DESIGN 2002

OFFICE FURNITURE DESIGN ACCORDING TO A HUMAN ANTHROPOMETRIC DATA

Ž. Ivelic, I. Grbac, B. Ljuljka and S. Tkalec

Keywords: Office furniture, workstation, backpain, RSI, anthropometry, ergonomy

1. Introduction

Office furniture includes a variety of constructional types of furniture, such as office desks, office chairs of different constructions, intentions and place of usage, different designs of cabinets, conference halls and waiting rooms furniture, different supplementary office furniture components, different constructions of partition walls etc.

If the design of the working place does not follow ergonomic principles, and if there is lack of exercises or relaxation during working hours, it is possible that various forms of physical deformations can occur. Because of this, the need for an interdisciplinary research into safe furniture for sitting has arisen. Figure 1 shows how one average office employee spends most of his day in a seating position.

**Figure 1. Average office employee spends most of his day in a seating position**

2. Standards, directives and definitions for office furniture

The physical design of workstations has a great impact on the work of employees. Proper placement and design of computer equipment and other office items, so as to avoid injury risk factors, is an aim of ergonomics, standards and directives. It can also increase productivity, improve health and safety, increase job satisfaction, increase work quality, lower worker turnover, lower lost time at work and lower worker's compensations claims. In US, Canada and Europe much research has been done in this field. The results of the research are international and European standards and directives. For ergonomic principles of correctly designed workstations, International standards group ISO 9241 Ergonomic requirements for office work with visual display terminals (VDTs) are used.

For dimensions of office furniture, it is recommended to use European standards EN 527-1; Office furniture-work tables and desks: dimension and EN 1335-1; Office furniture-office work chairs: dimension which have been adopted as Croatian standards as well. European Community has adopted Directive 90/270/EEC of 29 May 1990 on the minimum safety and health requirements for work with display screen equipment. According to this directive, employers are obliged to analyse workstations, evaluate the safety and health conditions and remedy any risks to eyesight, physical problems and problems of mental stress.

3. Pains caused by poorly designed workstations

Statistics show that the reason for the majority of sick-leaves lies in the patients' lower back pain and neck pain, and that, apart from the hard, physical jobs, administrative work is the major cause of the spine deformations. Professor Hetinger's research published in the journal Ergonomics show that apart from the hard, physical jobs, administrative work is the major cause of the spine deformations. The reason for this is modern living, an increased IT and Internet usage, with users spending more time at the computer desk, be it at work or at home. Research has shown that inappropriate sitting, caused by poorly designed furniture, accounts for headaches (14%), pain in the neck and shoulders (24%), backpain (57%), backside (16%), lower leg (19%) and pain in knees and feet (2%).
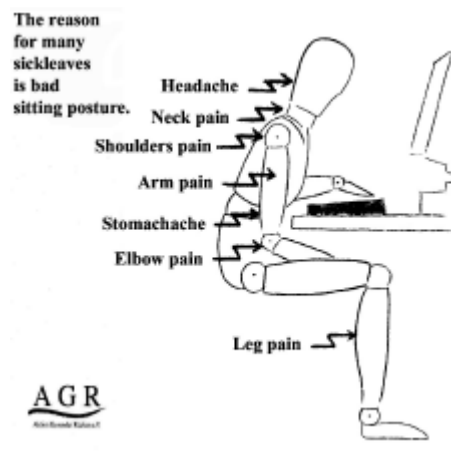
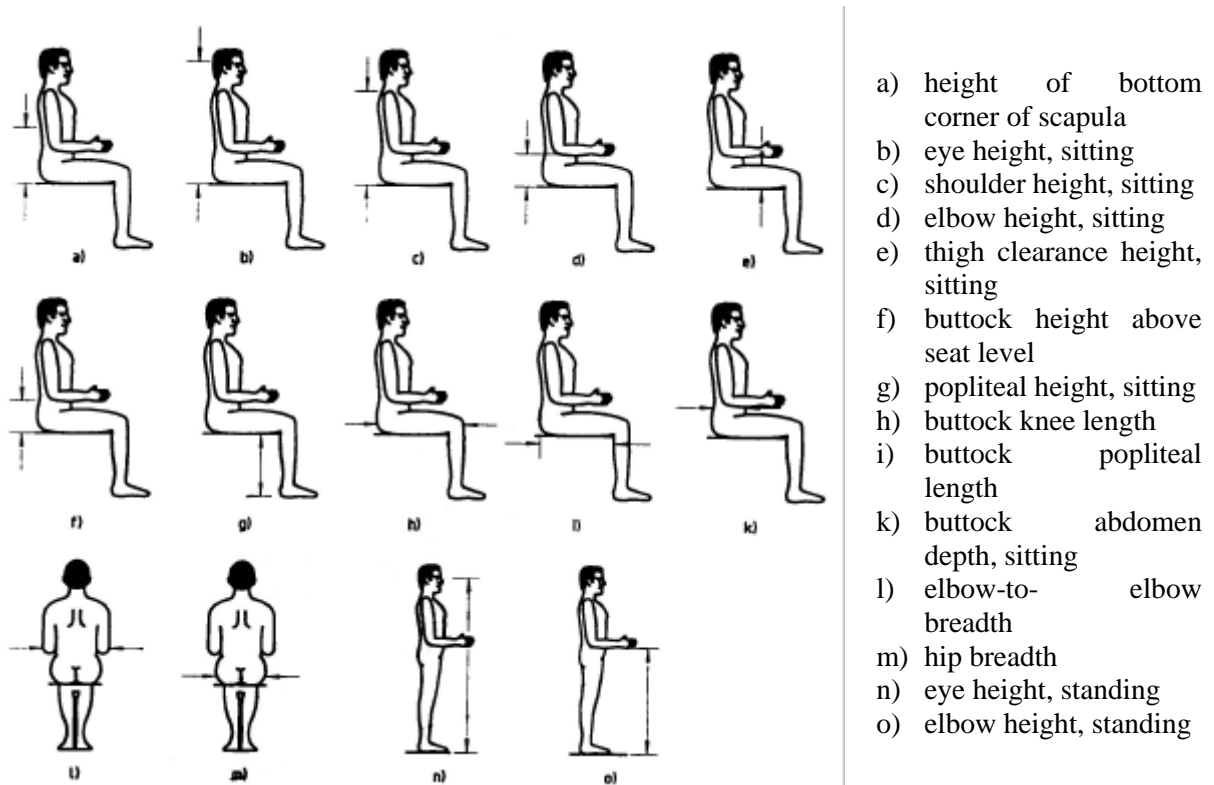**Figure 2. Pains caused by inappropriate sitting position**

Static sitting posture, while sitting at the poorly designed working chair that has no support for the lumbar region and small depth of the seat, causes neck pain because of constant strain on the muscles of the shoulders and neck and backache because of increased pressure on the intervertebral disc. Small depth of the seat has harmful effects on muscles and on the circulation of blood and lymphatic fluid in the legs. Static sitting can induce stress on the cardiovascular system, and can have detrimental effect on the digestive organs.

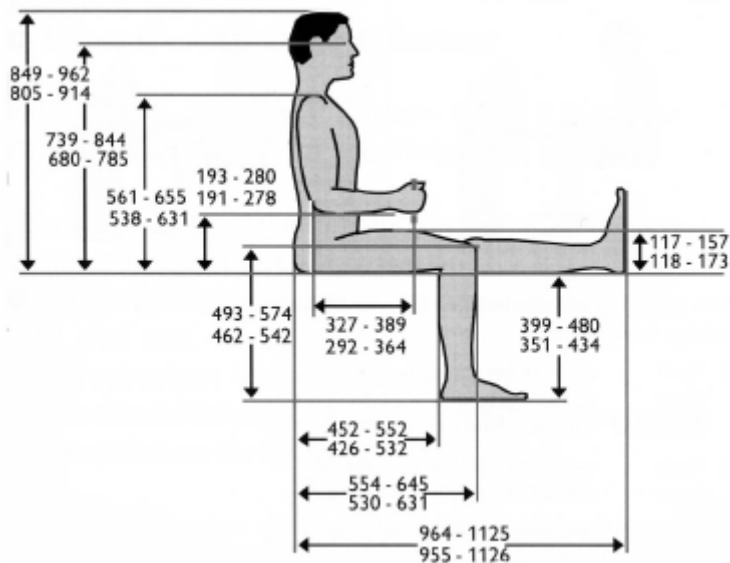## 4. Design of workstation according to ergonomic principles

Ergonomic design of the office workstation requires some anthropometric data. According to the ISO 9241-5 standard, figure 3 shows which measures of the human body should be taken to get the needed anthropometric data. Apart from the anthropometric data, dimensions of clothing and allowances, shown in table 1, should be taken into account when work tables and work chairs are designed. Standard ISO 9241-5 recommends that, for general population, samples larger than 1000 people should be taken by means of statistical analysis and in that sample adults aged 16 to 65 should be measured. It is important that the anthropometric data chosen should adequately reflect the body sizes and shapes of the intended user population. Anthropometric data according to DIN 33402-2 are shown in figure 4. Upper values represent population in the 5% and 95% percentage for males aged 16 to 60, and lower values represent population in the 5% and 95% percentage for females aged 16 to 60.

Table 1. Clothing and related allowances

	DIMENSION	ALLOWANCES
1	Floor-underside of thigh	30 mm footwear
2	Width between hips	10 mm for light clothing 25 mm for medium clothing
3	Sitting eye height	Reduction of up to 65 mm (40 mm for slump and 25 mm for seat compression)
4	Shoulder height	Reduction of up to 65 mm (40 mm for slump and 25 mm for seat compression)
5	Seat-back rest height	≤ 25 mm for seat compression

a) height of bottom corner of scapula
b) eye height, sitting
c) shoulder height, sitting
d) elbow height, sitting
e) thigh clearance height, sitting
f) buttock height above seat level
g) popliteal height, sitting
h) buttock knee length
i) buttock popliteal length
k) buttock abdomen depth, sitting
l) elbow-to-elbow breadth
m) hip breadth
n) eye height, standing
o) elbow height, standing

Figure 3. Important anthropometric data for workstation design

Figure 4. Anthropometric data according to DIN 33402-2

During the first half of the 20th century it was widely assumed that scientific ergonomics could define the perfect sitting posture. Based on their research of the 1950's and 60's. Grandjean and associates had designed general easy chair. During the 1970's and 80's a number of creative Scandinavian solutions appeared based on the concept of "active sitting" sometimes called "dynamic sitting." These are a generic terms for a range of different postures which emphasise continuous mobility. One briefly popular solution was the knee support chair. Unfortunately, experience has shown that few of these designs are suitable for long periods of uninterrupted deskwork. The half-kneeling posture placed too much stress on the knees of the users and proved uncomfortable in the long term. These chairs are also difficult to get into and out of.

The chair is one of the most important parts of the workstation; therefore, a properly designed and properly adjusted chair, along with appropriate posture, is important to help reduce or prevent back stress, restricted circulation, irritation and fatigue, and other distractions caused by the discomfort of an inappropriate posture.

Average office employee spends 80.000 hours at the workstation during his working time and time spent in school. Because of excessive use of computer in offices employees can spent eight or more hours per day in their offices. Because of that, a good work chair should provide the user comfortable and healthy sitting during his working hours. Such a work chair should have at least the following features: seat height adjustability, adjustable seat tilt (4°), seat depth adjustability, individually adjustable support resistance of the backrest, backrest opening angle, chair recline or tilt, seat pan angle adjustability, height-adjustable armrests, width-adjustable armrests, padded armrests, adjustable lumbar support, backrest height adjustability, lumbar depth adjustability and neck support with adjustable hight and tilt. Surface seat should be anatomically shaped, has sufficient friction to avoid slipping off and permeable fabrics for thermal comfort.

Figure 5. Some of the features that ergonomically designed work chair should have

Work surface height should be appropriate for the type of work being performed and the worker's dimensions, so that today's quality work tables have adjustable table top height. Individual standing or seated elbow heights usually determine this. Most work surfaces are horizontal, which is preferred for writing and many other daily activities. However, where poor postures are noticed, such as leaning over a table to read documents, it may be advantageous to tilt the work surface towards the worker. This will reduce stressful, static postures of the torso and neck. Frequently used items such as keyboards, telephones, calculators, etc., are recommended to be within easy reach and not requiring stressful postures to obtain or use. The work desk or work surface shall have a sufficiently large, low-reflectance surface and allow a flexible arrangement of the screen, keyboard, documents and related equipment. The document holder shall be stable and adjustable and shall be positioned so as to minimise the need for uncomfortable head and eye movements. Leg space needs to be adequate for the worker and clear of obstacles.

Eye-to-screen distance should be at least 62.5 cm, preferably more. That distance depends on the size of the monitor and viewing abilities of the user, but the further the better. It is better to change the size of the paper on the screen than to bring monitor closer. Viewing area of the monitor should be between 15° and 50° below horizontal eye level. Top of the monitor should be slightly farther from the eyes than the bottom of the monitor, just like the book or paper is held for reading. Lighting on the ceiling should be suspended, and indirect lighting should be used. For reading documents, small direct light should be used like desk lamp. Blinds and shades should be used to control outside light. For screen colours, it is recommended to use dark letters on a light background. Emitted noise, heat, radiation and humidity should also be taken into account. For detailed information we refer to the directive 90/270/EEC.

5. Home offices and young office systems

In today's dynamic societies, an increasing number of people work at home. Some companies even prefer to employ people who will work for them from their homes; the employees are granted some privileges in such way. More and more people work at home with computers, for profit or pleasure, which has initiated the development of the so call called home-offices furniture.

Even very small children tend to have access to computers and can be exposed to some body deformations, so it is time that we started thinking about ergonomically designed furniture for children and educating children not to use computers too much. It is well known that it is in the period of children's growth that the most intensive and dramatic changes and reshaping of the human body occurs. External forces have an important impact on the process (treatment of the spine or feet deformations, treatment of hip dislocation by orthosis, which correct deformations by direct pressure on specific parts of the body).

Unfortunately, the market sees numerous computer desks that do not satisfy minimal ergonomic principles and minimal conditions for strength, durability and stability. Both adults and children use these computer desks due to their low cost.

6. Conclusions

Our industrialised society is transforming into an information processing society in which more and more employees are transacting business while sitting for long periods of time. With the advent of the information processing age, it is becoming increasingly clear that there is a significant mismatch between people and the furniture in their working environments, as is evident from the increasing numbers of employees suffering from chronic backache. The most likely explanation is that people are sitting in the wrong way, thereby abusing their backs, necks and arms.

Prevention of injuries that can happen at poorly designed workstation involves ergonomics (changing the work environment), ergonomics education (changing work styles or habits), medical management (optimising treatments and return-to-work procedures), and management (monitoring statistics to find the most hazardous jobs and working proactively). That injuries usually cannot be adequately dealt with without all four approaches happening together.

On the basis of recent research and standards, basic rules how to design office workstations according to ergonomic principles are shown in figure 6. Dimensions of workstations in sitting and standing posture are shown in figures 3 and 4, and table 1.
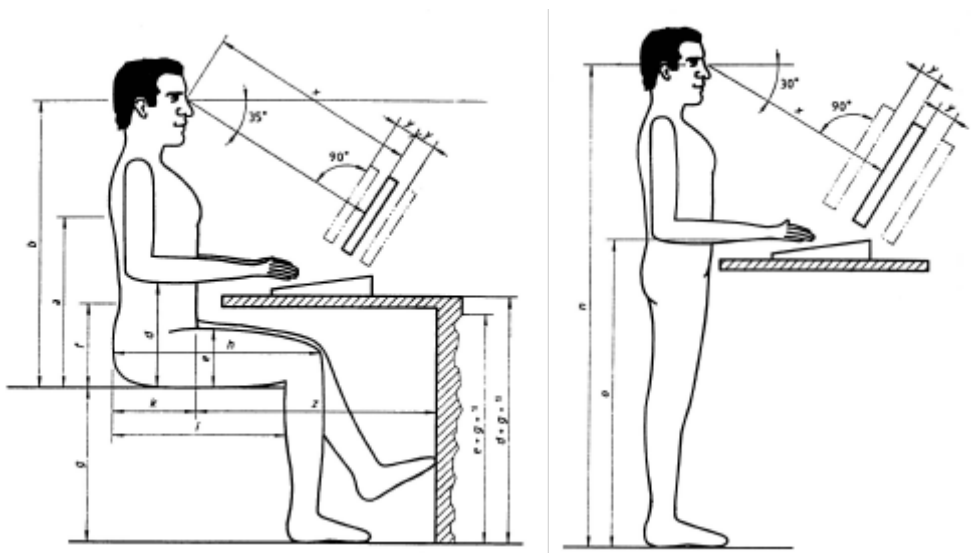
Figure 6. Dimensioning of a workstation using anthropometric data of the intended user population (sitting and standing position)
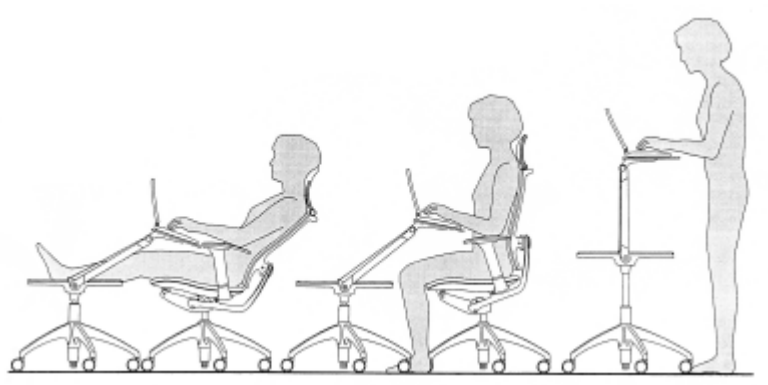
Figure 7. Dynamic office workstation with work chair and table for laptop computer

One of the new workstations for laptop computers, which can provide for a dynamical work in standing, sitting and half-lying position, is shown in figure 7. Work chair and work table with footrest have castors so they should be easier to move. A drawback in this workplace is an insufficient working place, but when it is used only for writing on the laptop computer, than it is almost an ideal solution. An ergonomically designed workstation, which provides for appropriate posture in all age groups, can be work chairs and work tables that have the possibility of their height being adjust to all the sizes of the human body, and provide comfortable, dynamic work in all postures.

Finally, the authors recommend that designers of office furniture, architects, and companies which design office interior apply the international standards group ISO 9241 Ergonomic requirements for office work with visual display terminals (VDTs), and the European standards EN 527-1; Office furniture-work tables and desks: dimension and EN 1335-1; Office furniture-office work chairs: dimension.

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***** standards ISO EN 9241-5; 1998, HRN EN 527-1; 2000, HRN EN 1335-1; 2000, EC directive 90/270/EEC*

Želimir Ivelic, BSc.
Faculty of Forestry of University of Zagreb,
Department for furniture design and wood technology
Svetošimunska 25, 10000 Zagreb, Croatia
Tel.: +385 1 235 25 13, +385 1 235 25 31,
Email: zelimir@hi.hinet.hr