What's wrong with sitting?

A research review of the risks associated with sedentary/sitting behaviour

Wellnomics® White Paper

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Introduction

"Sitting is the new smoking!"

This is the alarming phrase seen in the media recently[1,2,3,4]. So is sitting really so bad for you? And is it really reasonable to compare its risks with something like smoking?

Perhaps surprisingly, recent research does support there being significant risks associated with sedentary behaviour, where sedentary behaviour basically means spending long periods sitting during the day. The risks include musculoskeletal discomfort, metabolic syndrome, type II diabetes, cardiovascular disease, cancer, and mortality (or "premature death", to use another alarming phrase from the media).

Worryingly, recent evidence also suggests that these health risks are independent of whether you do regular physical exercise. Even if you run three times a week and go to the gym regularly it appears you may still have an increased health risk if you're sitting most of the day[5]. This has significant implications for organisations and office workers. It is important that this problem is understood and that there is clarity around ways to manage the risk.

This paper summarizes the current research on the health risks related to sitting, based upon an extensive literature review of the published and peer-reviewed research in this area[†].

A further paper will look at the research on how best to address this risk and the effectiveness of different interventions that can be considered in a workplace, such as the use of sit stand desks.

The health risks of sitting

There has been a surge of interest recently in the health risks of sitting, spurred by the recognition that in the developed world people are leading increasingly sedentary lives. This sedentary behaviour includes computer-based office work, sedentary leisure, such as TV watching and screen-based entertainment, and sedentary commuting such as cars and public transport. As people's lives have become increasingly sedentary there has been a concurrent increase in medical conditions such as heart disease, diabetes, obesity and cancer which are associated with enormous public health costs. In addition, research into sedentary behaviour has been enhanced by technology allowing people's movements, or lack thereof, to be objectively measured. Although previous research relied on self-reports of sedentary behaviours the latest research has been able to make use of small, portable accelerometers to measure the intensity and frequency of activity and thereby obtain increasingly accurate and objective measures of real activity levels[6].

Sedentary behaviour involves very low energy expenditure, less than 1.5 METs[‡], meaning the person may be sitting (or lying down) and have little whole-body movement. It is important to note that this is not the same as physical inactivity which is measured by the absence of health-enhancing exercise[7] such as

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[†] This literature review was conducted using five databases - EBSCO Academic Search Premier, SCOPUS, CINAHL, Ergonomic abstracts and MedLine. The search terms used separately and in combination were: sit-stand desk, sit-stand workstation, standing work, prolonged sitting work, computer users, sedentary work, and health outcomes. Abstracts were read and the full paper sourced if it was considered relevant. Additional relevant references were sourced from the reference lists included in articles.

[‡] METs is 'metabolic equivalents of task', a physiological measure expressing the energy cost of physical activities

walking, cycling or physical exercise like running, playing sports or going to the gym. The problem is that people can achieve or exceed the public health guidelines for physical exercise (generally recommended as 150 minutes per week of moderate to vigorous exercise) but still be sedentary or sitting most of the day. This has been called the '*active couch potato*' phenomenon and some studies have found that healthy, physically active adults still have negative health markers associated with, for example, high levels of TV watching, that is, long periods spent sitting[5]. So moderate intensity exercise doesn't appear to offset the health risks of sedentary behaviour to the degree previously thought.

A number of systematic reviews and meta-analyses have been published recently on this subject and the results of these are looked at in more detail here, with a specific focus on the evidence for increased risks of musculoskeletal pain, metabolic syndrome and diabetes, cardiovascular disease, cancer and mortality related to sitting and sedentary behaviour. By combining the results from multiple studies, scoring the quality of each study (e.g. its methodological strength) and identifying findings with strong evidence across multiple studies, these meta-analyses can provide stronger conclusions than those available from any one single study.

Sitting and musculoskeletal pain

Research has shown that a flexed back posture is common in office work, with low activation of lumbar muscles[8,9]. This may lead to a sustained passive stretch of lumbar structures and exacerbate low back pain. This said, reviews of sedentary behaviour and low back pain, neck pain, shoulder pain, hand pain and arm pain suggest there is limited evidence of an association specifically between sedentary work and musculoskeletal pain and discomfort[10]. What this means is that sitting per se doesn't give you pain, rather these type of problems are more likely to be associated specifically with poor postures (e.g. excessive neck extension, raised shoulders), intense keyboard and mouse work, working techniques and psychosocial factors[11,12]. This suggests that interventions that reduce sitting may only have an effect on musculoskeletal pain if they also result in postural or behavioural changes (such as taking more breaks).

Sitting, metabolic syndrome and type 2 diabetes

Metabolic syndrome refers to a group of metabolic risk factors for developing diabetes. Metabolic syndrome is commonly defined by central obesity (waist circumference) plus any two of the following risk factors: raised blood pressure, raised triglycerides, reduced high density lipoprotein (HDL) cholesterol and raised fasting plasma glucose.

Identifying metabolic syndrome in individuals is important as its presence increases the risk of diabetes, cardiovascular events (e.g. heart attacks or strokes) and mortality[13]. Metabolic syndrome is linked to multiple factors, but research has shown it is also associated with too much sitting.

A meta-analysis of 10 studies[13] found greater sitting time increased the odds of metabolic syndrome by 73%. The surprising result, as alluded to earlier, was that participation in physical exercise did not change the result. The correlation between increased sitting and metabolic syndrome was consistent across multiple studies and independent of gender, the method used to measure the sedentary behaviour and the income of the study participants' country.

What about diabetes? Several reviews of multiple studies have all found strong evidence for a relationship between sedentary behaviour and type 2 diabetes[14,15,19]. Comparing those most sedentary with those

least sedentary in one review[14] a hazard ratio of 1.9 was found, meaning a nearly doubling of the risk of diabetes, and another review found a 112% increase[15], more than doubling the risk of diabetes.

A prospective study looking at adults with a parental history of type 2 diabetes found that increasing sedentary time was related to increased metabolic syndrome risk independent of physical exercise[16]. Thus, if you have a family history of diabetes then being sedentary further increases your risk of also developing diabetes. The authors suggested that,

"Decreasing sedentary time by 2 h/day would be associated with an approximately 7% lower risk of cardiovascular events" p.309[16]

where cardiovascular events are referring to an event such as a heart attack or a stroke.

A meta-analysis looking at just occupational sitting (i.e. sedentary work such as office work) found 3 out of the 4 studies reviewed showed an increased risk of diabetes associated with sitting at work[17].

Overall the evidence strongly indicates that:

Extended sitting almost doubles the risk of metabolic syndrome

Extended sitting doubles the risk of diabetes

The increased risk does not appear to be significantly reduced by regular physical exercise

Sitting and strokes/heart attack

Cardiovascular diseases are a group of disorders of the heart and blood vessels which can lead to "cardiovascular events" such as stroke and heart attacks. These are the leading cause of death globally[18]. Risk factors for cardiovascular disease include unhealthy diet, physical inactivity and smoking, with the effects showing up as high blood pressure, raised blood glucose and lipids, and being overweight or obese. The latest research reviews indicate that cardiovascular disease events like stroke and heart attacks are also associated with too much sitting.

Cardiovascular disease events

Multiple research reviews[10,14,15] have found significant associations with sedentary time and the incidence of cardiovascular disease, including an increased association with death from cardiovascular disease[14]. One meta-analysis cited by found that every 2 hours per day of sitting time was associated with a 17% increase in stroke and heart attacks (cardiovascular events)[10]. Another study looking at the number of hours sitting, a prospective study on 71,000 Danish adults found 10+ hours of daily sitting was associated with a 38% increase in stroke and heart attacks (cardiovascular events) when compared with sitting less than 6 hours[26]. One review of 18 studies found a significant 147% increase in the risk of stroke and heart attacks amongst those sitting the longest compared with those sitting the least[15].

A review that specifically examined occupational sitting (i.e. sitting at work) found there was less consistency in the results when specifically looking at the association between prolonged sitting at work and cardiovascular disease. Four studies showed a positive association, three showed no increased risk and one showed that there was increased cardiovascular risk with increasing occupational activity[17].

Many of these studies found some protection from regular physical exercise – with the risks being reduced for those that had regular exercise. However, it is important to note that although physical exercise appears to provide some protection from the increased health risks associated with sitting, it does not appear to fully compensate for it. In other words, even with significant exercise prolonged sitting is still associated with an increased risk of cardiovascular events (e.g. heart attacks, stroke).

Cardiovascular disease biomarkers

Although one review of prospective studies found insufficient evidence of a link between sedentary behaviour and biomarkers for cardiovascular disease such as cholesterol, leptin and insulin[19], another review comparing cardiovascular and diabetes biomarkers did find an association with television-viewing and weaker associations with sitting at work[20]. This may be because there are adverse socio-economic and lifestyle factors associated with television-viewing, for example snacking, which are not present in the workplace. As with the studies looking at cardiovascular events the link between sedentary time and cardio-biomarkers is much less pronounced when people are fitter[21].

To summarise, the best evidence to date suggests that:

> Sitting is associated with a significantly increased risk of stroke and heart attack of 38% to 147%
>
> The risk is dose dependent – the longer you sit, both at work and during leisure, the greater the risk, and is only partially offset by regular exercise
>
> The risks are not clearly detected by biomarkers

Sitting and cancer

An extra cause for concern is that sitting has also been associated with a variety of cancers. Some recent reviews have found sedentary behaviour associated with increased colorectal, endometrial, ovarian and prostate cancer risk[7,10], although the authors cautioned there was insufficient accumulation of evidence at that time to make firm conclusion about the associations. More recent reviews in the last year reported a 30%[22] greater risk of colon cancer and a 13%[14] overall increased risk of cancer for people who spend a lot of time sitting – risks which were again found likely to be independent of physical exercise[23].

Looking specifically at occupational sitting the evidence is less clear. One review considered 17 studies exploring a relationship between sitting at work and cancer[17]. Although 10 of these studies found no evidence of an association, 5 did find occupational sitting was associated with higher risk of breast, ovarian or colorectal cancer.

Overall, there are indications that too much sitting could be associated with cancer but there is not currently enough consistency in the findings to be certain of this yet, leading to the conclusion:

> Preliminary evidence suggests an association between sitting and cancer
>
> The increased risk of cancer in several studies was between 13% to 30%

Sitting and mortality

Taking the serious health risks of sitting further, several studies have considered the link with sitting and mortality (i.e. death). Using accelerometers to objectively and accurately measure activity in a group of adults 50 years over a period of 2.8 year those who were most sedentary were found to have 5 times the risk of dying compared with those who were least sedentary[24]. Remarkably, this was independent of physical exercise – with moderate to vigorous exercise not affecting this increased risk of dying.

In reviews with broader population age ranges (18 to 90 years old) strong evidence has been found for a link between sedentary behaviour and death from all causes, including cardiovascular disease[14, 19, 10, 25], with increased risks ranging from 24%[14] to 49%[10] when comparing sitting the most with those sitting the least.

With respect to occupational sitting these results are partly supported by a review that found four prospective studies showed sitting at work was associated with increased risk of mortality[17], although the results were somewhat mixed with the reviewing also finding one study with no association and one showing sitting decreased mortality risk.

A study on 71,000 Danish adults[26] was able to quantify the risks with the following:

> *'Compared to sitting less than 6 hours per day sitting for 10 hours or more per day was found to be associated with a 38% higher risk of MI [heart attack] and 31% higher risk of all-cause mortality.' [26]*

Similar results were found in an 2012 Australian study[27] where the increase in mortality from any cause was:

- 2% for 4-8 hours sitting
- 15% for 8-11 hours sitting
- 40% for 11+ hours sitting

when compared to those sitting less than 4 hours per day. This was again independent of physical exercise. These results are reinforced yet again by another review in 2013[28] which found all-cause mortality to be 34% higher for those sitting 10 hours per day compared with those sitting for 1 hour per day, again independent of physical exercise[§].

[§] Without the protective factor of physical exercise all-cause mortality increased by a further 18% to 52% for those sitting 10 hours per day compared with 1 hour per day.

Overall there is a clear dose-response relationship between sitting and mortality – every additional hour of sitting further increases the risk.

> Sitting 10+ hours a day has a 30-40% increased risk of mortality (death).
>
> There is a dose-response relationship – every hour increases the risk
>
> Exercise does not significantly reduce the mortality risk from sitting

Comparing death by sitting vs death by smoking

One way to look at how much sitting may theoretically contribute to mortality is to calculate what is called the "population-attributable fraction", which is used to estimate the proportion of cases that can be attributed to one or more specified risk factors. Several recent studies have done this calculation for sitting with results suggesting sitting contributes to between 5.9%[28] and 6.9%[27] of all deaths when adjusted for physical exercise. The World Health Organization reports[29] that 8.7% of global mortality can be attributed to tobacco use, 5.5% to physical inactivity and 4.8% to being overweight and obese. So sitting appears to rank as a significant health issue with a negative impact on a part with some of the biggest health issues in modern society.

> Sedentary behaviour (sitting) is estimated to contribute to 6%-7% of all deaths
>
> This compares with 8.7% for smoking, 5.5% for insufficient physical exercise and 4.8% for obesity

Reporting rates of mortality related to too much sitting has led to estimations of what this means in terms of reduced life expectancy. It is this extrapolation which has led to the comparison with smoking which has attracted so much media attention. It is worth unpacking these calculations as it is important that people don't swap sitting for smoking or continue to smoke standing up!

Using television viewing as the measure of sitting time a 2012 study estimated that compared to no TV watching, those who spend a lifetime average of 6 hours per day watching TV can expect to live 4.8 years less[30]. Another study estimated that limiting sitting to less than 3 hours per day and limiting television viewing to less than 2 hour per day may increase life expectancy at birth in the USA by approximately 2.0 and 1.4 years respectively[31]. It is important to note that the authors caution about the low precision between TV viewing and mortality, that is, does TV viewing and sitting actually cause death or are there other mediating pathways? These calculations have then been compared with the estimates that the difference in life expectancy between smokers and non-smokers is between 4.1 to 6.5 years[32,25].

Extrapolating further, the 2012 study above calculated that, on average, every single hour of TV viewed (and assumed sitting) after the age of 25 reduced life expectancy by 21.8 minutes[30]. This has then been compared with a 2000 study what estimated each cigarette smoked (men only, smoking from age 17 to

death) reduced life expectancy by 11 minutes[32]. Comparing these is how the '*sitting is the new smoking*' phrase has been derived to convey the idea that sitting is as bad for you as smoking when it comes to looking at contribution to reduced life expectancy.

Note, however, that to get these figures there has been a lot of assumptions made and the calculations rely on averages (e.g. assumes even health effects over a lifetime and that habits are constant). Even the authors admit that the 'calculation is crude'[32]. Presenting it this way, has however, had impact in the media and does help to highlight the fact that sedentary behaviour is an important risk factor for all-cause mortality. But it certainly does not replace the high risk of illness and death, not to mention costs, associated with smoking.

van der Ploeg (2012)[27] provides a succinct summary about sitting and mortality,

> *'In conclusion, prolonged sitting is a risk factor for all-cause mortality. Shorter sitting times and sufficient physical activity are independently protective against all-cause mortality not just for healthy individuals but also for those with cardiovascular disease, diabetes, overweight, or obesity' p.499*

Why does sitting cause health risks?

The research suggests a link between sedentary behaviour and adverse health outcomes. But how can an innocuous activity like sitting be associated with such scary health effects? While this question has not been answered definitively as yet there are several theories that have been presented.

Sitting increases cholesterol and blood glucose levels

During sedentary behaviour there are unbroken periods of muscular unloading where muscles are not contracting which leads to the suppression of skeletal muscle lipoprotein lipase (LPL) activity. This is important as it is the substance that is needed for triglyceride clearance and HDL cholesterol production, that is, clearing away 'bad cholesterol' and making 'good cholesterol'. In addition the lack of muscle loading reduces the uptake of glucose which may result in higher glucose levels. Higher than normal glucose levels increase the risk of developing diabetes. Standing and moving, on the other hand, simulates muscle contractions and skeletal muscle LPL changes[5].

Sitting reduces energy expenditure, leading to weight gain

Sedentary behaviour may be related to being overweight and obese through decreased energy expenditure and excess energy consumption through snacking[17]. Being overweight or obese is then linked to metabolic syndrome and type 2 diabetes[13].

Secondly, body fat itself may influence pathways which negatively impact on health outcomes[20]. This includes cancer, as there are established connections between being fat and changes in sex hormones, increased insulin and glucose, and increased inflammation markers, all of which are likely to be associated with cancer development and progression[7].

Sitting negatively affects cell energy metabolism

Sedentary behaviour has been associated with mitochondrial[**] dysfunction, dysregulation of cellular redox status and increased inflammation in older, sedentary adults compared to more active adults which may lead to accelerated cellular aging and cell death[24].

Sitting reduces cardiac output

There may be a change in cardiac stroke volume and output[††] related to the increased effects of cardiovascular disease and metabolic syndrome related to sitting[19].

In summary, there are multiple plausible biological pathways to explain why sitting and sedentary behaviour is linked to so many negative health outcomes. Actual causation and mechanisms are still to be confirmed by further research.

[**] Mitochondria are the energy generating structures within cells

[††] Cardiac output is the amount of blood the heart is able to pump in one contraction and per minute

Summary

Overall there is good evidence that sedentary behaviour or "too much sitting" is related to negative health outcomes and there are plausible biological mechanisms through which this can occur. However, all the researchers note that the results are limited by the variations in the research design and sedentary time measures. They also suggest that the relationship between sedentary behaviours and health outcomes is complex. Despite the limitations, the general consensus is that

'…evidence to date suggests that interventions aimed at reducing sedentary behaviour are needed'[19]

In conclusion:

> The evidence clearly supports a need to reduce sitting and sedentary behaviour to avoid significant negative health outcomes

The next obvious question is how do we reduce sitting? Generally people's lifestyles have become increasingly sedentary with screen-based entertainment, vehicle based travel and seated work becoming more prevalent. Across 20 countries the median sitting time for adults has been reported as 5 hours per day[33] and more than 90% of adults do not meet the guidelines for general exercise[34]. For employers some of the key questions that arise from this are:

- How much of this sitting is at work?
- What is the effectiveness of interventions aimed at reducing sedentary behaviour? Particularly interventions aimed at the workplace?
- Sit stand desks are being promoted heavily as a possible solution for workplaces. But how effective are sit stand desks? And what are the recommendations for using them to maximise the benefits and minimize any potential unwanted negative effects from introducing a new 'standing work' paradigm to the workplace?

These questions are looked at in a follow up paper that once again reviews the most recent published research on these subjects, with the goal of identifying the recommendations for employers looking to safeguard the health of their workforce.

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