Occupational Sitting and Health Risks

A Systematic Review

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Context: Emerging evidence suggests that sedentary behavior (i.e., time spent sitting) may be negatively associated with health. The aim of this study was to systematically review the evidence on associations between occupational sitting and health risks.

Evidence acquisition: Studies were identified in March–April 2009 by literature searches in PubMed, PsycINFO, CENTRAL, CINAHL, EMBASE, and PEDro, with subsequent related-article searches in PubMed and citation searches in Web of Science. Identified studies were categorized by health outcome. Two independent reviewers assessed methodologic quality using a 15-item quality rating list (score range 0–15 points, higher score indicating better quality). Data on study design, study population, measures of occupational sitting, health risks, analyses, and results were extracted.

Evidence synthesis: 43 papers met the inclusion criteria (21% cross-sectional, 14% case–control, 65% prospective); they examined the associations between occupational sitting and BMI (n=12); cancer (n=17); cardiovascular disease (CVD, n=8); diabetes mellitus (DM, n=4); and mortality (n=6). The median study-quality score was 12 points. Half the cross-sectional studies showed a positive association between occupational sitting and BMI, but prospective studies failed to confirm a causal relationship. There was some case–control evidence for a positive association between occupational sitting and cancer; however, this was generally not supported by prospective studies. The majority of prospective studies found that occupational sitting was associated with a higher risk of DM and mortality.

Conclusions: Limited evidence was found to support a positive relationship between occupational sitting and health risks. The heterogeneity of study designs, measures, and findings makes it difficult to draw definitive conclusions at this time.

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Introduction

In epidemiologic studies focusing on the benefits of physical activity, those who are physically inactive have typically been described as sedentary.[1] However, the term *sedentary behavior* has begun to be used to describe prolonged sitting, instead of the absence of physical activity. Sedentary behaviors usually have very low energy expenditure (typically less than 1.5 METs; multiples of the basal metabolic rate).[2] There is a rapidly expanding body of evidence[3–9] suggesting that time spent in sedentary behaviors is associated adversely with health risks, which may be independent of the protective contributions of physical activity.

Prior to the 1970s, physical activity epidemiology studies focused on occupational activity. For example,

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in their landmark studies on occupational activity in 1953, Morris et al.[10] observed higher rates of cardiovascular events in sedentary bus drivers and mail sorters than in more active bus conductors and postal workers. Since then, as transport and work have become more automated, the focus of most physical activity studies, especially in the large cohort studies, has been on leisure-time physical activity. However, findings of recent studies have led to a renewed interest in the health effects of prolonged sitting.[11] These have demonstrated associations of sitting time with obesity,[4,6,7] metabolic syndrome and diabetes,[3,6] markers of cardiovascular disease risk,[7,9] and premature mortality.[5,8] The associations between sitting time and health outcomes in these studies may be independent of physical activity participation, as they remained significant after adjustment for physical activity.[3–9] These studies have mainly addressed sitting during leisure time rather than occupational sitting, with a particular focus on TV-viewing time.

Sitting in an occupational context is also likely to be important, given that many adults in Western, developed countries are in occupations that require prolonged sitting time. For example, in Australia and the U.S., about two thirds of adults are employed, 83% of these in full-time work (>35 hours/week).[12,13] Data from the Netherlands and Australia suggest that working adults can spend up to half their work day sitting down.[14,15] In the U.S., time-use surveys have shown that people in full-time employment spend an average of 9.2 hours working on weekdays,[16] much of which will involve sitting. In contrast, they spend an average of just over 2 hours per day watching TV and playing (computer) games.[16] A study[14] of Australian workers found that those working full-time sit for an average of 4.2 hours per day at work, and spend 2.9 hours in leisure-time sitting. Thus, for full-time employees in physically inactive jobs, occupational sitting is likely to be the largest contributor to overall daily sitting time.

In the context of these major contributions of occupational sitting to working adults' overall sitting time, and the high percentages of adults employed in mainly sedentary occupations, there is a need to clarify the strength of evidence on the potentially deleterious impact of prolonged sitting at work. Thus, the aim of this systematic review was to critically review and summarize the evidence from studies that have examined associations between occupational sitting and the risk of lifestyle diseases, or markers thereof.

See related Commentary by Marshall in this issue and watch related pubcast at www.ajpm-online.net.

Evidence Acquisition

Literature Search

In March–April 2009, the databases PubMed, PsycINFO, CENTRAL (The Cochrane Central Register of Controlled Trials), CINAHL, EMBASE, and PEDro were searched for relevant studies (full search for all databases, except for the EMBASE, which was searched from 1980). Groups of thesaurus terms as well as free terms were used to search the databases. Terms for *adults* were used in AND-combination with terms for *workplace setting*, *sitting*, and search terms representing study designs and languages. Subsequently, the librarian performed a related-articles search in PubMed and a citation search in Web of Science for selected papers. Further, additional articles were identified by manually checking the reference lists of included papers and searching the authors' own literature databases.

Inclusion Criteria and Selection Process

In order to be included in the review, studies were required to (1) focus on adults; (2) use a specific measure of occupational sitting (categoric or continuous; self-report or objective), or of occupational activities below 1.5 METs; (3) examine the association between occupational sitting and the risk of lifestyle diseases, or markers thereof, or mortality. Only full-text peer-reviewed articles were considered for inclusion. Papers written in Chinese, Dutch, English, French, German, Italian, Norwegian, and Spanish were checked for eligibility. Titles and abstracts of the identified references were reviewed to exclude articles out of scope. Subsequently, two reviewers independently reviewed the full text of all potentially relevant references for eligibility. Disagreements between these reviewers were discussed with two more reviewers and a consensus decision was made.

Data Extraction and Quality Assessment

Data on the study population, measure of occupational sitting, health risks, analyses, and results were extracted for each paper. Papers describing multiple health risks[6,17–19] were included in each of the relevant tables. The studies describing the associations of occupational sitting with all-cause, cardiovascular, and cancer mortality were clustered in one table. Methodologic quality of the included studies was independently determined by two reviewers using a quality rating list based on checklists for the reporting of observational studies and a list used for quality rating.[20–22] This quality rating list consisted of 15 criteria assessing different methodologic aspects (Table 1). Criteria had a *yes* (1 point); *no* (0 points); or *unclear* (0 points) answer format. All criteria had the same weight, and a quality score ranging from 0 to 15 points was calculated for each study.

Terminology Used in the Review

In this review, the term *occupational sitting* is used as an umbrella term in the abstract, introduction, and discussion. However, in the results section, the term *occupational activity* is used

Table 1. Criteria for quality assessment and the number (%) of studies scoring a point for each separate item[a]

Item	Criterion	Description	*n* (%)
1	Objectives	Are the objectives or hypotheses of the research described in the paper stated?	43 (100)
2	Study design	Is the study design presented?	43 (100)
3a	Target population	Do the authors describe the *target* population they wanted to research?	41 (96)
3b	Sample	Was a random sample of the target population taken? AND was the response rate 60% or more?	28 (65)
3c	Sample	Is participant selection described?	42 (98)
3d	Sample	Is participant recruitment described, or referred to?	16 (37)
3e	Sample	Are the inclusion and/or exclusion criteria stated?	36 (84)
3f	Sample	Is the study sample described? (minimum description=sample size, gender, age and an indicator of SES)	26 (61)
3g	Sample	Are the numbers of participants at each stage of the study reported? (Authors should report at least numbers eligible, numbers recruited, numbers with data at baseline, and numbers lost to follow-up)	37 (86)
4	Variables	Are the measures of occupational sitting and the health outcome described?	42 (98)
5a	Data sources and collection	Do authors describe the source of their data (e.g., cancer registry, health survey) AND did authors describe how the data were collected? (e.g., by mail)	42 (98)
5b	Measurement	Was reliability of the measure(s) of occupational sitting mentioned or referred to?	4 (9)
5c	Measurement	Was the validity of the measure(s) of occupational sitting mentioned or referred to?	10 (23)
6a	Statistical methods	Were appropriate statistical methods used and described, including those for addressing confounders?	41 (95)
6b	Statistical methods	Were the numbers/percentages of participants with missing data for sitting and the health outcome indicated AND If more than 20% of data in the primary analyses were missing, were methods used to address missing data?	33 (77)

[a]Quality assessment for each paper is shown in Appendix A (available online at www.ajpm-online.net).

if papers used a categoric measure of activity, with sitting or sedentary as the reference category. In contrast, if a paper used the highest level of occupational activity as the reference category (often heavy labor), or compared categories of sitting time, then the term *occupational sitting* is used. For consistency, the term *occupational sitting* is used in the beginning and concluding sentences for each health risk in the results.

Evidence Synthesis

Study Selection

The literature searches yielded 3202 unique potentially relevant articles (Figure 1).[23] After excluding the records out of scope, the full text of 355 records was checked. In all, 312 of these articles did not meet the inclusion criteria; the most common reason for exclusion was that there was no measure of occupational sitting (number of studies [*n*]=232, 70%). Finally, 43 papers examining the associations between occupational sitting and the following health risks were included in this review: BMI (*n*=12); cancer (*n*=17); CVD (*n*=8); DM (*n*=4); and mortality (*n*=6).

Quality Assessment

The criteria for quality assessment and the number and proportion of studies scoring a point for each quality criterion are reported in Table 1. The agreement between

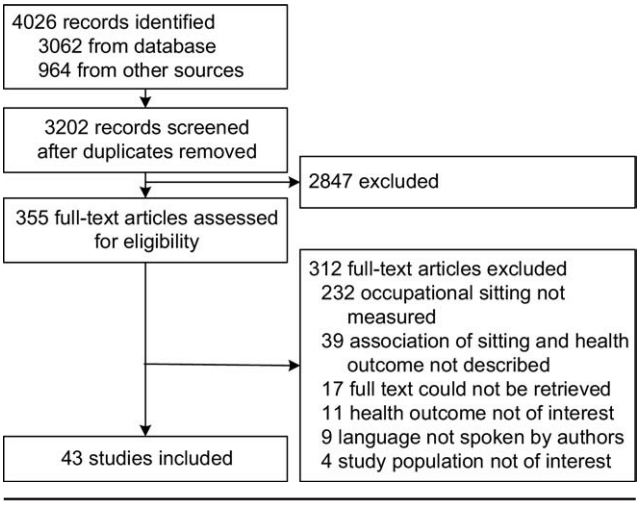

Figure 1. Information flow through the phases of the review

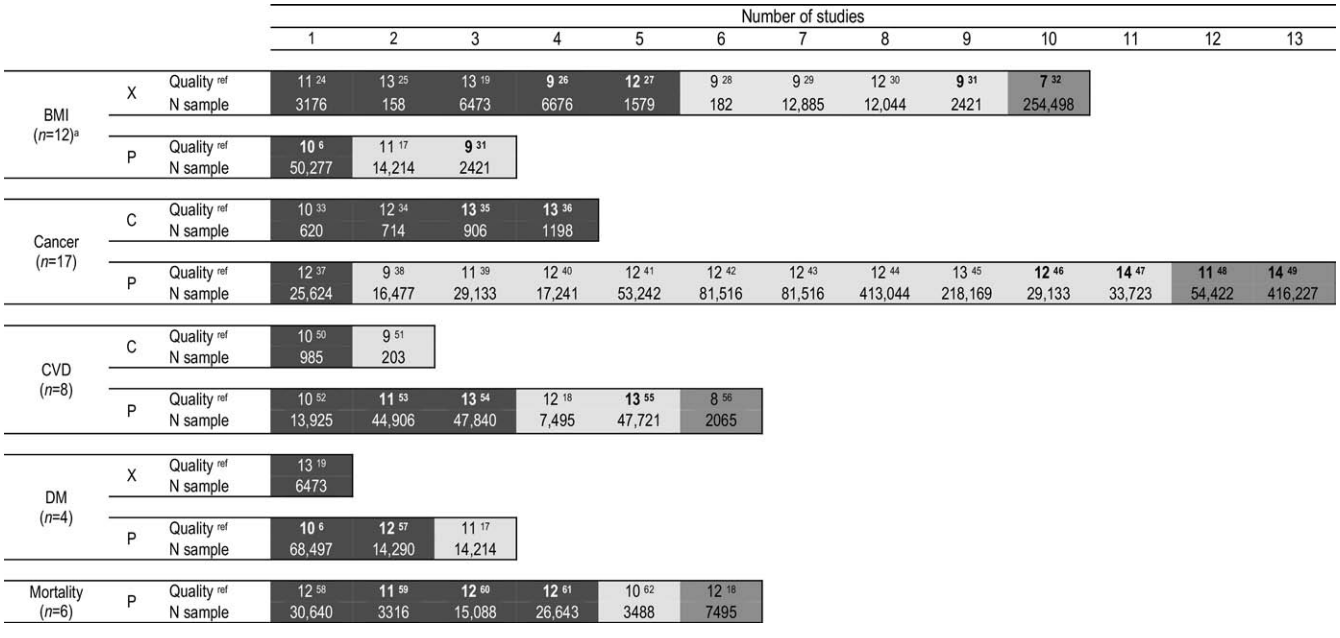

Figure 2. General overview of study designs, findings, quality scores, adjustment for physical activity and sample sizes (ordered by increasing quality score, within categories of adjustment for physical activity, findings based on adjusted analysis if presented in included papers)
[a]Number adds up to 13, because one study[31] reports both cross-sectional and prospective findings
Dark shading = sitting associated with higher risk; light shading = no association; medium shading = sitting associated with lower risk. Bold font = analysis adjusted for physical activity.
C, case–control study; CVD, cardiovascular disease; DM, diabetes mellitus; P, prospective study; Quality, quality score (range 0–15 points, higher score indicates better quality); ref, reference; X, cross-sectional study

the quality raters ranged from 10/15 to 15/15, and the mean percentage agreement was 87 (SD=9). The median quality score for the included papers was 12 (25th–75th percentiles=10–12) points of 15. Hypotheses and study design were reported for all studies, and more than 90% of the included studies scored a point for identifying the target population, the source of the data, variables included in the analyses, and for the use of appropriate statistical methods. Very few studies reported the validity (ten studies) or reliability (four studies) of the measure used for occupational sitting. See Appendix A (available online at www.ajpm-online.net) for the quality assessment of each paper included in this review.

General Findings

For each outcome, an overview of study designs, findings, quality scores, adjustment for physical activity, and sample sizes is presented in Figure 2. There were no evident differences in quality scores of studies finding (1) that occupational sitting was associated with an increased health risk (n=22, of which 12 adjusted for physical activity); (2) that there was no association (n=20, four adjusted for physical activity); or (3) that sitting was associated with a decreased health risk (n=5, three adjusted for physical activity).

Associations of Occupational Sitting with BMI, Waist Circumference, and Waist-to-Hip Ratio

Twelve studies examined the association between occupational sitting and BMI (Figure 2, details in Appendix B, available online at www.ajpm-online.net). Nine studies[19,24–30,32] used a cross-sectional design, two[6,17] were prospective, and one study[31] reported both cross-sectional and prospective data. Participant numbers ranged from 158 in one study[25] to more than 250,000.[32] All studies used self-report measures of occupational sitting. Three studies, two[26,27] with a cross-sectional design and one[6] prospective, used a continuous measure for occupational sitting time and then categorized data for the analyses. The other studies used a categoric measure of occupational sitting with descriptive categories (e.g., *most of the time* versus *hardly ever*)[25] or a categoric measure of occupational activity with *sitting* or *sedentary* as one of the response options.[17,19,24,28–32] Six studies used a dichotomized outcome for BMI with cut-offs of 25 kg/m^2,[27] 30 kg/m^2,[6,29–31] or 27 kg/m^2.[32] Three studies[19,24,28] used multiple BMI categories, and four[17,25,26,30] analyzed BMI as a continuous outcome. In addition to BMI, one study[28] also examined the association between occupational sitting and waist circumference and another study[26] examined waist-to-hip ratio.

Five of the ten cross-sectional studies reported a significant positive association between occupational sitting and BMI; one[27] for BMI ≥25 (in men, but not in women); one[26] for BMI as a continuous outcome (in men, but not in women); and one[25] in a study including women only. The other two studies[19,24] reported that men with a higher BMI were more likely to have a sedentary job. The results of these five cross-sectional studies were adjusted for at least sociodemographic variables, such as age and education, except for one study[25] that reported unadjusted results only.

One cross-sectional study[32] found that Norwegians who reported being active at work (*walking*, *walking and lifting*, or *heavy activity in the last year*) had higher odds of having a BMI ≥27 kg/m^2 than participants who were *mostly sitting* during work. Another study[30] also found that a higher level of occupational activity was associated with higher BMI, and increased odds of having a BMI ≥30 kg/m^2 (only in women). However, this association did not remain significant after adjustment for sociodemographic and lifestyle factors and health. In other cross-sectional studies, occupational activity was not associated with obesity,[29,31] or with waist circumference,[28] but sedentary hours per working day were positively associated with waist-to-hip ratio, although in women only.[26]

Two of the three prospective studies reported no significant positive associations between sitting and the maintenance or development of obesity[31] or between sitting and BMI.[17] One study[6] found a significant trend for increased obesity risk across categories of sitting time; however, the difference was only significant for women who sat more than 40 hours/week compared with those who sat <1 hour/week.

In summary, five of the ten cross-sectional studies showed a positive association between occupational sitting and BMI, but four studies found no association and one study found a negative association. Of the three prospective studies, one found a positive association, but the other two found no association.

Associations Between Occupational Sitting and Cancer

Seventeen studies described the association between occupational sitting and various cancers (Figure 2).[33–49] Details of these studies are provided in Appendix C (available online at www.ajpm-online.net); the studies are arranged according to the type of cancer, including breast cancer (n=3)[33,37,45]; endometrial and ovarian cancer (n=3)[35,36,47]; colon and rectal cancer (n=4)[34,38,42,44]; renal and pancreatic cancer (n=3)[39,40,46]; prostate and testicular cancer[41]; and lung cancer (n=3).[43,48,49]

Four[33–36] of the 17 studies were case–control studies and the other 13 were prospective studies. The number of participants was less than 1000 in three[33–35] of the case–control studies and 1,198 in the fourth study.[36] Participant numbers in the prospective studies ranged from 16,477[38] to 416,227.[49] The mean follow-up duration for the prospective studies was 12.0 (SD=5.0) years, and ranged from 5 to 22.6 years. All studies, except one, used a categoric measure of occupational activity, with *mostly sedentary/mainly sitting* as one of the response options. The case–control study that directly assessed sitting time as a continuous measure (hours/day) then categorized it for the analyses.[35]

Three case–control studies[33,35,36] and three prospective studies[37,45,47] included women only. These examined breast cancer,[33,37,45] ovarian cancer,[35,36] and endometrial cancer.[47] Compared with breast cancer risk in *sedentary/mainly sitting workers,* one study[45] found no association between *standing* and *manual and heavy manual work* and breast cancer risk, and two[33,37] found that more occupational activity was associated with lower breast cancer risk. However, in the Norwegian study[37] this was the case for premenopausal women only. The studies examining ovarian cancer found that *light, moderate,* or *strenuous* occupational activity was associated with lower cancer risk compared with *sitting*[36] and that more sitting was associated with increased cancer risk.[35] There was no association between occupational sitting for more than half of working time and endometrial cancer.[47]

Three prospective studies[38,42,44] and one case–control study[34] examined the association between occupational activity and colon and rectal cancer in men and women. There was no significant association between categories of occupational activity and risk of cancer in the prospective studies. However, in the case–control study,[34] *standing* or *tiring occupational activity* was associated with a lower risk of colon or rectal cancer (compared with *mainly sitting*).

Two prospective studies, one in men and women[40] and one in men only,[46] found that there was no association between occupational activity and risk of renal cell cancer. Other studies in only men found that this was also the case for pancreatic cancer[39] as well as prostate and testicular cancer.[41]

The association between occupational sitting and lung cancer was also examined in three prospective studies.[43,48,49] Two of these studies[48,49] found a higher lung cancer risk for *standing* versus *sitting during work/sedentary*, although in one study[49] this was true for men only. The third study[43] concluded that occupational activity was not associated with lung cancer risk.

In summary, of the 17 studies, only five found that occupational sitting was associated with higher risk of

breast cancer,[33,37] ovarian cancer[35,36] or colorectal cancer.[34] Four of these studies were case–control studies,[33–36] with one prospective study.[37] Ten prospective studies[38–47] found no evidence of an association, and two studies[48,49] observed an increased lung cancer risk in people who were more active at work, compared with those in sedentary jobs.

Associations Between Occupational Sitting and Cardiovascular Disease

Eight papers described the association between occupational sitting and cardiovascular outcomes (Figure 2, details in Appendix D, available online at www.ajpm-online.net), of which three[50,52,53] examined risk of infarction, two[54,56] examined risk of coronary heart disease, and one[18] examined both. Six[18,52–56] were prospective cohort studies, and two[50,51] were case–control studies. All studies used a self-report, categoric measure of occupational activity with *sedentary*, or *mainly sitting*, or *physically very easy sitting office work* as one of the response options, except for one that used a categoric measure with combinations of total occupational sitting time and *time without getting up*.[51]

Compared with having a sedentary occupation, more physical activity at work was associated with a lower risk of infarction[50,52,53] or CVD[54] in four studies. However, two of these studies included overlapping data,[53,54] and in another, a significant association was seen only in the 1960s and early 1970s.[52] In contrast, other papers reported that being more active at work was associated with higher cardiovascular disease risk[56] or that there was no association.[18] The remaining studies concluded that there was no clear association between prolonged sitting and thromboembolism[51] and between occupational activity and stroke,[55] compared with *physically very easy sitting office work*. The latter study, however, observed a lower risk of stroke in people with *high* occupational activity in men and women together, but this association was not present for genders separately.

In summary, the CVD papers showed conflicting results, with four showing an increased risk of CVD outcomes with occupational sitting, three showing no association, and one showing the opposite effect of increased CVD risk with increasing occupational activity.

Associations Between Occupational Sitting and Diabetes Mellitus

Four studies examined the association between occupational sitting and DM, of which one[19] was a cross-sectional study and three[6,17,57] were prospective studies (Figure 2, details in Appendix E, available online at www.ajpm-online.net). All studies used self-report measures; three[17,19,57] used a categoric variable for occupational activity, with *sedentary or physically very easy sitting office work* as a response option and one[6] used a continuous measure of sitting time that was categorized for the analyses. Two studies[6,17] used self-reported DM as the outcome, whereas the remainder derived data on DM from national registers[57] or used DM as diagnosed by a doctor or blood sample.[19]

The cross-sectional study[19] found a decrease in DM risk across categories of increasing occupational activity, compared with *sedentary*. Two of the prospective studies also found a positive association. In one study,[6] compared with occupational sitting of *less than one hour*, more sitting was associated with a higher risk of DM. In another study,[57] more occupational activity was associated with a lower risk of DM, compared with *physically very easy sitting office work*. The third prospective study[17] did not find a significant association across categories of occupational activity and DM. In summary, for DM, two prospective and one cross-sectional study found that sitting was associated with increased risk of DM, whereas one prospective study found no association.

Associations Between Occupational Sitting and Mortality

Six prospective studies[18,58–62] examined the association of occupational sitting with all-cause mortality,[18,58,59,62] cardiovascular mortality,[18,59–62] and cancer mortality[62] (Figure 2, details in Appendix F, available online at www.ajpm-online.net). Follow-up duration was 10–20 years, except for two studies with a follow-up of less than 10 years.[60,62] All six studies used a categoric measure for occupational activity, with *mainly/primarily sitting* or *sedentary work* or *physically very easy sitting office work* as one of the response options.

Compared with a job that involved mainly *physically very easy sitting office work/primarily sitting*, more physical activity during work was associated with lower all-cause mortality in men and women[59] or in women only[58] and lower CVD mortality in samples including both men and women[59,61] and in a sample with unknown gender distribution.[60] One study[18] in middle-aged men found that more occupational activity was associated with a higher level of all-cause mortality, but there was no association with CVD mortality. One study[62] found no association between prevalent working posture (*sitting, standing, walking*) and cancer, CVD, or all-cause mortality.In summary, for mortality, four prospective studies found that sitting was associated with an increased mortality risk, one study found no association, and one study found that sitting was associated with a decreased mortality risk.

Discussion

In this systematic review of the relationships between occupational sitting and health risks, 43 papers were identified that met the inclusion criteria. In those papers, 22 studies were found with (1) cross-sectional and prospective evidence for a positive association between occupational sitting and BMI and DM and (2) case–control and prospective evidence for a positive association of occupational sitting with cancer, CVD, and mortality. However, 20 studies were identified that did not find any association, and five studies found that sitting was associated with a decreased risk of various health conditions.

The World Cancer Research Fund/American Institute for Cancer Research (WCRF/AICR) uses a continuum of five grades, ranging from convincing evidence to substantial effect on risk unlikely, to judge the evidence on causal relationships between behaviors and health risks.[63] The first two WCRF/AICR criteria that must be met for the evidence of a causal relationship to be "convincing" are that there must be (1) evidence from more than one study type and (2) evidence from at least two independent cohort studies. For the outcomes included in this review, these two criteria were met for cancer and CVD only. The third criterion for convincing evidence is that there must be no substantial unexplained heterogeneity within or between studies or in different populations relating to the presence or absence of an association, or direction of effect. As there was substantial heterogeneity in terms of the presence or absence of associations, this criterion was not met for the cancer and CVD studies.

The next level of evidence (probable evidence) also requires that there is no unexplained heterogeneity. This criterion was also not met for the other outcomes in this review (BMI, DM, and mortality). Because of the heterogeneity in study results, which may reflect major differences in study designs, explanatory and outcome variables, the WCRF/AICR grade of evidence at this stage is limited–suggestive (mortality) or limited–no conclusion (BMI, cancer, CVD, DM). This does not indicate that there is no relationship between occupational sitting and these health risks, but that further research is necessary to clarify the evidence.

The WCRF/AICH criteria for convincing evidence are useful as a guide for future research. In order for the evidence to be convincing, three additional criteria, apart from the three already described in the previous paragraphs, must be met: (4) good quality studies to exclude with confidence the possibility that the observed association results from systematic error, and selection bias; (5) the presence of a plausible biological gradient (dose response); and (6) strong and experimental evidence either from human studies or relevant animal models.[63] To provide directions for future research, the evidence in relation to WCRF/AICH Criteria 4, 5 and 6 is considered below for BMI, cancer, CVD, DM and mortality.

Criterion 4

The WCRF/AICH Criterion 4 reads: Are there good quality studies to exclude with confidence the possibility that the observed association results from random or systematic error, including confounding, measurement error, and selection bias? In general, the quality of the studies in this review was good. However, remarkably, few studies reported on the reliability and validity of the sitting time measures. There is encouraging evidence of good reproducibility and validity of self-reported measures of occupational activity, including sitting, although most general occupational activity measures provide only a rough quantification of sitting duration.[64] It is strongly suggested that the measurement characteristics be reported in all future studies.

Adjustment for physical activity in these studies should be a priority. However, less than half of the papers that were reviewed adjusted their analyses for leisure-time physical activity or exercise ($n=19$, of which four were cross-sectional studies). These studies were, overall, more likely to show positive associations between occupational sitting and health risks than those that did not adjust for physical activity; 12/22 studies that found a positive association adjusted for physical activity, whereas only 4/20 in those that found no relationship did this. Some studies that examined the relationships between occupational activity and leisure-time physical activity found that employees in more-active jobs were more likely to be active in leisure time[65–67]; this was especially the case in men.[66,67] However, others found no association between occupational activity and leisure-time physical activity[15] or an inverse association.[68] It is therefore recommended that future studies include measures of both occupational and leisure-time sitting and activity, so that the independent relationships of both sitting and physical activity with health risks can be studied. Future studies should also adjust for socioeconomic and demographic variables and other potential confounders of the relationships between sitting time and health risks, such as alcohol and energy intake and smoking. Adjustment for these variables could limit the potential bias in the relationship between occupational sitting and health risks that could be caused by self-selection (i.e., people with certain characteristics could be more likely to choose a sedentary occupation).[69]

In future studies, consideration should also be given to differentiating between prolonged and "interrupted" sitting at work, as there is cross-sectional evidence that increased breaks in sedentary time are beneficially associated with indicators of metabolic risk.[70]

Criterion 5

The WCRF/AICH Criterion 5 reads: Is there a plausible biological gradient ("dose response")? Evidence of dose–response relationships plays an important role in gathering evidence for causal relationships. The majority of studies in this review used a categoric measure of occupational activity and compared the outcomes in more active workers with the risk in sedentary workers. Only two case–control[35,51] and one prospective study[6] compared the risk across different amounts of occupational sitting. The lack of occupational sitting measures with quantification of the amount of time spent sitting may have contributed to the lack of significant associations between occupational sitting and health. A recent study,[71] which included a measure of leisure-time sitting and a measure of occupational activity, found that people sitting more than 4 hours in leisure had almost double the risk of metabolic syndrome than those sitting less than 1 hour, whereas there was no association between occupational sitting (*sit during the day and do not walk about very much*) and metabolic syndrome, compared with a higher level of occupational activity. Future studies should consider the inclusion of a sitting measure with a quantification of sitting duration that allows for the analysis of dose–response relationships; objective measures may be the optimal method for doing this.[72]

Criterion 6

The WCRF/AICH Criterion 6 reads: Is there evidence from human or animal studies that occupational sitting can lead to the health outcome of interest? There is emerging animal and human evidence for biological plausibility of an association between sitting and health risks. The chronic, unbroken periods of muscular unloading associated with prolonged sitting time may have deleterious biological consequences.[73,74] Physiologically, it has been suggested[73,74] that the loss of local contractile stimulation induced through sitting leads to both the suppression of skeletal muscle lipoprotein lipase activity (which is necessary for triglyceride uptake and high-density lipoprotein cholesterol production), and reduced glucose uptake through blunted translocation of GLUT-4 glucose transporters to the skeletal muscle cell surface. A more detailed account of these important mechanistic studies has been provided in several recent reviews.[1,75] From a behavioral perspective, prolonged sitting can displace the opportunity for engagement in light-intensity, incidental activities, which can lead to a reduction in whole-body energy expenditure.[76] Sitting may also promote excess energy consumption (snacking),[77] which is likely to contribute to a positive daily energy balance and poor metabolic outcomes.[78]

This is the first systematic review to examine the associations between occupational sitting and BMI, DM, CVD, cancer, and mortality. The strengths of this review are the extensive search strategies and the fact that papers in numerous languages were considered for inclusion. A limitation of the review is the possibility that relevant papers may have been missed, as the search was complicated by the lack of standard search terms for occupational sitting. However, the search in the primary databases was complemented with other search strategies. Another limitation is that the majority of criteria for the quality assessment in this review rated whether specific study characteristics were reported in the included papers, rather than rating the study quality on the basis of these characteristics.

Although 43 papers have examined the associations between occupational sitting and health risks, the wide heterogeneity of study findings led us to conclude that, using the WCRF/AICH criteria for judging causal relationships, there is at this time only limited evidence in support of a positive relationship between occupational sitting and health risks. Although the quality of most studies was good, it will be important to include specific measures of sitting time with demonstrated reliability and validity in future studies, as this will enable dose–response issues to be examined. The lack of such measures of sitting time and failure to account for the effects of leisure-time sitting and physical activity make it difficult to draw firm conclusions at this stage.

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Appendix

Supplementary data

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.amepre.2010.05.024.