In **Chapter 1** the background of the studies included in this thesis is presented. The main objective of this thesis was to investigate the dose-response relationship between the duration of computer use at work and the occurrence of arm-wrist-hand and neck-shoulder symptoms. In addition, the relative contribution of risk factors related to work exposure, leisure time exposure and individual characteristics for the occurrence of arm-wrist-hand and neck-shoulder symptoms among office workers is determined. A number of reasons justify this research endeavor. Firstly, nowadays office work and computer use are almost synonyms. In 2004, 3.3 million workers reported to frequently use a computer at work. This means that this research project focuses on roughly half of the working population in the Netherlands. Secondly, one out of three workers experienced regular or prolonged symptoms in the arm-wrist-hand or neck-shoulder region in the past 12-months. Thirdly, these symptoms are associated with reduced well-being, reduced productivity and medical consumption. These symptoms thus impact individuals, companies, and societies.

In **Chapter 2** a systematic review of longitudinal studies is presented in which the association between the duration of computer use at work and the onset of arm-wrist-hand and neck-shoulder symptoms among office work was evaluated. In total nine longitudinal studies were included. The available evidence was assessed based on the methodological quality of the studies and the consistency of results amongst studies. Evidence for an increased risk of a long duration of computer use at work on the onset of arm-wrist-hand and neck-shoulder symptoms among office workers was only found for the duration of mouse use at work and arm-wrist-hand symptoms. Indications for a dose-response relationship were found for this relationship. Based on the limited number of high quality studies that were performed, moderate evidence instead of strong evidence was concluded for this association. The empirical findings were in line with a pathophysiological model in which sustained muscle activation plays an important role. The main limitation of the studies included in the systematic review was the reliance on self-reported duration of computer use instead of objective measurements. In theory, the use of self-reports can lead to underestimation of the strength of association in case of non-differential misclassification, while in the case of differential misclassification overestimation can also occur.

In **Chapter 3** the reliability and validity of a questionnaire which measures workstation characteristics and work postures during computer use is described**.** In this questionnaire pictures have been added to the questions to clarify the items. Since web-based questionnaires were used, participants could compare their own postures to the pictures. A group of 84 office workers filled out the questionnaire twice, with an in-between period of two weeks. For a subgroup of workers (n=38) additional on-site observations and multiple manual goniometer measurements were performed. It appeared that most self-reported variables related to work posture had acceptable test-retest reliability over a period of two weeks. However, self-reports showed low to moderate agreement with observed work postures. The percentages agreement ranged between 26% and 71% for agreement between questionnaire and manual goniometer measurements. For 9 out of 12 tested items

the percentage agreement was below 50%. The use of self-reports on work posture during computer use might explain the lack of association in epidemiological studies between work posture or workstation characteristics and the onset of arm-wrist-hand and neck-shoulder symptoms among office workers. In addition, these findings question whether workstation characteristics are related to work postures during computer use. This might also question whether preventive efforts focusing on changing workstation characteristics in order to change work postures during computer use can be effective in the primary prevention of arm-wrist-hand and neck-shoulder symptoms.

In **Chapter 4** the reliability and validity of the self-reported duration of computer use at work is described. Contrary to previous research, a questionnaire with predefined categories is used, since it is known that self-report is, in general, low in precision. In the reliability study, 81 office workers filled out the questionnaire twice with an in-between period of two weeks. In the validity study self-reported data on the duration of computer use at work of 572 office workers were compared to data from software registrations. Imperfect test-retest reliability of self-reports resulted in at least 25% of misclassification of exposure. Moreover, using self-reports resulted in more than 80% of misclassification if compared to the gold standard. Approximately a third of all subjects overestimated their daily duration of computer use by more than 2 hours. No clear indications of differential misclassification by symptom status, registered duration of computer use at work, individual characteristics, job title or psychosocial factors at work could be found.

In **Chapter 5** the background and study design of the PROMO study (Prospective Research on Musculoskeletal disorders in Office workers) is described. The PROMO study was a prospective cohort study among 1951 office workers, with a follow-up of 24 months. Data on exposure and outcome was collected using web-based self-reports. Outcome assessment took place every three months during the follow-up period. Data on the duration of computer use at work were collected at baseline and continuously during follow-up using a software program. The advantages of the PROMO study included the 24-month follow-up period, the repeated measurement of both exposure and outcome, the measurement of a broad range of potential risk factors (i.e. physical and psychosocial risk factors, and individual characteristics), and the objective measurement of the duration of computer use at work. The data collected in the PROMO study formed the input for Chapters 6 and 7.

In **Chapter 6** the association between the duration of computer use at work and the onset of arm-wrist-hand and neck-shoulder symptoms is evaluated. One of the main features of this study was that objective data on the duration of computer use at work were collected by means of software registrations. Contrary to the expectation that registered exposure data would show stronger associations with the onset of arm-wrist-hand and neck-shoulder symptoms than self-reported exposure data, no association between the registered duration of computer use at work and arm-wrist-hand symptoms, nor between the registered duration

of computer use at work and neck-shoulder symptoms was found. Positive associations were only found for self-reported data on the duration of computer use at work.

In **Chapter 7** risk factors related to physical work exposures, psychosocial work exposures, physical leisure time exposures and individual characteristics are evaluated and the impact of the identified risk factors on population level is estimated. An increased risk for the onset of arm-wrist-hand symptoms was found for at least 4 hours per day of self-reported computer use at work, never squeezing firmly with hands at work, often / always using computer and telephone at the same time, moderate to low reward, low task variation, at least 4 hours per day of self-reported computer use during leisure time, female gender, higher age (i.e. 49 – 68 years), moderate to high levels of overcommitment, BMI exceeding 24 kg / m^2, and having had disabling symptoms in arm-wrist-hand or neck-shoulder region in the past year. The strength of the associations was in general low, with the exceptions of disabling arm-wrist hand symptoms in the past year (RR 3.9, 95% CI 3.0 – 5.1), and at least 4 hours per day of self-reported computer use at work (RR 2.0, 95% CI 1.2 – 3.2). An increased risk for the onset of neck-shoulder symptoms was found for at least 4 hours per day of self-reported mouse use at work, often / always performing repetitive hand movements (excluding computer use), sometimes / often / always using computer and telephone at the same time, arm support during keyboard use, low task variation, female gender, medium age (i.e. 40 – 48 years), work continuation during formal breaks, having an acquaintance experiencing disabling symptoms, and having had disabling neck-shoulder symptoms in the past year. The strength of associations was low, with the exception of disabling neck-shoulder symptoms in the past year (RR 5.3, 95% CI 4.4 – 6.3). Previous symptoms had a large impact on population level (PAF 0.33, 95% CI 0.26 – 0.41, for the onset of arm-wrist-hand symptoms; PAF 0.44, 95% CI 0.39 – 0.51, for the onset of neck-shoulder symptoms). In addition, at least 4 hours per day of self-reported computer use at work had a considerable impact on the onset of arm-wrist-hand symptoms (PAF 0.46, 95% CI 0.11-0.68), and arm support during keyboard use on the onset of neck-shoulder symptoms (PAF 0.38, 95% CI 0.12-0.56). In this study a range of potentially modifiable risk factors for the onset of arm-wrist-hand and neck-shoulder symptoms among office workers was identified. These risk factors had in general a weak association with the onset of arm-wrist-hand and neck-shoulder symptoms (i.e. RRs of 1.2 to 1.7). Moreover, subjects had on average 3 of these potentially modifiable risk factors, and a strong association between the number of potentially modifiable risk factors and the onset of arm-wrist-hand and neck-shoulder symptoms was found.

In **Chapter 8** the results of the performed studies in this thesis are summarized, possible explanations for the findings are given and methodological strengths and weaknesses of the performed studies are discussed. Weak or absent associations between the registered duration of computer use at work and the onset of arm-wrist-hand and neck-shoulder symptoms in the current and other prospective cohort studies challenge the existence of a causal relation between the duration of computer use at work and the onset of arm-wrist-

hand and neck-shoulder symptoms. The results of the current thesis also question whether pathophysiological theories that focus on local tissue injury or local physiological events can explain symptom onset among office workers. Future research should include theories that explicitly take symptom perception into account to gain more insight in the mechanism underlying symptom onset. More prospective cohort studies are needed, for which the following recommendations can be made: objective data for the duration of computer use at work should be used, more refined exposure estimates of computer use at work should be used, and the time window between exposure and outcome should be investigated. In order to prevent the onset of arm-wrist-hand and neck-shoulder symptoms among office workers multiple risk factors should be targeted at the same time.