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Effects of a standing and three dynamic workstations on computer task performance and cognitive function tests

Dianne A.C.M. Commissaris [a], Reinier Könemann [a], Suzanne Hiemstra-van Mastrigt [a], Eva-Maria Burford [b], Juliane Botter [b], Marjolein Douwes [a,*], Rolf P. Ellegast [b]

[a] TNO Work and Employment, Schipholweg 77-89, Hoofddorp, 2316 ZL Leiden, The Netherlands
[b] Institute for Occupational Safety and Health of the German Social Accident Insurance, Sankt Augustin, Germany

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ABSTRACT

Sedentary work entails health risks. Dynamic (or active) workstations, at which computer tasks can be combined with physical activity, may reduce the risks of sedentary behaviour. The aim of this study was to evaluate short term task performance while working on three dynamic workstations: a treadmill, an elliptical trainer, a bicycle ergometer and a conventional standing workstation. A standard sitting workstation served as control condition. Fifteen Dutch adults performed five standardised but common office tasks in an office-like laboratory setting. Both objective and perceived work performance were measured. With the exception of high precision mouse tasks, short term work performance was not affected by working on a dynamic or a standing workstation. The participant's perception of decreased performance might complicate the acceptance of dynamic workstations, although most participants indicate that they would use a dynamic workstation if available at the workplace.

1. Introduction

The adverse health effects of insufficient physical activity have been known for many years. Physical inactivity is associated with, among others, cardiovascular disorders, type II diabetes, depression, obesity and some forms of cancer (Garber et al., 2011). The World Health Organisation (WHO, 2013) estimates that each year, 3.2 million people worldwide die a premature death because of an inactive lifestyle. Persons who meet the current guidelines on physical activity and health are still exposed to increased health risks, if they are engaged in sedentary work (van der Ploeg et al., 2012), i.e. work that is characterised by long periods of uninterrupted sitting. So far, premature death in general, type II diabetes and obesity have been associated with sedentary work, although the evidence for mortality is stronger than that for morbidity (van Uffelen et al., 2010). A dose–response relationship between health problems and sitting time was reported: each 2 h per day increase in sitting time at work was associated with a 5% increase in risk of obesity and a 7% increase in risk of diabetes (Hu et al., 2003). Physically active persons who reported to be “sitting almost all of the time” had a 1.4 times higher chance to be dead 12 years after the start of the study than their counterparts who reported to be “sitting almost none of the time” (Katzmarzyk et al., 2009).

The number of persons exposed to the sedentary work related health risks is difficult to estimate, since a commonly accepted definition of sedentary work is absent. In 2012, the Sedentary Behaviour Research Network proposed a definition of sedentary behaviour as “any waking behaviour characterized by an energy expenditure ≤1.5 METs while in a sitting or reclining posture”. In The Netherlands, about 50% of the adult working population reports sitting 4 or more hours per day at work (report period 2000–2004; Bakhuys Roozeboom et al., 2007). Based on the self-reported hours of computer time at work in Koppes et al. (2012), sedentary work is estimated to be most prevalent in the Dutch sectors ICT (6.9 h computer time per day), financial institutions (6.7 h/d), public administration (5.4 h/d) and business services (4.9 h/d). For the USA, Church et al. (2011) stated that in 2008, about 25% of all occupations had a sedentary character (<2.0 METs), whereas this was only 15% in 1960. In the USA, sedentary occupations are, like in the Netherlands, located in the sectors information, financial activities, and professional and business services. Based on

* Corresponding author.
E-mail addresses: dianne.commissaris@telfort.nl (D.A.C.M. Commissaris), reinier.konemann@tno.nl (R. Könemann), suzanne.hiemstra@tno.nl (S. Hiemstra-van Mastrigt), eva-maria.burford@dguv.de (E.-M. Burford), juliane.botter@dguv.de (J. Botter), marjolein.douwes@tno.nl (M. Douwes), rolf.ellegast@dguv.de (R.P. Ellegast).

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the studies above, we estimate that between 25% and 50% of all adults in Europe and the USA are exposed to sedentary work related health risks.

Although the link between sitting at work and an increased risk of coronary heart disease was already established in the 1950s by Morris et al. (1953a,b), efforts were mainly aimed at increasing exercise and physical activity in leisure time. In the 1980s, the awareness arose that the workplace could be a platform for physical activity interventions too. Since then, various initiatives have been described, for instance: a fitness program aimed at reducing work related stress (Frew and Bruning, 1988), walking during lunchtime (de Kraker et al., 2005), promoting stair use (Engbers et al., 2007), a workplace-based physical activity program (Naito et al., 2008), active computer breaks in which the employee performs a set of flexibility and/or strength exercises (Samani et al., 2009), and walking or cycling while performing the usual work tasks (Levine and Miller, 2007; Straker et al., 2009). These interventions can be distinguished into physical activity programmes organised in an occupational setting that do not affect the on-going work ('worksite health promotion programmes') and physical activity performed at the workplace during the on-going work ('dynamic workstations'; Commissaris et al. (2011), or 'active workstations'; Ohlinger et al. (2011)). All of these occupational setting interventions primarily focused on increasing physical activity and not on interrupting and decreasing sedentary time (Chau et al., 2010). With regard to sit-stand desks at work, their aim was until recently to prevent musculoskeletal disorders of neck and upper limbs and not to decrease sedentary time (e.g. Robertson et al., 2013).

In recent years, sit-stand workstations have been evaluated with respect to their potential to reduce sedentary time as they provide the most elementary form of 'not sitting' during on-going work. While Alkhajah et al. (2012) report a significant reduction in sedentary time at the workplace following the introduction of a personal sit-stand workstation, Gilson et al. (2012) did not find a significant change in proportion of work time spent in sedentary behaviour after fitting a pod of four height adjustable desks into the centre of an open plan office space. Alkhajah et al. also evaluated acceptability, showing a strong preference of the users (83%) not to return to their old workstation set-up after three months of using the sit-stand workstation. Work performance was evaluated with one question only; when asked if the new workstation improved their productivity, 33% agreed and 22% disagreed (Alkhajah et al. (2012).

The present study concerns a more comprehensive comparison of work performance while working at a standing or at a dynamic workstation with that of working in a traditional seated position. Previous studies on dynamic workstations report positive short term health outcomes, though sometimes at the expense of work performance. Walking while working was found to raise the energy expenditure on average in obese subjects (Thompson et al., 2008; Levine and Miller, 2007), but computer tasks requiring hand or finger use, such as typing and mouse pointing, were performed slower with more errors (John et al., 2009; Straker et al., 2009; Thompson and Levine, 2011; Ohlinger et al., 2011), while the performance of mental tasks was unaffected (John et al., 2009; Cox et al., 2011; Ohlinger et al., 2011). Both stepping and cycling while working increased the energy expenditure compared to sitting, even more than walking did (John et al., 2009; McAlpine et al., 2007). However, more intensive cycling was found to lead to more errors in work performance (Straker et al., 2009). The decline in task performance is suggested to arise from an interference of upper body motions with the arm stability that is required for fine motor tasks (Straker et al., 2009). However, from general studies on the effects of physical exercise on mental and psychological processes, we know that moderate levels of aerobic, steady state exercise bouts up to one hour improve cognitive performance via facilitation of specific stages of information processing (Tomporowski, 2003).

Given the serious health effects of sedentary work and the large number of people exposed to this health risk, innovative health promotion strategies in the workplace are required. Innovative strategies such as dynamic workstations allow sedentary workers to increase their physical activity without interrupting the on-going work. Therefore, the aim of the present study is to evaluate the effects of those workstations on work performance. A joint paper of Botter et al. (submitted for publication) describes the physiological and postural effects, while the paper at hand deals with the short term effects on performance during computer tasks and cognitive function tests. We hypothesise that compared to sitting:

(1)the short term performance of computer tasks requiring fine motor actions of the hands (e.g., mouse pointing and clicking, typing texts) will deteriorate on all dynamic workstations because of the interference of upper body motions with arm stability, and that this decline will be larger at the higher movement intensity;
(2)the short term performance of computer tasks that do not require fine motor actions of the hands (e.g., reading and correcting texts, cognitive function tests) will improve on all dynamic workstations because of the positive effects of moderate levels of aerobic, steady state exercise on mental processes;
(3)the short term perceived task performance will decline on all dynamic workstations because people are not accustomed to perform their work while being physically active at the same time;
(4)the short term objective and perceived performance will not decline nor improve on a standing workstation, since none of the arguments in hypotheses 1–3 is applicable to a standing workstation.

2. Methods

2.1. Participants

Fifteen adults (see Table 1 for details) volunteered to participate in the study. They were recruited by email among connections of TNO employees and a database of test participants. Inclusion criteria were: at least 18 years old, a Body Mass Index (BMI) between 18 and 30, experienced with computer tasks and involved in physical activity/exercise 1–3 times per week, and no musculoskeletal health complaints. Computer experience, physical activity and musculoskeletal health were self-reported. All participants signed an informed consent at the beginning of the test day and received an aforementioned reward of € 100,- afterwards.

Table 1
Participants' information.

Age	29 (SD 12) years	
Gender	8 females–7 males	
Stature	176 (SD 11) cm	
Weight	70 (SD 13) kg	
BMI	22.3 (SD 2.1) kg/m^2	
Fitness (estimated VO_2 max)	44 (SD 8) ml/min/kg	
Exercise intensity	Frequency	Duration
Moderate ($n = 14$)	2.8 (SD 1.2)/week	48 (SD 16) min per exercise
Intensive ($n = 9$)	2.0 (SD 0.5)/week	44 (SD 11) min per exercise
Touch typist	15 participants	