Comparison of a 3D dynamic office chair with a conventional 2D dynamic office chair: Impact upon local muscle metabolism, range of motion and physical activity

Dr. Boris Feodoroff, Peter Schams & Prof. Ingo Froböse
German Sport University Cologne, Germany
Institute of Movement Therapy and Movement-oriented Prevention and Rehabilitation

Introduction

Prolonged sitting has become an accepted part of the modern office. However, epidemiological evidence suggest that sedentary postures are linked to many adverse effects on health (Holmes et al., 2015). To give the back sufficient stimuli and keep it fully functional and healthy, the back has to be able to move physiologically while sitting comfortably for long periods. The approach of dynamic sitting at work in a chair providing a three-dimensional range of motion (ROM) could promote movements that result in more varied trunk postures and increased muscle metabolism. The purpose of this German research project is to evaluate the impact of the 3D movement opportunities on the lumbar back muscle’s oxygen saturation (SmO\textsubscript{2}) using innovative sport scientific methods.

Methods

This project compared sitting on a 2D-chair (Neos, Wilkhahn, GER) to sitting on a 3D-chair (IN, Wilkhahn, GER) (Fig. 1). Healthy volunteers [n= 25] used the chairs in a random order to do standardized office work (20 min) which included working with the keyboard only, with mouse only, desk work, as well as a personal conversation and taking a phone call. Each task took 4 min. The first two tasks were defined as static office work, the remaining three tasks as dynamic office work. During standardized office work skeletal muscle oxygen saturation (SmO\textsubscript{2}) was measured by a NIRS-sensor (DR2, Oxy4,GER), which provides non-invasive mobile real-time measurements. It was placed on the erector spinae muscles of the lower back in the midline of the spine approximately 2-3cm lateral to the L3 vertebra. The seats’ movements were captured by a 9-axis absolute orientation sensor (BNO055, Bosch Sensortec, GER) placed under the seats’ bottoms. In addition, six optical infrared cameras (Qualisys, SWE) collected kinematic data of both, the chairs and the test subjects. To create 3D models retroreflective markers were placed on the test subjects and the chairs, marker locations were chosen to correspond with joints and anatomical points (Fig. 2).

Results

Range of motion (seats)

![Range of motion (seats)](image-url)

Rotation and lateral tilt of users’ trunks and chairs’ backrests

![Rotation and lateral tilt of users’ trunks and chairs’ backrests](image-url)

Office workers’ metabolism

![Office workers’ metabolism](image-url)

Questionnaire

![Questionnaire](image-url)

Conclusion & Outlook

Movement analysis shows that the 3D-office chair leads to a significantly larger range of motion than the 2D-office chair (Fig. 3). The 3D-office chair’s multi-joint construction allows and supports rotary and sideways movements along the user’s longitudinal axis (Fig. 4). The crucial factor in this range of motion is not to put too much strain on the muscles. Prolonged contractions of back muscles lead to less muscle oxygenation (Kell et al., 2008). For optimal muscle oxygenation muscles need the opportunity to contract and relax alternating.

Static office work shows less SmO\textsubscript{2} in back muscles than dynamic office work. As van Dieën et al. (2001) showed the lumbar muscle activity is strongly affected by tasks performed. This study does not show any differences in SmO\textsubscript{2} while doing static office work sitting on 2D- or 3D-office chairs. SmO\textsubscript{2} shows promising results while doing dynamic office work (Fig. 5): The larger variance represents the activation of the human metabolism due to greater level of dynamism that the 3D-chair offers by supporting both, activating and relaxing the lumbar muscles. The one-sided nature of 2D-office chairs, with principally locked muscles, leads to less SmO\textsubscript{2} even if doing dynamic office tasks. In contrast, the 3D-office chair follows the office workers’ movements and helps countering fatigue (Fig. 4). While sitting on the 3D-office chair, subjects noted a bigger activation effect on the back and felt a positive effect on their lumbar health. Furthermore, subjects perceived that the 3D-office chair fosters more back movements than the 2D-office chair (Fig. 6).

These light movements are a rhythmic succession of gentle muscle activity and relaxation. Blood requirements and blood flow are in equilibrium - which is why gentle dynamic muscle activity can easily be performed over a longer period of time. In the office, sitting on a 3D-office chair proves to be an efficient approach to counteract monotonous sitting and the accompanying poor lower back muscle oxygen_saturation.

References

