STILLESIDDENDE ARBEJDE
EN RISIKOFAKTOR FOR NAKKE-SKULDER- OG LÆNDERYGBESVÆR?
– Et overblik over sammenhænge mellem siddetid og nakke-skulder- og lænderygbesvær. Af Mette Korshøj & Andreas Holtermann. Udgivet fra Det Nationale Forskningscenter for Arbejdsmiljø Maj 2019.

Mundtlig populær formidling

1. Arbejdsmiljøforum Varde Kommune, oktober 2017, Varde, oplæg, paneldebat og workshop

2. Arbejdsmiljøkonferencen, november 2017, Nyborg, workshop

3. Falck Healthcare, april 2017, København, oplæg og debat med konsulenter

POPULÆRARTIKEL

GIVER MEGET SIDDETID ONDT I RYGGEN?

RESULTATER FRA EN UNDERSØGELSE BLANDT MEDARBEJDERE I RENGØRING, INDUSTRI OG TRANSPORT

Af Mette Korshøj, Forsker ved Det Nationale Forskningscenter for Arbejdsmiljø

Stillesiddende adfærd

At være meget stillesiddende er en selvstændig risiko for forringet helbred. Særligt, hvis man sidder i længerevarende perioder. En helbredsrisiko ved megen stillesiddende tid være ondt i ryggen. Forklaringen bag at meget siddetid kan give ondt i ryggen er en mangelfuld brug (inaktivitet) af musklerne over længere tid eller den ensidige kropsposition som stillesiddende perioder medfører. I Danmark sidder vi mere og mere stille, både i fritiden og under arbejde, og 40 % af alle danske medarbejdere angiver at sidde ned mere end 75 % af arbejdsdagen. Stillesiddende arbejde forekommer dermed ikke kun blandt kontoransatte, men også blandt ansatte i øvrige jobs, så som i industri og transport branchen.

Hidtil er information om stillesiddende adfærd indsamlet ved hjælp af spørgeskemaer, men denne information har vist sig at være påvirket af mange faktorer og at være upræcis. Dog er det muligt at indsamle information om stillesiddende adfærd ved hjælp af bevægelsesmålere, hvilke angiver præcist stillesiddende perioders varighed og frekvens.

Sammenhænge mellem stillesiddende adfærd ondt i ryggen

En undersøgelse af stillesiddende perioder i arbejde og fritid viste inden sammenhæng med ondt i ryggen, hverken ved undersøgelsens start eller henover et år, blandt arbejdstagere i rengøring, industri og tranport branchen, ej heller ved opdeling af ryggen i nakke, skuldre, øvre ryg og lænd.

Særligt for nakke, skuldre og øvre ryg sås at når stillesiddende perioder blev opdelt i forskellig varighed, en øgning af stillesiddende perioder i arbejde på 5 – 20 min ledte til øget besvær, ved undersøgelsens start. Omvendt sås at mere stillesiddende tid i korte perioder på op til 5 minutter gav mindre besvær, ved undersøgelses start. Henover et år sås de største fald i besvær blandt de med den højeste tredjedel af stillesiddende tid i arbejde.

Særligt for lænden, sås for deltagere med en BMI ≥ 25 kg/m² (overvægtige) beskyttede stillesiddende perioder mod besvær, hvorimod at deltagere med en BMI < 25 kg/m² (normalvægtige) fik mere besvær hvis de sad mere ned. Ved inddeling af deltagerne i jobgrupper sås ingen forskelle mellem jobgrupperne rengøring, industri og transport.

Data til undersøgelsen blev hentet fra DPhacto-kohorten der har information om stillesiddende perioder fra 704 medarbejdere fra 15 danske virksomheder, målt med bevægelsesmålere henover ca. 4 døgn samt oplysning om ondt i nakke, skuldre, øvre ryg og lænd hver måned gennem 1 år. Ved undersøgelsens start havde mere end hver tredje af deltagerne (37 %) ondt i ryggen.

Perspektiver på stillesiddende adfærd og ondt i ryggen

Overordnet ser det ikke ud til at siddetid giver ondt i ryggen blandt medarbejdere indenfor rengøring, industri og transport. Det ser nærmere ud til at siddetid er en beskyttende faktor. Denne undersøgelse er gennemført blandt medarbejdere der primært har manuelt arbejde og derfor kan siddetid i arbejde fungere som pause og hvile fra aktiviteter der i højere grad end siddetid leder til ondt i ryggen, hvilket ser ud til at gøre sig særligt gældende blandt deltagere med en BMI ≥ 25 kg/m^2. Påvirkningen fra det man laver når man ikke sidder, er derfor vigtig at undersøge for at kunne forklare hvorfor der er forskellig sammenhæng mellem siddetid i korte og mellemlange perioder og ondt i nakke og skuldre. Derfor er det vigtigt at anbefalinger om at mindske siddetid tager højde for hvilke aktiviteter siddetiden erstattes med, da en anbefaling om at mindske siddetid ellers vil kunne lede til mere ondt i ryggen.

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Is prolonged sitting at work associated with the time course of neck–shoulder pain? A prospective study in Danish blue-collar workers

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ABSTRACT

Objectives: This study aimed to determine the extent to which objectively measured sitting time at work is associated with the course of neck–shoulder pain across 1 year in blue-collar workers.

Methods: Data were analysed from 625 blue-collar workers in the Danish PHysical ACTivity cohort with Objective measurements (DPHACTO) cohort study (2012–2013). Objective data on sitting time were collected at baseline using accelerometry. Self-reported pain intensity (numeric rating scale 0–10) in the neck–shoulder region was registered for 1 year using repeated text messages (14 in total). Linear mixed models were used to determine the relationship between per cent time in sitting at work and trajectories of neck–shoulder pain, with and without adjustment for demographic, occupational and lifestyle factors, and baseline pain intensity.

Results: More sitting time at work was associated with a faster decline in pain intensity over 12 months, as indicated by a statistically significant effect of sitting on pain trajectories in the crude (p=0.020) and fully adjusted models (p=0.027).

Conclusions: In blue-collar workers, more sitting time at work was associated with a favourable development of pain intensity over time. The relationship between sitting at work and pain needs further investigation before explicit recommendations and guidelines on sedentary behaviour among blue-collar workers can be developed.

Strengths and limitations of this study

- Some of the strengths of this study are:
  - Strength: the association between occupational sitting and musculoskeletal pain is a topical issue.
  - Strength: a large, prospective study with objective measurements of time in sitting.
  - Strength: monthly assessments of neck–shoulder pain for 1 year.
- One of the limitations of this study was that the exposure assessment was only conducted at baseline.

INTRODUCTION

Neck–shoulder pain is common in the working population[1] but little is known about the role of occupational factors in determining the time course of neck–shoulder pain.[2] Increased knowledge about occupational factors influencing the occurrence, aggravation and alleviation of pain would support a better prevention of pain and aid in promoting recovery among workers afflicted with pain.

Excessive sitting is a potential occupational risk factor for neck–shoulder pain, even in occupations not typically regarded as 'sedentary', such as blue-collar work.[1 3] Cross-sectional studies have documented a positive association between occupational sitting time and neck–shoulder pain,[4–7] while prospective studies are sparse and show inconsistent results.[8] Previous studies have mainly relied on self-reported measures of sitting, which have poor accuracy[9] and precision,[10] and thus may introduce biased associations between sitting and health outcomes.[11] Thus, prospective studies based on objective measurements (eg, accelerometry) are needed to clarify possible causal associations between sitting at work and neck–shoulder pain.[12]

The majority of studies examining associations between biomechanical work exposures and self-reported pain development have assessed pain at a few points in time interspersed by long intervals. This may introduce bias since past experiences of pain are difficult to recall after some time.[13] In addition, since pain severity may vary substantially over time, study designs with few measurement points may reflect the true course of pain poorly, and this may result in misleading relationships between exposure and pain.[14] Characterising the time course (trajectory) of pain requires repeated pain assessment, preferably on a frequent basis over an adequate period of time.[15]

A plausible physiological explanation for a positive association between sitting and neck–shoulder pain is that a constrained sitting posture for a prolonged period of time results in sustained muscle activation,[16–18] which is a presumed causal factor for neck–shoulder pain.[19] Further, inactivity may affect cardiovascular and pain regulatory systems in the central nervous system.[20–23] Thus, extensive sitting may lead to less effective pain modulation. On the other hand, sitting could also be expected to be associated with a favourable course of neck–shoulder pain in occupations including high physical demands, such as blue-collar work. This can be explained by sitting resulting in less exposure to biomechanical risk factors occurring during heavy work,[7 12 24] in addition to permitting more recovery.

The aim of the present study was to investigate the relationship between objectively measured sitting time at work and the time course (trajectory) of neck–shoulder pain across 1 year in blue-collar workers. We hypothesise that the extent of sitting time at work is associated with the trajectory of pain during this follow-up period.

METHODS

Study design and population

The current prospective study is a part of the Danish PHysical ACTivity cohort with Objective measurements (DPHACTO), aimed at investigating relationships between objectively measured physical activities at work and the time course of musculoskeletal pain in blue-collar workers. The study protocol of DPHACTO is presented in detail elsewhere.[25] In brief, data collection was conducted from spring 2012 to spring 2013 at 15 Danish workplaces in three occupational sectors, namely: cleaning (four workplaces, n=120), transportation (two workplaces, n=448) and manufacturing (nine workplaces, n=57). The initial contact and recruitment of workplaces in these sectors were performed in collaboration with a large Danish worker union. Blue-collar workers were specifically selected to minimise confounding due to socioeconomic status while obtaining a sufficient occurrence and dispersion in occupational sitting and physical activity.[26] Also, the prevalence of neck–shoulder pain in blue-collar workers is generally high.[1]

The study consisted of two phases: (1) baseline measurements including questionnaires, health measures and objective exposure data collection, and (2) continual measurements of neck–shoulder pain over 12 months.

In total, 2107 employees from 15 companies were invited to participate. Workplaces were considered eligible if they allowed measurements during working hours. Participants were included if they reported blue-collar work as their main occupation. Workers reporting predominant white-collar work, managing position, pregnancy or allergy to adhesives were excluded. Among the 901 blue-collar workers who were considered eligible, 755 participated in objective measurement (accelerometry) at baseline, resulting in valid measures (explained below) from 662 workers. Longitudinal data on self-reported neck–shoulder pain were collected from 625 of these workers, comprising the analysed study population. The main reason for non-participation was lack of interest (n=988), and main reasons for exclusion were predominant white-collar work (n=186) and not taking part in the objective measurements at baseline (n=141).

All participants provided their written informed consent prior to participation. This study was conducted according to the Helsinki declaration, approved by the Danish data protection agency, and evaluated by the local Ethics Committee (H-2-2012-011).

Procedure

At baseline, participants filled out a short questionnaire, underwent a health check and a physical examination, and took part in objective field measurements using accelerometry (see below). They were asked to wear four accelerometers for 24 hours during 4–5 days, including at least two working days. The participants were instructed to wear the equipment during the whole measurement period, and to perform a reference measurement in upright stance for 15 s each day, to ensure accurate activity detection from the accelerometer signals. They were also instructed to remove the equipment if it caused any kind of discomfort. During this period, a paper diary was used by the participant to note working hours, leisure time, and time for going to bed in the evening and getting out of bed in the morning, as well as time of the reference measurements. At the end of the data collection, the equipment was returned to the research staff. After the baseline measurements, the participants were instructed to report their neck–shoulder pain intensity using text messages (see below) continually over 12 months.

Objective assessment of occupational sitting time

The participants were equipped with triaxial accelerometers (Actigraph GT3X+, ActiGraph LLC, Florida, USA) attached on the thigh, dominant upper arm, hip and trunk. The devices, attachment, and the processing and analysis of the accelerometer signals are described in detail elsewhere.[27 28] The accelerometers were initialised for recording and downloading of data using ActiLife software V.5.5 (ActiGraph LLC, Pensacola, Florida, USA). Data obtained from the accelerometers were processed offline and analysed using a custom-made MATLAB-based software, Acti4 (The National Research Centre for the Working Environment, Copenhagen, Denmark and BAuA, Berlin, Germany). This software determines the type and duration of different physical activities and body postures (including sitting) with a high sensitivity and specificity, both in standardised and free-living conditions.[28–31]

Non-wear was identified when (a) the software detected a period longer than 90 min with zero acceleration counts, or (b) the participant reported non-wear time, or (c) artefacts or missing data were detected by visual inspection. Non-work days and time in bed were excluded from further analyses. Valid work intervals (determined from the diary) had to contain at least 4 hours/day of accelerometer wear time or 75% of the average wear time across days for the individual. Records were excluded if they had less than one recorded day.[27]

The occurrence of sitting periods was identified from the accelerometer outputs based on previously described procedures.[27 28] The occurrence of sitting and non-sitting periods at work was identified for each measurement day, averaged across days (hour/day), and expressed as percentage of total time at work. In addition, sitting time was trichotomised using tertiles of sitting time at work to obtain three exposure groups as a means to enhance interpretation of the results. Specifically, the change in pain is presented across three categories of sitting time to allow an interpretation of the statistical interaction between continuous sitting time and changes in pain over 12 months. The range of sitting time for the tertiles was 1.6–17.1% (low), 17.2–35.6% (middle), and 35.8–91.5% (high).

Continual assessment of neck–shoulder pain intensity

Text messages ('SMS-Track' (https://sms-track.com/)) were used to collect repeated data on self-reported pain intensity during a 12-month period. The participant received one text message every fourth week over 12 months, starting at baseline, resulting in 14 text messages in total. The text messages were sent on Sundays, with a reminder the following day. The participants rated their peak pain intensity in the neck–shoulder region during the previous month on the numerical rating scale (NRS), which ranges from 0 ('no pain') to 10 ('worst pain imaginable'). The NRS is a valid instrument for assessment of pain severity,[32] and it is recommended as a 'core outcome measure' by the 'Initiative on Methods, Measurement, and Pain Assessment in Clinical Trials'.[33]

Assessment of possible confounders

A broad selection of individual and biomechanical factors were chosen a priori as potential confounders based on previous literature and theoretical assumptions concerning their possible influence on sitting behaviour and neck–shoulder pain. Age was determined from the workers' Danish civil registration numbers. Body mass index (BMI, kg/m^2) was calculated from objectively measured height (cm) and body weight (kg). Seniority in the current job (months) was assessed using the question: 'For how long have you had the kind of occupation that you have now?'. Lifting and carrying at work was assessed using a single item from the Danish Work Environment Cohort Survey (DWECS): 'How much of your working time do you carry or lift?', using a six-point response scale ranging from 1 ('never') to 6 ('almost all the time').[34] Change in physical work tasks over the 12-month period was assessed using a single-item question in the follow-up questionnaire: 'Have your physical tasks changed over the past year?' with two response categories ('yes' or 'no'). Psychosocial factors at work were assessed using four items from the Copenhagen Psychosocial Questionnaire (COPSOQ),[35] representing two dimensions, that is, influence at work (decision authority): 'Do you have a large degree of influence concerning your work?'; 'Can you influence the amount of work assigned to you?' and social support at work: 'Is there a good co-operation between the management and the employees?'; 'Is there good co-operation between the colleagues at work?'. The five-point response scale ranged from 1 ('always') to 5 ('never'). Based on these items, an index (scale 0–8) was computed for each dimension according to the COPSOQ manual (http://www.arbejdsmiljoforskning.dk), whereby higher numbers indicate more influence and better social support, respectively. The number of days with pain was assessed using the question 'In the past 12 months, how many days in all have you had pain or discomfort in the neck/shoulders?' with six response categories ranging from '0 days' to 'every day'. Intake of pain medication was assessed using the question: 'In the past 3 months, how many days have you been taking analgesics due to pain in muscles or joints?' with six response categories ranging from '0 days' to 'more than 60 days'.

Physical activity was assessed objectively using data from the accelerometers described above.[29 30] The total time spent in walking, climbing stairs, running and cycling was added up and expressed in percentage of total time at work and leisure, respectively. The extent (hour/day) of working with the dominant upper arm elevated >60° was estimated from the accelerometer signals according to Korshøj *et al*.[31] Sitting time during leisure was obtained from the processed accelerometer signals, as explained above, and expressed in percentage of total leisure time.

Statistical analyses

All statistical analyses were performed using SPSS V.22 (IBM). Descriptive data are presented as mean and SD between subjects, or as frequency and percentage, where appropriate. Associations between sitting time at work and pain intensity at baseline were examined using Pearson's correlation coefficients. Differences in pain intensity at baseline between the three occupational sectors were tested statistically using one-way analysis of variance (ANOVA).

The association between sitting time at work and the 1-year time course (trajectory) of neck–shoulder pain intensity was analysed using linear mixed models.[36] Subject and intercept were included as random factors, while *sitting* (percentage of working hours, continuous variable), *time* (14 measurement points over 1 year) and their interaction (*sitting*×*time*) were included as fixed factors, as were the covariates in the adjusted models (see below). Neck–shoulder pain intensity was the dependent variable in all models. Subjects with missing values in the repeated outcome were kept in the models. Since non-linear representations of pain trajectories did not improve model fit, the association was modelled linearly. An autoregressive covariance structure (AR1) was used to accommodate for correlations between pain intensity ratings getting weaker with time. Inspection of the residuals indicated no marked deviation from normal distribution.

The primary analysis of the association between sitting time and individual trajectories of pain consisted of three models: that is, *crude model* (model 1) without any additional covariates; *individual factors* (model 2): adjusted for age, gender and BMI; *biomechanical factors*: (model 3) adjusted for the covariates in model 2 and occupational sector, lifting/carrying time at work, sitting time at leisure, physical activity at work and during leisure, working with dominant arm elevated >60°. To examine whether the relationship between sitting time and pain was modified by sector (ie, cleaning, manufacturing and transportation), the second primary model was rerun including a three-way interaction (*sector*×*sitting*×*time*). If this interaction was significant, the primary models 1, 2 and 3 were performed with stratification for occupational sector. In each model, we derived the estimates (B), SE, 95% CIs and p values of the main effects of *sitting* and *time* and their interaction on pain intensity.

Three sensitivity analyses were performed to verify the robustness of the results from the primary analyses. First, the three primary models were performed with exclusion of participants having less than five valid pain responses. Second, the primary models were performed using absolute values of time in sitting (hour/day) instead of relative percentages. Third, the fully adjusted primary model was performed with additional adjustment of four additional covariates in separate models: (1) baseline pain intensity, (2) influence and social support at work, (3) pain medication and (4) self-reported change in physical work tasks across the study period.

RESULTS

Descriptive information of the study population

Descriptive data of the study population are shown in table 1. The population consisted of 625 workers, including men (55%) and women (45%) between 18 and 68 years of age. The gender distribution differed between sectors, with women dominating the cleaning sector (86%), while transportation (96%) and manufacturing (62%) were dominated by men.

The recorded sitting time per day was, on average, 31% at work and 53% during leisure, while physical activity occurred for 17% of the working hours and 10% of leisure time (table 1). Compliance with pain ratings via text messages was very high; from 95% response rate during baseline to 85% at the last measurement 12 months later. Ninety per cent of the study population had at least 10 valid pain responses (out of 14 requested) during the period. Almost 70% of the population reported baseline pain intensity in the neck–shoulder region above 1 on the 0–10 scale, and only 29% were completely free of pain. Seventy-five per cent reported at least 1 day with neck–shoulder pain during the past year, 25% reported more than 30 days with pain, and 17% reported more than 90 pain days.

Per cent sitting time at work was not correlated with baseline pain intensity (r=−0.01, p=0.87). Per cent sitting time at work differed between the three occupational sectors (ANOVA: $F(2,622)=88.8$, $p<0.001$) with, on average, higher values in the transportation sector (60.5%, SD 14.8) than in cleaning (26.6%, SD 11.6) and manufacturing (29.0%, SD 19.8).

Primary analysis results on the effect of sitting at work on pain trajectories

The results from the crude (model 1) and adjusted primary analyses (models 2 and 3) are shown in table 2. Pain intensity tended to decrease, on average, over the 12-month period, as indicated by the main effect of *time*. Higher sitting time at work showed a borderline significant association (p=0.055) with higher overall pain intensity, as indicated by the main effect of *sitting* on pain in the fully adjusted model, but this trend was not present in the crude model or when adjustments for individual factors were made (model 2). More sitting time at work was associated with a faster decline in pain intensity over time (figure 1), as indicated by the significant interaction between *sitting* and *time*, which persisted after adjustment for covariates (models 2 and 3).

Difference between occupational sectors

The primary analysis was rerun with a three-way interaction term comprising *sector*, *sitting* at work and *time*, which was significant (model 3: B −0.04, 95% CI −0.006 to −0.001). Stratified analyses by sector revealed no difference between sectors in the direction of the association between *sitting* and *time*, but significant estimates were only found in the transportation sector (table 3). The main effect of *sitting* on pain was not significant in any stratified model. The effect of *time* on pain showed negative estimates in the cleaning and manufacturing sectors, while positive estimates were found in the transportation sector.

Sensitivity analyses

Three sensitivity analyses were performed to verify the results from the primary analyses (corresponding model estimates are presented in online supplementary material S1–S3). When the primary models (1, 2 and 3) were resolved after exclusion of participants having less than five valid pain responses, the interaction between *sitting* and *time* remained significant in all models, and

Table 1 Descriptive information of the Danish PHysical ACTivity cohort with Objective measurements (DPHACTO) study population at baseline

	Valid data (n)	n (%)	Mean	SD
Women	625	280 (45)		
Sector	625			
Cleaning		120 (19)		
Manufacturing		448 (72)		
Transportation		57 (9)		
Age (years)	625		44.8	9.8
Body mass index (kg/m^2)	610		27.5	4.9
Lifting and carrying at work (scale 1–6)	622		3.5	1.4
Seniority in the job (years)	599		13.2	10.2
Social support at work (scale 0–8)	429		6.3	1.3
Influence at work (scale 0–8)	429		5.0	2.1
Objective exposure levels				
Accelerometer wear time (number of working days)	625		2.6	1.0
Physical activity* at work (% work time)	625		16.9	7.0
Physical activity* at leisure (% leisure time)	625		9.7	4.2
Arm elevation >60° at work (hour/day)	611		0.5	0.4
Sitting time at work (hours/day)	625		2.4	1.7
Sitting time at leisure (hours/day)	625		4.6	1.4
Per cent sitting time at work (%)	625		30.8	20.4
Per cent sitting time at leisure (%)	625		52.6	12.5
Pain intensity at baseline (scale 0–10)	625		3.1	2.7
Pain-free at baseline	625	180 (29)		
Number of days with pain in the past year† (days)	622			
0–7		338 (54)		
8–90		180 (29)		
>90		104 (17)		
Pain medication in the past 3 months‡ (days)	622			
0		279 (45)		
1–7		206 (33)		
8–30		92 (15)		
>30		45 (7)		

*Physical activity was calculated based on accelerometry by summing time in walking, climbing stairs, running and cycling during work and leisure, respectively.
†The following categories were merged prior to presentation: '0 days' and '1–7 days'; '8–30 days' and '31–90 days'; '>90 days' and 'every day'.
‡The following categories were merged prior to presentation: '1–2 days' and '3–7 days'; '8–14 days' and '15–30 days'; '31–60 days' and '61–90 days'.

the CI of the effect estimates became smaller compared with the primary models without exclusion. The main effect of *sitting* was close to significant in model 3, but not in models 1 and 2 (see online supplementary material S1).

When the primary models (1–3) were resolved using absolute values of sitting time (hour/day) instead of percentages, the interactions between *sitting* and *time* were similar to those in the primary analyses, but the main effect of *sitting* was not significant in any model (see online supplementary material S2).

Inclusion of additional covariates in the primary, fully adjusted model did not change the estimates of the interaction between *sitting* and *time* markedly, neither when including baseline pain intensity, influence and social support at work, pain medication, or self-reported change in physical work tasks across the study period (see online supplementary material S3). The borderline significant main effect of *sitting* persisted from model 3, but it became less significant when adjusting for pain medication and for self-reported change in physical work tasks.

DISCUSSION

This study aimed to determine the relationship between objectively measured sitting time at work and the course of neck–shoulder pain over 1 year in blue-collar workers. We found that more sitting at work was associated with favourable trajectories of neck–shoulder pain (ie, reduced pain intensity over 12 months).

Prospective studies on occupational sitting and neck–shoulder pain are sparse and show conflicting results. Our key finding of a negative association between objectively measured sitting time and trajectories of neck–shoulder pain intensity is in contrast to the study by Ariens *et al*,[37] while it corroborates the studies by Grooten *et al*[24] and Picavet *et al*.[12] Grooten *et al*[24] used a self-report to assess sitting time in 803 workers, and found that sitting for more than 75% of the working time was associated with a higher relative chance of being free of neck–shoulder pain after 5 years compared with sitting less. Similarly, Picavet *et al*[12] found that more self-reported time sitting at work was associated with less upper extremity pain over a 15-year period. In contrast, Ariens *et al*[37] used video observations (ie, four 10–14 min video recordings in one-fourth of the workers) to estimate sitting time in the whole sample of 977 workers from different occupations. They found that sitting for more than 95% of the working time increased the risk of reporting regular or prolonged neck pain 3 years later compared with sitting very little.

To the best of our knowledge, this is the first prospective study on neck–shoulder pain using multiple accelerometers to obtain accurate and precise records of sitting time over several working days, thus minimising possible bias associated with self-reported measures of sitting.[9–11]

Our findings suggest that more sitting time at work has a favourable influence on the course of neck–shoulder pain in blue-collar workers. This may be explained by sitting being associated with less exposure to physically heavy work and more time for recovery, which suggests that sitting is a proxy for other risk factors for pain.[7 12 24] This indicates that occupational sitting is not a risk factor for enhanced neck–shoulder pain in blue-collar workers. Thus, recommendations to reduce sitting in blue-collar work may impose harmful consequences with respect to musculoskeletal health.

To account for possible confounding by biomechanical factors related to work, we adjusted for self-reported occurrence of lifting/carrying, and objectively measured physical activity and upper arm elevation. We also accounted for biomechanical exposures occurring during non-work hours, by adjusting for objectively assessed sitting and physical activity during leisure time. None of these adjustments changed the results. Overall, the association between sitting time and pain trajectories remained stable after adjustment for individual (model 2) and biomechanical factors (model 3), and even in the sensitivity analyses adjusting for psychosocial factors, baseline pain intensity, pain medication and self-reported change in physical work tasks over the study period (see online supplementary material S3).

The stratified analyses by occupational sector showed a stronger effect of sitting on pain trajectories in the transportation sector compared with the other two sectors. This suggests that occupational sector is a modifier for the relationship between sitting and pain trajectories. However, the marked gender imbalance across sectors

Table 2 Effect of per cent sitting time at work on trajectories of neck–shoulder pain intensity (scale 0–10) in the Danish PHysical ACTivity cohort with Objective measurements (DPHACTO) study population

				95% CI	
	Estimate	SE	p Value	Lower	Upper
Model 1 (n=625)					
Intercept	2.976	0.179	<0.01	2.624	3.327
Time	−0.020	0.010	0.053	−0.040	0.000
Sitting	0.000	0.005	0.966	−0.009	0.010
Interaction (sitting×time)	−0.001	0.000	0.020	−0.001	0.000
Model 2 (n=610)					
Intercept	1.280	0.695	0.066	−0.085	2.645
Time	−0.019	0.010	0.072	−0.039	0.002
Sitting	0.003	0.005	0.582	−0.007	0.012
Interaction (sitting×time)	−0.001	0.000	0.020	−0.001	0.000
Model 3 (n=595)					
Intercept	3.020	1.084	0.006	0.891	5.149
Time	−0.019	0.010	0.065	−0.040	0.001
Sitting	0.012	0.006	0.055	0.000	0.025
Interaction (sitting×time)	−0.001	0.000	0.027	−0.001	0.000

Model 1: unadjusted.
Model 2: adjusted for gender, age and body mass index.
Model 3: adjusted for the covariates in model 2 and occupational sector, lifting/carrying time at work, sitting time at leisure, physical activity at work and leisure, upper arm elevation >60° at work.
'Time' indicates the 14 pain ratings over 12 months, starting at baseline; 'sitting' represents sitting time in percentage of working hours; 'interaction' indicates the effect of sitting on the rate of change in pain intensity over time.

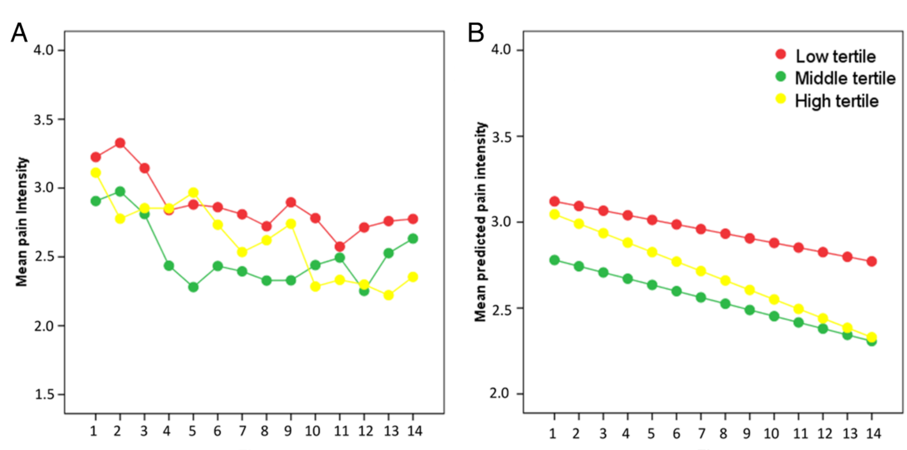

Figure 1 Pain trajectories in the Danish PHysical ACTivity cohort with Objective measurements (DPHACTO) study population stratified on tertiles (ie, low, middle and high) of per cent sitting time at work. The y-axis represents the mean neck–shoulder pain intensity on a 0–10 scale (A), and the estimated mean neck–shoulder pain intensity (scale 0–10) according to the crude model (B). The x-axis represents the 14 time points over the 12 months follow-up period.

Table 3 Association between per cent sitting time at work and trajectories of neck–shoulder pain (scale 0–10), stratified by occupational sector in the Danish PHysical ACTivity cohort with Objective measurements (DPHACTO) study population

	Cleaning (n=120)				Manufacturing (n=448)				Transportation (n=57)			
			95% CI				95% CI				95% CI	
	Estimate	p Value	Lower	Upper	Estimate	p Value	Lower	Upper	Estimate	p Value	Lower	Upper
Model 1 (n=625)												
Intercept	**3.040**	**0.000**	**2.023**	**4.058**	**2.762**	**0.000**	**2.351**	**3.173**	1.583	0.174	−0.712	3.878
Time	−0.023	0.436	−0.081	0.035	**−0.024**	**0.039**	**−0.048**	**−0.001**	**0.157**	**0.038**	**0.009**	**0.305**
Sitting	0.021	0.294	−0.018	0.060	0.005	0.383	−0.006	0.017	0.014	0.464	−0.023	0.051
Interaction (sitting×time)	−0.001	0.363	−0.003	0.001	0.000	0.270	−0.001	0.000	**−0.004**	**0.003**	**−0.006**	**−0.001**
Model 2 (n=610)												
Intercept	2.536	0.131	−0.764	5.836	0.651	0.441	−1.010	2.313	0.877	0.687	−3.457	5.212
Time	−0.024	0.417	−0.082	0.034	−0.023	0.055	−0.047	0.000	**0.157**	**0.038**	**0.009**	**0.305**
Sitting	0.011	0.595	−0.030	0.053	0.005	0.368	−0.006	0.017	0.017	0.393	−0.023	0.058
Interaction (sitting×time)	−0.001	0.389	−0.003	0.001	0.000	0.272	−0.001	0.000	**−0.004**	**0.003**	**−0.006**	**−0.001**
Model 3 (n=595)												
Intercept	3.940	0.091	−0.643	8.523	**3.020**	**0.006**	**0.867**	**5.174**	4.859	0.197	−2.596	12.314
Time	−0.023	0.431	−0.081	0.035	**−0.024**	**0.045**	**−0.048**	**−0.001**	**0.156**	**0.044**	**0.004**	**0.309**
Sitting	0.019	0.407	−0.026	0.064	0.007	0.296	−0.007	0.021	0.009	0.841	−0.077	0.094
Interaction (sitting×time)	−0.001	0.394	−0.003	0.001	0.000	0.351	−0.001	0.000	**−0.004**	**0.004**	**−0.006**	**−0.001**

Significant ($p<0.05$) estimates are boldfaced.
Model 1: unadjusted.
Model 2: adjusted for gender, age and body mass index.
Model 3: adjusted for the covariates in model 2 and lifting/carrying time at work, sitting time at leisure, physical activity at work and leisure, upper arm elevation >60° at work.

may have influenced these results due to possible gender differences in sitting time patterns at work.[26]

The higher tertile of sitting (n=209) had an average sitting time of 55% of the working hours, which is noteworthy considering that the study population consisted of blue-collar workers. Still, it is not known from this study whether the observed association with neck–shoulder pain is consistent in occupations with a higher occurrence of sitting at work. Thus, we recommend future prospective studies to investigate this association further based on objective exposure assessment in more sedentary populations, such as office workers.

The borderline significant association between sitting and neck–shoulder pain in the fully adjusted model indicated higher pain intensity, on average, with more sitting time at work. This would be in agreement with previous cross-sectional studies.[5,7] However, since this main effect of sitting was present along with an interaction with time, and only observed in the fully adjusted model, it should be interpreted with caution.

Methodological discussion

This study has several methodical strengths. First, we relied on continuous objective measurements of sitting over several working days to obtain reliable and valid exposure estimates. This is important because self-reported measures of sitting may be imprecise and biased,[9,10] which can lead to deceptive associations between sitting and health outcomes.[11] Second, assessing pain intensity every 4 weeks over a 1 year period allowed for a precise estimation of individual pain trajectories. Third, the sample size was relatively large (n=625), and thus our study was considered to be sufficiently powered to determine the association between sitting and neck–shoulder pain, even with multiple adjustments.[25]

There are also study limitations which may have implications for the interpretation of the results. We did not measure sitting exposure repeatedly over the 1 year period, which precludes us from inferring whether changes in sitting occurred with time, and thus whether sitting affected neck–shoulder pain in the short term. We did, however, adjust our analyses for self-reported change in physical work tasks across the 12-month period, and found that the association between sitting and pain trajectories persisted (see online supplementary material S3). A strength of this study is its prospective design, even though we acknowledge that causal inferences from observational studies should be interpreted with greater caution than effects determined in, for example, randomised controlled trials. Thus, observational studies suffer the risk of reversed causality. However, it appears unreasonable that the observed changes in pain during the 12-months follow-up would have caused a higher sitting time during baseline. Also, to account for possible confounding by baseline pain on the association between sitting time and pain trajectories, we did adjust for baseline pain intensity (see online supplementary material S3), and found the association to be maintained. This is a strong indication that occupational sitting time affected the course of neck–shoulder pain rather than the reversed causation. The stratified analyses by occupational sector should be interpreted with caution due to the reduced sample size; the transportation sector contained only 57 workers, and thus, the models in this stratum were most likely overfitted. Further, the cleaning and transportation sectors differed markedly in gender distribution. Consequently, the effect of sector on the association between sitting and pain trajectories may have been confounded by gender. Still, adjusting for gender and sector in the primary analysis did not change the estimates of the association between sitting and pain trajectories, which indicates that our main findings were not confounded by any of these factors. There is currently a lack of data on within-subject variability in occupational sitting (ie, across days or weeks). The average accelerometry wear time in this study was 2.6 days, while more days may be needed to obtain a more reliable record of sitting exposure.[38] Given that the observed effect sizes were relatively small, the clinical relevance of our findings may be put into question. The difference between the lower (mean 11%) and higher (mean 55%) tertiles in sitting time at work was 44% of the working hours, which corresponded to an estimated 12-month reduction in pain intensity of 0.5 units on the 1–10 scale. Further, since our study focused on blue-collar workers, the results are not generalisable to workers in office-based jobs. The association between sitting and neck–shoulder pain was investigated in the whole study population, including even workers without symptoms at baseline, since analyses of subgroups would have led to less representative results and compromised statistical power. Thus, it is of interest to further examine the impact of sitting on neck–shoulder pain in people with more severe chronic pain.

CONCLUSION

We found that more sitting time at work, as assessed objectively, was associated with a favourable course of neck–shoulder pain intensity over 12 months in blue-collar workers. The relationship between sitting at work and pain needs further investigation before explicit recommendations and guidelines on sedentary behaviour among blue-collar workers can be developed. Future prospective studies with objective assessment of sitting should examine this association further in other populations, such as office workers.

Contributors DMH contributed to the statistical data analyses and drafting of the manuscript. AH and MBJ contributed to the conception and design of the full DPHACTO study, and data collection. All authors contributed to the conception of this study, interpretation of results, and critical revisions of the manuscript; and they all agreed on its final appearance.

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Competing interests None declared.

Patient consent Obtained.

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Data sharing statement The DPHACTO data set is available on request (contact: AH, email aho@arbejdsmiljoforskning.dk).

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Is prolonged sitting at work associated with the time course of neck–shoulder pain? A prospective study in Danish blue-collar workers

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ORIGINAL ARTICLE

Temporal patterns of sitting at work are associated with neck–shoulder pain in blue-collar workers: a cross-sectional analysis of accelerometer data in the DPHACTO study

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Abstract

Background Our aim was to examine the extent to which temporal patterns of sitting during occupational work and during leisure-time, assessed using accelerometry, are associated with intense neck–shoulder pain (NSP) in blue-collar workers.

Methods The population consisted of 659 Danish blue-collar workers. Accelerometers were attached to the thigh, hip, trunk and upper dominant arm to measure sitting time and physical activity across four consecutive days. Temporal sitting patterns were expressed separately for work and leisure by the proportion of total time spent sitting in brief bursts (0–5 min), moderate (>5–20 min) and prolonged (>20 min) periods. The peak NSP intensity during the previous 3 months was assessed using a numerical rating scale (range 0–10) and dichotomized into a lower (≤4) and higher (>4) NSP score. Logistic regression analyses with multiple adjustments for individual and occupational factors were performed to determine the association between brief, moderate and prolonged sitting periods, and NSP intensity.

Results Time in brief bursts of occupational sitting was negatively associated with NSP intensity (adjusted OR 0.68, 95 % CI 0.48–0.98), while time in moderate periods of occupational sitting showed a positive association with NSP (adjusted OR 1.32, 95 % CI 1.04–1.69). Time in prolonged periods of occupational sitting was not associated with NSP (adjusted OR 0.78, 95 % CI 0.78–1.09). We found no significant association between brief, moderate or prolonged sitting periods during leisure, and NSP.

Conclusion Our findings indicate that the association between occupational sitting time and intense NSP among blue-collar workers is sensitive to the temporal pattern of sitting.

Keywords Neck pain · Sedentary · Time pattern · Physical activity · Occupational health

Background

Excessive sitting has been proposed to be a determinant of upper extremity musculoskeletal disorders (MSDs) in the working population (Ariëns et al. 2001). Several cross-sectional studies have found a positive association between the duration of occupational sitting and occurrence of pain in the neck–shoulder region (Ariëns et al. 2000; Cagnie et al. 2007; Hallman et al. 2015b; Skov et al. 1996; Yue et al. 2012), while prospective studies on sitting and neck–shoulder pain, albeit few, are inconclusive (Ariëns et al. 2001; Mayer et al. 2012).

It is well documented that white-collar workers spend a substantial proportion of their time at work sitting (Ryan et al. 2011; Thorp et al. 2012; Toomingas et al. 2012). Thus, investigations of associations between sitting and neck–shoulder disorders are often conducted on workers in what is usually considered "sedentary" occupations (Cagnie et al. 2007; Skov et al. 1996), such as office-based jobs. However, recent studies based on objectively measured sitting time show that prolonged occupational sitting also occurs in blue-collar occupations such as manufacturing

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and construction (Gupta et al. 2015). These workers may even sit extensively during their leisure-time (Hallman et al. 2015a).

In a previous study on 202 blue-collar workers (Hallman et al. 2015b), we found that sitting, measured using accelerometry, for more than a total of 8.2 h a day was associated with increased pain intensity from the neck–shoulder region, compared to moderate sitting, in the range from 6.5 to 8.2 h. We also found that, among males, sitting little (<2.0 h) at work was associated with reduced pain intensity, compared to moderate sitting (i.e., 3.7–6.6 h), even after adjustment for several other occupational risk factors. While these results suggest that sitting may show an association with neck–shoulder pain in blue-collar work regardless of established risk factors, including heavy lifting and awkward postures (Côté et al. 2009; Palmer and Smedley 2007), it is still not clear whether extensive sitting is associated with pain in its own right, or just a proxy for other important risk factors. In order to disentangle this question, associations between sitting and pain need to be examined in more detail, accounting, for instance, for important biomechanical exposures that may be correlated with sitting, such as constrained upper extremity postures or low levels of physical activity during work and leisure (Ariëns et al. 2001; Hildebrandt et al. 2000; Mayer et al. 2012).

Epidemiological and experimental studies suggest that the temporal pattern of sitting (or "sedentary behavior") is an important determinant of essential health outcomes (Carson et al. 2014; Healy et al. 2008; Henson et al. 2013), including MSDs (Thorp et al. 2014). Breaking up prolonged sitting by periods of standing or walking has shown beneficial effects compared to uninterrupted sitting on the regulation of cardiovascular (Larsen et al. 2014; Thosar et al. 2014) and pro-inflammatory biomarkers (Henson et al. 2013; Latouche et al. 2013; Yates et al. 2012) suggested to be involved in causal pathways of neck–shoulder pain (Barbe and Barr 2006; Bruehl and Chung 2004). This agrees well with the more general notion in occupational health research and practice that variation in biomechanical exposure is important for musculoskeletal health and well-being (Mathiassen 2006; Straker and Mathiassen 2009). It therefore appears reasonable to expect that a possible relationship between sitting and neck–shoulder pain would depend on the temporal pattern of sitting, including whether it is accumulated in periods of longer or shorter durations. Specifically, sitting in long uninterrupted periods could be expected to show a positive association with neck–shoulder pain, while the opposite relationship would occur for short periods in sitting.

A thorough analysis of temporal sitting patterns needs to be based on objective measurement data, as self-reported measures of sitting cannot be expected to operate at the time resolution required for a detailed record of sitting and non-sitting periods, and furthermore are prone to bias and insufficient precision (Celis-Morales et al. 2012; Clark et al. 2011). The common use of self-reports may be one important reason that studies reporting temporal sitting patterns in detail are rare (Thorp et al. 2012; Toomingas et al. 2012), particularly among blue-collar workers.

Our aim was to investigate the extent to which temporal patterns of occupational and leisure-time sitting, as assessed using accelerometry, are associated with intense neck–shoulder pain among blue-collar workers. We hypothesize that the proportion of time spent in moderate and prolonged, uninterrupted periods of sitting is positively associated with intense pain, while the opposite association holds for the occurrence of short sitting periods.

Methods

Study design and population

The present study is a part of the Danish PHysical ACTivity cohort with Objective measurements (DPHACTO). The main objective of DPHACTO is to investigate the association between objectively measured physical activities at work and frequent prospective measurements of musculoskeletal pain among blue-collar workers. The complete study protocol is described in detail elsewhere (Jørgensen et al. 2013).

The present study is a cross-sectional analysis of data from the baseline measurements. Data were collected from spring 2012 to spring 2013 at workplaces within three different occupational sectors (i.e., cleaning, transport and manufacturing) in Denmark. Employees ($n = 2107$) from 15 companies were invited to participate (see Fig. 1 for the recruitment of participants). Workplaces were considered eligible if they allowed measurements to be collected during working hours. Participants were included if they reported blue-collar work as their main occupation. Exclusion criteria were predominant white-collar work, managing position, pregnancy and allergy to adhesives.

Eligible blue-collar workers ($n = 901$) were invited to fill in a short baseline questionnaire, to undergo a health check and a physical examination, and to take part in field measurements, including objective exposure data collection across four consecutive days. Data on self-reported neck–shoulder pain were obtained from 896 workers, among whom 712 were subjected to accelerometer measurements, resulting in valid measures from 659 workers.

All workers provided their written informed consent prior to participation. The present study was conducted according to the Helsinki Declaration and approved by the Danish data protection agency and local ethics committee (H-2-2012-011).

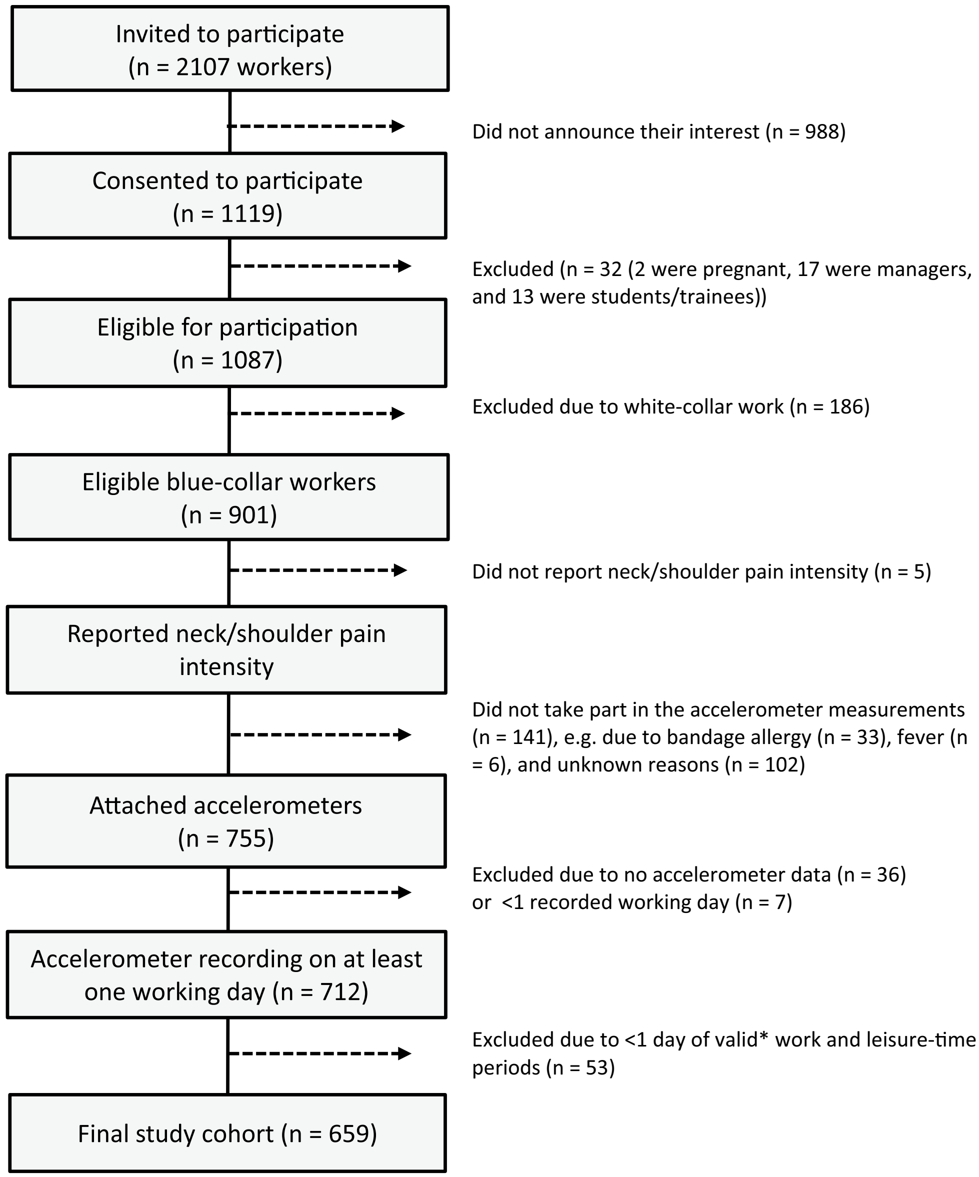

Fig. 1 Recruitment of participants. *Valid (work and leisure) is defined as at least 4 h or 75 % of the average duration of work and leisure for a particular worker

Procedure

The participants were asked to wear four accelerometers (see below) around the clock during four consecutive days, including at least two working days. The participants were instructed to wear the equipment the whole measurement period, and to perform a reference measurement in upright stance for 15 s each day, to secure accurate activity detection from the accelerometer signals. They were also instructed to remove the equipment if it caused any kind of discomfort. During the measurement period, a paper diary was used by the participant to note working hours, leisure-time, and time for going to bed in the evening and waking up in the morning, as well as time of the reference measurements. At the end of the four-day data collection, the equipment was returned to the research staff.

Accelerometry

The participants were equipped with triaxial accelerometers (Actigraph GT3X+, ActiGraph LLC, Florida, USA) placed on the thigh, dominant upper arm, hip and trunk, using previously described procedures (Gupta et al. 2015; Hallman et al. 2015b; Skotte et al. 2014). Acceleration data were sampled at a frequency of 30 Hz with a dynamic range of ±6G and a 12-bit precision. The accelerometers were initialized for recording and downloading of data using the Actilife software version 5.5 (ActiGraph LLC, Pensacola, FL, USA), while the data obtained from the accelerometers were processed off-line and analyzed using a custom-made MATLAB-based software, Acti4 (The National Research Centre for the Working Environment, Copenhagen, Denmark and BAuA, Berlin, Germany), which determines the type and duration of different activities and body postures with a high sensitivity and specificity, both in controlled experiments and free-living conditions (Ingebrigtsen et al. 2013; Korshøj et al. 2014; Skotte et al. 2014; Stemland et al. 2015).

Non-wear was judged to occur when (a) the software detected a period longer than 90 min with zero acceleration counts, or (b) the participant reported non-wear-time, or (c) artefacts or missing data were detected by visual inspection. Non-work days, bedtime and sleep-periods were also excluded from further analyses. Each work and leisure-time interval had to contain at least 4 h/day of accelerometer wear-time or 75 % of the average wear-time across days for the individual. The overall accelerometer non-wear-time in the final study population was 0.5 % for the thigh and 0.5 % for the hip/trunk accelerometers.

Assessment of sitting time

The occurrence of sitting periods was identified from the accelerometer outputs based on previously described procedures (Gupta et al. 2015; Skotte et al. 2014; Stemland et al. 2015). Sitting was detected using the signals from the thigh and trunk accelerometers, while data from the hip accelerometer (if available) were used for periods classified as non-wear-time for the trunk accelerometer. In brief, the accelerometer signals were first low-pass filtered at 5 Hz using a fourth-order Butterworth filter and then split up in 2-s windows with 50 % overlap. Sitting periods were then determined to occur when thigh inclination was above 45° *and* trunk inclination was below 45° relative to the recorded reference position, i.e., upright standing (Gupta et al. 2015). The temporal sitting pattern was quantified using exposure variation analysis, EVA (Mathiassen and Winkel 1991). Based on the time line of the processed accelerometer signal for each measurement day, the occurrence of uninterrupted sitting periods of different durations were derived from work and leisure-time, respectively. Interruptions from sitting were required to be at least 5 s to qualify as a non-sitting period. Three EVA derivatives were selected based on Ryan et al. (2011) and Straker et al. (2014): "brief bursts" (time in sitting periods ≤5 min), "moderate periods" (time in sitting periods of >5–20 min) and "prolonged periods" (time in sitting periods >20 min). For each worker, the mean time (h/day) spent during work and during leisure in each of these categories (i.e., ≤5 min, >5–20 min, >20 min) was calculated by dividing the total accumulated sitting time in that category across all measurement days by the number of days. Then, these values were expressed in percent of the daily average of total wear-time at work and leisure, respectively.

Assessment of neck–shoulder pain intensity

Self-reported information about neck and shoulder pain intensity was obtained using the Standardized Nordic Questionnaire for the analysis of musculoskeletal symptoms (Kuorinka et al. 1987). Peak pain intensity in the neck–shoulder region during the previous 3 months was rated on a numeric rating scale (NRS), ranging from 0 ("no pain") to 10 ("worst pain imaginable"). The NRS is a valid instrument for assessment of pain intensity (Ferreira-Valente et al. 2011), and it has been recommended as a "core outcome measure" by the "Initiative on Methods, Measurement, and Pain Assessment in Clinical Trials," IMMPACT (Dworkin et al. 2005). As the pain intensity scores were not normally distributed, scores were categorized into "low" (0–4) and "high" (>4) pain intensities prior to further analysis. This cut-point has previously been shown to have clinical relevance (Andersen et al. 2012). Also, for descriptive purposes, the number of days with pain was assessed using the question "In the past 12 months, how many days in all have you had pain or discomfort in the neck/shoulders?" with six response categories ranging from "0 days" to "every day."

Assessment of possible confounders

A large selection of individual and occupational factors were chosen a priori as potential confounders or effect modifiers based on previous literature and theoretical assumptions concerning their possible influence on sitting behavior and neck–shoulder pain.

Age was determined from the workers' Danish civil registration numbers, while smoking was assessed by the question "Do you smoke?" using four response categories, which were merged into a dichotomized variable: yes ("yes daily", "yes sometimes") and no ("used to smoke", "I have never smoked"). Body mass index (BMI, kg m^{-2}) was calculated from objectively measured height (cm) and body weight (kg). Seniority in the current job (months) was assessed using the question: "For how long have you had the kind of occupation that you have now?" Lifting and carrying at work was assessed using a single item from the Danish Work Environment Cohort Survey (DWECS): *How much of your working time do you carry or lift?*, using a six-point response scale ranging from 1 ("never") to 6 ("almost all the time") (Tüchsen et al. 2006). Psychosocial factors at work were assessed using four items from the Copenhagen Psychosocial Questionnaire (Pejtersen et al. 2010) representing two dimensions, i.e., influence at work (decision authority): "Do you have a large degree of influence concerning your work?"; "Can you influence the amount of work assigned to you?" and Social support: "Is there good co-operation between the management and the employees?"; "Is there good co-operation between the colleagues at work?" The five-point response scale ranged from 1 ("always") to 5 ("never"). After reversing the scale and recoding it to 0–4, answers to the two items were added up to a 0–8 scale for each dimension according to the questionnaire manual (available at: www.arbejdsmiljoforskning.dk), whereby higher numbers indicate more influence and better social support, respectively.

Physical activity was assessed using data from the accelerometers described above (Ingebrigtsen et al. 2013; Stemland et al. 2015). The total time (h/day) spent in walking, climbing stairs, running and cycling was added up separately for work and leisure. Sitting (h/day) with the dominant upper arm elevated >90° was estimated from the accelerometer signals according to Korshøj et al. (2014) for work and leisure separately.

Statistical analyses

All statistical analyses were performed in IBM SPSS Statistics 22.0 for Windows. Binary logistic regression analyses were performed to determine the association between temporal sitting patterns and intense neck–shoulder pain.

Table 1 Descriptive data on 659 blue-collar workers with accelerometer measurements of sitting time

	n	*n* (%)	Mean	SD
Age (years)	659		45.0	9.9
Gender	659			
Females [*n* (%)]		296 (44.9)		
Smokers [*n* (%)]	641	196 (30.6)		
Sector				
Cleaning [*n* (%)]		128 (19.4)		
Manufacturing [*n* (%)]		470 (71.3)		
Transportation [*n* (%)]		61 (9.3)		
Body mass index (kg/m^2)	649		27.5	4.9
Seniority (years)	635		13.0	10.2
Influence at work (scale 0–8)	458		4.9	2.1
Social support at work (scale 0–8)	458		6.3	1.3
Lifting and carrying time at work (scale 1–6)	661		3.5	1.4
Valid work per day (h/day)	659		7.59	1.28
Valid leisure per day (h/day)	659		8.84	1.69
Total valid work (h)	659		19.86	8.05
Total valid leisure (h)	659		23.01	9.11
Occupational sitting (% work time)	659		30.1	20.2
Leisure-time sitting (% leisure-time)	659		52.0	12.5
Sitting at work with upper arm above 90° (h/day)	643		0.02	0.03
Sitting at leisure with upper arm above 90° (h/day)	643		0.12	0.18
Physical activity at work (h/day)	659		1.29	0.55
Physical activity during leisure (h/day)	659		0.86	0.40
Peak neck–shoulder pain intensity (scale 0–10)	659		3.4	3.0
Pain intensity ≤4 [*n* (%)]		413 (62.7)		
Pain intensity >4 [*n* (%)]		246 (37.3)		
Days with neck/shoulder pain previous year	659			
0 days [*n* (%)]		172 (26.1)		
1–7 days [*n* (%)]		186 (28.2)		
8–30 days [n (%)]		134 (20.3)		
31–90 days [*n* (%)]		60 (9.1)		
>90 days [*n* (%)]		39 (5.9)		
Every day [*n* (%)]		68 (10.3)		

The regression models were performed in two steps (crude and adjusted models), using the dichotomized peak pain intensity variable (low pain 0–4; intense pain 5–10) as an outcome. First, the independent variables consisted of the EVA derivatives only, i.e., time (%) spent sitting in brief, moderate and prolonged periods, which were entered together in the same model (crude model). Second, in addition to the EVA derivatives, the potential confounders (described above), except for psychosocial factors, as well as interaction terms between gender and each EVA derivative were included (adjusted model). Due to the skewed distribution of the EVA derivatives and the covariate "Sitting with upper arm elevated >90°," these variables were square root (*sqrt*)-transformed prior to the analyses, which resulted in closer to normal distributions. Each analysis was performed for work and leisure-time separately.

To determine whether the results were consistent when also accounting for psychosocial factors, the adjusted models were refitted using self-reported influence and social support at work as additional covariates. These two covariates were not included in the first adjusted analysis because they caused a reduction of the sample size, i.e., from $n = 659$ to $n = 458$, due to missing values.

In order to determine whether the association between the temporal pattern of occupational sitting and pain intensity was consistent across different levels of total occupational sitting time, additional logistic regression analyses were performed on data stratified on total sitting time at work (more/<25 % of total work time spent sitting) and on total sitting time in leisure (more/<50 % time spent sitting), both cut-points being close to the median values in the population. Finally, all regression analyses were also performed on EVA derivatives in absolute time (*sqrt* h/day) rather than proportion of time, as used above.

Data are presented in text and tables as means with standard deviations between subjects, or frequencies and proportions, if not otherwise stated. For each regression model, odds ratios (OR) and 95 % confidence intervals (CI) were derived. Associations with *p* values <.05 were considered significant.

Results

Objective measurements of sitting time were collected from 659 blue-collar workers, including males ($n = 363$) and females ($n = 296$) from three occupational sectors, i.e., cleaning, manufacturing, and transportation (Table 1). The age of the workers ranged between 18 and 68 years, and they had been in their current job for, on average, 13 years (SD 10). About 31 % of the workers were smokers. Accelerometer data were collected for, on average, 2.6 (SD 1.0) days per worker, comprising 19.9 (SD 8.0) and 23.0 (SD 9.1) h per worker of valid recordings during work and leisure-time, respectively. Cumulative distributions of uninterrupted sitting time in brief, moderate and prolonged periods are shown in Fig. 2.

Among the 659 workers, the peak pain intensity was, on average, 3.4 (SD 3.0) on a 0–10 scale. Thirty-seven percent of the workers reported a peak pain intensity score >4, and 63 % reported a pain intensity ≤4. Twenty-six percent of the workers reported 0 days with neck–shoulder pain over the past year, 48 % reported 1–30 days, and 25 % reported >30 days with pain.

Primary analyses of the association between sitting patterns and neck–shoulder pain

The results from the crude and adjusted logistic regression models for occupational and leisure-time sitting patterns are shown in Table 2. We found that the temporal sitting pattern at work, expressed by EVA derivatives, was associated with

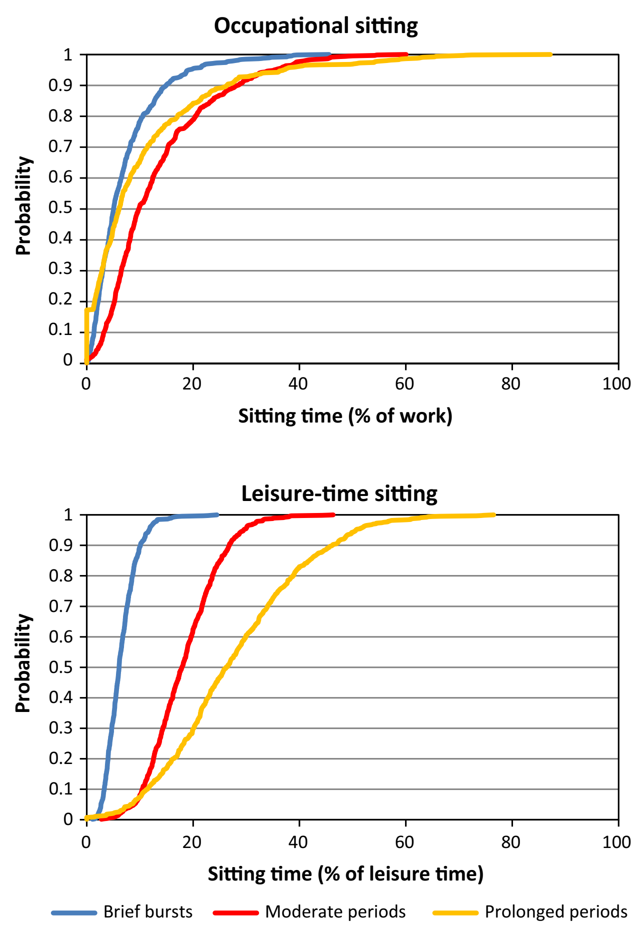

Fig. 2 Cumulative probability distributions of EVA derivatives in the study population, i.e., *brief bursts* (time in sitting periods ≤5 min), *moderate periods* (time in sitting periods of >5–20 min) and *prolonged periods* (time in sitting periods >20 min) for occupational and leisure-time sitting, respectively

Table 2 Associations between temporal patterns (EVA derivatives) of occupational and leisure-time sitting and intense neck–shoulder pain (>4 on a 0–10 scale)

	n	B	*p*	OR	Lower 95 % CI	Upper 95 % CI
Occupational sitting patterns						
Crude model						
Brief bursts	659	**−0.27**	**.00**	**0.77**	**0.64**	**0.92**
Moderate periods		**0.16**	**.03**	**1.17**	**1.02**	**1.35**
Prolonged periods		−0.01	.85	0.99	0.91	1.08
Adjusted model[a]						
Brief bursts	595	**−0.38**	**.04**	**0.68**	**0.48**	**0.98**
Moderate periods		**0.28**	**.02**	**1.32**	**1.04**	**1.69**
Prolonged periods		−0.08	.33	0.92	0.78	1.09
Leisure-time sitting patterns						
Crude model						
Brief bursts	659	0.19	.25	1.21	0.87	1.69
Moderate periods		−0.04	.69	0.96	0.77	1.19
Prolonged periods		−0.01	.85	0.99	0.86	1.13
Adjusted model[a]						
Brief bursts	595	0.23	.44	1.25	0.71	2.21
Moderate periods		−0.27	.15	0.76	0.52	1.10
Prolonged periods		−0.11	.37	0.90	0.71	1.14

Odds ratios (ORs) indicate the relative increase in risk for reporting intense pain with each unit (*sqrt* percent time) increment in sitting

All sitting variables were normalized to percentages of total wear-time at work or leisure, and square-root-transformed prior to the logistic regression analyses. Significant ($p < .05$) associations are bold-faced

[a] Adjusted for age, gender, smoking, BMI, job seniority, lifting/carrying time at work, physical activity at work, physical activity during leisure, sitting with arms above 90° (either at work or at leisure depending on the modeled domain)

the intensity of neck–shoulder pain. Specifically, we found a significant ($p < .05$) negative association between "brief bursts" (<5 min) of occupational sitting and pain intensity, and a positive association between "moderate periods" (>5–20 min) at work and pain intensity (Fig. 3). These associations remained significant after adjusting for multiple covariates, including several individual and biomechanical factors. We found no association between "prolonged periods" and pain intensity. We did not find any significant association between sitting patterns during leisure-time and neck–shoulder pain intensity. There was no significant main effect of gender, and no interaction between gender and the sitting variables in any of the models (all $p > .05$).

Adjustment for psychosocial factors

Adding the psychosocial factors *influence at work* and *social support at work* as additional covariates in the primary (adjusted) logistic regression models did not change the results for occupational sitting to any notable extent (adjusted model: "brief bursts" OR 0.60, 95 % CI 0.40–0.91; "moderate periods" OR 1.23, 95 % CI 0.93–1.63; "prolonged periods" OR 0.84, 95 % CI 0.69–1.02), although the 95 % CIs became wider and now included 1.00 for *moderate periods*. All associations remained nonsignificant for leisure-time sitting.

Stratification on total sitting time

The same logistic regression models as above were resolved with stratification for total sitting time at work (cut-point sitting more or less than 25 % of the working time). We found that the association with neck–shoulder pain intensity persisted for "brief bursts" (adjusted OR 0.49, 95 % CI 0.26–0.91) and "moderate periods" (adjusted OR 1.52, 95 % CI 0.94–2.45) in the lower total sitting time stratum ($n = 332$), with comparable ORs to those found in the primary models. The same trends, although nonsignificant, were observed in the higher sitting stratum ($n = 327$) for "brief bursts" (adjusted OR 0.62, 95 % CI 0.35–1.09) and "moderate periods" (adjusted OR 1.17, 95 % CI 0.81–1.70). *Prolonged periods* was not associated with pain in the lower (adjusted OR 0.98, 95 % CI 0.71–1.36) or higher sitting time strata (adjusted OR 0.80, 95 % CI 0.59–1.09). When stratifying for total leisure-time sitting (cut-point: sitting for 50 % of the leisure-time), all associations between EVA derivatives and neck pain remained nonsignificant in both the crude and adjusted models.

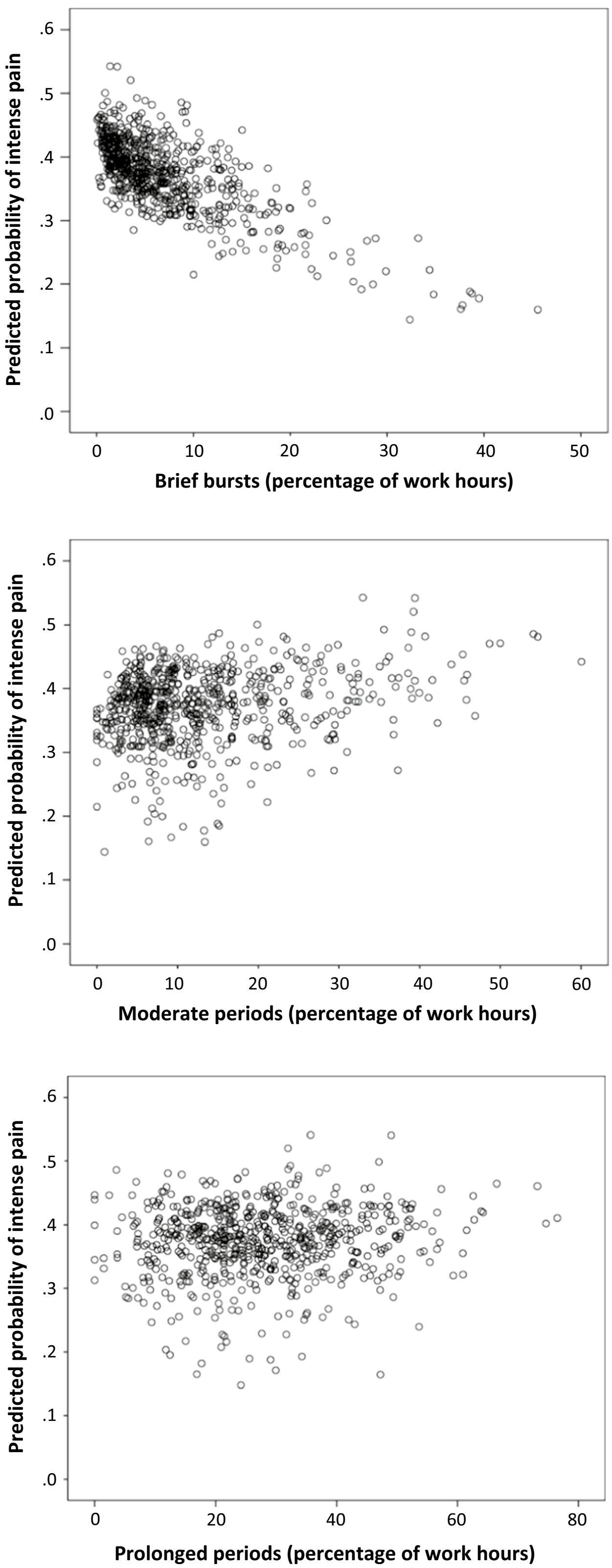

Fig. 3 Crude association between temporal sitting patterns [*brief burst* (≤5 min), *moderate periods* (>5–20 min), *prolonged periods* (>20 min)] at work and neck–shoulder pain intensity. *X-axes* show the proportion of sitting time at work occurring in the two categories; *y-axes* show the predicted probability of reporting intense (>4, scale 0–10) neck–shoulder pain

Absolute sitting time instead of percentages

All the regression models were also carried out based on absolute sitting time (*sqrt* h/day) instead of percentages. For the pattern of occupational sitting, absolute values led to slightly stronger ORs for "brief bursts" (adjusted OR 0.27, 95 % CI 0.07–1.00) and "moderate periods" (adjusted OR 2.73, 95 % CI 1.15–6.52) than time proportions, while "*prolonged periods*" were still not significantly associated with pain (adjusted OR 0.74, 95 % CI 0.40–1.37). Associations with leisure-time sitting were similar for EVA metrics expressed in absolute values and percentages.

Discussion

Our main findings were that occupational sitting spent in uninterrupted periods of brief and moderate duration showed opposite associations with intense neck–shoulder pain among blue-collar workers, even after adjusting for a range of individual and occupational factors of relevance to musculoskeletal pain. No significant association with pain was found for prolonged periods of occupational sitting, and temporal sitting patterns during leisure-time were not found to be associated with neck–shoulder pain at all. Thus, our results suggest that information on total sitting time only is not sufficient to appreciate the association between sitting exposure at work and neck–shoulder pain.

The current findings corroborate previous research suggesting a positive association between occupational sitting time and neck–shoulder pain (Ariëns et al. 2001; Cagnie et al. 2007; Hallman et al. 2015b; Skov et al. 1996; Yue et al. 2012), although negative results have also been reported (Holm et al. 2013), with one study reporting sitting time (>75 % of the working time) even to be associated with a favorable prognosis of neck–shoulder pain (Grooten et al. 2007). A possible reason for these inconsistent findings is that most previous studies have assessed exposure to sitting using self-reports (Celis-Morales et al. 2012; Clark et al. 2011). A major strength of the current study is the use of multiple triaxial accelerometers to objectively assess the uninterrupted time line of sitting and non-sitting across several days. This also allowed us to derive detailed temporal sitting patterns with high accuracy, which would not have been possible using questionnaires. By combining data from three accelerometers, we could discriminate sitting from lying and standing, while also monitoring arm movements during sitting, as well as walking, running and cycling, which are believed to be important exposures for work-related pain. Also, our study population is very large compared to previous studies using direct measurements of occupational biomechanical exposures, including sitting, and the recruited blue-collar worker are rather homogenous with respect to socioeconomic status, which will minimize socioeconomic confounding. Exposure variation analysis (EVA) approach is a generic tool for retrieving important elements of the temporal structure (i.e., the variation) in physical exposure, and it has been used in previous accelerometer-based studies for analyzing time patterns of physical activity and sedentary behavior (Hallman et al. 2015a; Straker et al. 2014). Still, very few studies have so far investigated the utility of EVA when disentangling associations between temporal patterns of exposure, and health outcomes. The results of the present study suggest that the metrics produced by the EVA method are clinically relevant.

Our findings are in line with the stated hypothesis that time spent in short sitting periods at work would be negatively associated with intense neck–shoulder pain. Specifically, we found that the likelihood of reporting a pain intensity score >4 (i.e., "intense" pain) was reduced with increasing occurrence of occupational sitting in uninterrupted periods shorter than 5 min. Also, we found the inverse relationship for moderate sitting periods at work: the likelihood of reporting intense neck–shoulder pain increased with increasing occurrence of sitting in uninterrupted periods lasting between 5 and 20 min (Fig. 3). However, in contrast to our hypothesis, we did not find any significant association between the occurrence of prolonged periods (>20 min) of occupational sitting and pain intensity. This may be explained by limited time accumulated in sitting periods exceeding 20 min during work for many of the workers (Fig. 2). Still, we consider the occurrence of sitting in our sample of blue-collar workers, as well as the dispersion among workers of temporal sitting patterns to be adequate for investigating associations with health outcomes both during work and leisure (Fig. 2).

Our finding of opposite associations for *brief bursts* and *moderate periods* of occupational sitting with neck–shoulder pain is in line with recent studies indicating that breaking up seated work with periods of standing or walking is associated with beneficial outcomes related to health (Carson et al. 2014; Healy et al. 2008; Henson et al. 2013), including, muscle fatigue and discomfort (Thorp et al. 2014). More time spent in brief sitting periods at work may be a sign of more variation in biomechanical loading of the musculoskeletal system, which may protect against MSDs (Mathiassen 2006; Toomingas et al. 2012). In contrast, "constrained" working postures maintained for long periods of time is an accepted occupational risk factor for neck–shoulder pain (Côté et al. 2009; Mayer et al. 2012). During uninterrupted sitting periods, work may be characterized by little posture variation and sustained low-intensity muscle contractions, which are considered potential causal determinants for work-related muscle pain (Visser and van Dieën 2006). In contrast, work performed in short sitting periods may less likely be associated with constrained upper extremity postures and sustained muscle activity, since it will probably be more dynamic even in these respects. Further, excessive sitting, as well as sitting in uninterrupted periods, is associated with changes in cardiovascular (e.g., increased blood pressure) and inflammatory markers (e.g., increased systemic levels of pro-inflammatory cytokines) (Henson et al. 2013; Larsen et al. 2014; Yates et al. 2012), which may, in turn, play important roles in mediating muscle pain via different peripheral and central mechanisms (Barbe and Barr 2006; Bruehl and Chung 2004). However, these theories on possible pathways explaining the relationship between sitting patterns and intense neck–shoulder pain remain to be verified.

The cross-sectional design of the current study precludes us from making inferences about the causal relationship between temporal sitting patterns and pain intensity. However, it is worth noting that previous studies did not find sitting time to be distributed differently across the day between workers with and without chronic neck–shoulder pain (Hallman et al. 2014; Hallman and Lyskov 2012). This suggests that the temporal pattern of occupational sitting has an influence on neck–shoulder pain intensity rather than the reversed causation.

In order to account for possible confounders or effect modifiers, we adjusted the statistical models for several individual and biomechanical risk factors of relevance to neck–shoulder pain and found persistent associations between occupational sitting and neck–shoulder pain. Also, to examine whether the associations determined in the crude and adjusted models persisted when accounting for the total time in occupational sitting, we stratified our population by total sitting time at work using a cut-point close to median sitting time, i.e., sitting for more or less than 25 % of the working hours. In both sitting time strata we found the associations between *brief bursts* and *moderate periods* in sitting, and neck–shoulder pain to be equally strong (ORs of similar sizes) as those obtained in the primary analysis, while not reaching statistical significance (Table 2). Thus, our results suggest that the temporal pattern of sitting at work is associated with neck–shoulder pain independently of other biomechanical exposures at work, including total sitting time, sitting with elevated upper arm, occupational physical activity and the extent of lifting and carrying in the job. Also, the level of leisure-time physical activity did not modify the association between sitting and pain, which further suggests that sitting patterns at work are independently associated with musculoskeletal health. However, because of missing values in self-reported influence and social support at work, we were not able to fully adjust for psychosocial factors, which may interact with biomechanical exposures in the development of neck–shoulder pain (Widanarko et al. 2015). Thus, this may be viewed as a limitation of the current study. Further, the data material does not allow an empirical analysis of whether the current sample was fully representative of the target population with respect to sitting exposure. However, self-reported workloads and neck–shoulder pain did not differ between those participating in the measurements and those not participating (data not shown), which suggests that our results are not afflicted by any critical selection bias.

In contrast to occupational sitting, there was no clear association between leisure-time sitting patterns and intense neck–shoulder pain. This finding corroborates a few previous studies, which did not find significant associations between total leisure-time sitting and pain (Hallman et al. 2015b; Hildebrandt et al. 2000). The reason why work and leisure would show different associations with pain is not clear. However, a viable hypothesis could be that the relationship between the temporal pattern of sitting and other exposures of relevance to neck–shoulder pain, such as sustained muscle activity following from constrained neck postures (as noted above), is more consistent, or even different, during occupational work than during leisure. Using sitting as a proxy for those exposures would then lead to more diluted and less significant results for leisure than for work. To this end, measurements of neck posture could have provided important complementary information of relevance to the interpretation of associations between sitting and pain, but it was not feasible to equip the participants with additional instrumentation.

Conclusion

Brief and moderate periods of sitting at work showed negative (brief) and positive (moderate) associations with intense neck–shoulder pain among blue-collar workers, while prolonged periods of sitting at work did not show an association with pain. These relationships persisted after adjustment for several other established risk factors for neck–shoulder pain. Thus, our results suggest that an effect of occupational sitting on musculoskeletal health may depend on the temporal distribution of sitting. We encourage further prospective and experimental studies to disentangle the causal direction of associations between sitting and musculoskeletal pain, as well as the underlying mechanisms.

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Compliance with ethical standards

Conflict of interest The authors declare none.

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Original article

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Is objectively measured sitting at work associated with low-back pain? A cross sectional study in the DPhacto cohort

by Korshøj M, Hallman DM, Mathiassen SE, Aadahl M, Holtermann A, Jørgensen MB

Low-back pain (LBP) is a substantial health challenge. Sitting is believed to be a risk for LBP. The association of sitting at work and during whole days and intensity of LBP was investigated. Intensity ofLBP was measured on a 0-10 scale and sitting was measured by accelerometry. The associations between sitting and LBP were not significant.

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Key terms: accelerometer; back pain; DPhacto; DPhacto cohort; inactivity; low-back pain; musculoskeletal disease; musculoskeletal disorder; musculoskeletal pain; occupational health; occupational sitting; pain; physical activity; sedentary; sitting at work; temporal pattern; time pattern

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Is objectively measured sitting at work associated with low-back pain? A cross sectional study in the DPhacto cohort

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Korshøj M, Hallman DM, Mathiassen SE, Aadahl M, Holtermann A, Jørgensen MB. Is objectively measured sitting at work associated with low-back pain? A cross sectional study in the DPhacto cohort. *Scand J Work Environ Health*. 2018;44(1):96–105. doi:10.5271/sjweh.3680

Objectives Low-back pain (LBP) is a substantial health challenge due to the risk for long-term sickness absence and early retirement. Several biomechanical exposures at work, including sitting, have been suggested to increase the risk for LBP. The objectives of this study were to determine (i) the extent to which temporal patterns and total amount of objectively measured sitting is associated with LBP intensity and (ii) whether selected modifiers influence these associations.

Methods This cross sectional study uses baseline data from the Danish PHysical ACTivity cohort with Objective measurements (DPhacto) of physical activities in the cleaning, transport and manufacturing sectors. Peak intensity of LBP was collected by questionnaire on a 0–10 scale and sitting was expressed in terms of total duration and temporal pattern, ie, time spent in brief bursts (≤5 minutes), moderate periods (>5–≤20 minutes), and prolonged periods of sitting (>20 minutes); both during work and whole day (waking hours only). Associations were determined using linear regression in models accounting for moderation and confounding. Factors evaluated as moderators or confounders were assessed by questionnaire.

Results The population consisted of 704 participants. No significant associations were found between total duration or temporal patterns of sitting and LBP intensity, neither during work nor for the whole day. Body mass index (BMI) significantly moderated the association between sitting and LBP; participants with a high and low BMI showing a negative and positive association, respectively.

Conclusion Sitting was not independently associated with peak LBP intensity, suggesting other exposures are more powerful risk factors for LBP.

Key terms accelerometer; inactivity; musculoskeletal disease; musculoskeletal disorder; musculoskeletal pain; occupational health; occupational sitting; physical activity; temporal pattern; time pattern; sedentary.

Low-back pain (LBP) is a substantial health challenge in the general Danish population. In 2013, 47% of workers in Denmark reported pain or discomfort in the back during the preceding 14 days (1). Severe LBP increases the risk for long-term sickness absence and early retirement (2) and has profound consequences for individuals, organizations, and society (3–5).

Biomechanical exposures at work, such as heavy lifting or awkward trunk postures, are believed to be key determinants of LBP (6). However, many traditional work tasks posing heavy physical work demands on the lower back while standing or walking have been replaced by sedentary tasks. Thus, sitting at work has been increasing during the last two decades (7, 8). A

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Danish study from 2014 (9) showed that 40% of all employees in Denmark were sitting >75% of their working hours. Even in blue-collar occupations, workers now appear to be exposed to considerable sitting during the working day (10–12). This suggests that effects of sitting may also be relevant to address in blue-collar occupations.

In theory, prolonged sitting at work could cause LBP due to limited posture variation (13, 14). This may, hypothetically, decrease flexibility and muscle strength in the lower back (15), which may in turn lead to disc degeneration, rupture, or herniation (16, 17). Yet, evidence supporting these hypothetical mechanisms of mechanical damage to tissues is not convincing. Furthermore, systematic reviews of the available evidence have not been able to verify a consistent association between sitting and LBP (18–20).

The inconsistent results may be due to the different methods used in previous studies to assess sitting, ie, self-reports, observations, or objective measurements, resulting in a dispersion in the extent and quality of information (18, 20). Self-reported sitting is less valid than sitting measured objectively, for instance by accelerometry (21, 22), due to recall bias (23) or differential misclassification (24, 25). Thus, objectively measured sitting is preferable in the context of trustworthiness and also has the advantage of allowing detailed investigations of temporal sitting patterns (10, 12). The development of LBP has even been suggested to be associated with the temporal patterns of sitting (18, 26). A few recent studies have used accelerometer-based sitting data in studies of associations with LBP (11, 27). However, these studies pointed in opposite directions: Gupta and colleagues (11) found that an increased amount of sitting was positively associated with LBP intensity while Lunde and colleagues (27) concluded that sitting was negatively associated with intensity of LBP. Only two studies have addressed associations between LBP and the temporal patterns of sitting, expressed in terms of the occurrence of prolonged uninterrupted periods of sitting (26) or as the frequency of transitions between sitting and other body postures, such as standing (18). Thus, further studies on objectively measured sitting and LBP are justified, focusing on both total amount and temporal patterns of sitting.

Therefore, the objectives of this paper were to (i) investigate the extent to which LBP is associated with the total amount and the temporal patterns of objectively measured sitting, both at work and for whole days, and (ii) investigate whether these associations are influenced by selected moderators.

Our main hypothesis was that more time spent sitting is associated with an increased level of LBP intensity, in particular if sitting occurs for long uninterrupted periods of time.

Methods

Study design and population

This study was based on data from the Danish PHysical ACTivity cohort with Objective measurements (DPhacto). Participants were recruited from 15 companies in the cleaning, transport, and manufacturing occupational sectors between December 2011 and March 2013 in collaboration with a large Danish labor union (21). The study was conducted according to the Helsinki declaration and approved by the Danish Data Protection Agency and local ethics committee (H-2-2012-011). All workers provided their written informed consent prior to participation. Baseline measures included questionnaires, objective measurements of anthropometrics, blood pressure and physical capacity, and objective measurements of physical activity and body postures based on accelerometry. Further details can be found in previous studies based on the DPhacto cohort (28, 29). The present study is a cross sectional analysis of baseline data.

Inclusion criteria for companies were that they allowed measurements to take place during paid working hours. Pregnant workers were excluded from participation in the study. Workers with allergy to bandages or adhesives were excluded from the objective monitor-based measurements (21).

Assessment of exposure. Objective data on sitting were collected using two accelerometers (ActiGraph GT3X+) (30), mounted on the skin at the front of the right thigh (medial between the iliac crest and the upper border of the patella) and at the trunk (at processus spinosus at the level of T1-T2) by adhesives (11, 12, 31). Participants wore the accelerometers for 4–6 days, 24 hours a day. During the measurement days, participants were asked to keep a diary stating: working hours, time off work, time in bed (when they went to bed and got up in the morning), and periods when they did not wear the accelerometers.

Data were sampled by the accelerometers at a frequency of 30 Hz with a dynamic range of ± 6 G and a 12-bit precision. The accelerometers were initialized and data downloaded using the Actilife software version 5.5 (ActiGraph LLC, Pensacola, FL, USA). Accelerometer signals were low-pass filtered at 5 Hz using a fourth-order Butterworth filter and then split up in 2-s windows with 50% overlap. Then, the accelerometer data were analyzed using the customized software Acti4 (31). The Acti4 software determines a variety of body postures and activities and has shown a sensitivity of 99.9% and specificity of 100.0% for sitting in standardized field settings (31). Non-wear periods were identified when one or more of the following criteria applied: (i) the participant registered non-wear in the diary, (ii) the Acti4 detected periods >90 minutes with zero acceleration, or (iii) missing data and/or artefacts were detected by visual inspection.

These analyses only included days where the participant had been working. Measurements during working hours were included if they were ≥4 hours/day (continuous periods) or a duration of ≥75% of average wear time during work across days per participant. Similar inclusion criteria were used for the intervals during time-off work.

Sitting periods were determined using data from the trunk and thigh accelerometers (28) as periods when thigh inclination was >45° *and* trunk inclination was <45° relative to the recorded vertical reference position (11). Sitting during the whole day was calculated as the accumulated time in sitting while being awake, and expressed in percent of the total duration of the measurement day. For each participant, results were then averaged across days, and this average was used in the statistical models described below. Similarly, sitting during work was calculated for each participant by adding up periods of sitting during working hours for each measurement day, expressing the result as percent of working time that day, and averaging across days.

Temporal patterns of sitting were quantified using exposure variation analysis (EVA) (32). Uninterrupted periods of sitting were identified throughout the entire time line of the processed accelerometer signal. An interruption in sitting was defined to occur when non-sitting occurred for ≥5 consecutive seconds. Sitting periods were then categorized according to duration (10): ie, brief bursts (≤5 minutes), moderate periods (>5–≤20 minutes) and prolonged periods (>20 minutes). For each participant, the mean daily duration (hours/day) spent in each of the EVA categories for both working hours and the whole day was calculated by dividing the total accumulated duration of sitting in the specific category across all measurement days by the number of days. Additionally, the mean time spent in each EVA category was expressed as percent of the daily average of total wear-time, both during working hours and for the whole day.

The distributions of the categorized EVA data were skewed and therefore these variables were square root transformed before proceeding with further analyses. The square root transformation resulted in distributions closer to normal.

Assessment of outcome. Intensity of LBP was determined using the question: "In the last 3 months, state your worst pain in lower back" from the standardized Nordic Questionnaire for the analysis of musculoskeletal symptoms (33), with response options on an 11-point scale from 0 ("no pain") to 10 ("worst pain imaginable").

Assessment of potential confounders and moderators. A number of factors have been shown in previous research to be associated both with LBP and the amount of sitting; they were therefore considered as potential confounders: age (34); sex (34); smoking (35, 36); BMI (37, 38); level of occupational lifting (34); occupational sector (39); previously diagnosed with a herniated disc (40); leisure-time physical activity (41, 42); and intensity of physical activity during working hours (43, 44), measured as rate of perceived exertion and aerobic workload in this study.

Since the factors listed above may also act to moderate the association between sitting and LBP, the following factors were entered in the analysis through an interaction term (sitting × factor): age, sex, BMI, occupational sector, level of physical activity during leisure time, and intensity of physical activity during working hours. Factors were centered prior to their inclusion in interaction terms to reduce effects of collinearity between data in interaction and main effects.

Age was based on the date of birth for the participant. Sex was determined from the question: "Are you male or female?". Smoking was assessed by the question "Do you smoke?" using four response categories, which were merged into a dichotomized variable: yes ("yes, daily", "yes, sometimes") or no ("used to smoke", "I have never smoked"). Objective measurements of body weight (in kg; Tanita BC418) and height (in m; Seca model 123 1721009) were obtained, and used to calculate the BMI (kg/m^2). Occupational lifting and carrying was assessed by a single item from the Danish Work Environment Cohort Survey (DWECS): "How much of your working time do you carry or lift?" with a 6-point response scale from 1 ("almost all the time") to 6 ("never"). Occupational sector was determined by the workplace of the participant and whether the participant stated to be working in administration (white-collar work) or production (blue-collar work). The following occupational sectors were represented: cleaning, manufacturing, transportation and administration (irrespective of occupational sector). A previous diagnosis with a herniated disc was assessed by the question: "Do you have herniated discs?" with the dichotomized response "yes" or "no". Moderate-to-vigorous leisure-time physical activity was assessed by the Acti4 software, adding up leisure time spent in one of the following activities: running, climbing stairs, and cycling. The accumulated time was expressed as percentage of the total measured leisure time and participants were classified into high or low level physical activity by a median split. Intensity of physical activity during working hours was measured by the rate of perceived exertion, assessed by the question: "How physically demanding do you normally consider your present work?" with a 10-point response scale from 1 ("sedentary, not demanding") to 10 ("very demanding"); and aerobic workload was assessed in terms of relative heart rate (45), with objectively measured resting heart rate and estimated maximal heart rate (46).

Social support and influence at work were determined by items from the Copenhagen Psychosocial Questionnaire (47). Influence at work was determined by the question: "Do you have a large degree of influence concerning your work?"; "Can you influence the amount of work assigned to you?". Social support was determined by: "Is there good cooperation between the management and the employees?"; "Is there good cooperation between the colleagues at work?" The response categories were on a 5-point scale, ranging from 1 ("always") to 5 ("never"). The scale were reversed and recoded to 0–4; answers given for the two items were added up to a 0–8 scale for each dimension as described in the questionnaire manual (available at: www.arbejdsmiljoforskning.dk). Thus, in the analyzed data, higher numbers indicate more influence and better social support.

Statistical analysis. Associations between sitting variables and LBP were determined using linear regression. The different variables of sitting [total sitting, EVA derivatives describing temporal patterns (brief bursts, moderate and prolonged sitting periods)] were analyzed during work and for the whole day in separate regressions. Exposure variables were square root transformed in order to better approach a normal distribution. Intensity of LBP was entered as a continuous variable. The assumption of a linear association between exposure and outcome was justified according to visual inspection of data plots.

Interaction terms between centered variables of exposure and potential moderator factors were included in the regression one by one. If the interaction term showed to influence the association between exposure and outcome significantly ($P<0.10$), the interaction term was included in the final model, and a complementary stratified analysis was conducted. Those potential moderator factors that did not significantly influence the association between sitting and LBP were instead considered as potential confounders.

Multicollinearity between the potential confounders was assessed by variance inflation; if substantial multicollinearity was present, the potential confounder was not included in the final model. Potential confounders were included in the final model one by one if they significantly ($P<0.10$) affected the association between exposure and outcome. Three sensitivity analyses were performed based on the final model. In the first, age and sex were added as forced confounders to the final model. In the second, social support and influence at work were added. This second sensitivity analysis could only be performed for cleaning and manufacturing since none of the participants from the transport sector received the questions regarding influence and support at work due to a technical error. In the third sensitivity analysis, the final model was run on a population excluding all participants reporting 0 on the LBP scale, ie, no LBP.

Additionally, analyses both for work and the whole day were conducted in which the EVA derivatives were expressed in percentages of total sitting, as opposed to percentages of the total measurement time, as above. These analyses were performed to determine the extent to which the temporal pattern of sitting was associated with LBP irrespective of total sitting.

Results

Flow of participants

Figure 1 shows the flow of the participants from DPhacto included in this study. Of the 909 participants that took part in the diurnal accelerometer measurements of sitting, 704 participants were included in the analysis, based on the quality criteria for accelerometer data described above.

Baseline characteristics of the study population. The DPhacto contains data from three occupational sectors, ie, cleaning, manufacturing, and transport, as well as the administrative staff within these occupational sectors. The study population included 704 of the participants in the DPhacto (figure 1), 312 females and 392 males (table 1), aged 18–68 years. The participants had a mean seniority in their current job of 13.0 [standard deviation (SD) 10.1] years (table 1).

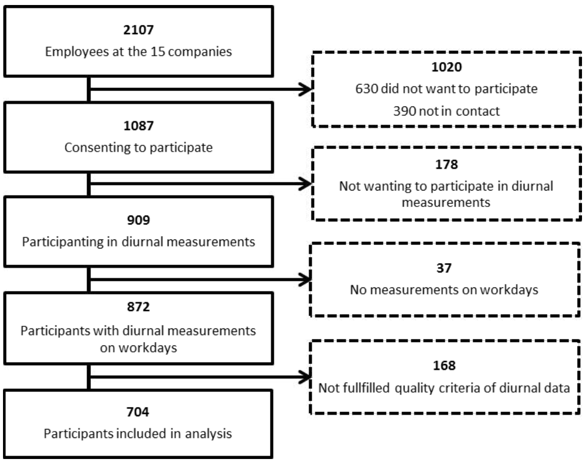


Figure 1. Flow of the participants

Table 1. Baseline characteristics of the study population (N=704).

	Mean	SD	N	%	Range
Age (years)	45.0	9.9	704		18–68
Sex (females)			312	44.3	
Current smoker			204	29.7	
Body mass index (kg/m²)	27.4	4.9	688		16.2–45.1
<25 kg/m²			448	65.1	
≥25 kg/m²			240	34.9	
Lifting & carrying at work (scale 1–6)	3.6	1.5	700		
<50% of working hours			412	58.9	
≥50% of working hours			288	41.1	
Occupational sector					
Cleaning			128	18.2	
Manufacturing			472	67.0	
Transport			62	8.8	
Administration			42	6.0	
Rate of perceived exertion at work (scale 1–10)	5.8	2.2	674		
Moderate-to-vigorous physical activity during leisure (hours/day)	0.5	<0.1	704		0.0–0.5
Peak low-back pain intensity in the past 3 months (scale 0–10)	3.4	3.1	701		
0			212	30.2	
1–4			228	32.5	
≥5			261	37.2	
Diagnosed with a herniated disc			56	8.0	
Total duration of included measurements of working hours (hours)	19.9	8.0	704		4.0–51.3
Total duration of included measurements of whole day (hours)	42.9	15.7	704		10.7–88.7
Included measurements of working hours (hours/day)	7.7	1.6	704		3.3–14.5
Included measurements of whole day (hours/day)	16.8	1.7	704		9.3–24.0
Occupational sitting (% working hours)	33.2	21.8	704		1.6–91.6
Whole day sitting (% whole day)	43.9	12.6	704		9.0–82.6

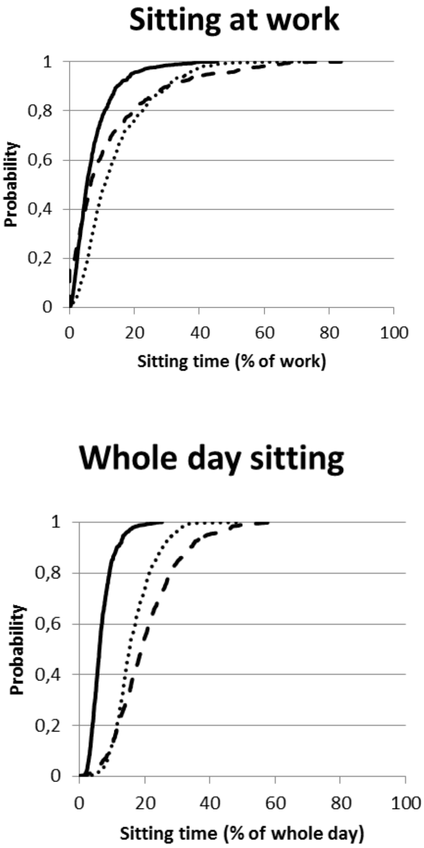


Figure 2. Cumulative probability distributions of exposure variation analysis (EVA) derivatives in the study population, ie, brief bursts (time in spent sitting <5 minutes), moderate periods (sitting periods of >5-20 minutes) and prolonged periods (sitting for more than >20 minutes) during work and the whole day.

The mean intensity of LBP during the last 3 months was 3.4 (SD 3.1) on a 0–10 point scale, where 10 indicated the worst imaginable pain (table 1). More than half of the population (62.8 %) reported a level of LBP <5 within the last 3 months and 30.2% reported to be pain-free. Seventy-three percent of the population stated having <31 days with LBP during the last year and 24.3% stated having no days with LBP during that period.

On average, accelerometer data were collected for 2.6 days for each participant (SD 1.0 day), in total comprising 19.9 hours (SD 8.0 hours) of work and 22.9 hours (SD 8.9 hours) of valid recordings off work (table 1). Cumulative distributions of the EVA derivatives describing the temporal pattern of sitting are shown in figure 2.

Building of statistical models

Variance inflation estimates did not indicate any critical multicollinearity among the potential confounders.

The models including interaction terms between exposure variables and potential moderators only showed a significant interaction with BMI. Thus, only this interaction was entered in the final model, and other potential moderators were entered as confounder main effect terms. Secondary, a complementary model stratified on high (≥25 kg/m²) and low (<25 kg/m²) BMI was applied.

Of the potential confounders, only diagnosis with a herniated disc and rate of perceived exertion affected the association between exposure and outcome significantly. Thus, the final model included these two confounders only.

Primary analysis of association between sitting and LBP

The results from the crude and final models describing the association between sitting and LBP are shown in table 2. Sitting during work and whole day were not significantly associated with LBP intensity in crude, univariate models, neither for the total sitting nor for the EVA derivatives reflecting the temporal patterns of sitting. However, BMI, as the only moderating factor, appeared to interact significantly with total amount of sitting and sitting in brief bursts and moderate periods both during work and whole day (table 2).

Table 2. Associations between sitting (total time and temporal patterns (EVA derivatives)) during work and for the whole day (waking hours), and the intensity of low back pain (scale 0–10). 701 participants were included in the crude, univariate model (model 1) and 653 in the final model (model 2). [BMI=body mass index; CI=confidence interval.] **Significant (P<0.05) associations are marked with bold.**

	R^2	B	SE	P-value	95 % CI
Sitting at work					
Total (% of occupational hours spent sitting)					
Model 1 [a]	0.002	-0.07	0.06	0.28	-0.19–0.06
Model 2 [b]	0.04	0.04	0.07	0.60	-0.10–0.17
Sitting×BMI interaction		**-0.002**	**0.001**	**0.03**	**-0.005– -0.0002**
Brief bursts (≤ 5minutes)					
Model 1 [a]	0.00	-0.02	0.11	0.87	-0.23–0.19
Model 2 [b]	0.04	-0.01	0.11	0.91	-0.23–0.20
Sitting×BMI interaction		**-0.007**	**0.003**	**0.03**	**-0.01– -0.0006**
Moderate periods (>5–20 minutes)					
Model 1 [a]	0.002	-0.09	0.08	0.31	-0.25–0.08
Model 2 [b]	0.04	0.01	0.09	0.92	-0.17–0.18
Sitting×BMI interaction		**-0.005**	**0.002**	**0.02**	**-0.009– -0.0007**
Prolonged periods (>20 minutes)					
Model 1 [a]	0.0009	-0.04	0.06	0.43	-0.16–0.07
Model 2 [b]	0.04	0.05	0.06	0.41	-0.07–0.18
Sitting×BMI interaction		-0.0009	0.002	0.62	-0.004–0.003
Whole day sitting					
Total (percentage of whole day spent sitting)					
Model 1 [a]	0.003	-0.17	0.12	0.16	-0.41–0.07
Model 2 [b]	0.04	0.01	0.13	0.92	-0.24–0.27
Sitting×BMI interaction		**-0.004**	**0.002**	**0.04**	**-0.008– -0.0003**
Brief bursts (≤5 minutes)					
Model 1 [a]	0.0001	0.04	0.18	0.81	-0.31–0.40
Model 2 [b]	0.03	0.08	0.18	0.68	-0.28–0.44
Sitting×BMI interaction		**-0.01**	**0.01**	**0.03**	**-0.03– -0.001**
Moderate periods (>5–20 minutes)					
Model 1 [a]	0.0007	-0.11	0.15	0.49	-0.40–0.19
Model 2 [b]	0.04	0.02	0.16	0.90	-0.29–0.33
Sitting×BMI interaction		**-0.01**	**0.004**	**0.01**	**-0.02– -0.003**
Prolonged periods (>20 minutes)					
Model 1 [a]	0.003	-0.15	0.10	0.15	-0.35–0.05
Model 2 [b]	0.03	-0.04	0.11	0.71	-0.26–0.18
Sitting×BMI interaction		-0.0003	0.002	0.89	-0.005–0.004

[a] Model 1 is unadjusted (univariate).
[b] Model 2 is adjusted for herniated disc, rate of perceived exertion, and the interaction between sitting and BMI.

An alternative model, in which data on temporal patterns of sitting were expressed in percent of the total amount of sitting rather than in percent of the overall measurement time, did not show any significant associations of temporal patterns with LBP intensity, neither for sitting during work nor whole day.

Stratified analyses of association between sitting and LBP

An unadjusted analysis was conducted in sub-populations stratified on BMI (low <25 kg/m^2 and high ≥25 kg/m^2). These stratified analyses showed that among participants having a low BMI, more sitting (total, brief bursts, and moderate periods) was associated with an increased LBP intensity, both during work and whole day (table 3, figure 3). In contrast, among those having a high BMI, more sitting during work or for the whole day was associated with a decreased LBP intensity. The stratified analysis was additionally adjusted for herniated disc and rate of perceived exertion, just as the final model for the entire population; however, this adjustment didn´t change the estimates numerically or statistically (results not shown).

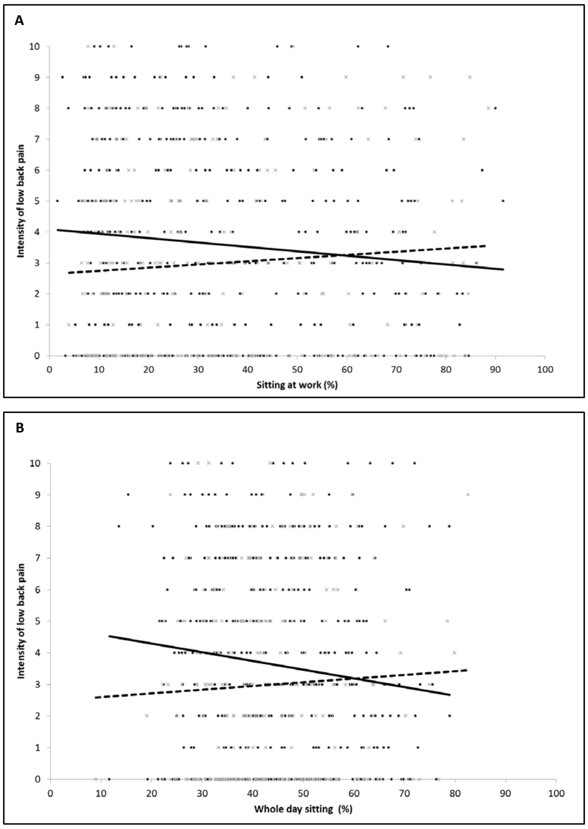
Sensitivity analyses

All of the sensitivity analyses – one including age and sex as confounders, one including social support and influence at work as confounders, and one exploring associations only among participants with LBP (N=212) by excluding those reporting to have no LBP – resulted in numerically and statistically similar findings to those reported in table 2 (results not shown).

Discussion

We did not find any significant associations between total sitting and intensity of LBP (table 2), neither during work nor the whole day. Neither did we find associations between temporal patterns of sitting (brief bursts, moderate periods, prolonged periods) and intensity of LBP (table 2). Therefore, we rejected the hypothesis of a positive association between sitting and LBP intensity.

None of the previous studies addressing associations between sitting and LBP (11, 19, 20, 27) considered the possible effect of moderating factors (20). Therefore, we investigated the extent to which the association between sitting and LBP was moderated by factors traditionally classified as confounders (24, 25). Among the investigated potential moderating factors, only BMI significantly interacted with sitting, and was therefore included in the final model. An analysis stratified on high and low BMI indicated that in the low BMI (<25 kg/m^2) group LBP intensity increased with an increased amount of sitting, while LBP intensity decreased with an increased amount of sitting in the high BMI (≥25 kg/m^2) group (figure 3, table 3); even if none of these associations were very strong. An explanation for the association between increased sitting time and decreased LBP among those with high BMI could be that sitting indirectly protects against alternative non-sitting activities that may cause added strain on the back among those with high BMI. However, high BMI may also reflect high muscle mass rather than obesity, as suggested by Fogelholm (48). If so, the mechanisms behind BMI as a potential modifier are less straight forward and should



Figures 3A and B. Scatter plots and regression lines illustrating the crude association between sitting during work (A) and the whole day (B) expressed in percent and pain intensity and stratified on body mass index (BMI): low <25kg/m², N=238; high ≥25 kg/m², N=447. The solid line represents participants in the high BMI category. The dashed line represents the participants in the low BMI category.

Table 3. Crude associations between sitting (total amount and temporal patterns (EVA categories)) during work and for the whole day (waking hours), and the intensity of low back pain (scale 0–10), stratified on low (<25 kg/m², N=238) and high (≥25 kg /m², N=447) body mass index (BMI). **Significant (P<0.05) associations are marked with bold.**

	Low BMI (<25 kg/m²)			High BMI (≥25 kg/m²)		
	B	SE	P-value	B	SE	P-value
Occupational sitting						
Total (% of occupational hours spent sitting)	0.13	0.10	0.22	**-0.16**	**0.08**	**0.04**
Brief bursts (≤5 minutes)	**0.35**	**0.17**	**0.04**	-0.19	0.14	0.18
Moderate periods (>5–20 minutes)	0.17	0.14	0.21	-0.21	0.11	0.051
Prolonged periods (>20 minutes)	-0.01	0.10	0.89	-0.07	0.07	0.33
Whole day sitting						
Total (% of whole day spent sitting)	0.17	0.20	0.41	**-0.37**	**0.15**	**0.02**
Brief bursts (≤5 minutes)	**0.70**	**0.26**	**<0.01**	-0.26	0.25	0.30
Moderate periods (>5–20 minutes)	**0.57**	**0.24**	**0.02**	**-0.46**	**0.19**	**0.02**
Prolonged periods (>20 minutes)	-0.26	0.17	0.13	-0.18	0.13	0.17

be further explored in future studies with measurement, eg, muscle mass or muscle strength.

To our knowledge, no previous studies have addressed the temporal pattern of sitting in relation to LBP. Our analyses indicated that EVA derivatives reflecting the temporal sitting pattern (ie, brief bursts, and moderate and prolonged periods) were not associated with LBP intensity. This stands in contrast to studies arguing that breaks from prolonged sitting are beneficial for health outcomes (49–51). However, breaks from sitting may increase the exposure to other risk factors for LBP, such as awkward working postures (6, 52). On the other hand, longer uninterrupted periods of sitting may also increase the risk for LBP due to the constrained body posture. Accordingly, prolonged sitting has been shown to be associated with periods of uninterrupted, low-intensity muscle contractions, which may lead to increased blood pressure and increased systemic levels of pro-inflammatory cytokines (51, 53, 54). The proposed beneficial health effects from breaking up prolonged periods of sitting are consistent with the general notion that sufficient variation in body postures and loads is a necessary prerequisite for good musculoskeletal health (13, 14).

The limited importance of sitting for LBP found in our study suggests that LBP likely depends on what workers do when they do not sit. Thus, future research into associations between sitting and LBP should focus on the whole timeline of physical activities and postures, and examine the effect of combinations of different physical activities, including their temporal pattern. Such studies would be particularly warranted among workers that do not sit for considerable parts of their working hours. Also, emphasis should be given to understanding the extent to which a possible effect of sitting is moderated by what workers do when they do not sit. Additionally, prospective studies of associations between sitting and LBP should be encouraged to gain a better understanding of sitting as a possible predictive risk factor.

Methodological considerations

The present study was based on objective measurements of duration of sitting by use of two tri-axial accelerometers. This allows discrimination of, eg, sitting from lying and standing, and thus minimizes misclassification of exposure. Thus, detailed patterns of sitting (and other activities) can be assessed validly across several days. The relatively large size of the present study population is an additional strength since it allows detection of even small effect sizes with a good statistical power. The study population mainly consisted of blue-collar workers with a reasonably homogenous socioeconomic status, minimizing possible confounding.

However, the study also suffers from some limitations. The cross-sectional design of the study prevents conclusions regarding causal relationships between sitting and intensity of LBP. An additional limitation is the different time windows for assessing exposure and outcome; the exposure was recorded by accelerometers mounted at the health check and measuring during 2–4 working days after that, and the intensity of LBP was measured retrospectively in a questionnaire. However, we assume the recorded exposure to be representative even for a period preceding the measurements, thus these non-synchronous time windows should not present a serious flaw with respect to the investigated associations. Additionally, these results are derived from a population of mainly blue-collar workers and are therefore not valid in other populations, such as mainly white-collar workers. Data were not available from all included participants on self-reported social support and influence at work. Therefore, we could not completely rule out confounding by psychosocial factors. However, we conducted a sensitivity analysis in a sub-sample (N=460) of workers allowing additional adjusting for self-reported level of social support and influence at work. This analysis led to numerical and statistical results similar to the final model on the entire population (table 2), suggesting these results to be robust.

Concluding remarks

The present study found no significant associations between total duration or temporal patterns of sitting and intensity of LBP, neither during work nor for the whole day. Thus, the investigated hypotheses – that an increased amount of sitting will increase the intensity of LBP and the temporal pattern of sitting is important to LBP – were rejected. BMI significantly interacted with sitting and LBP, and a stratified analysis showed weak positive associations among those having a low BMI (<25 kg/m^2), and weak negative associations among those with a high BMI (≥25 kg/m^2).

Together, these results suggest that sitting may not be independently associated with peak intensity of LBP, which points towards other exposures being more powerful risk factors for LBP or to the association between sitting and LBP intensity being significantly modified by exposures during non-sitting periods of work.

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