Charles's University

FACULTY OF PHYSICAL EDUCATION AND SPORTS

Department of Anatomy and Biomechanics

THE CZECH SOCIETY FOR BIOMECHANICS

FAKULTA TĚLESNÉ VÝCHOVY A SPORTU

Katedra anatomie a biomechaniky

ČESKÁ SPOLEČNOST PRO BIOMECHANIKU

A SEAT SURFACE PROTOTYPE TEST

INTRODUCTION

A seat surface of a present standardly used chair (hereinafter referred as NORM) is formed by a compact solid seat surface, which is in a power contact with the whole part of the lower pelvis and the upper part of the tights (anus, coccyx, pelvic bones, genitals etc). A recently designed type (author: Ing. arch. Peter Doričko, hereinafter referred as TEST) whose prototype has been tested at our workplace, has its seat part formed of the elements that are, due to their shapes and adjustability enable to eliminate undesirable pressures on the area of the pelvis when sitting.

"TEST" type chair

The following biomechanical and anatomical findings result from this first sight:

- Adjustability of the parts ensures individual fitting and adjustment of the parameters according to the activity performed;
- The coccyx, the pelvic bones, the anus and the genitals stay free, the pressure affects the sitting and the tight muscles on the perimeter only;
- The TEST type seat structure passively ensures not only the stability of the legs, but also the stability of the pelvis due to the fact that the pelvis is supported on its perimeter and not just simply placed on a moulded surface of a chair (as it is with a standard chair), the pelvis is passively more stabile.

Initial experiment

Testing was executed on 1st February 2002 in the laboratories of the Biomechanics and Anatomy Department at the Faculty of Physical Education and Sports of Charles's University in Prague. The experiment was carried out on two healthy male subjects, aged 21, not suffering from any identified vertebral difficulties. A comparative method of the comparison a physiological response to long lasting sitting on the both types of the chair was chosen. There were tested two chairs. One standard office chair called a "control chair" (NORM) and the other a prototype chair of a new design without a back (TEST). The methodology follows the standard procedures already tested and applied earlier at the Department of Anatomy and Biomechanics of the Faculty of Physical Education and Sports, Charles's University, Prague.
It consists of the subjective evaluation of DYSPAINQUEST by the tested subject in the course of the experiment and of the evaluation of the axial system distortions time factor (shadow moiré contourography). Within the experiment the goniometric measurements of the pelvis position have been carried out as well.

The evaluation of the shape and the geometric distortions (e.g. the extend of the kyphoscoliotic curvature of the pelvic spine and the constrained position of the upper part of the thoracic vertebrae influencing the position of the upper limbs and their muscles as well as the cervical vertebrae and the head in a dynamopathic relation) was based on the 3D moire contourography. A long-term repeated evaluation of the thorax topography – the pelvis, and the axial system have been executed on the tested prototype and on the control chair. The measurements were done after 5 minutes since the sitting position had been taken, then after 15 and 30 minutes, and then after 3 hours of sitting on these chairs.
The experiment was simulating one working shift with exchanging a chair. The MO subject was working on the TEST type chair for three hours and then, after 30 minutes' break, for another 3 hours on the NORM type chair. The JL subject was working in the reversed order: for three hours on the NORM type chair and after 30 minutes' break for the next 3 hours on the TEST type chair.

Results and discussion:

The seat surface of the TEST type chair is designed the way, which creates a kind of a ring into which the pelvis is seated. The power effect is not transmitted vertically and it is not concentrated onto sitting moulds; the powers affect diagonally onto the pelvis and so the pelvis is more stabile. The relaxation of the pelvis strain into retroversion does not occur even after long time. The pelvis, which represents the functional and the structural base for the position of the spine, becomes this way more stabile and keeping the more optimal position of this base is less dependent on the effect of the muscles. It is of a great importance at working activity when a person must keep an upright position sitting for a long time and must ensure

sufficiently constant position of the upper limbs and the head. The energy demand within some hours keeping this position is remarkably lower what can make a contribution to the lower strain which occurs when keeping the upright static position.

The back wheels underlay of 4 cm on the TEST chair caused the seat inclination. This way the pressure on the popliteal part of tights, which could be observed mostly with shorter persons not being able to lighten this part by putting the feet on the floor to enlarge the flexion angle of ilium, was decreased. It emphasizes the importance of the accurate adjustment of the seat – its height above the floor. In the TEST case, both of the tested persons always took the initial position of the pelvis more often than not with a tendency to the retroversion. Even after more than a 30 minutes' period the antero-posterior lean was the same. It can be assumed that these conditions enable decreasing of the energy, necessary for keeping the upright sitting position, as they require less muscles work and can also reduce the strain and fatigue levels and the speed of their invasion. After some hours' sitting on the individual seat surfaces the pelvis position parameters are the same as they were at the beginning of the whole process of the measurement.

The tights adduction was always bigger with the TEST chair prototype than with the control chair. The prototype has an undisputed advantage of the seat adjustability in the side direction; a correction of the sitting ring "diameter" is possible. This way the seat surface can be optimized according to the individual proportions and needs. However, the middle part of the seat surface enforces a higher tights adduction (by its design/structure and stiffness) what, for some people, can be unpleasant and consequently even uncomfortable. The spinal column position has never been remarkably deflected from the expected medial plane during sitting on any of the both seat surfaces. The executed measurements showed how the different seat surfaces influence the shape of the axial system and the time tendency to its change. The kyphosis of the spinal column has been found at both of the persons on the tested seat, but it was less progressive (at a hypermobile person adequately bigger). The changes started after 30 minutes by the slight kyphosis extension in the lumbar region, which was caused by the bigger forward thorax lean. In any of the cases it is not possible to find a dorsal lean of the lower part of the spinal column or of the pelvis. The strain occurs mostly, when shoulders and arms are hold raised forward and the whole thorax is tensed forward.

A similar test executed on a the control office chair (NORM) showed that already in the initial period the top point of kyphosis is situated more caudally (towards the pelvis) and also by the influence of the time factor the extend of the kyphotic curvature is getting bigger, most of all by leaning of the pelvis backward – retroversion. The progressing kyphotic curvature in the lumbar region and the descent of this curvature top point are the unfavourable factors of the strained passive parts connecting the individual vertebrae of the spinal column. It means a local strain of the intravertebral discs, an extended ratio of shear stress, an extrusion of synovial liquid, as well as a tensile load of fibrous apparatus. If it comes to long-term activities in this regime, degenerative changes can be facilitated.

After straining the axial system by sitting on the both seat surfaces during some hours (3 up to 4) at standard work with PC a remarkable strategy of the body positioning is visible. In all the cases (both persons on both seat surfaces) the axial system was leant more anteriorly (forward) at minimization of the kyphotic curvature at the lumbar region. In this case the seat prototype seems to be more favourable as it ensures the higher stability of the pelvis and this way also the stability of the lower part of the lumbar spinal column at lower demands on the muscles activity. As it results from the 3D analysis, the shape of the seat does not solve the position and the shape of the thorax or the cervical vertebrae in a given working position. It

logically depends on the working activity of the upper limbs (in our case it was PC), it means on the total workplace setting-up.
A subjective discomfort evaluation was being recorded continuously into a DYSPAIQUEST form within an hour periods (see the appendix). The NORM type chair: discomfort or even pain always started to occur at both of the subjects after ½ - 1 hour of work and was getting worse, leading to the severe ache. In the case of the TEST variant, such an effect did not occur within the whole experiment (3 hours) at the tested person MO (started with the TEST variant). The tested person JL (started with the NORM variant, finished with the TEST variant): the initial discomfort or the severe ache in the lumbosacral region were disappearing gradually and finally changed into a light discomfort.

Conclusion

The results of the subjective evaluation of the sitting positions by the method of DYSPAIQUEST by comparison of the variants of long lasting sitting; TEST versus NORM; definitely prove the abovementioned expected advantages of the TEST variant. They are also proved by the results of the 3D moire analysis. It can be said that the design structure TEST satisfies condition of strain minimizing at long-lasting sitting position without restriction.

The TEST type improves the ergonomic quality of the seats design by its new, original conception of the seat surface in a remarkable way. Its dominant positive contribution can be seen in a reduction of the presses on the pelvic bottom simultaneously with the fixation of the pelvis in an optimal, adjustable position. This new element does not exist in any other variant of present standard seats. Therefore we recommend this principle to be implemented for the seats determined for workplaces with a monotonous and sedentary working mode, e.g. office workplaces with PCs, operators' workplaces, car seats, and the like. We recommend also utilisation in health service, for example at the reduction of handicap consequences, vertebrogen syndrom and the like.

In Prague, 15th February 2002

Prof. Ing Stanislav Otáhal, CSc

Ing. Monika Chalupová, PhD

Appendix:
A commentary on the biomechanics of sitting position
Questionnaire DYSPAINQUEST – results
3D moire analysis of sitting - results