

Summary

More movement in sedentary workspaces

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Forward

Some 80-90% of all gainfully employed people in Germany primarily work in sedentary jobs. As travelling to workplaces is usually done sitting down (in buses, trains or cars) and people like to sit down in their spare time as well, they don't move enough. The minimum recommended level of physical activity (World Health Organization, 2010) is no longer being achieved and impairing health. The negative consequences of physical inactivity are wide ranging and have an impact on the musculoskeletal and cardiovascular system.

In addition to active structures, passive ones can also degenerate due to constant static pressure and lead to restrictions that can affect the range of motion from a purely functional point of view. These can also be responsible for pain and musculoskeletal problems occurring. Backache is one of the most commonly cited outcomes. The degeneration of torso muscles is quoted as a possible cause of back pain due to sitting for long periods of time (Mörl and Bradl 2013).

The current German healthcare insurance company DAK's 2018 Health Report emphasises this problem: the most frequent cause of days lost to sickness in the workplace are still musculoskeletal complaints. We could expect these developments to be slowing down because our bodies are seemingly having to work less hard due to automation, digitalisation and ergonomic progress. In fact, the opposite is true. No improvement has been made despite all the effort made and the company health management programmes offered. Back exercise courses, movement trackers, fitness programmes and similar measures are clearly falling short and not reaching the very people who need them the most.

Long periods of physical inactivity need to be interrupted to give the body enough stimuli and keep it in healthy working order. The workplace is an ideal starting point for adding more movement to day-to-day life because gainfully employed people spend half the day there, allowing a large number of physically inactive people to be reached (Conn et al. 2009).

It's all about making sitting per se more active and supporting people in their natural range of motion while they're sitting. Nowadays, we know that adequate movement's responsible for nearly all areas of health and well-being: good mental health, the ability to combat stress, healthy bones and joints, the cardiovascular and immune system, the lungs, metabolic processes and even the neurological development of the brain. In other words, people must be encouraged to move while they're sitting down.

Research questions

We need new strategies in ergonomics that are based on biological requirements and above all on the fundamentals of metabolic processes. The purpose of the IN office chair, examined in this study, is to stimulate the joints through a variety of three-dimensional stimuli and to encourage local metabolism of the lumbar dorsal muscles in order to combat the negative consequences of sitting down for too long. This study compares the impact of using the IN chair and its three-dimensional range of motion with a conventional 2D office chair in office environments. The oxygenation of the lumbar dorsal muscles is the parameter measuring the impact on the local metabolism. This gives rise to the following research questions:

- Compared with a conventional office chair, does IN enable a wider range of motion (ROM)?
- Compared with a conventional office chair, does movement on IN, under conditions similar to the real world, enable better oxygenation in the lumbar dorsal muscles?
- How do the test persons subjectively notice and assess the extra range of motion offered?

A measurement tool is also to be evaluated that reflects movement on the office chair. A motion analysis is often a very painstaking process. Which is why we attempted to integrate a simpler sensor in the office chair in order to quantify movements on it. This also leads to the following research question:

- Can an orientation sensor on the office chair sufficiently reflect the movement of the person sitting on it?

Methods

Item studied

To answer the research questions, two office chairs produced by Wilkening+Hahne GmbH+Co.KG are compared with one another. The conventional Neos office chair has the traditional kinematic concepts of dynamic office chairs that are characterised by a synchronised tilt of the seat and backrest to the front and back. Throughout the rest of the study, this chair will be called the 2D office chair and compared with the IN (3D office chair). In addition to the backwards and forwards tilt, the IN office chair can also tilt the seat and backrest sideways and rotate the backrest in particular. Both office chairs are illustrated in figure 1.



Figure 1: The IN 3D office chair (on the left) and the Neos 2D office chair (right).

Procedure

A total of 25 test persons with a healthy medical history (aged: 27.9 ± 4.9 years; height: 184 ± 3.8 cm; weight: 80.4 ± 5.6 kg) used the office chairs to be compared in a random order for standardised office tasks. Figure 2 is a procedural diagram. The physiological stimulation of the dorsal muscles and the movement of the office chairs and test persons were documented while they were working. Before and after 20 minutes of carrying out office tasks, the test persons lie on their stomachs for 10 minutes on a lounge to establish the resting value of physiological activation or to compensate for any change in the way their bodies were stimulated. After completing the standardised office tasks, a questionnaire is handed out asking the test persons what their subjective perception of using the office chair was.

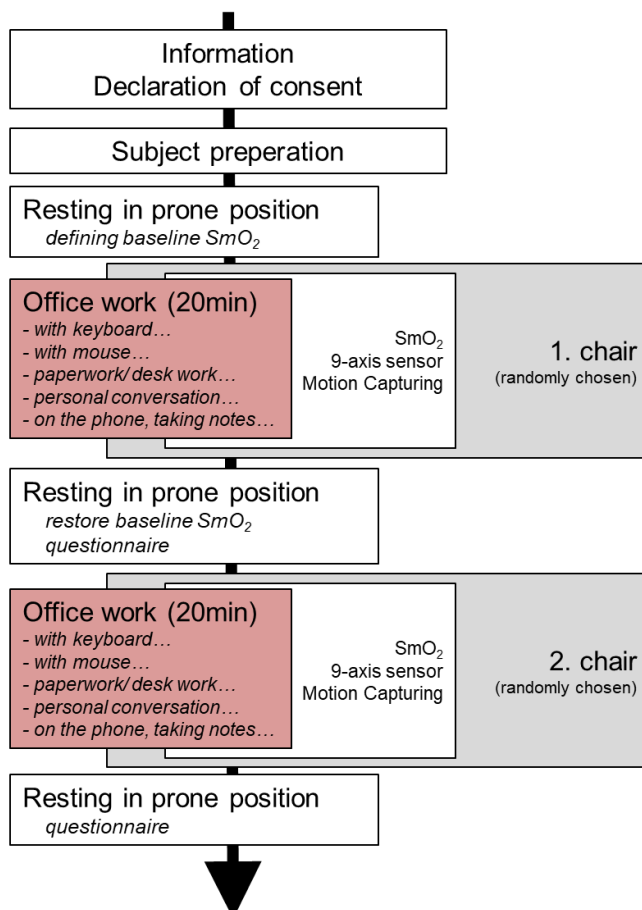


Figure 2: Procedural diagram

Standardised office tasks

The standardised office tasks include five phases lasting 4 minutes each when the test persons carry out typical office tasks (see Ellegast, R. P. et al. 2012; Grooten, W. J. et al. 2017; O'Sullivan, K. et al. 2012; Van Dieën, J.H., De Looze, M.P., Hermans, V., 2001). The phases included the following tasks:

- Phase 1: Working on a keyboard
 - o Typing a printed test using the keyboard into a word processing program on the PC
- Phase 2: Working with a PC mouse
 - o Transferring a printed graphic to a drawing program using a PC mouse
- Phase 3: Desk work
 - o Moving objects about on the desk, e.g. sorting files and filing documents, finding information in books etc.
- Phase 4: Personal chat with the employee
 - o Personal chat with an employee – brainstorming, presenting ideas, holding a discussion
- Phase 5: Telephone call
 - o Talking to an employee on the phone – finding information in files and online, working with one hand using the PC mouse or keyboard, holding discussions, brainstorming etc.

The office tasks are the same for each test person and carried out to an equal degree while using both office chairs. Only the contents of the discussions are adapted.

Measurement methods used

Tried-and-tested measurement methods are applied that comply with customary scientific quality criteria. All methods have already been attested a high level of validity, reproducibility and reliability in previous analyses. The testing equipment and procedures used are described below.

Oxygenation (SmO₂) – analysis of physiological stimulation

The DR2 sensor (Oxy4[®]) is used to analyse the physiological stimulation of the lumbar back muscles (see figure 3). By using near infrared technology (NIRS), this sensor enables non-invasive mobile measurement of the SmO₂ skeletal muscles in real time and therefore records local metabolic responses. Before measuring on the muscle belly of the M. erector spinae, the sensor is placed 2 - 3 cm laterally of the third lumbar vertebrae.



Figure 3: NIRS DR2 sensor Oxy4[®]

Motion capturing – motion analysis

A Motion Capturing (MoCap) system is used (Qualisys®) to analyse the motion of the test persons and the office chairs objectively. A simple biomechanical model is drawn up that allows the position of parts of the body in relation to one another to be determined.

To record the motion made by the people and the office chairs, reflective markers were placed on 19 anatomical reference points on the test persons' bodies (van Sint Jan, S., 2007) and 14 on each of the chairs (figure 4).

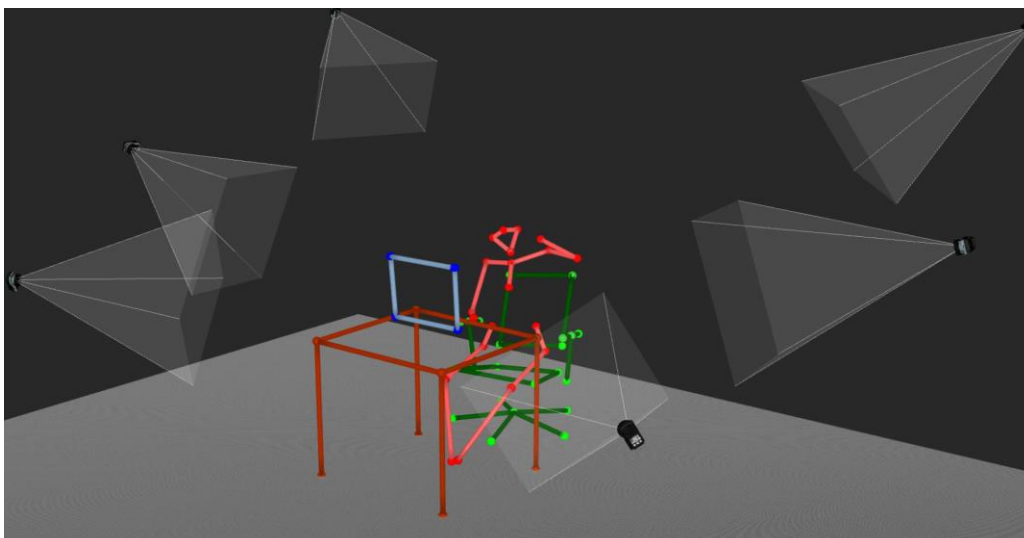


Figure 4: Biomechanical model in the study setting with camera cones (red = person; green = office chair; brown = desk; blue = monitor)

The markers' positions were recorded with six infrared high-speed cameras (Oqus 100, Qualisys®) at a frequency of 100 Hz. The average measurement tolerance is <1 mm. The cameras were positioned around an office desk (see figure 5).

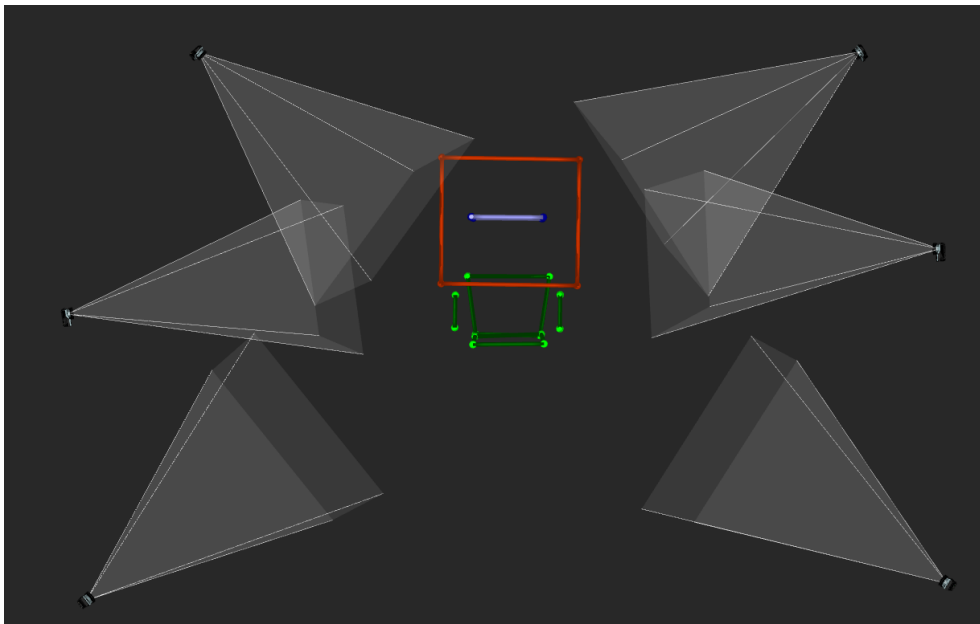


Figure 5: A bird's eye view of the layout of the motion capturing setting without a person model with camera cones

Orientation sensor – motion analysis

The motion in the seat is also recorded with another measurement instrument. A 9-axis orientation sensor (BNO055, Bosch Sensortec) is integrated into the office chairs (see figure 6) to record and analyse the way the user sits. Euler angles are used to calculate motion or change in orientation of the seat. The Euler angles define the orientation of a rigid body in a three-dimensional space based on three separate angles that describe the rotation around the axes of the 3D coordinate system. The orientation sensor records the changes in angle positions at a frequency of 25 Hz.



Figure 6: Position of the orientation sensor underneath the office chair and diagram of the measurement levels

Questionnaire – subjective perception of usage

After using each office chair, the test persons are asked to make the following statements (ranging from “correct” to “incorrect”) based on a five-stage Likert scale:

- I discovered the new 3D motion options while sitting.
- My back felt stimulated.
- I feel as if the office chair’s motion options have a positive impact on the lower section of my back.
- This office chair encourages movement in the lower back.
- This office chair fosters movement in the hips.
- I would like to use this office chair in my own workplace.
- I like sitting on this office chair.

Results

Motion analysis

While using the two office chairs, the motion by the test persons was analysed in the following three planes:

- Sagittal plane → view from the side
- Transverse plane → view from above (or below)
- Frontal plane → view from behind (or the front)
-

Figure 7 illustrates these planes.

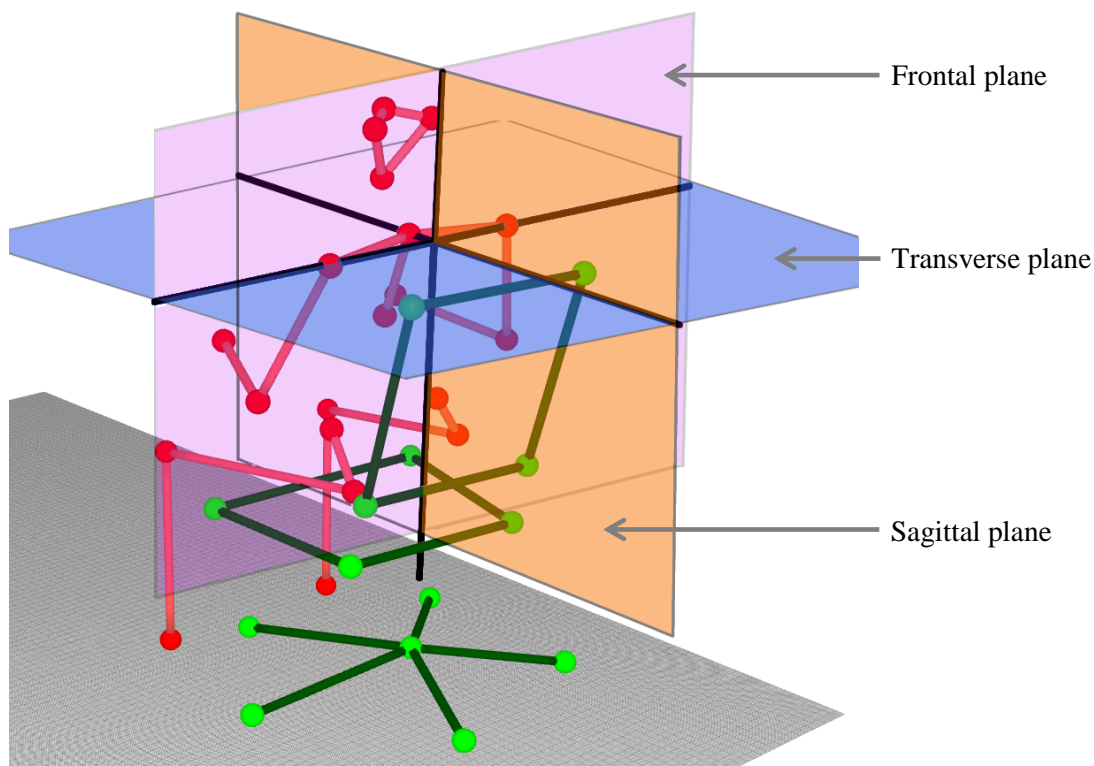


Figure 7: Diagram of the planes in the motion analysis setting (frontal plane = purple; transverse plane = blue; sagittal plane = orange)

Both office chairs' range of movement is described below by the information on the average maximum angles of all test persons of various body and office chair axes. These results are divided into the various phases of the standardised office tasks:

- Phase 1: Working on a keyboard
- Phase 2: Working with a PC mouse
- Phase 3: Desk work
- Phase 4: Personal chat with the employee
- Phase 5: Telephone call

Phases 1 and 2 are summarised below as *static phases* because movement using hands primarily takes place in these phases and the rest of the body remains relatively rigid. On the other hand, phases 3 to 5 with lots of movement by the torso are called *dynamic phases*.

Motion capturing

Transverse plane – rotation of the shoulder axis and backrest

The transverse plane and the axes of the shoulder and backrest are shown in figure 8. The rotation of the above-mentioned axes is shown in the following description without any rotation of the office chair itself. The rotation of the conventional swivel joint, which is located underneath the seat, doesn't have any impact on the results. Only the rotation of the shoulder axis or the backrest to the seat is described.

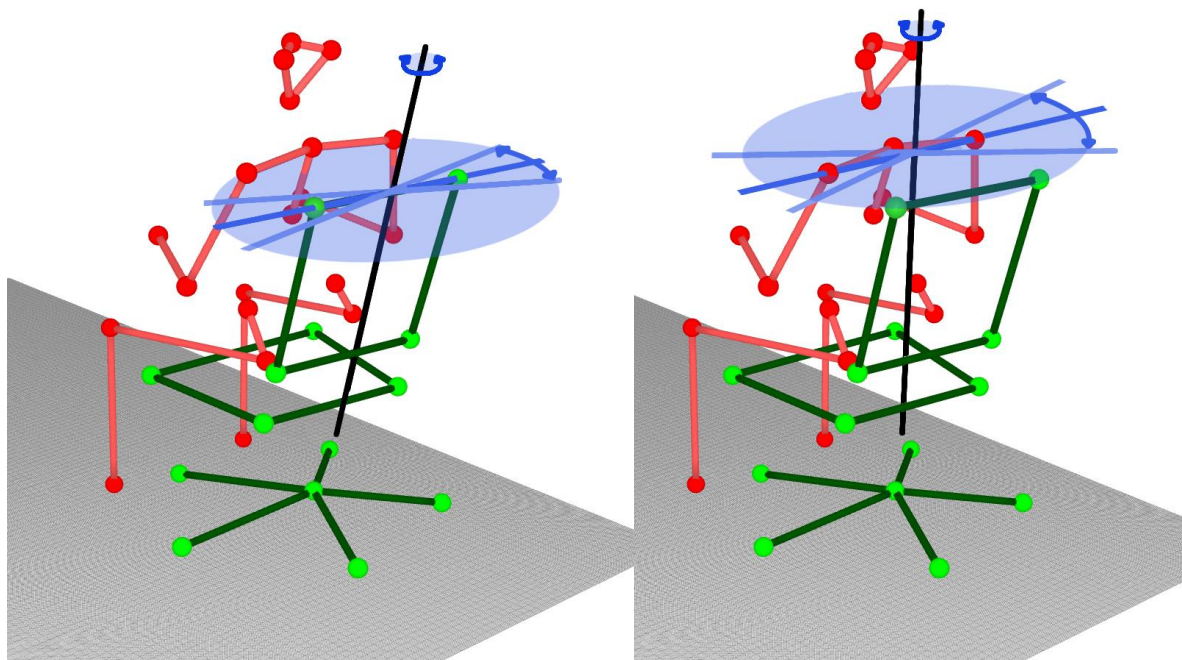


Figure 8: Rotation of the backrest (picture on the left) and the shoulder axis (picture on the right) in the transverse plane (blue); person model (red), office chair model (green)

The static phases show that the shoulder axis only rotates slightly in the transverse plane. Therefore, in both office chairs the average maximum angles while working on a keyboard and with a mouse are between approx. 8° and 12° . Average maximum figures of over 12° all the way to 44° are achieved in the dynamic phases. Compared with the shoulder axis, the rotation of the backrest in the transverse plane is lower. In static phases, the 2D office chair's backrest rotates less than 0.7° but the 3D office chair's backrest rotates between 1° and 2° . In dynamic phases, average maximum angles of up to 1.3° are used on the 2D office chair but a

maximum angle of 3.5° on the 3D office chair. It's important to note that when looking at individual cases, an absolute maximum rotation of the 3D office chair's backrest of 11.6° is used. However, this movement option isn't exploited by all test persons. On the other hand, the 2D office chair's backrest only indicates an absolute maximum rotation of 3.4°. Table 1 lists the average maximum angles in the various phases.

Table 1: Average maximum angle (n=25) of the rotation of the shoulder axis and the backrests in the transverse plane [angle degree] divided into the various phases of standardised office tasks

During usage:	Axes	Angle [°] Phase 1	Angle [°] Phase 2	Angle [°] Phase 3	Angle [°] Phase 4	Angle [°] Phase 5
3D office chair	Shoulder	8.42	11.61	36.49	14.02	29.40
	Backrest	0.98	1.55	3.49	2.33	2.72
2D office chair	Shoulder	9.06	9.33	43.91	13.24	30.71
	Backrest	0.68	0.48	1.29	0.72	1.09

Frontal plane – sideways tilt of the shoulder axis and backrest

Figure 9 shows the sideways tilt of the shoulder axis and the backrests in the frontal plane – viewed from behind the office chair. The angle degrees are stated with relation to the general horizontal.

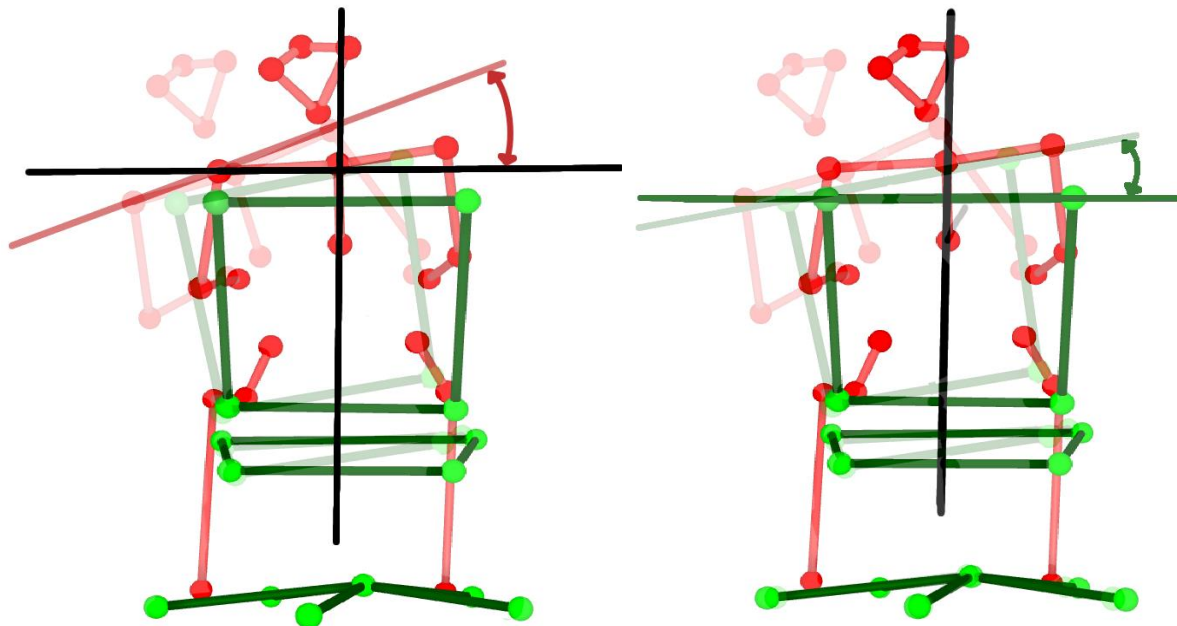


Figure 9: Sideways tilt of the shoulder axis (figure on the left, red) and the backrest (figure on the right, green) in the frontal plane (viewed from behind); person model (red), office chair model (green)

During the static phases, an average maximum sideways tilt of below 6.33° in the shoulder axis while using the 2D office chair was identified in the frontal plane. On the other hand, while using the 3D office chair, the test persons' shoulder axis tilted sideways by an average of 11.27° . There's a much more significant sideways tilt due to the greater level of physical movement in the dynamic phases. This extended sideways tilt of the shoulder axis of people sitting is present while both office chairs are used. There's no remarkable sideways tilt of the 2D office chair either in the static or dynamic phases. On the other hand, the 3D office chair can mirror the movements of the person sitting on it in the static and dynamic phases and therefore support the person sitting on the chair. Table 2 shows all the average maximum angles.

Table 2: Average maximum sideways tilt angles of the shoulder axis and the backrest in the frontal plane, stated in angle degrees and divided into the various phases of standardised office tasks and recorded by the motion capturing system

During usage:	Axes	Angle [°] Phase 1	Angle [°] Phase 2	Angle [°] Phase 3	Angle [°] Phase 4	Angle [°] Phase 5
3D office chair	Shoulder	4.71	11.27	44.08	18.44	30.90
	Backrest	1.66	2.36	8.86	4.40	7.29
2D office chair	Shoulder	3.77	6.33	51.51	9.68	32.40
	Backrest	0.28	0.30	1.47	0.89	1.51

Motion analysis comparison: orientation sensor with motion capturing

This measurement instrument is compared with the MoCap system to check whether the orientation sensor adequately reflects the motion of the seat. The MoCap system is the gold standard in sport sciences to determine motion and therefore used as a reference system. To ensure a more detailed analysis, motion is described separately in the sagittal and frontal plane to start with. Figure 10 illustrates the definition of the angles in the two planes. The angles of the two planes are subsequently shown in two pictures (figures 11 and 12) to examine the range of motion.

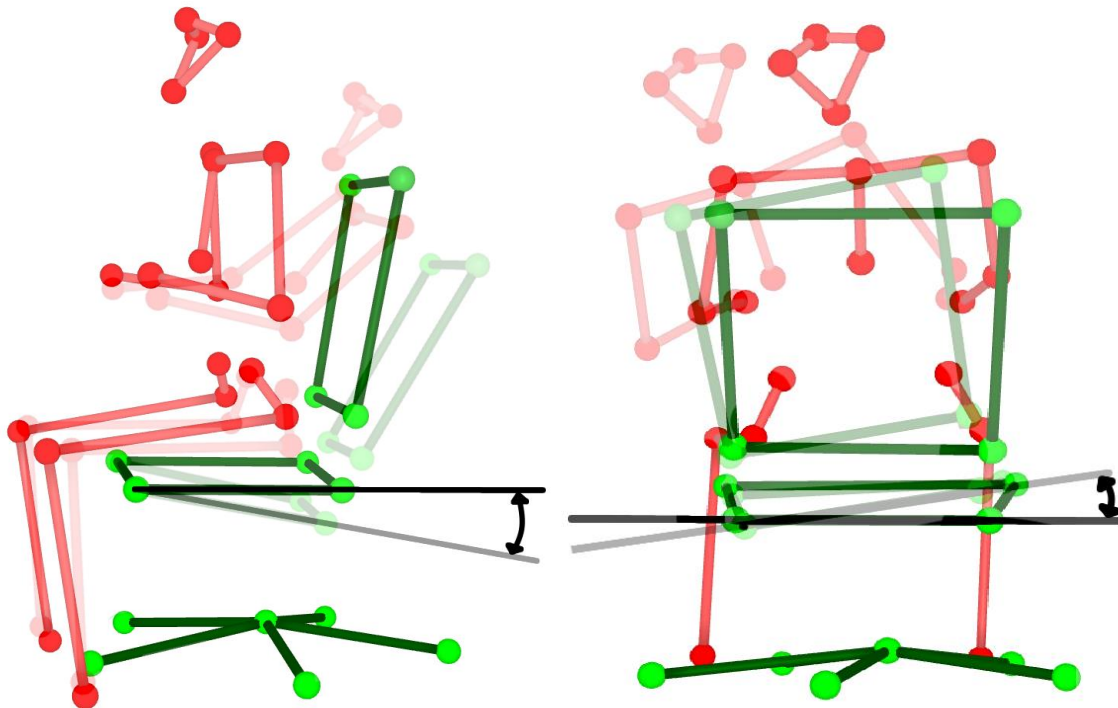


Figure 10: Tilt of the office chair's seat in the sagittal plane (figure on the left, black) and sideways tilt of the seat in the frontal plane (figure on the right, black); person model (red), office chair model (green)

Seat – motion in the sagittal plane

The office chairs examined in this study have a different structure so that the seats can demonstrate different tilts in the sagittal plane without any influence by the person sitting on the chairs. Therefore, for comparison purposes, the angles in the sagittal plane are always stated based on the initial tilt angle of the office chair concerned. The angles are documented positively and always refer to the backwards or forwards tilt of the seat.

When looking at the average maximum tilt of the MoCap system's sagittal plane, the seats on both office chairs tilt equally far.

The data from the orientation sensor varies on average by 3.8° from that of the MoCap system, whereby when smaller movements are made during the static phases, the discrepancies are lower than when greater movements are made during the dynamic phases.

Table 3: Average maximum tilt angles of the seat in the sagittal plane [angle degree] divided into the various phases of standardised office tasks, recorded with the motion capturing system and the orientation sensor

Average maximum tilt of the seat in the sagittal plane		Angle [°] Phase 1	Angle [°] Phase 2	Angle [°] Phase 3	Angle [°] Phase 4	Angle [°] Phase 5
Motion capturing	3D office chair	5.27	5.75	17.97	14.66	17.52
	2D office chair	5.29	5.00	19.56	17.38	19.17
Orientation sensor	3D office chair	4.83	4.94	12.08	8.62	11.71
	2D office chair	3.25	2.55	8.43	7.73	8.76

Seat – motion in the frontal plane

On the 2D office chair, the MoCap system shows no greater movement in the frontal plane than a 1.2° sideways tilt in all phases. On the other hand, the 3D office chair tilts sideways by up to 3.12° in the static phases and even up to 9.23° in the dynamic phases.

In the frontal plane, the results of the orientation sensor also diverge from those of the MoCap system (approx. 1° on average). In this analysis, the orientation sensor also records smaller tilts than the gold standard process.

Table 4: Average maximum angles of the sideways tilt of the seat in the frontal plane [angle degree] in the various phases of standardised office tasks, recorded by the motion capturing system and the orientation sensor

Average maximum sideways tilt of the seat in the frontal plane		Angle [°] Phase 1	Angle [°] Phase 2	Angle [°] Phase 3	Angle [°] Phase 4	Angle [°] Phase 5
Motion capturing	3D office chair	2.50	3.12	9.23	4.92	8.22
	2D office chair	0.65	0.67	1.18	1.17	1.20
Orientation sensor	3D office chair	1.45	3.18	7.50	2.39	6.81
	2D office chair	0.44	0.55	2.16	2.35	1.91

Range of motion

Figures 11 and 12 show the ROM in the seats. They round off the previous results of the orientation sensor and show how the seats behave in the frontal and sagittal planes.

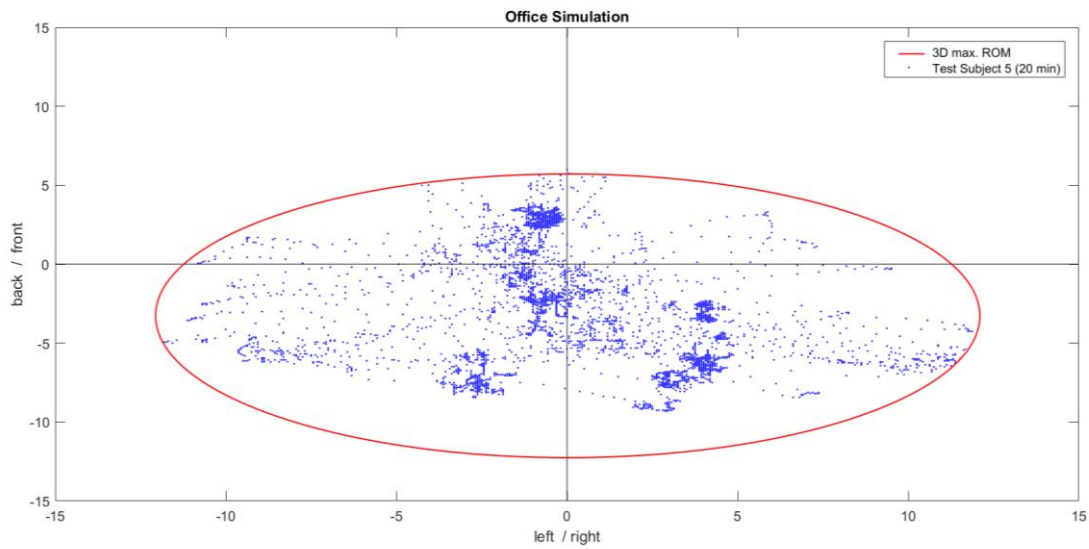


Figure 11: Range of motion of the 3D office chair's seat. The blue points show the angle positions in the frontal plane (x axis) and sagittal plane (y axis) to one another. The red line marks the maximum range of motion possible.

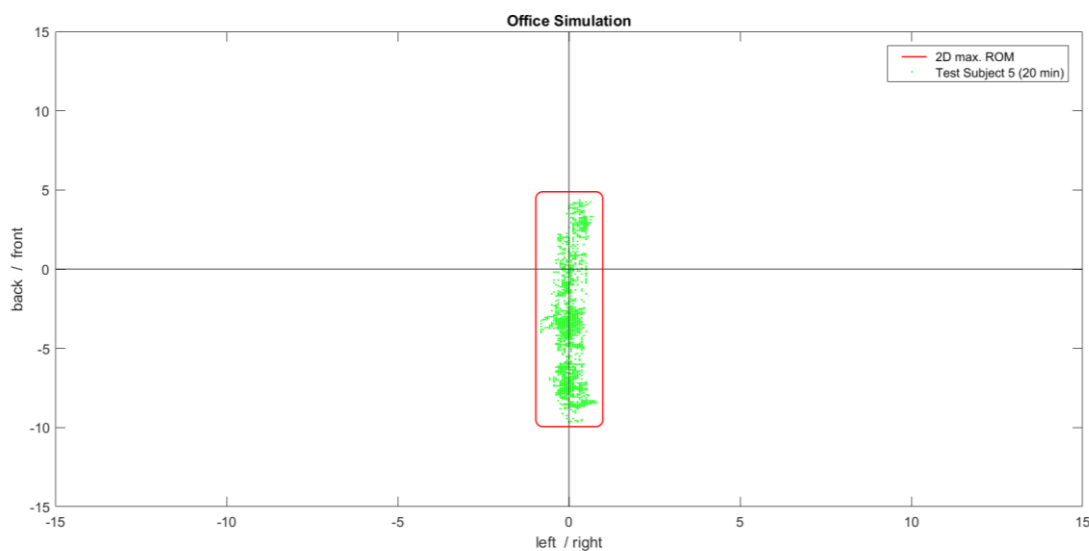


Figure 12: Range of motion of the 2D office chair's seat. The green points show the angle positions in the frontal plane (x axis) and sagittal plane (y axis) to one another. The red line marks the maximum range of motion possible.

Oxygenation

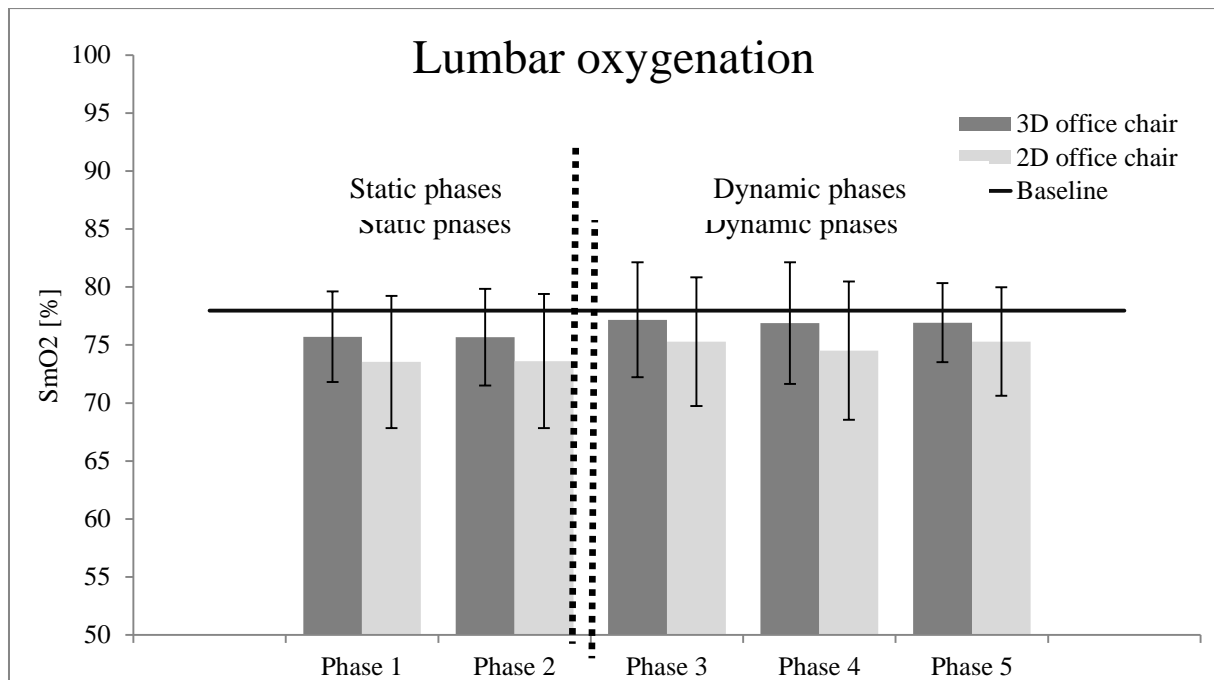


Figure 13: Average oxygenation figures and their standard deviation and the average resting value [%] divided into the various phases of standardised office tasks

An average baseline oxygenation value in the lumbar dorsal muscles of 78% ($\pm 5.3\%$) is captured in the resting phases before completing the standardised office tasks. In the static phases of the standardised office tasks, the average figures while sitting on the 3D office chair are approx. 75.7% ($\pm 4.0\%$) or 73.5% ($\pm 5.7\%$) on the 2D office chair.

In the dynamic phases, the average oxygenation figures increase compared with the figures during the static phases. In the dynamic phases, oxygenation while using the 3D office chair rises to an average figure of 78% $\pm 4.5\%$ and from 75% $\pm 5.4\%$ on the 2D office chair.

Therefore, in all phases, the difference between the resting value while using the 3D office chair is generally lower than when using the 2D office chair. Figure 13 shows the average oxygenation in the lumbar dorsal muscles and the average resting value. The exact results are shown in table 5.

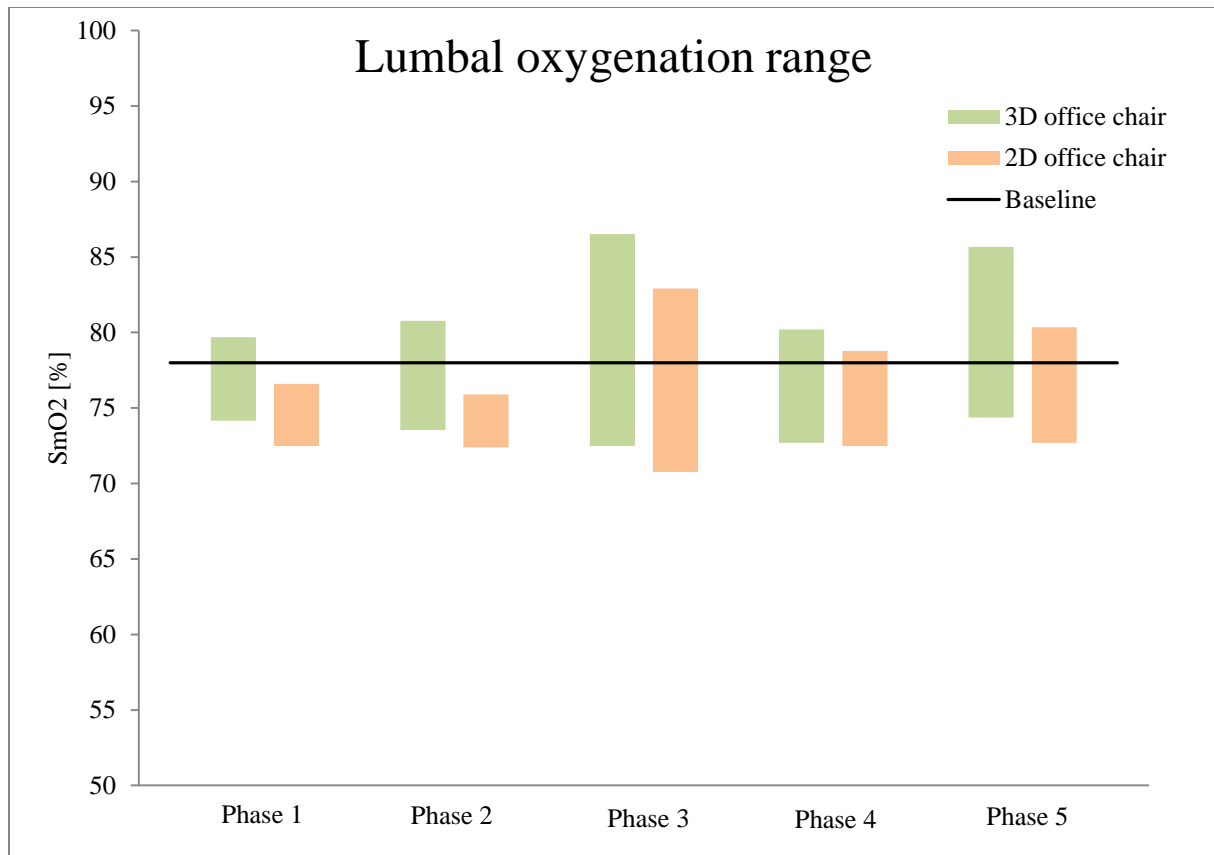
Table 5: Average oxygenation in the lumbar muscles in percent divided into the various phases of standardised office tasks

		SmO ₂ [%] Phase 1	SmO ₂ [%] Phase 2	SmO ₂ [%] Phase 3	SmO ₂ [%] Phase 4	SmO ₂ [%] Phase 5
3D office chair	Average figures	75.72	75.68	77.17	76.88	76.93
	Standard difference	± 3.90	± 4.16	± 4.95	± 5.24	± 3.42
	Summarised in the phases	75.7 ± 4.0		78 ± 4.5		
2D office chair	Average figures	73.54	73.61	75.29	74.51	75.29
	Standard difference	± 5.71	± 5.78	± 5.55	± 5.97	± 4.68
	Summarised in the phases	73.5 ± 5.7		75 ± 5.4		

Oxygenation fluctuations during the phases do occur when the test persons are looked at individually. These fluctuations can be explained because of the alternation between muscle contraction and relaxation. When a muscle contracts, blood flow is poorer because the blood vessels constrict. When the muscle relaxes, the blood vessels expand and the muscle compensates for the previously lower blood flow. Better blood flow can even occur depending on the duration and intensity of the contraction.

The measurement of oxygenation in each phase takes 4 minutes and is then summarised as an average value for each phase. This procedure is carried out for each test person and then an average value has to be created for all test persons in order to make a comparison between the chairs. Averaging the values of all the test persons shows the variance between the test persons and the variance within a measurement therefore disappears. Therefore, the variance of the individual measurements based on the range as a dispersion measure is illustrated in figure 14. The following figure therefore demonstrates the average minimum values (the bottom of the bars) and the maximum values (top end of the bars) of oxygenation in the lumbar dorsal muscles and the resulting range (whole bar).

Figure 14: Graphic of the average minimum and maximum results and resulting oxygenation range in the lumbar dorsal muscles [%], divided into the various phases of standardised office tasks



Subjective assessment questionnaire

The results of the test persons' questionnaire after using the office chairs are shown below. Furthermore, the average values and the standard difference in the answers are listed in brackets based on the five-stage Likert scale (from "correct" to "incorrect"). These values have no units and are paraphrased in the study to make the issue clearer.

After using the 3D office chair, on average the test persons clearly state that they were able to discover the three-dimensional motion options (4.08 ± 0.81). The test persons feel that the 3D office chair definitely stimulates their back significantly more (4.2 ± 0.65) than the 2D office chair (1.32 ± 0.48). These results tally with the observations that the lumbar dorsal muscles are stimulated to a much higher degree due to an improved supply of oxygen.

While using the 2D office chair, the test persons notice hardly any to no positive effects on their lower backs (1.76 ± 0.60). By contrast, the test persons on the 3D office chair notice significantly more positive effects (2.96 ± 0.61). But it should be noted that the relatively

short period of dynamic use (12 minutes) probably limited the effects the people were able to notice significantly.

After using the 3D office chair, the test persons notice that the level of freedom provided by the office chair encourages movement in the back (3.92 ± 0.91) and the hips (hips: 3.12 ± 0.67). On the other hand, after using the 2D office chair, these assessments tended to be judged as “not really correct” (back: 2.00 ± 0.44 ; hips: 1.68 ± 0.48). The test persons like sitting on the 3D office chair (3.72 ± 0.89) and would like to use this office chair in their workplace (4.16 ± 0.69). In this respect, the 2D office chair achieves a much lower rating. The results of the questionnaire are illustrated in a network diagram in figure 15.

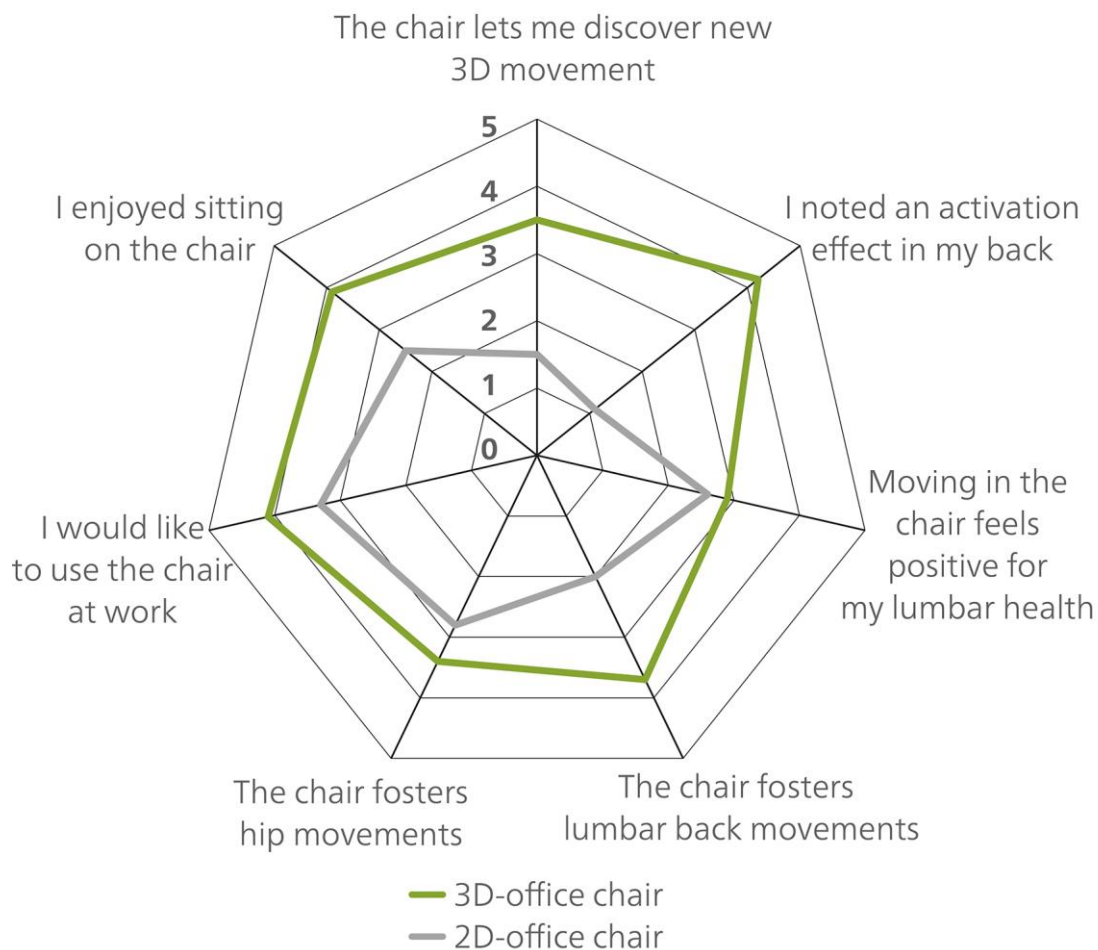


Figure 15: Diagram of the results of the questionnaire after using the office chairs

Summary

This study's goal is to investigate whether the new three-dimensional range of motion offered by the IN office chair in (simulated) office conditions is used and whether, in comparison with motion while sitting on a conventional office chair, this leads to better oxygenation in the lumbar dorsal muscles. What's more, the study assesses whether a user-friendly orientation sensor is suitable for establishing motion on an office chair.

The motion analysis shows that, above all, the sideways tilt of the 3D office chair is used by the people sitting on it while carrying out typical office tasks and the rotation of the backrest is only partially used. Furthermore, the supply of oxygen-rich blood to the lumbar dorsal muscles is fostered due to the more varied motion on the 3D office chair. An orientation sensor is only partially suitable for quantifying this stimulation.

The motion analysis based on the MoCap system and the orientation sensor show that both the person sitting on the chair and the office chair itself move very significantly depending on the task that needs accomplishing. The body of the person sitting on the chair stays relatively rigid in the static phases when virtually all work is done using hands. Consequently, the office chair also doesn't move very much. If the person sitting on the chair has to accomplish a task which, in addition to their hands, also requires the use of other limbs or the torso to tilt, both office chairs move more. The higher level of physical activity is reflected in the results of the analysis of the metabolic processes. More activity while sitting leads to a rise in oxygenation of the lumbar dorsal muscles. These results are backed up by previous studies on the activity of the muscle during active sitting phases (Ellegast, R. P. et al. 2012; van Dieën, J. H., Looze, M. P. de, Hermans, V. 2001). This study shows that the frequency of motion and range of motion depend directly on oxygenation in the lumbar dorsal muscles.

Furthermore, when the motion analysis is looked at in more detail, there are differences in the range of motion in the office chairs and the users, which can also have an impact on oxygenation of the dorsal muscles:

a comparison of motion on the office chairs shows that the 3D office chair supports the movements made by the people sitting on them to a greater degree than the 2D office chair in all phases. And above all, this occurs in a physiological manner because bending, tilting and rotating the pelvis can hardly be carried out in isolation at all.

The two office chairs only score equally where the range of motion in the sagittal plane is concerned. The 2D office chair merely enables slight movements in the transverse and frontal plane; the range of motion used in the 3D office chair is significantly greater on the other hand. The rotation movements of the 3D office chair aren't fully exploited, as the analysis on the range of motion shows. This is explained by the fact that when people lean sideways to grab something they prefer to lean back rather than rotate. In some cases, a rotation of the backrest of up to 11° was observed but isn't used very often by the test persons. Furthermore, the 3D office chair tends to tilt significantly sideways. In static phases, the 3D office chair even fosters a change in the sitting position.

This greater level of physical activity, fostered by the 3D office chair, is reflected in a better supply of oxygen to the lumbar dorsal muscles both in dynamic and static phases. The 3D office chair encourages alternation between contracting and relaxing the dorsal muscles to a much greater extent so that the dorsal muscles have a much better supply of oxygen-rich blood (see fig. 14). While the 3D office chair is being used, average oxygenation departs significantly less from the baseline value than the 2D office chair does (see fig. 13).

A comparison of the motion analysis of the seat between the orientation sensor and MoCap system shows that the orientation sensor does offer a way of reflecting the user's sitting behaviour. Movements in the seat are captured with tolerable measurement accuracy. Considering the fact that it's so user friendly and saves time and costs, this sort of orientation sensor is a promising approach. As a result, a difference in the movement frequency and the range of motion options offered becomes clear. The analysis of the backrest movements does however need a further sensor. Assumptions made regarding the movements made by the person sitting on the chair can at least be applied to a limited extent.

The questionnaire handed out to the test persons after they had used the office chairs shows that the three-dimensional motion options offered by the 3D office chairs are discovered intuitively. While using the greater variety of movement options offered by the 3D office chair, the people sitting on it noticed that their back was definitely stimulated, whereas this wasn't the case on the 2D office chair. Furthermore, the test persons feel that the 3D office chair has a positive impact on their lower backs, whereas this wasn't the case with the 2D office chair.

Conclusion

While conducting typical office tasks during which the body remains relatively rigid, the 3D office chair encourages changes in the sitting position. Furthermore, it supports the movements the person sitting on the chair makes in a natural way. By encouraging more physical activity, the 3D office chair is an effective way of cutting down on the negative consequences of sitting for long periods of time. The results of the physiological supply of oxygen to the dorsal muscles are also promising. Sitting on 3D chairs leads to better oxygenation of the lumbar dorsal muscles compared with conventional office chairs.

Combined with a height-adjustable table, the 3D office chair is a very efficient way of counteracting the impact of monotonous periods of sitting still.