Virtual 3D forming of working place and the analysing of burdening of a worker during work with computer

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Abstract: Biomechanical burdening of the workers during scientific-research work with a larger number of computer working stations was investigated in the work. Minimum and maximum angles of bending during sitting positions of the worker were investigated. The biomechanical analysis of movements based on real correlation in the space of interactions, a worker and a work place was effected on made virtual 3D models of a worker and a work place. Using parameters of biomechanics analysis, dynamic anthrop measures, used for simulation character animation, were calculated. For the analysis of co-relation of worker's body and dimension and forms of elements of work place within this work, 3D virtual characters of feminine gender of various body heights and weights were taken and 3D model of working chair and work place. By computer scientific visualisation, values of angles of spine curving, angle curving of hands and upper part of the body for three digitally generated workers of various anatomic features were calculated. By knowing anthropometrics measures and by applying computer graphics an ideal work place for each person was digitally modelled and ergonomically formed.
Key words: sitting working position, virtual 3D models, computer visualization

1. Introduction

In ergonomically functionally studied work place, where a worker works with computer working stations, harmony of static and dynamic burdening of human body is achieved and muscle fatigue is decreased [1,2]. Sitting requires constant changing of positions in order to meet requirements of various activities performed by a worker during working activities. Sitting position is adequate for manual works and body mobility is limited to kinematics systems of hands, head and partially of a body with limited degrees of movement freedom [3]. Optimal relation of human body and work place influence correct position during work, during which fatigue and body energy consumption is reduced to the smallest possible extent [4]. Working process should be organized so as to enable easy and natural working course of a man, and to enable breathing by rhythmic relaxation of rib cage and abdominal muscles.

Working chair is one of the important elements of work place during work with a computer since the job is performed in sitting position. It meets the requirements and necessity of comfort and mobility of a worker's body. While choosing the chair, attention has been dedicated to possibility of adapting the height of sitting, depth and wideness of occupied space with simultaneous mobility, possibility of suitable working tasks, good layout of the space, sitting comfort and similar, and this depends on form and height of sitting and on angle of back curve [5]. In this case a high level of visual control is necessary, so it is necessary to form a work place so as to use visual zones which are in comfortable space of sight transfer, by shifting line of watching and in comfortable space of eye rotation and head movement. Possibility of work in upstanding, central and front working positions has been analyzed in the work. In which process the workers worked with one hand and with two hands simultaneously.

2. Methods

Sitting working position may completely change sagital flexion of the spine, and this refers to lumbal lordosis. This depends on manner of sitting and construction of basis on where one sits. With a working surface being too high, distance of eyes from the center of work is big and thus a worker is bending more forward and this causes back pains. During upright sitting without a back, pelvis is bent forward, and lordosis is expressed lumbally. For normal sitting, it is necessary for both hips to be mobile, since only then flexes is possible, necessary for parallel position of upper leg and in this process pelvis in horizontal plane is parallel with the base. In this position, normal flow of physiological sagital bending of spine, and burdening is equally distributed on two of its constituent parts. In this process it is necessary to take lengths of reach of a worker with freedom of movement and visibility. During a working process, a worker in regard of requirements of dynamic work, occasionally exchange central and forward sitting position, and frequency of such movements of a body causes dynamic burdening of spine.

Regarding establishing of dimensions of realistically made work place, longitudinal and space measurements of working elements and working environment were performed. In order to establish body dimensions, author’s computer program of static body anthropometrics "*ErSABA*", figure 1 was used, which with incoming data of various kind of work, gender and height of a worker, determines optimal ergonomic parameters during forming of work places.

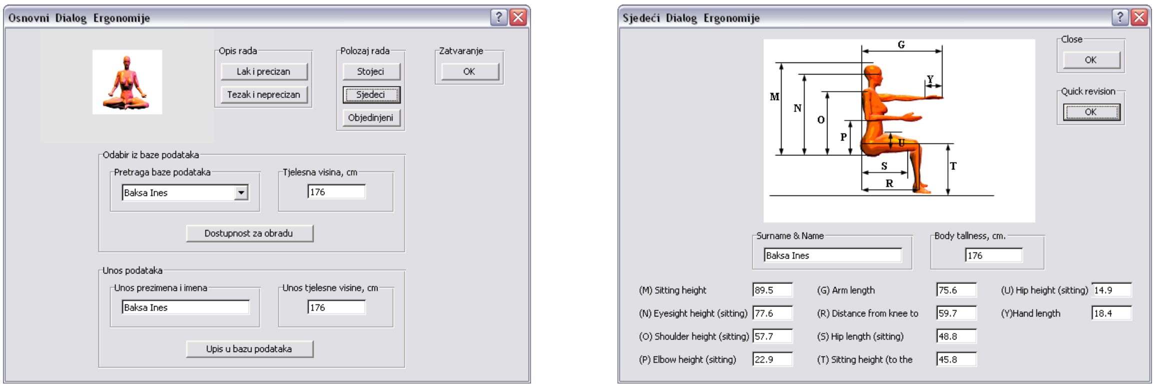


Figure 1: *Basic and sitting presentation of display dialogue of computer program of statical body anthropometrics "ErSABA" for feminine gender.*

For body measurements of real worker and their work places within CG (computer graphics) of working environments, for requirements of virtual planning, designing, modelling and visualisation of elements of work place and models of humans author’s computer program systems were also used, of space digital three-dimensional body scanning "*BodySABA*" and dynamic body anthropometrics "*VatoSABA*".

2.1 Experimental Set-up

Experimental investigation of change of bending angle and spine rotation during work with computer working stations was carried out in the work.. The measurement was effected on several workers working with computers. Possibilities of work in upright, central and front working positions were analyzed. In this process the workers work with one hand and with two hands simultaneously. A special chair was made for the stated measurement. Recording of measurement of an bending angle of spine was done by three cameras. In this way comparative photographs of all positions and movements of extremities and worker’s bodies were obtained during performance of work on work place. The obtained photographs were digitalized and entered in a computer and scientific-visualization analysis has been effected for the purpose of obtaining bending angle. The recording was done individually on workers during working in the sitting position, figure 2. Prior to start of the recording the workers put on their bodies special attached adhesive cotton t-shirts and leggings with marked signs which were put from head to lumbal part of the spine and on shoulders left and right.

On the base of the photographed workers and work place in the process of work, computer 3D model of a worker, computer work stations and complete work place was made figure 2. Obtained computer 3D model was compared and put in accordance with real model of work place and chosen worker height 176 cm and weighing 64 kg who was recorded during work with computers. According to realistic data on the received 3D scene, biomechanic analysis of work movements of worker's body was effected by scientific vizualisation. Digitally generated 3D model of a worker, a machine and work place form part of 3D scene under which in computer graphics oriented part of space is understood, to which coordinated system is associated in relation to which position and entity orientation, object ands their group are defined [1].

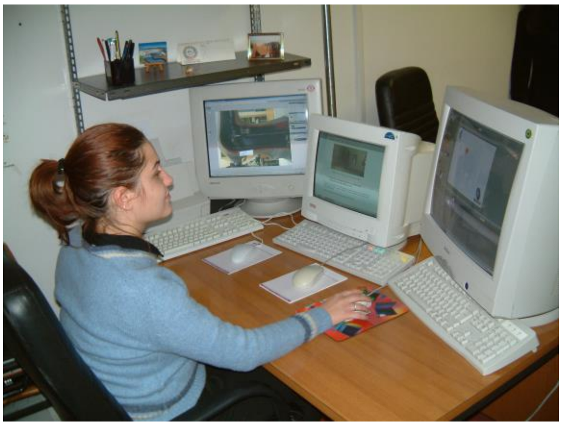
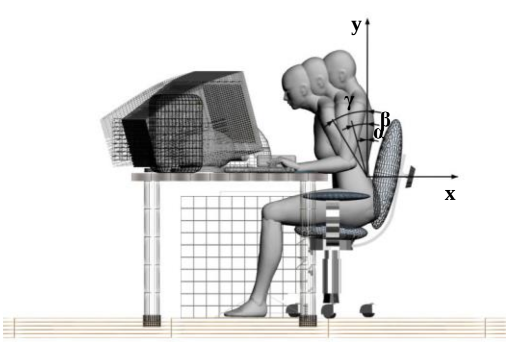


Figure 2: *Work position of a worker for realistically performed and virtually generated work place.*

3. Results

Based on testing conditions and workers recording, results of bending of cervical, thoracic and lumbal part of the spine was obtained and also rotation of dorsal and lumbal part of the spine and rotation of dorsal part of the spine, figure 3 and table 1.



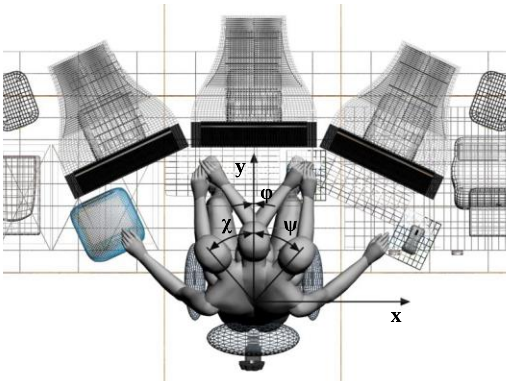


Figure 3: *Presentation of bending of vertebral column in front, central and upright work position and rotation of dorsal part of a body in front work position.*

Table 1: *The average values of bending angles and angles of torsion of the upper part of virtual body in relation to longitudinal axis of digitalized worker.*

	Upright position		Central position		Inadequate position	
	Angle of bending, α (^{0})	Torsion angles, χ, φ, ψ (^{0})	Bending angle, β (^{0})	Torsion angles, χ, φ, ψ (^{0})	Bending angle, γ (^{0})	Torsion angles, χ, φ, ψ (^{0})
Computer A	- 10	+ 43,4	- 15	+ 42,3	- 31	+ 41,7
Computer B	0	0	- 15	0	- 31	0
Computer C	- 10	- 44,2	- 15	- 42,4	- 31	- 42,8

According to the results from table 1 and figure 3 for work on a computer A (left computer) average angles of bending are obtained at upright $\alpha = -10^0$, average $\beta = -15^0$ and inadequate position $\gamma = -31^0$ and torsion at upright $\chi = +43{,}4^0$, average $\chi = +42{,}3^0$ and inadequate position $\chi = +41{,}7^0$. For a computer B (computer in the center) average angles in bending are $\alpha = 0^0$, $\beta = -15^0$ and $\gamma = -31^0$, and in torsion are $\varphi = 0^0$, $\varphi = 0^0$ i $\varphi = 0^0$. Obtained results for a computer C (right computer) at bending are $\alpha = -10^0$, $\beta = -15^0$ i $\gamma = -31^0$, and in torsion are $\psi = -44{,}2^0$, $\psi = -42{,}4^0$ and $\psi = -42{,}8^0$. In upright position during work on computers A and C it has been observed that a work bends less forward, but compensate it by increase of reaching space of hands in the way that she extends hands towards keyboard, to graphic tablet or computer mouse.

4. Discussion and Conclusions

The results show that the values of bending and rotation in a worker in upright, central and inadequate positions are different and this shows that they depend on manner of performing a certain movement during work with a computer positions of computer monitoring units and position of entering – managing computer elements. It is possible to perform virtual shaping of work place from the point of ergonomics by knowing anthropometrics measures. Such optimally shaped adapted work place will diminish time of performance of working operations and enable higher working effect. It will also influence increase of work humanization by reducing lumbal, dorsal and cervical part of the spine, side bending and rotation of the column.

5. References

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