Prolonged work- and computer-related seated immobility and risk of venous thromboembolism

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DECLARATIONS

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Summary

Objective To determine the risk of venous thromboembolism (VTE) associated with prolonged work- and computer-related seated immobility.

Design Case-control study in which cases were patients aged 18–65 years attending outpatient VTE clinics, and controls were patients aged 18–65 years admitted to CCU with a condition other than VTE. Interviewer-administered questionnaires obtained detailed information on VTE risk factors and clinical details.

Setting VTE Clinics and Coronary Care Unit (CCU), Wellington and Kenepuru Hospitals, Wellington between February 2007 and February 2009.

Main outcome measure The relative risk of VTE associated with prolonged work- and computer-related seated immobility, defined as being seated at work and on the computer at home, at least 10 hours in a 24-hour period and at least 2 hours at a time without getting up, during the four weeks prior to the onset of symptoms that led to VTE diagnosis or CCU admission.

Results There were 197 cases and 197 controls. Prolonged work- and computer-related seated immobility was present in 33/197 (16.8%) and 19/197 (9.6%) cases and controls, respectively. In multivariate analyses, prolonged work- and computer-related seated immobility was associated with an increased risk of VTE, odds ratio 2.8 (95% CI 1.2–6.1, P=0.013). The maximum and average number of hours seated in a 24-hour period were associated with an increased risk of VTE, with odds ratios of 1.1 (95% CI 1.0–1.2, P=0.008) and 1.1 (95% CI 1.0–1.2, P=0.014) per additional hour seated.

Conclusion Prolonged work- and computer-related seated immobility increases the risk of VTE. We suggest that there needs to be both a greater awareness of the role of prolonged work-related seated immobility in the pathogenesis of VTE, and the development of occupational strategies to decrease the risk.

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Reviewer

Judith Rosta

Introduction

The risk of prolonged seated immobility in the pathogenesis of venous thromboembolism (VTE) following long distance air travel is well-recognized.[1–6] However, the nature and magnitude of the association between VTE and prolonged seated immobility at work is less well understood. The association was first recognized from case reports of VTE events in patients who sat for prolonged periods at work prior to their presentation,[7–10] and a cases series of patients admitted to hospital with VTE, in whom information on work-related seated immobility was collected.[11] A number of case reports have also highlighted the association between prolonged recreational computer use and VTE.[12–15] These work- and computer-related VTE events could be both life-threatening and occur in individuals without other recognized risk factors. The term seated immobility thromboembolism (SIT) syndrome was proposed to encompass all situations in which prolonged seated immobility contributes as a risk factor for VTE, including prolonged air, car or train travel, work and recreation.[8,9]

In a previous case-control study we observed that prolonged seated immobility at work is a potentially important risk factor for deep vein thrombosis (DVT) or pulmonary embolism (PE) requiring hospital admission.[16] Both the maximum time seated at work in a 24-hour period and the maximum time seated without getting up were associated with an increased risk of VTE. The interpretation of the findings was limited by the low statistical power of the study to detect associations, the focus on the role of the maximum time seated without consideration of average time seated, and the lack of information on occupation and on workplace environment and habits. To address these limitations we now report a larger case-control study with more detailed information of the role of work- and computer-related seated immobility and the development of VTE.

Methods

Consecutive patients attending the Capital & Coast District Health Board (CCDHB) VTE Service outpatient clinics, based at Wellington and Kenepuru Hospitals between February 2007 and October 2008 were included as cases. The VTE Service follows patients who have presented to or have been referred to Wellington Hospital or Kenepuru Hospital for management of DVT or PE. Patients aged between 18–65 years were approached to take part if they had a hospital discharge diagnosis of DVT and/or PE within the previous six months. The upper age limit of 65 years was chosen as this is the standard retirement age in New Zealand.

Patients with arterial thromboembolic disease or who had superficial thrombophlebitis with no extension into the deep venous system were excluded. The clinical diagnosis of DVT or PE required radiological confirmation by one of the following: positive compression Doppler ultrasound, high or intermediate probability V/Q scan or positive helical CT with pulmonary angiography.

Control participants were recruited from the Wellington Hospital Coronary Care Unit (CCU) between February 2007 and February 2009. Patients were approached if they were between 18–65 years with an attempt made to match to within five years of a case, and if their admission to CCU was not for a VTE.

Cases and controls completed an interviewer-administered questionnaire with demographic data, occupational status, clinical details of the presenting VTE event or CCU admission, and detailed information on VTE risk factors. The VTE risk factors were grouped into categories as defined in Table 1.

The main risk factor of interest was prolonged work- and computer-related seated immobility, defined as being seated at work and on the computer at home, for at least 10 hours within a 24-hour period and at least 2 hours at a time without getting up. Subjects had to meet this criterion at least once in the four weeks prior to the onset of symptoms that led to the VTE diagnosis or CCU admission. Other recreational activities that involved being seated, such as being seated for meals or watching television or at the theatre, were not included in the above calculation. Likewise time spent commuting to and from work was not included; however, when travel was a necessary component of the occupation (i.e. taxi driver, travelling salesman) then this was included. In the previous case-control study,[16] this measure identified subjects at increased risk of VTE with an odds ratio of 2.7 (95% CI 1.2–6.0,

Table 1
Risk factors for venous thromboembolism

1	Age
2	Gender
3	Obesity (BMI >30 kgm^{-2})
4	Personal history of VTE – confirmed previous VTE event >6 months prior
5	Family history of VTE – confirmed VTE in parents or siblings
6	Active malignancy
7	Medical risk factors: • General acute or chronic medical immobility for greater than >2 days duration, other than postoperatively. Includes bed rest, overdose with reduced level of consciousness, or wheelchair use in the four weeks preceding the event • Relevant chronic medical illness known to predispose to VTE, such as inflammatory bowel disease, cardiomyopathy/congestive heart failure, connective tissue disease including inflammatory arthritis
8	Hormonal: • Hormone therapy – hormonal contraceptive or hormone replacement therapy or hormonal antagonist therapy for malignancy • Pregnancy
9	Surgery: • Surgery – requiring general anaesthetic or spinal/epidural anaesthesia in the four weeks preceding the event
10	Trauma or cast immobility: • Trauma – requiring medical attention • Cast immobility – orthopaedic limb/foot cast in the 4 weeks preceding the event
11	International air travel: • International air travel in the four weeks preceding the event*
12	Prolonged seated immobility: the duration seated at work and at home seated at a computer, in the four weeks preceding the event, defined as: • seated at least 10 hours in a 24 hour period and at least 2 hours at a time without getting up

* International air travel beyond New Zealand involves air flight of ≥3.5 hours

P=0.014) and a c statistic for the area under the receiver operating curve of 0.562. The other measures of seated immobility included the continuous variables of the maximum number of hours seated in a 24-hour period, the average number of hours seated in a 24-hour period, and the maximum number of hours seated at one time without getting up.

Occupation was initially categorized into one of the eight major classification groups from the Australian and New Zealand Standard Classification of Occupations (ANZSCO), available online from the Australian Bureau of Statistics website (Appendix 1, Table A – see http://jrsm.rsmjournals.com/cgi/content/full/jrsm.2010.100155/DC1).[17] An additional category comprised those not in paid employment, including invalid or sickness beneficences, household organizers and child minders, pregnant women on maternity leave, and those receiving short-term ACC compensation following trauma. All other subjects were coded according to the occupational group of their primary employment. Volunteer workers were included under an occupational grouping if their community involvement provided services to the community and involved tasks that potentially could have provided an income. Occupational groups were then classified into high and low sedentary categories, based on the published data on average sitting time among different occupational groups.[18] The high sedentary group comprised managers, professionals, clerical and administrative workers. Technicians and trade workers, community and personal service workers, sales workers, machinery operators and drivers, labourers and unemployed were included in the low sedentary group.

Information was also obtained on the work environment and work habits for those currently employed. For those with their own desk space, subjects were asked if they could stretch their legs out fully while seated, if their chair was adjustable, and whether they ate their lunch at their work office, desk or elsewhere.

Statistical methods

Logistic regression measured the strength of association between possible risk factors and the probability of being a case or control. For continuous variables the difference in mean values was also assessed with a simple t-test. In the multivariate logistic regression, the predictor variables of prolonged work-related seated immobility, maximum hours seated per 24 hours, maximum hours seated without getting up, and average hours seated per 24 hours were all adjusted for the other confounding variables described in Table 1. In the multivariate analysis, a stepwise model selection was used with the probability for entry to and exit from the model set at 0.1. The variable of medical risk factor was omitted from the multivariate analyses as almost all (92%) controls admitted to the CCU had medical risk factors, predominantly ischaemic heart disease. A Chi-square test for independence determined the differences in proportions of occupations by case-control status.

Statistical analysis was performed using SAS version 9.1.

Power calculation

Based on a previous case-control study[16] we anticipated between 10–15% of the controls would meet the definition of seated immobility. A sample size of 400 (200 cases and 200 controls) has 80% power to detect an odds ratio for risk of 2.0, if the control rate is 15%, and 2.25 if the control rate is 10%, with a type I error rate of 5%.

The study was approved by the Central Regional Ethics Committee (CEN/05/08/054) and informed consent was obtained prior to commencing with the questionnaire.

Results

A total of 202 cases and 209 controls were approached to participate in the study. All cases approached gave informed consent, but seven of the controls declined to take part. Four cases were later excluded as not having a radiologically confirmed DVT or PE, and one case was excluded as he had previously been enrolled as a control for a CCU admission not related to VTE. Two controls were excluded during the questionnaire process as they were unable to reliably complete the questionnaire and three controls were excluded as duplicates. As a result, a total of 197 cases and 197 controls were included in the study analysis. The mean age (SD) of the cases was 45.6 years (12.0) and of the controls 48.4 years (10.1); 101/197 (51.2%) cases were men compared to 144/197 (73.1%) controls.

There were 119 cases with radiologically confirmed DVT, of which 54 proximal lower limb DVT, 53 distal lower limb DVT, four confirmed lower limb DVT site unspecified, five upper limb DVT (all following IV cannulation), one jugular vein thrombosis, one renal vein thrombosis and one pelvic vein thrombosis. There were 97 cases with radiologically confirmed PE, of whom 19 also had radiological confirmation of a DVT. There were 9/97 (9.3%) massive and 26/97 (26.8%) sub-massive PE.

Among the controls, the most common disorders resulting in a CCU admission were an acute coronary event (60%), elective admission for investigative angiogram (7%), decompensated CHF or cardiomyopathy (6%), unstable angina (4%), arrhythmia (4%), or requirement for cardiac monitoring for an acute medical condition not primarily cardiac in origin (4%), such as in the setting of polypharmacy overdose, pneumonia, sepsis, cerebral haemorrhage and symptomatic diabetes mellitus.

The univariate analysis of the association between the different risk factors and VTE is shown in Table 2. Prolonged work- and computer-related seated immobility was associated with a 1.9-fold increased risk of a VTE event. The multivariate analyses, adjusted for confounding variables, of the association between risk factors and VTE are shown in Table 3. Age, obesity and malignancy were not included in the multivariate analyses as these variables were not independently associated with VTE. Prolonged work- and computer-related seated immobility was significantly associated with VTE, with an odds ratio of 2.8 (1.2–6.1).

A sedentary occupation was associated with an increased risk of VTE in the univariate analyses (odds ratio 1.7 [1.1–2.5], P=0.014), but not the multivariate analyses after adjusting for other confounding variables including prolonged work- and computer-related seated immobility (odds ratio 1.5 [0.9–2.7], P=0.16). The proportion of cases and controls in the specific occupational groups is shown in Table 4. A Chi-square test for independence suggested different proportions of

Table 2
Univariate odds ratios (95% CI) for association between risk factors and VTE, *n*=197 for cases and controls except where indicated

Risk factor	*Case* n *(%)*	*Control* n *(%)*	*Odds ratio (95% CI)*	P *value*
Age[1]	45.6 years (12.0 SD)	48.4 years (10.1 SD)	0.8 (0.7–1.0)	0.014
Gender (women)	96 (48.7)	53 (26.9)	2.6 (1.7–3.9)	<0.001
Obesity	77[2] (40.1)	81[2] (41.5)	0.9 (0.6–1.4)	0.77
Personal history of VTE	37 (18.8)	3 (1.5)	15.0 (4.5–49.4)	<0.001
Family history of VTE	44 (22.3)	16 (8.1)	3.3 (1.8–6.0)	<0.001
Active malignancy	14 (7.1)	5 (2.5)	2.9 (1.0–8.3)	0.034
Medical risk factors	49 (24.9)	182 (92.4)	0.03 (0.01–0.05)	<0.001
Hormonal/pregnancy	37 (18.8)	4 (2.0)	11.2 (3.9–32.0)	<0.001
Surgery	38 (19.3)	3 (1.5)	15.5 (4.7–51.0)	<0.001
Trauma or cast immobility	45 (22.8)	10 (5.1)	5.5 (2.7–11.3)	<0.001
International air travel	29 (14.7)	3 (1.5)	11.2 (3.3–37.3)	<0.001
Prolonged work- and computer-related seated immobility	33 (16.8)	19 (9.6)	1.9 (1.0–3.4)	0.04

[1] Per decade older
[2] Cases (*n*=192); controls (*n*=195)

occupations by case-control status (P=0.013). The cases had a larger proportion of clerical/administration and professionals (which included IT professionals) and a lower proportion of labourers, technicians and trade workers compared to the control group.

The analysis of risk of work- and computer-related hours seated is shown in Table 5. In multivariate analyses the risk of VTE increased by 10% for each additional hour seated, for both the maximum and average time seated in a 24-hour period. The risk of VTE increased by 20% for each additional hour seated at a time without getting up, however, this was not statistically significant.

The risk of VTE was significantly increased in subjects with their own desk at work (odds ratio 2.1 [1.3–3.3], P=0.003) and in those who usually or always ate lunch at their desk (odds ratio 2.2 [1.1–4.1], P=0.02). There was no significant reduction in risk associated with having an adjustable chair (odds ratio 0.5 [0.2–1.4], P=0.20) or being able to stretch one's legs out fully while seated (odds ratio 0.8 [0.3–2.0], P=0.79).

Discussion

This case-control study provides evidence that prolonged work- and computer-related seated

Table 3
Multivariate odds ratios (95% CI) for association between risk factors and VTE

Predictor variables	*Odds ratio (95% CI)*	P *value*
Gender (women)	2.0 (1.0–3.7)	0.04
Personal history of VTE	40.0 (11.4–140.8)	<0.001
Family history of VTE	2.5 (1.1–5.7)	0.024
Hormonal/pregnancy	14.8 (4.5–48.1)	<0.001
Surgical	22.6 (6.4–80.3)	<0.001
Trauma or cast immobility	10.3 (4.4–24.0)	<0.001
International air travel	28.0 (7.8–100.4)	<0.001
Prolonged work- and computer-related seated immobility	2.8 (1.2–6.1)	0.013

[1] Per decade older

Table 4
The number and proportion of cases and controls in each occupational group

Occupational group	*Cases* n *(%)*	*Controls* n *(%)*
1. Managers	22 (11.3)	26 (13.3)
2. Professionals	53 (27.2)	40 (20.4)
3. Technicians and trade workers	14 (7.2)	27 (13.9)
4. Community and personal service workers	10 (5.1)	7 (3.6)
5. Clerical and administrative workers	34 (17.4)	19 (9.7)
6. Sales workers	11 (5.6)	11 (5.6)
7. Machinery operators and drivers	8 (4.1)	10 (5.1)
8. Labourers	4 (2.1)	17 (8.7)
9. Unemployed	39 (20.0)	39 (19.9)
TOTAL	195	196

In two cases and one control, the occupation could not be classified into an occupational group from the information available.

immobility is a risk factor for VTE. Both the maximum and average time seated during a 24-hour period were associated with an increased risk of VTE. We suggest that there needs to be a greater awareness of the role of prolonged work- and computer-related seated immobility in the pathogenesis of VTE and the development of occupational strategies to reduce the risk.

There are some important methodological issues relevant to the interpretation of this study. Consistent with our previous case-control study,[16] the controls were selected from patients presenting to the CCU, predominantly due to thrombosis in the arterial system, rather than thrombosis in the venous system, as in the cases. This method of selection was originally based on that used in the large case-control study on traveller's thrombosis[19] and recognizes that VTE and atherosclerosis share some common risk factors.[20] It is acknowledged that this approach may have resulted in an under-estimation of the risk associated with prolonged seated immobility, as patients with cardiovascular disease may be more likely to have a sedentary occupation due to the limitations placed on them by their co-morbidity. Inherent in any study of this design, the cases differed from the controls in terms of the numerous recognized factors that contribute to the risk of VTE, such as previous or family history of VTE, hormonal treatment or pregnancy, surgery, trauma or cast immobility, and international air travel. Over 90% of controls had a medical risk factor, giving a decreased risk of VTE in the univariate analysis. This is an artefact of the control selection, as it is well-known that medical co-morbidity, including cardiac disorders, is a risk factor for VTE,[21] and it is for this reason that it was not included in the multivariate analyses.

The criterion for prolonged work- and computer-related seated immobility was based on that used in the previous case-control study,[16] which identified that both the total duration of being seated and the duration seated at any particular time may both contribute to the risk of VTE. However, it was modified to include both the time seated in a work environment and that at home at a computer. This decision was based on the recognition that many people undertake a significant proportion of their work at home and that the seated position while in front of a computer is similar to that for most sedentary occupations. To meet the criterion, subjects were required to have been seated at least 10 hours in a 24-hour period and 2 hours seated at any time without getting up in the four weeks preceding the sentinel event. In our previous case-control study,[16] this criterion had the best discrimination of the combination variables in determining the risk of VTE, based on the area under the receiver operating characteristics curve and the statistical significance of the relative risk. Time spent seated in other sedentary activities outside work was not included in this criterion as the focus of enquiry was on work-related seated immobility and it would have been difficult to accurately measure recreational seated immobility from the questionnaires. Prolonged seated

Table 5
Odds ratios (95% CI) for association of measures of seated immobility and VTE event by hours seated

Predictor variables	*Mean (SD)*		*Odds ratio (95% CI)*		P *value*	
	Case	*Control*	*Univariate*	*Multivariate*	*Univariate*	*Multivariate*
Maximum work- and computer-related hours seated in 24 hours*	5.8 (3.9)	4.6 (4.3)	1.1 (1.0–1.1)	1.1 (1.0–1.2)	0.005	0.008
Average work- and computer-related hours seated in 24 hours	4.4 (3.1)	3.4 (3.3)	1.1 (1.0–1.2)	1.1 (1.0–1.2)	0.003	0.014
Maximum work- and computer-related hours seated without getting up*	1.8 (1.3)	1.6 (1.5)	1.1 (0.95–1.3)	1.2 (1.0–1.4)	0.20	0.071

* Per hour longer seated

immobility associated with international air travel was included as a separate VTE risk factor.

While most eligible cases of VTE would have been included in the study, due to the comprehensive nature of the VTE Service, patients who died from PE were not. This is unlikely to have influenced the study findings as there is no reason to suggest that patients with prolonged seated immobility at work are more or less likely to develop a fatal PE.

In our study, we identified that prolonged work- and computer-related seated immobility was associated with a 2.8-fold increased risk of VTE. When work- and computer-related seated immobility was expressed as a continuous variable, both the average and maximum number of hours seated during a 24-hour period were associated with VTE. For each hour longer spent seated in a day, the risk of VTE increased by about 10%. There was a non-significant 20% increased risk of VTE for each hour longer spent seated at a time without getting up. It is likely that measures to reduce both these factors may be important from an occupational health perspective.

This study also found that predominantly sedentary occupations, broadly grouped into professional (including IT), managerial, clerical and administrative, were also associated with an increased risk of VTE, compared with less sedentary occupations. However, the association between sedentary occupation and VTE was not significant after adjusting for other confounding variables including prolonged seated immobility at work and at a computer at home, suggesting that it is the prolonged seating rather than other aspects of the occupation that are responsible for the increased risk.

Our findings also suggested that the work environment and behaviours contributed to the risk of VTE. Subjects were twice as likely to have a VTE event if they had their own desk at work or if they usually or always ate their lunch at work. Reassuringly, the majority of subjects had adjustable chairs and the facility to stretch their legs fully in the work environment. Although these features were not associated with a reduced risk of VTE, the point estimates were consistent with a protective role. Interestingly, it has previously been reported that workers who sit for long periods at work do not compensate for this lack of activity by adopting less sedentary behaviours during leisure time.[18]

To put these findings in perspective, it is informative to compare the findings relating to prolonged work- and computer-related seated immobility with long distance air travel, the other major risk factor associated with prolonged seated immobility. Prolonged work- and computer-related seated immobility and long distance air travel were present in a similar proportion of cases (16.8 vs 14.7%, respectively), although air travel was associated with a considerably greater relative risk (28.0 vs 2.8, respectively). The greater relative risk with long distance air travel is likely to relate to the more cramped seating conditions and seat design, which may explain why particularly tall or short travellers are at greatest risk.[22] In addition, air travellers who develop VTE are likely to have been seated for considerably longer periods without getting up, as illustrated by the observation that most subjects who developed a

life-threatening PE did not get up during the flight at all.[2]

We conclude that prolonged work- and computer-related seated immobility increases the risk of VTE. Recognition of its role would lead to more accurate determination of whether a VTE event is idiopathic or provoked, which has implications for management including the duration of anticoagulant treatment.[23] It would also allow advice to be given to patients on preventive measures that they might follow to reduce the risk of further VTE events. Our findings also provide support for the development of occupational health strategies to reduce the sedentary nature of many occupations.

Finally, we propose that the term seated immobility thromboembolism (SIT) syndrome is used to encompass cases of VTE occurring in the setting of prolonged seated immobility at work as well as other situations such as long distance air, car and train travel,[1–6,19,24] and those related to lifestyle such as attending the theatre[8,25] and recreational computer use.[12–15] This would raise medical, occupational and public awareness of prolonged seated immobility, in its many and varied forms, as a risk factor for VTE.

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