Tests of the ergonomic functions of the ‘Moteo’ office swivel chair with pneumatic modules (‘celligence® system’) in the seat pad and backrest

Test report

ESK-BDS/05/20100. Summary

1. Problems associated with a seated body position
2. The ‘Moteo’ test chair
3. Ergonomic analysis of dimensions and movements, with measurements of the pressure on upholstered components
4. Evaluation of the functionality of the pneumatic components incorporated in the seat pad and backrest
5. Bibliography

Publication of this test report, in whole or in part, requires the prior approval of the publishers.
0. Summary

The attached report comprises tests of the ergonomic functionality of the office swivel chair ‘Moteo’ manufactured by Klöber GmbH.

The office swivel chair ‘Moteo’ has a synchronous movement (‘procomfort-synchomechanism’) and a variety of adjustments to meet individual requirements (seat height, seat depth, backrest counter-pressure, armrests, headrest/neck support). One functional uniquely of ‘Moteo’ from an ergonomic point of view is the inclusion of pneumatic components (‘celligence® system’) in the seat pad and backrest. In the backrest, the pneumatic module is at a constant pressure, while in the seat pad the pressure can be regulated by means of a valve. A product description of the test chair is given in Chapter 2.

The evaluation of the basic ergonomic functions was based on the relevant requirements for the test certificate ‘TESTED ERGONOMICS’ of the TÜV Rheinland LGA Products GmbH.

The ergonomic/functional analysis was carried out using the ‘Sedometer’ chair measurement device, which provides a standardised measurement of office swivel chairs based on human physiological data (cf. Chapter 3).

In addition, the Sedometer provided a standardised measurement of the pressure on the upholstery of the seat pad, which let the pressure-reduction effect of the upholstery be determined for different groups of users: small/light, average height and weight, tall/heavy (cf. Chapter 3).

The completed analysis of dimensions and movements, along with the seat pad pressure measurements, demonstrates that all tested functions of the ‘Moteo’ test chair correspond to the requirements of the test certificate ‘TESTED ERGONOMICS’ (cf. Chapter 3: Table 1):

The available adjustments for seat depth and armrests provide a generous range of settings. The synchronous mechanism has a harmoniously regulated movement and a wide rotational range. The headrest/neck support, so important when reclining to work or to rest, is suitable for a wide range of users thanks to the available adjustments for height and position. An additional positive ergonomic feature is the position and ease of use of the different controls.

Furthermore, the integral pneumatic modules in the seat pad and backrest provide additional and ergonomically significant benefits for the seated user:

The pneumatic module in the seat pad, which redistributes air when under pressure, encourages an upright forward sitting position with stronger support for the pelvis. This special construction of the seat pad also supports lateral mobility on the seat and thus promotes dynamic sitting. An essential feature of this celligence® system is that one can operate a valve to adjust the air-pressure in the chamber to suit the physical characteristics of the user and thus provide the preferred properties for the upholstery.
The functional uniquely of the **pneumatic module in the backrest** is that, thanks to the flexibility of the backrest construction and the possibility of air redistribution, the contour of the backrest, within a certain range, adjusts quasi-automatically to the individual back shape of the user; this achieves approximately the same effect as a height-adjustable backrest or lumbar support. Also worthy of mention is the flexible response of the backrest to lateral movement, which provides positive support for dynamic sitting.

In order to make a judgement of those chair functions which depend on the pneumatic modules in the seat pad and backrest, **seating trials with 6 test users** were carried out, with the users having different physical characteristics between the 5th percentile female and the 99th percentile male. The subjective ratings of the chair functions were made by a simple questionnaire with a five-step opinion scale (cf. Chapter 4). Without exception, the rating of the functions described above was positive, particularly in the case of users of average height and weight and of users who are tall/heavy.

In summary therefore, the seating functions incorporated in the ‘**Moteo**’ test swivel chair - both the **basic functions** required for the test certificate ‘TESTED ERGONOMICS’ and the **additional functions** obtained from the **effect of the pneumatic modules** – are **rated as positive from the point of view of ergonomics**.
1. Problems associated with a seated body position

While exogenous pressures in the office workplace – those coming from outside – are generally considered as not too great, office workers have an increased tendency to suffer from skeleto-muscular disorders – especially back problems. The main factors which can be listed as prime or contributory causes of problems associated with sitting are:

- Long-term and predominantly static sitting, leading to a stagnation of the metabolism in the muscles and in the vertebral discs.
  
  In the muscles, the static position causes reduced circulation, so that less oxygen and nutrients are supplied. This causes premature muscle fatigue, hardening of the muscles and muscle pain.
  
  In the discs, which in the adult person have no blood circulation, long-term static load leads to a stagnation of the osmotic metabolic processes and thus to an insufficient nutrient supply, which produces a premature degeneration of the discs.

  Degenerate discs have a negative effect on the load-bearing capacity of the corresponding moving part of the spine, which increases the likelihood of complaints.

- Incorrect positions, or non-physiological positions, which lead to an uneven load on the discs, e.g. the rounded back position with excess load on one side; in this context, we know that the mobile, central core tissue, under conditions of prolonged asymmetrical load, will gravitate to the segments which are less under pressure. This increased displacement of the nucleus pulposus or gelatinous core has a direct connection with disc-related complaints (prolapsed or herniated disc).

In order to counter these problems with the sitting position, scientists made the relevant recommendations for environmental and behavioural prevention. On the one hand, these recommendations concern the avoidance of incorrect positions by setting up an ergonomic workstation. This requires workstation components which can be adapted to the user’s anthropometric dimensions, i.e. office task chair, desk etc (called environmental prevention), as well as the correct adjustment of these components by the individual employee (behavioural prevention).
The second central ergonomic approach to the prevention of problems with sitting is the avoidance of static positions where possible and to integrate dynamic sitting into the working position.

This led to the recommendations to change the working position, both by alternating sit/stand working and through what is called dynamic sitting, i.e. the temporary change of sitting position (forward, central and rear sitting position).

The office swivel chair has a central role in incorporating these recommendations in the workplace:

- On the one hand, numerous adjustments of the seat height, the lumbar support height, the seat depth, the armrest height etc are an essential requirement if one is to give people of different body dimensions in different workplace situations the chance of a physiologically sensible body position, avoiding incorrect positions of the spinal column.

- On the other hand, a well-designed synchronous mechanism for the back and seat is a basic precondition of regular changes to the sitting position, as it counteracts long-term static load on the muscles and discs. The distinguishing features of a good-quality synchronous mechanism are the tilt ratio of seat and back, the adjustability and operation of the backrest counter-pressure and the angles which define the travel of the synchronous mechanism.

When designing office task chairs from an ergonomic viewpoint, in addition to the requirements of DIN 4551 and EN 1335, there has been since 1995 the test certificate ‘TESTED ERGONOMICS’ of TÜV Rheinland Products GmbH, which makes different requirements of high-quality office swivel chairs in respect of the following functions:

- dimensions and contours of the seat pad and backrest
- chair functions and their adjustment range
- synchronous mechanism
- matching of the upholstery to the user
- operating controls
2. The test office swivel chair ‘Moteo’

The test office swivel chair ‘Moteo’ (cf. image 1) has a synchronous movement (with a 4-stage adjustment to limit the reclining angle, an infinitely variable additional tilt of the seat pad, and individual adjustment of the backrest counter-pressure), an adjustable seat-depth, armrests with 4 adjustments (width, height, depth and in/out swivel action) and an adjustable headrest/neck support (adjusts in height and angle).

In addition, there are pneumatic modules integrated into the seat pad and backrest: the pressure in the backrest module is constant, while the pressure in the seat pad module can be controlled by means of a valve. For the analysis of dimensions and movement (cf. Chapter 3), a middle-range pressure in this pneumatic module was used.

The test results obtained are valid only for the model type described.

![Test task chair ‘Moteo’ with the ‘Sedometer’ measuring device and additional weights (cf. Chapter 3)](image1)
3. **Ergonomic analysis of dimensions and movements, with measurements of the pressure on upholstered components**

To judge the basic ergonomic functions of the ‘Moteo’ task chair, the requirements of the test certificate ‘TESTED ERGONOMICS’ of the TÜV LGA Rheinland Products GmbH were set as the standard.

The principal measuring instrument for this ergonomic/functional analysis is the chair measuring device ‘Sedometer’, which allows a **standardised measurement** of office swivel chairs, based on real human physiological data (cf. Fig.2, left).

In addition, the Sedometer can make a standardised measurement of the **pressure imposed on the seat upholstery**; for this, the device is equipped with pressure sensors in the area of the ischial tuberosity, the two projections on the lower pelvis (cf. Fig. 2, right). To simulate the pressure-reduction effect on different categories of people (small/light, of medium height and weight, tall/heavy), the Sedometer was loaded with different weights.

---

**Fig. 2:** Chair measurement device ‘Sedometer’ to test the ergonomic functionality of office task chairs.

**Fig. 3a and 3 b** show the relevant **dimensions and angles** for the ergonomic evaluation.
Table 1 summarises the results of the measurement of the ‘Moteo’ task chair. You will find in addition the target values for dimensions and angles. Table 1 also shows the results of the seat upholstery pressure tests (maximum pressure).
Tests of the ergonomic functions of the ‘Moteo’ office swivel chair

Fig. 3a: Schematic representation of the relevant chair dimensions (cf. Table 1)

Fig. 3b: Schematic representation of the relevant sitting angles (cf. Table 1)
Tests of the ergonomic functions of the ‘Moteo’ office swivel chair

Tab.1: Task chair ‘Moteo’ – Klöber GmbH: Ergonomic chair measurement and seat pressure measurement. Basis: Measurement with Sedometer; SB: ischial tuberosity; unspecified dimensions are in mm

<table>
<thead>
<tr>
<th>Item measured</th>
<th>No.</th>
<th>Ergonomic requirement</th>
<th>Ergonomic recommend.</th>
<th>Test result 5. female 50. male 95. male</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seat pad</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seat height (SB zone: min; max)</td>
<td>1a</td>
<td>&lt; 420; &gt; 515</td>
<td>&lt; 400; &gt; 530</td>
<td>420; 530 425; 535 425; 535</td>
<td>(pass)</td>
</tr>
<tr>
<td>Height of the seat pad in the area of the upper thighs (min; max)</td>
<td>1b</td>
<td>&lt; 440; &gt; 535</td>
<td></td>
<td>435; 545 440; 550 440; 550</td>
<td>pass</td>
</tr>
<tr>
<td>Remaining spring travel (downwards)</td>
<td>1c</td>
<td>&gt; 10</td>
<td>11</td>
<td></td>
<td>pass</td>
</tr>
<tr>
<td>Seat depth (effective)</td>
<td></td>
<td></td>
<td></td>
<td>400; 480 415 455 485</td>
<td>pass</td>
</tr>
<tr>
<td>Seat depth (design depth)</td>
<td></td>
<td></td>
<td></td>
<td>435 475 505</td>
<td>(pass)</td>
</tr>
<tr>
<td>Seat width (effective)</td>
<td>3</td>
<td>&gt; 430</td>
<td>&gt; 450</td>
<td>450</td>
<td>pass</td>
</tr>
<tr>
<td>Backrest</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Backrest height (design height)</td>
<td>4</td>
<td>---; &gt; 480</td>
<td>&lt; 500; &gt; 650</td>
<td>750 750 750 750</td>
<td>pass</td>
</tr>
<tr>
<td>Height of the thoracic curve of the spine</td>
<td>5</td>
<td>460 to 520</td>
<td>480</td>
<td>460 490 520</td>
<td>pass</td>
</tr>
<tr>
<td>Height of the lumbar section of the spine</td>
<td>6a</td>
<td>&gt; 210</td>
<td>230 to 290</td>
<td>260 270 280</td>
<td>pass</td>
</tr>
<tr>
<td>Depth of the lumbar support</td>
<td></td>
<td></td>
<td></td>
<td>20 to 40 10; 50</td>
<td>pass</td>
</tr>
<tr>
<td>Support for the iliac crest (top of pelvis)</td>
<td>7</td>
<td>170 to 230</td>
<td>---</td>
<td></td>
<td>pass</td>
</tr>
<tr>
<td>Space for buttocks</td>
<td>8</td>
<td></td>
<td></td>
<td>&lt; 130 130 130</td>
<td>pass</td>
</tr>
<tr>
<td>Backrest width (effective)</td>
<td>9</td>
<td>&gt; 360</td>
<td>&gt; 400</td>
<td>375</td>
<td>pass</td>
</tr>
<tr>
<td>Armrests</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Armrest height (SB zone)</td>
<td>10</td>
<td>220 to 280</td>
<td>190 - 300</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Armrest width (effective)</td>
<td>11</td>
<td>&gt; 35</td>
<td>40 to 60</td>
<td>90</td>
<td></td>
</tr>
<tr>
<td>Clear width between armrests</td>
<td>12</td>
<td>&gt; 470</td>
<td>&gt; 490</td>
<td>440 - 490</td>
<td></td>
</tr>
<tr>
<td>Mechanism</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seat tilt (min; max)</td>
<td>α</td>
<td>&gt; -4°; &lt; 15°</td>
<td>-3°; 11°</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seat tilt in start position</td>
<td></td>
<td>&gt; -2°; &lt; 5°</td>
<td>2° 2° 2° 2°</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Increase via tilt adjustment</td>
<td></td>
<td>&gt; 5°</td>
<td>9° 9° 9° 9°</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Backrest tilt (min; max)</td>
<td>β</td>
<td>&gt; 80°; &lt; 125°</td>
<td>93°; 123°</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Backrest tilt in start position.</td>
<td></td>
<td>90° to 95°</td>
<td>93° 93° 93° 93°</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Increase via tilt adjustment</td>
<td></td>
<td>&gt; 15°</td>
<td>31° 31° 31° 31°</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Opening angle seat/back (min)</td>
<td>δ</td>
<td>&gt; 84°</td>
<td>91° 91° 91° 92°</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Opening angle seat/back in start position</td>
<td></td>
<td>90° to 95°</td>
<td>91° 91° 92° 92°</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Increase in seat/back opening angle</td>
<td></td>
<td>&gt; 10°</td>
<td>22° 22° 22° 22°</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Synchronous ratio</td>
<td>μ</td>
<td>1:1,5 to 1:3,5</td>
<td>1:2 to 1:3</td>
<td>1:3 4</td>
<td></td>
</tr>
<tr>
<td>Lifting of seat front edge</td>
<td>ε</td>
<td>&lt; 20</td>
<td>-10 to -20</td>
<td>20</td>
<td>(pass)</td>
</tr>
<tr>
<td>Shirt-pull effect (relative movement)</td>
<td>χ</td>
<td>&lt; 1,5 mm/1°</td>
<td>&lt; 0,5 mm/1°</td>
<td>0 mm/1°</td>
<td></td>
</tr>
<tr>
<td>Loss of pelvic contact when reclining</td>
<td>γ</td>
<td>As low as poss.</td>
<td>useable/supportive</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strength of spring when reclining</td>
<td></td>
<td></td>
<td></td>
<td>useable/supportive</td>
<td></td>
</tr>
<tr>
<td>Seat upholstery</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Max. pressure (in N/cm²)</td>
<td></td>
<td>&lt; 3,0</td>
<td>2,1 2,5 2,7</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Given measurement tolerance, ratings shown in brackets are within acceptable values.
For better understanding of the test results in table 1, please see the explanation below.

If an office swivel chair has adjustable seat depth, then this function will be measured for 3 different categories of user (small person, average person, large person). In the current case, the ‘Moteo’ chair was measured with the following settings:

- for small people (5th percentile female) at the lowest setting for the seat depth
- for average people (50th percentile male) with a central setting for the seat depth
- for large people (95th percentile male) at the maximum setting for the seat depth

Since these 3 different settings of the seat depth produce different positions of the Sedometer on the chair, there can be significant differences in the resulting dimensions and in the angles of the seat pad and backrest.

Against this background, the test results for the ‘Moteo’ task chair shown in table 1 can be grouped as follows:

**Seat pad dimensions (dimensions 1-3)**

**Seat height dimensions 1a and 1b, remaining spring travel 1c:**
Both measured settings (approx. 110 mm) for the seat height in the area of the ischial tuberosity (dimension 1a) and in the area of the upper thighs (dimension 1b) meet in full the requirement for 95 mm; when measuring the ‘5th percentile woman’, the required minimum value for the seat height in the area of the ischial tuberosity is also met. The remaining spring travel (dimension 1c) at the lowest height setting is satisfactory.

**Seat depth dimensions 2a and 2b, seat width 3:**
These dimensions correspond to the relevant ergonomic requirements. Certainly, when measuring the ‘5th percentile woman’, the design seat depth of 435 mm is strictly speaking too great; but one must remember that the limit value of 430 mm was established in the past, based on the anthropometric measurement ‘seat depth’ contained in DIN 33 402 ‘Dimensions of the human body’. The current version of DIN 33 402, however, gives a seat depth for the 5th percentile woman of 435 mm – so the design seat depth of ‘Moteo’, as measured, corresponds exactly to this requirement.

From an ergonomic viewpoint, positive mention must be made of the extensive adjustment range for the seat depth (approx. 70 mm), to allow for the length of the individual user’s thigh; when set for maximum seat depth, there is a wide gap between seat pad and backrest, and in practice this setting will probably be little used.

**Backrest dimensions (dimensions 4-9)**
All backrest dimensions correspond to the relevant requirements and recommendations. As far as the height of the support in the lumbar area is concerned (dimension 6a), it should be noted that the dimensions taken in the three measurement situations (260/270/280 mm) represent
a sensible value for average back heights; the anthropometric values for the height of the lumbar support protrusion are approximately 230 mm (5th percentile female) to 290 mm (95th percentile male). While the ‘Moteo’ swivel chair possesses neither a height-adjustable backrest nor a separate lumbar support, the special construction of the backrest with its pneumatic module does however provide to a certain extent a ‘quasi-automatic’ adjustment to suit individual back shapes – based on the basic back contours, which are sensibly in the mid-range (see above). Further details are given in Chapter 4 of the individual adjustment of the backrest shape in conjunction with the pneumatic module of the ‘Moteo’ task chair.

**Armrests**
The armrests provide a wide height-adjustment range, and the armrest pads are of a generous size. The adjustment range of the clear width between armrests meets all requirements and recommendations; the additional in/out swivel action and the forward/backward adjustment can be helpful in special workplace situations.

**Synchronous mechanism**
The synchronous mobility of seat and back is an essential quality criterion for an office task chair, with a view to avoiding the dangers of a static seating position (cf. Ch. 1). Moreover, the synchronous mechanism of the ‘Moteo’ swivel chair has a demonstrably harmonious action, and there is only a slight loss of contact in the pelvis area when the user reclines. The so-called ‘shirt-pull’ effect (the relative movement of back and seat as the reclining angle increases) can scarcely be measured; and the lifting of the leading edge of the seat is within allowable limits.
The values which were measured for the seat tilt angle and for adjustments to the seat tilt angle, backrest angle and seat/back opening angle meet the relevant requirements in full, and the ability to adjust the basic tilt angle of the seat pad has certainly played a part in achieving this. The construction of the seat pad with the pneumatic module provides, in practice, an additional degree of freedom in the seat forward tilt angle and also in lateral movement. This matter is examined more thoroughly in Ch. 4.

Dynamic sitting on the ‘Moteo’ chair is supported by the lateral torsion motion of the backrest. While it is true that this aspect is not considered when evaluating the chair against the requirements of the test certificate ‘TESTED ERGONOMICS’, the chair testers commented positively on this function during their seating trials and comfort ratings (cf. Ch. 4).

The **counter-pressure of the synchronous mechanism** on the standard version of the ‘Moteo’ chair provides an adjustment range which is very good for users of medium height and weight, up to users who are tall/heavy. For small/light users, who require a lower counter-pressure in the synchronous mechanism, an optional lighter-duty pneumatic spring is available.

**Headrest / neck support**
In the case of office swivel chairs such as the one tested, which have a wide range of movement with the synchronous mechanism and which allow the user to adopt a reclining position to work or relax, it is particularly important from the ergonomics point of view to provide a
headrest/neck support to allow at least intermittent relief from the strain on shoulder and neck muscles by resting the head.

For this reason, in addition to the dimensions required for the test certificate ‘TESTED ERGONOMICS’ in Table 1, the adjustments of the headrest/neck support on the office task chair ‘Moteo’ were recorded.

The headrest/neck support has an effective pad height of approx. 170 mm, and the pad height (to pad centre) can be set between approx. 700-800 mm above the loaded seat pad, corresponding to an adjustment range of approx. 100 mm. This adjustment range of the headrest/neck support, in combination with the height of the pad itself, provides the necessary support to the back of the head to users from the 5th percentile female to the 95th percentile male. In addition to the basic position, the headrest/neck support has two additional tilt adjustments (tilted through approx. 15° and 30°) to allow individual adjustment to the head position when sitting forward, semi-reclined and totally reclined. The soft and elastic surface of the headrest/neck support also provides an effective pressure relief for the back of the head.

**Measurement of pressure on the seat upholstery**

The measured maximum values in Table 1, taken from the simulation of the 3 user groups, are well below the permissible maximum value of 3.0 N/cm²; this confirms the sensible structure and dimensions of the seat pad construction as an effective pressure relief. When the measurements were being taken, the pneumatic module in the seat pad was completely full. The hardness of the seat pad can be adjusted to suit individual preference, by regulating the amount of air in the pneumatic module. Further details of this effect are given in Ch. 4.

**Operating controls**

All operating controls are easily reached, and can be operated with relatively little effort. The rotating knob which sets the backrest counter-pressure is particularly effective, as its convenient position side/front/right, combined with the relatively short travel, make it easy to use. The same principle applies to the 4-stage backrest tilt limiter on the synchronous mechanism, situated side/front/left.

**4. Evaluation of the functionality of the pneumatic modules incorporated in the seat pad and backrest**

As explained in Ch. 2, the ‘Moteo’ test chair was equipped with pneumatic modules in the seat pad and backrest. The pneumatic module in the backrest is filled at constant pressure, while the pressure in the module in the seat pad can be controlled by a valve. These integral pneumatic modules provide special functions in the seat pad and backrest, which are described below from an ergonomic viewpoint.
Tests of the ergonomic functions of the ‘Moteo’ office swivel chair

The report made on the effectiveness of the pneumatic modules is supported by the subjective opinions of 6 test users (3 women representing the 5th/50th/95th body height percentile according to DIN 33 402, of standard weight; and 3 men representing the 5th/50th/95th body height percentile, of standard weight), with whom tests were made on the ‘Moteo’ task chair, with their subjective evaluation being recorded by a simple questionnaire (cf. Table 2).

The heights and weights of the test group are as follows (percentile definition according to DIN 33 402-2; age group 18 – 65 years). Note: Vp = test user

Vp 1: female / height 154 cm / weight 51 kg; ca. 5th percentile female
Vp 2: female / height 163 cm / weight 60 kg; ca. 50th percentile female
Vp 3: female / height 173 cm / weight 68 kg; ca. 95th percentile female
Vp 4: male / height 175 cm / weight 74 kg; ca. 50th percentile male
Vp 5: male / height 186 cm / weight 84 kg; ca. 95th percentile male
Vp 6: male / height 190 cm / weight 92 kg; ca. 99th percentile male.

Effect of the pneumatic module in the seat pad
The effect of the pneumatic module in the seat pad is evaluated from the following viewpoints:

a) Effect of the pneumatic module on the seat tilt angle when the user is in a forward sitting position

b) Effect of the pneumatic module on the user’s lateral mobility on the seat pad, from the viewpoint of ‘dynamic sitting’.

c) Effect of the pneumatic module on the comfort provided by the seat pad, from the viewpoint of ‘sitting pressure’.

Comments on a) Effect of the pneumatic module on the seat tilt angle when the user is in a forward sitting position
The following two functions of a task chair, depending on the sitting position adopted, are considered as functional aids in the prevention of what is known as kyphosis, or abnormal rounding of the back:
With a central or rear sitting position, the contact between the pelvis and the backrest is essential if the user is to avoid a tipping backwards of the pelvis and the associated tendency to an abnormally rounded back.
In a forward sitting position – in which the user is often sitting on the central or front part of the seat pad – the backrest no longer fulfils this function. But to prevent a rearward tilting of the pelvis, office task chairs can have a moderate forward tilt on the seat pad, with the aim of reducing the strain on the muscle / tendon / vertebra complex in the rear of the pelvis and to allow a more upright position. – and so counteract the abnormal rounding in the area of the
lumbar vertebrae. The principal effect can be compared with that of a gym ball: because the sitting surface is tilted forwards, the upper thighs are also at an angle, helping to keep the pelvis upright; at the same time, sinking into the ball gives a more upright pelvis position, avoiding abnormal rounding of the back.

A similar effect is obtained with the **pneumatic module** in the seat pad: thanks to the user’s sitting in the centre or towards the front of the seat, the user can sink further into the seat pad, creating an increased forward tilt angle with the desired effect described above – an easier return of the pelvis toward the vertical. In addition, the redistribution of air within the pneumatic module – in a situation comparable with that on the gym ball – gives increased support to the rear of the pelvis.

In order to use this effect regardless of the user’s physical characteristics (small/light person – tall/heavy person), it is essential that one should be able to control the pressure in the pneumatic module and thereby adjust the elasticity.

The **subjective opinions** of the test users confirmed the positive effect of the pneumatic module in a forward sitting position. Thanks to the re-distribution of the air, the pressure on the thighs is reduced, which makes it easier to adopt a forward seating position with sloping thighs. At the same time, the air re-distributed to the rear creates a slight bulge behind the pelvis, which gives support to the pelvis.

The relevant questioning of the test users showed that this effect is more clearly noticeable for tall/heavy users (cf. Table 3, fig.4).

**Comments on b) Effect of the pneumatic module on the user’s lateral mobility on the seat pad, from the viewpoint of ‘dynamic sitting’**.

As a complement to the synchronous movement of seat and back, an office task chair can possess additional possible movements which permit various degrees of dynamic sitting. One such effective mechanism is the encouragement of lateral movement on the seat pad, as a complement to the forwards/backwards motion of the synchronous mechanism. This lateral tilting/tipping of the pelvis – in the sense of providing a work-out for the neuro-muscular stabilisation mechanisms of the spine – is also familiar from sitting on gym balls.

The **pneumatic** module in the seat pad upholstery of the ‘**Moteo**’ office task chair has a similar effect: there is a pronounced lateral mobility on the seat pad, which was also perceived subjectively by the test users, who rated the effect as positive (cf. Table 3, fig.4).

**Comments on c) Effect of the pneumatic module on the comfort provided by the seat pad, from the viewpoint of ‘sitting pressure’**

Pressure distribution in the contact area between user and seat pad is an essential aspect of sitting comfort. On the one hand, this means one has to achieve an effective pressure reduction on the seat pad, i.e. allow the user to sink into the upholstery over a large area – which requires a
soft/elastic reaction from the seat pad. On the other hand, the whole construction of the seat pad cannot be too soft, as this can result in the upholstery ‘bottoming out’ below the ischial tuberosity, especially in the case of taller/heavier users.

Considering both these aspects, the **pneumatic module** in the seat pad has an interesting effect, as on the one hand the foam upholstery on top of the pneumatic element is very soft and elastic (surface pressure reduction, see above) while on the other hand the pneumatic module, thanks to its distinctively progressive reaction, prevents any ‘bottoming out’ of the upholstery.

Since, furthermore, the individual physical characteristics vary greatly from small/light users to tall/heavy users, a standard chair seat upholstery may have an insufficient ‘operating range’: given the limited thickness of upholstery construction, a soft upholstery designed for small/light users will often simply ‘bottom out’ below tall/heavy users. On the other hand, a harder grade of upholstery will prevent ‘bottoming out’, but will be too hard for small/light users.

Also, not all people have the same subjective sense of comfortable upholstery from the viewpoint of pressure reduction – which is why people subjectively prefer harder or softer upholstery.

In this context, the **pneumatic module** within the seat pad has the advantage of adjustability, by varying the amount of air in the system, which allows:
- on the one hand, an adjustment of the hardness to suit the objective physical characteristics of the user
- on the other hand, an adjustment to the subjectively preferred hardness.

These functional properties of the ‘Moteo’ chair with the pneumatic module in the seat pad were rated as positive by the user group (cf. Table 3, fig.4)

The sitting tests carried out demonstrate the principle that the intensity of the functional effects provided by the pneumatic module increases as the height and weight of the user increases (cf. Table 3).
Effect of the pneumatic module in the backrest

The pneumatic module in the backrest is evaluated from the following viewpoint:

**Effect of the pneumatic module on the individual backrest shape.**

One essential task of the backrest of an office swivel chair is to give the best possible support to the individual back shape of the user with a lordotic curve in the area of the lumbar vertebrae.

If a backrest is not height-adjustable in whole or in part (lumbar support), then the most sensible way of providing this shape is to have a curved protrusion in the area of the lumbar vertebrae which corresponds to the backrest shape of people of average height (50th percentile).

A functionally better alternative is backrest height adjustability in whole or in part (lumbar support), which permits an adjustment to the individual shape of the user’s spinal column.

From this aspect, the **pneumatic module** in the backrest upholstery of the ‘Moteo’ office swivel chair makes it possible to achieve an individual back shape, within certain limits, without requiring further adjustment controls. The pneumatic module has a special method of operation as a communicating system – it gives way in the more highly pressurised zones (pelvic area or thoracic vertebral area, depending on sitting position), with the displaced air providing support in less pressurised areas (lumbar vertebral area) – which provides a quasi-automatic adjustment to the height and curvature of the individual user’s spinal column.

As was shown by the measurement results using the Sedometer chair measuring device (cf. Ch. 3, Table 1), the backrest contour of the ‘Moteo’ office swivel chair has a sensible basic back shape to suit users of average height. Thanks to the pneumatic module, this basic contour reacts flexibly under pressure to offer an improved fit to the individual user’s back shape.

All the test users, regardless of height and back length, made a positive subjective judgement of the vertical backrest contour and the support provided (cf. Table 3, fig. 4).

One further aspect of the seat pad/backrest dynamics, which is not directly connected to the pneumatic module in the backrest, was also commented on positively by the test users: the laterally **flexible mounting of the backrest** provides a further degree of freedom to the upper body, with this function being once again primarily more useful to users of average height and weight and to tall/heavy users.
Tests of the ergonomic functions of the ‘Moteo’ office swivel chair

Table 2: Questionnaire for the subjective judgement of chair functionality when combined with pneumatic modules in the seat pad and backrest. The evaluation was made after a trial sitting period of 30 minutes.

<table>
<thead>
<tr>
<th>Questionnaire on chair functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Note:</td>
</tr>
<tr>
<td>First of all, adjust all functions to the individual user (seat height, seat depth, backrest counter-pressure, armrests, headrest/neck support, pressure setting in the seat pad)</td>
</tr>
</tbody>
</table>

Please rate the following properties of the **seat pad upholstery** in a forward, upright position (position without contact with the backrest):

1) How do you rate the pressure around the **front edge of the seat pad**?
   - **very comfortable** +2….+1……0…….-1…..-2 **very uncomfortable**

2) How do you rate the **support provided by the upholstery to the pelvis**? (coccyx/sacrum area) ?
   - **very good** +2….+1……0…….-1…..-2 **very bad**

3) How do you rate the **lateral mobility on the seat pad**?
   - **very good** +2….+1……0…….-1…..-2 **very bad**

4) How do you rate the **adjustability of the pressure in the pneumatic module**?
   - **very effective** +2….+1……0…….-1…..-2 **not effective**

   Comments................................................................

Please rate the following properties of the **seat pad upholstery** in a forward to central sitting position (sitting position with contact with the backrest):

5) How do you rate the **fit of the back contours** (support given in the lumbar area)?
   - **very good** +2….+1……0…….-1…..-2 **very bad**

6) How do you rate the **lateral mobility on the backrest**?
   - **very good** +2….+1……0…….-1…..-2 **very bad**

   Comments...................................................................
Table 3: Summary of the results of the questionnaire on the chair functions when combined with the pneumatic modules in the seta pad and backrest.

<table>
<thead>
<tr>
<th>Chair function questionnaire – summary of the results.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) <strong>Pressure at the front edge of the seat</strong></td>
</tr>
<tr>
<td>very comfortable +2……-2 very uncomfortable</td>
</tr>
<tr>
<td>Vp1  Vp2  Vp3  Vp4  Vp5  Vp6</td>
</tr>
<tr>
<td>0 +1 +2 +2 +2 +2</td>
</tr>
<tr>
<td>2) <strong>Support for the pelvis by the upholstery</strong></td>
</tr>
<tr>
<td>very good +2….-2 very bad</td>
</tr>
<tr>
<td>Vp1  Vp2  Vp3  Vp4  Vp5  Vp6</td>
</tr>
<tr>
<td>0 0 +1 +1 +2 +2</td>
</tr>
<tr>
<td>3) <strong>Lateral mobility on the seat pad</strong></td>
</tr>
<tr>
<td>very good +2….-2 very bad</td>
</tr>
<tr>
<td>Vp1  Vp2  Vp3  Vp4  Vp5  Vp6</td>
</tr>
<tr>
<td>+1  +2 +2 +2 +2 +2</td>
</tr>
<tr>
<td>4) <strong>Adjustability of the pressure in the pneumatic module</strong></td>
</tr>
<tr>
<td>very effective +2….-2 not effective</td>
</tr>
<tr>
<td>Vp1  Vp2  Vp3  Vp4  Vp5  Vp6</td>
</tr>
<tr>
<td>0 +1 +2 +2 +2 +2</td>
</tr>
<tr>
<td>5) <strong>Fit of the backrest contours</strong></td>
</tr>
<tr>
<td>very good +2….-2 very bad</td>
</tr>
<tr>
<td>Vp1  Vp2  Vp3  Vp4  Vp5  Vp6</td>
</tr>
<tr>
<td>+2  +1 +2 +1 +2 +2</td>
</tr>
<tr>
<td>6) <strong>Lateral mobility on the backrest</strong></td>
</tr>
<tr>
<td>very good +2….-2 very bad</td>
</tr>
<tr>
<td>Vp1  Vp2  Vp3  Vp4  Vp5  Vp6</td>
</tr>
<tr>
<td>0 +1 +1 +1 +2 +2</td>
</tr>
</tbody>
</table>
Fig. 4: Summary results of the subjective comfort ratings for seat pad and backrest.
Rounded average values for the 6 test users, derived from the individual ratings in Table 3.

The questions in full are:

1) How do you rate the **pressure round the front edge of the seat pad**?
2) How do you rate the **support provided by the upholstery to the pelvis** (coccyx/sacrum area)?
3) How do you rate the **lateral mobility on the seat pad**?
4) How do you rate the **adjustability of the pressure in the pneumatic module**?
5) How do you rate the **fit of the backrest contours** (support in the lumbar area)?
6) How do you rate the **lateral mobility on the backrest**?
5. Bibliography

BUNDESAMT FÜR WEHRTECHNIK UND BESCHAFFUNG (Hrsg.): Handbuch der Ergonomie, Bd.3.

DiN 33 402: Körpermaße des Menschen

HEIDINGER, F.; KURZ, B.; DIEBSCHLAG, W.: Sitz-Schaumpolster: Dimensionierung anhand von
Druck- und Klimameßdaten.
In: Plastverarbeiter 39 (1988), Nr. 12, S. 116-121

DIEBSCHLAG, W.; HEIDINGER, F.: Ergonomische Sitzgestaltung zur Prävention sitz-
haltungsbedingter Wirbelsäulenschädigungen.

Sitzens. Die Bibliothek der Technik Bd. 68, Landsberg/Lech: Verlag Moderne
Industrie, 1992. - S. 46-65

HEIDINGER, F.: Sitzentwicklung aus arbeitsphysiologischer Sicht.
In: FAUST, E. (Hrsg.): Optimale Sitzgestaltung. Renningen-Malmshein: expert verlag,
1994. - S. 66-82

HEIDINGER, F.; JASPERT, B.: Ergonomische Anforderungen an Sitzmöbel zur Vermeidung von
Wirbelsäulenschädigungen.
In: NETZER, N. (Hrsg.): Schmerz laß’ nach! Rückenprobleme • Rückenschmerzen.

HEIDINGER, F.; JASPERT, B.; DIEBSCHLAG, W.: Ergonomische Bewertung von Bürodrehstühlen:
Ein erweitertes Prüfprogramm.

RÜHMANN, H.; HEIDINGER, F., JASPERT, B.: Entwicklung eines ergonomisch optimierten
Hörsaalgestühls.

HEIDINGER, F.; JASPERT, B.; DUELLI, B.: Ergonomie und Arbeitsmedizin - Angewandte
Arbeitsplatzergonomie - Sitzarbeitsplätze
In: HÜTER-BECKER, A; SCHEWE, H.; HEIPERTZ, W. (Hrsg.): Physiotherapie. Band 1: