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Does a dynamic chair increase office workers' movements? – Results from a combined laboratory and field study

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ABSTRACT

Purpose: Dynamic chairs have the potential to facilitate movements that could counteract health problems associated with sedentary office work. This study aimed to evaluate whether a dynamic chair can increase movements during desk-based office work.
Methods: Fifteen healthy subjects performed desk-based office work using a dynamic office chair and compared to three other conditions in a movement laboratory. In a field study, the dynamic office chair was studied during three working days using accelerometry.
Results: Equivocal results showed that the dynamic chair increased upper body and chair movements as compared to the conventional chair, but lesser movements were found compared to standing. No differences were found between the conditions in the field study.
Conclusions: A dynamic chair may facilitate movements in static desk-based office tasks, but the results were not consistent for all outcome measures. Validation of measuring protocols for assessing movements during desk-based office work is warranted.

1. Introduction

Sedentary behavior has increased over the past ten years (van der Ploeg et al., 2015; Hagstromer et al., 2015) and sitting itself has been identified as an independent risk factor for several diseases and mortality (Hamilton et al., 2007; Katzmarzyk and Craig, 2002; Wilmot et al., 2012), although the physiological mechanisms modulating these risks are yet not fully understood (van Uffelen et al., 2010). Standing time seems to be positively associated with several positive health outcomes (van der Ploeg et al., 2014; Ebara et al., 2008) and therefore office workers with predominantly desk-based work are recommended to regularly break up their sitting time with standing bouts (Thorp et al., 2014) and light intensity physical activity for up to 2 h/working day (Buckley et al., 2015). However, another way to increase physical activity during desk-based work is to sit in a more "active way", i.e. on chairs without back support, on dynamic or unstable chairs (Ellegast et al., 2012), on exercise balls (Gregory et al., 2006), or on motor-driven chairs. However, it is not clear to what extent these methods actually increase the workers' movements. In fact, recent studies showed that users of an unstable chair had lower muscle activity levels and fewer body movements compared to sitting on a conventional office (stable) chair (Grooten et al., 2013; O'Sullivan et al., 2012). Another study that compared four dynamic office chairs with a conventional office chair in respect to muscle activity, sitting postures, as well as physical activity intensity (PAI), showed that dynamic chairs did not increase physical activity levels and movements (Ellegast et al., 2012). In contrast, the tasks performed affect more strongly the office workers' movements, totally independent of chair type (Ellegast et al., 2012; Groenesteijn et al., 2012).

Håg Sofi is a dynamic office chair that is equipped with a BalancedMovementMechanism™ below the seat that can be gradually unlocked. The office worker can rotate around the longitudinal and bilateral movement axes, when this mechanism is put in the unlocked mode, and theoretically the worker's movements are stimulated while seated. Positive effects on blood flow in the lower

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limbs in the unlocked compared to the locked mode has been found (Stranden, 2000). However, to our knowledge no studies have yet evaluated the effects on office workers' movements. The aim of this study was therefore to evaluate the effects of this dynamic chair, compared to a conventional office chair and working at a standing desk, on movements and secondly to investigate its effect on aspects of posture, comfort and task-performance in a combined laboratory and field study. "It was hypothesized that the greatest body movements would occur during the standing conditions, and that the unlocked condition subjects would enhance movement compared to the locked and conventional conditions."

2. Material and methods

This study was a combined laboratory and field study. The laboratory study was designed with 3 tasks and 4 chair conditions in a randomized order based on an online randomization program (www.randomization.org). In the field study, professionals with predominantly sedentary desk-based work were studied over three working days using three different conditions in a random order.

2.1. The laboratory study

2.1.1. Subjects

Included in the study were 15 subjects, students and staff from the university, (five males and ten females) that performed desk-based work for a substantial part of the working day. A predefined exclusion criterion was musculoskeletal complaints that interfered with their office work, and, although five of the subjects hade musculoskeletal complaints, it did not interfere with their work. Musculoskeletal complaints were assessed with the Nordic Musculoskeletal Questionnaire (Kuorinka et al., 1987). Five of the subjects were administrators (professional office workers), four university teachers with predominantly desk-based work and six university students (Table 1), all recruited from the Karolinska Institute and Karolinska hospital in Huddinge, Sweden. The subjects completed an informed consent and background questionnaire including questions on age, gender, height, weight, profession, years in profession, musculoskeletal problems (Kuorinka et al., 1987), average sitting time and screen time per day.

Table 1
Background data of the subjects included in A. the laboratory study (n = 15) and B. the field study (n = 13). Median values (min/max).

A. Laboratory study	Median	Range (min − max)
Age	30	20–49
Gender (Male/Female)	5M/10F	
Height (centimeters)	170	163–195
Weight (Kilograms)	65	45–99
Years in profession	3.0	0.5–20
Sitting (hours/day)	8.0	3.5–12
Screen time working seated (%)	55	12.5–100
MSC*/no MSC	5/10	
B. Field study	**Median**	**Range (min − max)**
Age	34	26–62
Gender (Male/Female)	7M/6F	
Height (centimeters)	172	157–194
Weight (Kilograms)	73	48–92
Years in profession	7	0.5–28
Sitting (hours/day)	9.5	4–12
Screen time working seated (%)	80	50–100
MSC*/no MSC	3/10	

*MSC = musculoskeletal complaints.

2.1.2. Conditions

Four conditions were used: UNLOCKED: the dynamic office chair (HÅG SoFi 7310; Scandinavian Business Seating, Norway) was used with the BalancedMovementMechanism™ in the unlocked mode, enabling the subject to move around 0.3 m in the sagittal plane, i.e. in the anterior/posterior (A/P) direction (forward/backward) (SOFI), and to rotate free around the longitudinal axes (i.e. right/left rotation). LOCKED: The HåG SoFi office chair with the BalancedMovementMechanism™ in the locked mode enables approximately 0.03 m in A/P direction but free rotation around the longitudinal axes. STANDING: working at a standing desk which was raised to elbow height. CONVENTIONAL: a conventional chair (Sedus Yeah!; Sedus, Waldshut, Germany) enabling approximately 0.07 m in A/P direction and the ability to rotate free around the longitudinal axes (Sedus).

The dynamic chair had a circular seat (length: 0.45 m, width: 0.49 m) and a back support height of 0.57 m, while the conventional chair had a nearly square seat (length: 0.46 m, width: 0.48 m) and a back support height of 0.47 m. Thus, the seat pans were of nearly similar size, but the back support was around 10 cm shorter for the conventional chair. This, however, should not have influenced the results, since the upper part of the back (shoulder blades) was not resting against the backrest in any of the situations.

The height of the chair and table were adjusted to the measurement set-up (the force plates), so that the knees were flexed to around 90° and the height and width of the arm supports of the chairs were adjusted to the individual by asking the subject to let their arms hang down alongside their trunk with 90° in elbow flexion. The table and computer screen heights were individually adjusted and the position of the mouse and keyboard were placed according the subject's own preferences. If the subject did not have preferences, the top of the screen was adjusted to eye-height. In the unlocked mode, "the balance point", i.e. the depth of the seat, was found after adjustment of chair height.

2.1.3. Tasks

In order to represent different types of desk-based work, three standardized different desk-based tasks (one dynamic and two static tasks) were created; the Desk Task, the Keyboard Task and the Mouse Task. The Desk Task, a dynamic task, included movements where the subjects searched for and kept a record of specific information found in two folders positioned on both sides of the screen. During the Keyboard Task, the first static task, the subject was asked to write an English text created using the "KeyBlaze Typing Tutor" (NHC Software), (designed to use all features of the keyboard), as fast as possible. During the second static task, the Mouse Task, the subjects were instructed to use a computer mouse to point and click as fast as possible at a black circle on a light screen that gradually became smaller. The first circle had a diameter of 52 mm, while the last had a diameter of 2 mm (http://games144.com/game/8895-mouse-speed-n-skill-test-game.php). Each task was performed for four minutes.

2.1.4. Setup

During this experiment, we measured the subjects' movements, posture, ground reaction forces and accelerations with a motion capture system (Elite 2002, version 2.8.4380; BTS, Milano, Italy), two force plates (AMTI, Advanced Mechanical Technology Incorporation Watertown, USA; model Mc818-6-1000; size 457 × 203 mm; accuracy 0.25 N with a sampling frequency of 100 Hz), and five triaxial accelerometers (ActiGraph, Pensacola, FL), respectively. In order to measure the subjects' movements and posture, eight cameras were used to capture 6 spherical retro-reflective markers placed on the tragus (ears) and the trochanter