
Anne Møller MD, 1,2,3, *, Susanne Reventlow DrMedSci 3, Johan Hviid Andersen PhD 4, Kirsten Avlund DrMedSci 5,6,7, Ole Steen Mortensen PhD 2,8

1) Department of Occupational and Environmental Medicine, Køge Hospital, Lykkebækvej 1, DK-4600 Køge, Denmark
2) National Research Centre for the Working Environment, Copenhagen, Denmark
3) The Research Unit for General Practice and Section of General Practice, Department of Public Health, University of Copenhagen, Copenhagen, Denmark
4) Danish Ramazzini Centre, Department of Occupational Medicine, Regional Hospital, Herning, Denmark
5) Section of Social Medicine, Department of Public Health, University of Copenhagen, Copenhagen, Denmark
6) Centre for Healthy Aging, University of Copenhagen, Copenhagen, Denmark
7) Danish Aging Research Centre, Universities of Southern Denmark, Aarhus and Copenhagen, Denmark
8) Department of Occupational and Environmental Medicine, Bispebjerg Hospital, Copenhagen, Denmark

ABSTRACT

Aims: In large epidemiological studies exposure assessment based on questionnaires is the most cost-effective method. A question about life-time exposure to occupational physical activity (OPA) was used in a population-based study and the aim of this study was to validate this question through a three-step process.

Methodology: First the response process was studied by cognitive interviewing of 7 persons. Second 64 persons participated in semi-structured interviews about their work-life, and expert judgments of exposure to OPA were compared with questionnaire-data. Exposure was 20 years of work in one of four categories of OPA: ‘sedentary’/ ‘standing and walking’ / ‘moderate’ or ‘high OPA’. Kappa values were calculated for agreement and interpreted according to Landis and Koch’s criteria. Agreement was visualised in Bland-Altman plots. Third intra- and inter-rater reliability of the expert judgments was tested.

Results: Response process: The question had a complicated instruction and the respondents found it hard to remember and summate exposures. Validity: Kappa value for exposure to ‘sedentary work’ was ‘substantial’ (0.71) but ‘fair’ for the other categories of OPA (0.29, 0.27 and 0.29 respectively). Agreement between questionnaire and interview was higher in sedentary jobs and jobs with high OPA. Intra-rater reliability of expert judgments was ‘substantial’ or ‘moderate’ (0.71, 0.62, 0.6 and 0.64 respectively). Inter-rater reliability was high in sedentary jobs but lower in the more active jobs.

Conclusion: Self-reports of life-time exposure to sedentary work are valid, whereas the validity of self-reports of
exposure to occupational physical activity (OPA) are questionable.

Keywords: Validity, self-reports, occupational physical activity, inter-rater reliability, intra-rater reliability, cognitive interviewing, Bland-Altman plots, qualitative methods.

1. INTRODUCTION

Reliable and valid assessments of occupational physical activity are needed in the study of work and health (Kwak et al., 2011). In epidemiological studies, which include participants with many different job-titles, exposure assessment based on questionnaires is the most cost-effective method. Many questionnaires and scales assessing occupational physical activity (OPA) have been used, and a recent review found good repeatability in four of 22 questionnaires. However, none of the reviewed questionnaires showed good validity compared to objective measurements (Kwak et al., 2011). This could be partly explained by the lack of standardized methods for assessment of OPA and, thereby, the lack of a ‘gold standard’ as reference method. The questionnaires reviewed by Kwak et al. assessed current OPA by asking questions about usual activity at work, a ‘typical workday’, or usual activity in the past week or year (Kwak et al., 2011). Assessment of lifetime exposure to occupational physical activity is an additional challenge, and personal interviews have been used to establish a retrospective job-history, which has been reviewed afterwards by experts, assessing lifetime occupational physical activity (Cassou et al., 1992). However, this is a time-consuming method in large epidemiologic studies and expert judgments have to be validated, too.

In the planning of a large cohort-study about ageing in middle-aged Danes we had the opportunity to contribute to a questionnaire with questions about work-life, in order to study the influence of work on the ageing process. The space was limited and a single question for assessment of lifetime occupational physical activity was formulated assessing frequency, intensity, and duration of exposure. In this paper we evaluate this question in a three-step process of validation.

2. MATERIAL AND METHODS

2.1 Study design

This study is a sub-study of the Copenhagen Aging and Midlife Biobank (CAMB) (Avlund et al., 2009). Participants in CAMB filled out a questionnaire about health, socio-economic factors and behavior before attending physical examination. Information about work-life from the questionnaire included a list of the five longest held occupations, current job type and physical, ergonomic, chemical, and psychosocial exposures at work. In the question about lifetime occupational physical activity (OPA), participants were asked to fill in years of work in four categories of physical activity: a) sedentary work, b) standing and walking at work, c) moderate OPA and d) high OPA (See appendix 1). This question has been used for assessment of OPA in current work (Lund et al., 2009), but time frame was changed to cover the entire work-life to serve as a cumulative exposure assessment in our sub-study about lifetime OPA and ageing. Due to this change, a three-step process of validation was initiated.

Firstly, comprehension and interpretation of the question about lifetime OPA was studied by ‘Cognitive interviewing’. Secondly, the validity of self-reports of lifetime OPA was evaluated, comparing questionnaire data and data from semi-structured interviews. Finally, intra- and inter-rater reliability of the expert judgment of OPA used in the semi-structured interviews was evaluated (see Table 1 for overview).
<table>
<thead>
<tr>
<th>Step</th>
<th>Content</th>
<th>Method</th>
<th>Material</th>
<th>Analyses</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Response process , comprehension and interpretation</td>
<td>Cognitive interviews</td>
<td>7 middle-aged workers primarily working in a hospital</td>
<td>Question Appraisal System, QAS-checklist</td>
</tr>
<tr>
<td>2</td>
<td>Validity of self-reports</td>
<td>Semi-structured interviews</td>
<td>64 participants from CAMB(^1)</td>
<td>Kappa</td>
</tr>
<tr>
<td>3</td>
<td>Intra-rater reliability</td>
<td>Re-test of interview-data from step 2 after 3 months</td>
<td>Primary rater’s first judgment in step 2 compared with blinded re-test</td>
<td>Kappa Bland-Altman plots</td>
</tr>
</tbody>
</table>
2.2 Comprehension and interpretation (step 1)

Qualitative interdisciplinary methods like ‘cognitive interviewing’ were suggested for validation of questionnaires concerning physical work load (Stock et al., 2005). Cognitive interviewing has been used since the 80’s to improve the quality of survey questions (Willis, 2005; Collins, 2003), and in medical research it has been used in the development of new questionnaires (Watt et al., 2008), revision of existing questionnaires after translation (Andersen et al., 2010), or, before use, in a different cultural setting than the primary one (Napoles-Springer et al., 2006; Cortes et al., 2007). Cognitive interviews study the cognitive aspects of the response process and, thereby, respondents’ interpretation and comprehension of questions (Tourangeau et al., 2000).

The respondents received a printed copy of the questions about work-life, and were encouraged to ‘think aloud’ while filling out the questionnaire, as described by Willis (Willis, 2005). However, the ‘think aloud’ technique is a challenge to some respondents, and we therefore used ‘verbal probing’, too, meaning that the interviewer asks questions (probes) during the interview (‘concurrent probing’) (Willis, 2005). Probes can either be prepared or spontaneous, and are used to explore the comprehension of terms and to catch silent misunderstandings of questions. ‘Retrospective probing’ was used at the end of the interview to make a concluding evaluation of the questions concerning work-life (Willis, 2005). Interviews were digitally recorded, and notes and comments were taken during the interview. The interviews were transcribed verbatim.

2.2.1 Population and data collection

From a pilot study it was known that participants with sedentary work filled out the question about lifetime exposure to OPA satisfactorily. However, participants with exposure to some OPA in work-life had difficulties answering the question. There were many missing values among blue-collar workers and misinterpretations of the question, too. To study the response process we invited participants not exposed to the questionnaire before. Based on the pilot study, a strategic sampling of participants was made based on age (minimum 50 years old) and working experience (at least 20 years of non-sedentary work) (Crabtree, Miller, 1999). Participants were primarily recruited among employees at the hospital: Three hospital workers, one secretary with former employment as an assistant nurse, and a laboratory assistant. Furthermore, two men with working experience from outside the hospital were invited. Interviews took place in January and February 2010. Inclusion continued until no further problems in the question of interest were revealed in the interviews, as in ‘sampling to redundancy’ (Streiner, Norman, 2008).

2.2.2 Analysis

The analysis was based on recordings and notes from the interviewer, according to Willis’ “The Question Appraisal System” (QAS) (Willis, 2005), using a check-list of seven categories covering the answering process: Problems with ‘Instructions’ were looked for from the respondent’s point of view. ‘Clarity’ identifies problems related to communicating the intent or meaning of the question, and relates to syntax, use of technical terms and reference periods. If assumptions of constant behavior or characteristics of the respondents were made, it was...
reported in ‘Assumptions’, and problems with ‘Knowledge/ Memory’ were categorized as a ‘recall failure’ or ‘computation problem’. ‘Sensitivity/Bias’ registers embarrassing or private topics and the ‘Response categories’ were evaluated for mismatches, overlapping or missing categories. Finally, ‘Other problems’ not included in the first six steps were listed. No quantitative measurement of responses was made because the aim of the interviews was to gain insight into the response process (Watt et al., 2008).

2.3 Validity of self-reports (step 2)

The overall aim of the semi-structured interviews was to establish a retrospective job-history, including information about exposures in work-life. The semi-structured interview was based on an interview-guide, but other questions were allowed to be brought up during the interview (Kvale, 1997).

2.3.1 Population and data collection

75 participants from the CAMB-study were invited to participate in a telephone interview about their work-life. They were selected strategically, based on their answers in the CAMB questionnaire about lifetime OPA. 15 participants with at least 20 years of exposure in each of the four categories (a-d) were selected and, in addition, 15 participants with mixed job-histories. They received a mailed invitation with information about the purpose of the study after their participation in the CAMB-study, and the researcher (AM) called them within the next two weeks to set an appointment for the telephone interview. The participants were anonymous in the data material, but coded with a unique registration number from the CAMB-study. At the time of the interview, the interviewer was blinded to the participant’s exposure status. The participants were interviewed in May and June 2010, and interviews were digitally recorded.

The interview-guide was based on results from the cognitive interviews and the first question in the retrospective part of the interview was: “Now we are going to talk about your employment since you left school, i.e. all the different jobs you have had during your working life. When did you finish school, and what did you do afterwards?” The interviewer took notes and was thus able to piece together a story about the entire work-life in cooperation with the respondent. Once the interviewer had an overview of the job-history, she asked more thorough questions about exposures in the work environment. Having finished the interview, the interviewer filled in data about employment and exposures in a database and went through the recordings at least once more. Finally, a judgment of level and duration of lifetime OPA was made.

2.3.2 Analysis

In the epidemiologic study, exposure was defined as at least 20 years of exposure to one of the four categories of physical activity (a-d). Long-term exposure to OPA is hypothesized to lead to chronic changes in the musculoskeletal system (de Zwart et al., 1995). Previous cohort studies of changes in physical capacity have used 10, 16 or 24 years of exposure (Cassou et al., 1992; Torgen et al., 1999; Savinainen et al., 2004). Validity was calculated as kappa coefficients of agreement between the dichotomized outcomes “exposed” or “non-exposed” in each category. The quantity of kappa values was judged according to Landis and Koch’s (Altman, 1999). However, the kappa coefficient is a dimensionless ratio, and the true agreement or clinical implication of the kappa coefficient is not obvious from the size of the coefficient. Therefore, Bland-Altman plots were used to visualize agreement between the measurements (Bland, Altman, 1999). For that reason, we calculated an index of OPA taking years of exposure into account, too (Appendix 2). Differences in the OPA-index in the
interview and the questionnaire were plotted against their mean, and the lines for the mean-value and the 95% limits of agreement were drawn. If the mean is 0 there is perfect agreement, and the narrower the 95% limits, the better agreement.

2.4 Intra- and inter-rater reliability (step 3)

2.4.1 Population and data collection

2.4.1.1 Intra-rater reliability

Inter-rater reliability of the expert judgment was evaluated by a test-retest of the OPA-index in all participants. The primary rater, AM, performed a blinded re-judgment of the exposure to OPA three months after the initial judgments, based on the data from the interview about job-history and exposures in work-life.

2.4.1.2 Inter-rater reliability

Three skilled, occupational physicians received information about 34 participants from the interview-database, and were asked to judge the level and duration of exposure to occupational physical activity (years of exposure in group a-d) in each participant.

2.4.2 Analysis

2.4.2.1 Intra-rater reliability

Kappa values for agreement to exposure in test and re-test were calculated. OPA-index for each participant was calculated, and the difference between the primary OPA-index and the re-tested OPA-index was plotted against the mean of the two indices in a Bland-Altman plot.

2.4.2.2 Inter-rater reliability

The difference between the OPA-index judged by the primary rater and each of the three skilled physicians was visualized in one Bland-Altman plot with a reference-line in y=0.

3. RESULTS AND DISCUSSION

3.1 Comprehension and interpretation (step 1)

3.1.1 Results

Four men and three women, average age 59 years, were interviewed. The instruction was complicated, aiming at assessing duration (years of exposure in each category), frequency ('mostly'), and intensity (level of physical activity in category a to d)) (Table 2). According to ‘Clarity’, some respondents were confused about category d) describing ‘high speed’ and ‘heavy and physically demanding work’, while they had been working at a ‘high speed’ but not with heavy work, and ‘speed’ was not mentioned in the other categories. Questions about employment and exposures back in time caused ‘recall problems’ in most respondents, and different approaches were used in the search of information, but most participants used first job or graduation as their starting point. ‘Computation problems’ were obvious in the search for duration of jobs and summation of exposures throughout work-life.
Response categories b), c) and d) were overlapping due to vague definitions of levels of physical activity. Category a) was interpreted as office work/work in front of a computer by everyone, and caused no problems. The distinction between category c) or d) was hard, and some respondents asked for examples of job-titles in the categories. Since the instruction included an option of ‘answering in more than one category’, some filled in e.g. 40 years of work in both category c) and d) to indicate their difficulties in categorization of exposure. One participant found that her job did not fit into any of the categories and wrote 0 years in all four boxes. Only one of seven respondents understood and answered the question about lifetime occupational physical activity the way it was intended by the researchers.

3.1.2 Discussion

It was hard to meet the demands of memory in the question about lifetime occupational physical activity, and the higher demands of memory in a question, the less accurate response (Tourangeau et al., 2000). Everyday experiences are liable to imply reconstruction or inference more often than special events. The longer distance in time between an experience from the past and the present time, the more difficult it is to remember, not only because of period of time, but because you may experience similar things in the meantime (Tourangeau et al., 2000). However, sedentary jobs were easily categorized as such in the interviews. One could argue that seven interviews were too few to reach redundancy. However, it was assumed that the semi-structured interviews could be planned, based on data from this step, as most respondents faced the same problems in the response process.

Introducing a qualitative method like cognitive interviewing in the occupational research field was beneficial to our study. Knowledge about comprehension of questions and retrieval of answers is essential to the validity, and, thus, cognitive interviewing should be recommended for use in occupational epidemiological research in the planning and pre-testing of questions about work-life. However, the cognitive interview should be used in association with reliability and validity measures (Drennan, 2003), as it was used in this study.

Table 2. The Question Appraisal System used in the analysis of the question about lifetime occupational physical activity. Some categories and citations are shown in this table.

<table>
<thead>
<tr>
<th>Category</th>
<th>Citations and notes from interviews</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instructions</td>
<td>Most respondents sighed when they read the question and explained that it was hard to understand and impossible to answer correctly</td>
</tr>
<tr>
<td>Clarity</td>
<td>The use of “speed” only in category d) was confusing. ‘I have always worked fast, but my work has not been hard, but “speed” is not mentioned in category a), b), or c’ ‘…..Standing and walking’ the respondent “tasted” the word and got confused about the meaning of the expression</td>
</tr>
<tr>
<td>Assumptions</td>
<td>In the question constant exposure during a work-day is assumed, but respondents were confused by this assumption: ‘I was sitting at the office</td>
</tr>
</tbody>
</table>
before lunch, and having heavy work while packaging in the afternoon.’

Knowledge/ Memory  Exposures up to forty years back in time are hard to recall, and the question requires difficult mental calculation.

Response categories  Vague response categories result in wrong answers, since they overlap: ‘my job is a mixture… I sit, I walk, I stand, I lift and I laugh…it is hard to choose which category’

3.2 Validity of self-reports

3.2.1 Results

64 of 75 (85%) participants accepted the invitation, 47% were women and mean length of work-life was 39 years (range 22-48). The kappa value for agreement between questionnaire data and interview data for exposure to ‘sedentary work’ was ‘substantial’ (0.71) (Table 3). For ‘standing and walking’ and ‘moderate OPA’ agreement was ‘fair’ (kappa 0.23 and 0.37 respectively). Exposure to 20 years of either ‘moderate’ or ‘high OPA’ (category c and d) together, resulted in a kappa-value of 0.53 (‘moderate’ agreement).

Figure 1 shows the Bland-Altman plot of agreement in OPA-index between interviews and questionnaires. Few participants had a high OPA-index. There is satisfactory agreement in low OPA-indices, which means that a passive job is judged equally by the respondent and the rater. The agreement decreases as the OPA-index increases, but for the few high index jobs agreement seems to increase again.

3.2.2 Discussion

Both kappa-values and Bland-Altman plots showed that the more passive the job, the higher agreement between self-reports and interviews. This is in line with other studies that have shown high reliability and validity comparing self-reports and observations of sedentary work (Wiktorin et al., 1993; Mortimer et al., 1999; Viikari-Juntura et al., 1996; Torgen et al., 1999). It is more difficult for both workers and experts to categorize jobs with a mixture of passive and active work. Overall, our results are in line with others, concluding that self-administered questionnaires may help to classify groups with heterogeneous occupational tasks, but the accuracy of the assessments is not suitable for studying quantitative exposure-effect relationships (Viikari-Juntura et al., 1996).

For lack of a ‘gold standard’ of OPA assessment we have studied the inter-method agreement (Gardner et al., 2010). Our hypothesis was that the information retrieved by interviews was more valid than self-reports, but this hypothesis has not been tested. However, interviews are superior to questionnaires if questions are complex and thorough information, e.g. about past exposures, is needed (White et al., 2008). One could argue that the validation is another way of assessing reliability of data, for lack of a ‘gold standard’.

The low agreement between self-reports and interviews in participants with strenuous job-types can be due to socioeconomic factors. Gender, age, and socio-demographics have been shown to influence self-reports of exposure assessment (Sembajwe et al., 2010; Quinn et al., 2007). The participants in the cognitive interviews were sampled strategically with a work-life with heavy work, and their educational background was therefore minimal. The
external validity of the results from the cognitive interviews is low, but the aim of this part of the study was explorative. The white-collar workers had primarily sedentary jobs, which are easy to categorize, as was seen in the semi-structured interviews. On the other hand, the difficult parts of the questions, e.g. the categorization of jobs with moderate or high OPA, affect the respondents with lowest education. Furthermore, other factors could influence the way people categorize their exposure, for instance, musculoskeletal diseases or physical fitness could influence your perceived workload.

Table 3. Validity of self-reports. Questionnaire versus interview.

<table>
<thead>
<tr>
<th>Exposure</th>
<th>Kappa</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>a)/ ‘sedentary’</td>
<td>0.71</td>
<td>0.50-0.93</td>
</tr>
<tr>
<td>b)/ ‘standing and walking’</td>
<td>0.23</td>
<td>-0.02-0.45</td>
</tr>
<tr>
<td>c)/ ‘moderate OPA’</td>
<td>0.37</td>
<td>0.17-0.57</td>
</tr>
<tr>
<td>d)/ ‘high OPA’</td>
<td>0.27</td>
<td>0.04-0.49</td>
</tr>
<tr>
<td>c) or d)</td>
<td>0.53</td>
<td>0.35-0.71</td>
</tr>
</tbody>
</table>

a) OPA: Occupational physical activity

Figure 1. A question about lifetime exposure to occupational physical activity (OPA) was validated, comparing questionnaire and interview data. An index of OPA was calculated (OPA-index) in each participant in both datasets. The difference between the two OPA-indices is visualized.
3.3 Intra- and inter-rater reliability

3.3.1 Results

3.3.1.1 Intra-rater reliability

Kappa was ‘substantial’ for sedentary work, standing/walking and high OPA (kappa 0.71, 0.62, and 0.64 respectively, table 4). For exposure to ‘moderate OPA’, agreement was ‘moderate’ (kappa= 0.60). In figure 2, intra-rater reliability is shown in a Bland-Altman plot of the agreement in the OPA-index. Intra-rater agreement between initial ratings and blinded ratings three months later was high, but full agreement between the judgments was not obtained.

3.3.1.2 Inter-rater reliability

In figure 3, inter-rater reliability is shown, plotting the primary rater against each of the three experts. Inter-rater reliability is high in low OPA-indices but increases with higher OPA-indices. In general, the primary rater tends to score the OPA-index higher than the other experts.

Table 4. Intra-rater reliability. Test-retest.

<table>
<thead>
<tr>
<th>Exposure to a) ‘sedentary’</th>
<th>Kappa</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.71</td>
<td>0.48-0.95</td>
</tr>
<tr>
<td>Exposure to b)/ ‘standing and walking’</td>
<td>0.62</td>
<td>0.42-0.82</td>
</tr>
<tr>
<td>---------------------------------------</td>
<td>------</td>
<td>----------</td>
</tr>
<tr>
<td>Exposure to c)/ ‘moderate OPA\textsuperscript{a}’</td>
<td>0.60</td>
<td>0.40-0.80</td>
</tr>
<tr>
<td>Exposure to d)/ ‘high OPA\textsuperscript{a}’</td>
<td>0.64</td>
<td>0.31-0.96</td>
</tr>
</tbody>
</table>

\textsuperscript{a}) OPA: Occupational physical activity

**Figure 2**
Intra-rater reliability was evaluated by a blinded re-judgment of exposure to occupational physical activity (OPA) three months after the initial judgment. The difference between the two OPA-indices was visualised against the mean of the indices in a Bland-Altman plot.

![Intra-rater reliability plot](image)

**Figure 3.** Three skilled occupational physicians judged the exposure to occupational physical activity (OPA) in 34 participants, based on data from interviews. The difference in the individual OPA-index between the primary rater and each of the three skilled physicians is visualized.
3.3.2 Discussion

The reproducibility of self-reports gives an upper boundary for reliability and validity, and we did not test the reliability of self-reports because it has been done in many studies before. In a review by Stock, it is concluded that the reliability of workers’ self-reports about general body postures (e.g. sitting and standing) is ‘good to excellent’, and questions about level of physical effort at work showed very good reproducibility (Stock et al., 2005). According to reliability of expert judgments, we found good agreement in sedentary jobs but lower agreement in the rating of more physically strenuous jobs. D’Souza found that inter-rater agreement for physical exposure in job-categories was low, except for “sitting position”, but the rating procedure was complicated due to heterogeneous exposure-groups (D’Souza et al., 2007). Retrospective expert-rating has shown good reliability concerning assessment of chemicals, whereas ergonomic exposures have not been studied thoroughly (Siemiatycki et al., 1997). Expert judgments are often seen as “gold standard”, but even this method has pitfalls (Fritschi et al., 2003).

4. CONCLUSION

Self-reports of lifetime exposure to sedentary work are valid in our cohort, but summing up exposure to occupational physical activity through work-life in one question is a challenge to the respondent. In our subsequent epidemiological study about work and ageing, we will supplement self-reports with information from a Job Exposure Matrix. Qualitative methods are useful in evaluation of survey questions, thus also in occupational medicine, and should be included in future studies of validity of exposure assessment.
ACKNOWLEDGEMENTS

AM is funded by The Danish Working Environment Research Fund and the Danish Ministry of Employment and the funders have no role in the design of the study, the data collection and analysis and interpretation of data nor in the writing of the manuscript.

Authors thank Helle Bruunsgaard, Nils-Erik Fiehn, Åse Marie Hansen, Poul Holm-Pedersen, Rikke Lund, Erik Lykke Mortensen and Merete Osler, who initiated and established the Copenhagen Aging and Midlife Biobank from 2009-2011 together with Kirsten Avlund. The authors acknowledge the crucial role of the initiators and steering groups of the Metropolit Cohort, The Copenhagen Perinatal Cohort, and The Danish Longitudinal Study on Work Unemployment and Health.

COMPETING INTERESTS

The authors declare no conflicts of interest.

AUTHORS’ CONTRIBUTIONS

AM, JHA, OSM and SR planned the study together with KA. KA was responsible for the CAMB data collection. AM interviewed the participants and made the first draft of the article. JHA, OSM, SR and KA made substantial contributions to the analysis and interpretation of data. They drafted the article critically for important intellectual content and all authors have read and approved the final manuscript.

ETHICAL APPROVAL

The study was presented to the Ethics committee, but the general approval of the CAMB project covered this project (The CAMB project was approved by the Regional Committee on Biomedical Research Ethics, Capital Region, Registration Number H-A-2008-126). “The Danish Data Protection Agency” refused registration of this project, because the questions in both cognitive and semi-structured interviews were only work-related.

REFERENCES


**DEFINITIONS, ACRONYMS, ABBREVIATIONS**

OPA: Occupational Physical Activity
CAMB: Copenhagen Aging and Midlife Biobank
QAS: The Question Appraisal System

**APPENDIX**

Appendix 1.
Question 32 in Danish from the questionnaire and an English translation. Groups of OPA below.

32. Når du ser tilbage på hele dit arbejdliv:
   (Du må gerne svare i mere end én kategori)

   a. Hvor mange år af dit arbejdliv har du haft mest stillesiddende arbejde, som ikke kræver fysisk anstrengelse?
   b. Hvor mange år af dit arbejdliv har du haft mest stående eller gående arbejde, som ikke kræver fysisk anstrengelse?
   c. Hvor mange år af dit arbejdliv har du haft mest stående eller gående arbejde med en del løfte- eller bærearbejde?
   d. Hvor mange år af dit arbejdliv har du haft mest tungt eller hurtigt arbejde, som er fysisk anstrengende?

32. Looking back on your entire working life:
   (You may answer in more than one category)

   a) For how many years of your working life have you had mostly sedentary work without physical strain?
   b) For how many years of your working life have you had mostly standing or walking work without major physical activity?
   c) For how many years of your working life have you worked mostly standing or walking with some lifting and carrying?
   d) For how many years of your working life have you had to work mostly at a high speed, with heavy and physically demanding work.

Categories of occupational physical activity (OPA) used in the study according to question 32:

   a): Sedentary work
   b): Standing and walking
   c): Moderate OPA
   d): High OPA
Appendix 2. The OPA-index

We created an arbitrary index of occupational physical activity (OPA), based on answers about lifetime OPA in the questionnaire. It was necessary to construct an index eliminating overlap, while many respondents had written 40 years of employment in more than one category. Filling out both category c) and d) was interpreted as the job having included elements of both moderate and high physical activity.

In the index, it is assumed that category d) has OPA 70% of the time and c) has 20% OPA. Having a job that primarily includes ‘standing and walking’/b) has OPA 10% of the time, and a job ‘mostly sedentary’ has 0% of OPA. The index is a summation of OPA in years divided with the total duration of employment.

An example:

a) A bricklayer working for 40 years in the same job categorized as d):
   
   OPA-index: \((0.7*40)/40=0.7\).

b) A nurse working in a clinical department for 20 years categorized as c), and in an administrative job for 10 years categorized as a).
   
   OPA-index: \((0.2*20+0*10)/(10+20)=0.13\).

c) A confectioner working for 30 years wrote “30 years of exposure” in both b), c) and d) in the questionnaire. Therefore, total years of exposure are 90 years.

   OPA-index: \((0.7*30+0.2*30+0.1*30)/(30+30+30)=0.33\). 