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IDENTIFICATION OF ANTHROPOMETRIC MEASUREMENTS' FACTORS OF SERBIAN ADMINISTRATIVE WORKERS: PRELIMINARY STUDY

Nuri Mohamed Saad Algheriani[1],Ahmed Ali Essdai[1]
[1]Faculty of Mechanical Engineering, University of Belgrade, Serbia

Abstract. *Many statistical techniques have been used in different sectors in order to minimize the production cost and increase the safety of the products. The aim of this paper is to find out the most important dimensions of the work places in the administration by applying a method based on multivariate statistical technique which would maximize the accommodation range of the population with greater safety. Accordingly, factor analysis is applied on anthropometric measurements of 50 administrative workers, since this is preliminary study. The results show that three dimensions space is obtained. Results of this research could be useful in administrative workers workplace designs and might lead to better productivity and safety.*
Key words: *anthropometric measurements, administrative workers, factor analysis*

1. INTRODUCTION

Products acceptance depends on the degree of comfort that users feel while using that product. In many cases the variability in human users will affect the acceptability of the products' design more than do the hardware from which the product is manufactured [7]. In many cases of product design problems safety and performance measures are based on body dimensions, therefore anthropometric measurements are required for ergonomic adaptations of workstations [7].According to that, for the effective design for human variability it is necessary to estimate the characteristics of the users and using of ergonomics principles is vital for increasing workers efficiency and productivity throughout reducing musculoskeletal symptoms, injuries, workers compensation claims, and reduction in lost and absent days [6]. There are many factors believed to influence the working posture including workstation layout, location and orientation of work, individual work methods, and the workers anthropometric characteristics. Therefore these factors must be taken into account in order to design high quality product in this case workplace in such a way that will increase the accommodation for human users and safety with reduction of design cost. Since variations on anthropometric characteristics are explained with a lot more than just two variables, multivariate analysis technique could be used in order to obtain precise and adequate results [8].

2. PREVIOUS RESEARCH

Ergonomic and hazard problems in the manufacturing process are important issues for many researchers and investigators. Some of them included manufacturing workers in companies in the United States and Taiwan [7]. These surveys showed that the workers are exposed to different ergonomic problems in the production process such as musculoskeletal problems of over exertion and repetitive motion without any fatal injuries as a result of improper anthropometric data used for design. Design according to general population or old data used for truck design also needs correction with new, more accurate anthropometric information from certain profession that should be used in truck cab designs [2]. Crane operators' anthropometric measurements survey has been done in different plants in Serbia in which multivariate statistical technique was applied to find out the critical dimension of the crane cabin affecting the adjustability and ergonomics of the product. Factor analysis technique was used on a sample of 83 crane cabin operators and results showed that critical anthropometric measures take three dimensions in design of working space [8].The forward head posture is commonly adopted by administrative workers and it involves a combination of lower cervical flexion, upper cervical extension as well as ''rounded shoulders'' [9]. Also, office work

frequently involves prolonged viewing of a visual display unit that additionally increases upper cervical extension [9]. Subjectively spoken, administrative workers complain about pain in head/neck, shoulders, elbows, wrists/hands, upper back, low back, hips, knees and ankles/feet [10] and there is the need to give further attention to developing specific measures to reduce or prevent musculoskeletal symptoms among employees in the office environment [5]. Some authors even argue that excessive sitting time is a risk factor for cardiovascular disease, diabetes and premature mortality [4].For several of the European countries, including both Serbia and Norway, anthropometric data relevant for new European standards and directives till now still are lacking or they are very old. One of rare surveys that included anthropometric measurements is done on the sample of 86 female and 13 male Norwegian administrative workers old between 20 and 39 years [1]. Previous research force the need to collect data on Serbian administrative works, while method used could be multivariate technique.

3. RESEARCH METHODOLOGY

This survey was conducted in Serbia and our sample consisted of 50 administrative workers (descriptive statistics is shown in Table 1). The participants were male and female with an average age 45 and standard deviation 10.42 years. Measurements were collected from several companies located in Serbia with appropriate number of administrative workers. The static anthropometry method was used to conduct the sample of research. A total of 9 basic static anthropometric dimensions including weight were recorded for each individual, namely foot length (mm), standing height (mm), sitting height (mm), lower leg length (mm), upper leg length (mm), shoulder width (mm), hip breadth (mm), and arm length (mm). Tools and equipment used in the anthropometric measurements of administrative workers were an anthrop meter, beam caliper, sliding calipers, steel tape, and other instruments including weight scale and stool for seated measurement. The participants remained in their clothes and shoes during the measurement.

Table1: Descriptive Statistics

Dimension	N	Minimum	Maximum	Mean	Std. Deviation
Foot length in mm	50	43	279	257.80	33.718
Year of Birth	50	1950	1989	1970.12	10.421
Weight in kg	50	54	100	79.18	12.157
Standing Height in mm	50	1600	1910	1761.90	75.023
Sitting Height in mm	50	800	970	886.50	42.176
Lower Leg Length in mm	50	500	680	579.30	37.621
Upper Leg Length in mm	50	490	960	630.90	63.211
Shoulder Width in mm	50	358	595	438.16	49.704
Hip Breadth in mm	50	300	485	382.00	38.039
Arm length in mm	50	580	780	675.20	42.269

The factor analysis method applied in this research was used to determine the groups of factors that characterize the body constitution of administrative workers. Factor analysis is a statistical approach used to analyze multivariate data correlated among each other with various degree, and starts by calculating correlation between variables which leads to correlation matrix. This matrix is analyzed in order to obtain the least possible number of factors enabling us to express as much variation as possible between the variables. Several assumptions are required for the data set in order to conduct factor analysis such as: (1) Sample size: as general rule the number of the observation should be at least 5 times the number of variables. (2) Measure of sampling adequacy: this value must be greater than or equal 0.5 to be appropriate for factor analysis. (3) No outliers in the data set: it means that no extreme data are present in the data set. (4) Identifying the significant loading: as the factor loading is the correlation of the variable and the factor, therefore the value of loading should be at least equal to 0.3 or more [3].

4. RESULTS

As indicated before factor analysis can be used to identify the structure of asset of variables as well as to provide a process for data reduction. The size of research sample meets the criteria of factor analysis with a ratio of 6.25 to 1, and measure sampling of sampling adequacy (Table 2) was 0.654 indicates appropriateness of applying factor analysis. Descriptive statistics of the input data is shown in Table 1. A correlation matrix was established as a first step in performing the factor analysis as illustrated in Table 3, and it appears clear that there are enough correlation coefficients greater than 0.3 to fulfill the criteria of factor analysis. The second step was the calculation of the eigenvalues as the sum of squared factor loading from a column representing the amount of variance explained with a factor. It can be seen from the eigenvalues presented in Table 4 the amount of possible factors to be retained was extracted and they were 3 factors by applying the latent root criterion. For the same purpose a diagram was constructed by plotting the eigenvalues against the number of components as can be seen in Figure 1 and greater than 1 are again three factors.

Table2: KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.654
Bartlett's Test of Sphericity	Approx. Chi-Square	140.345
	Df	28
	Sig.	.000

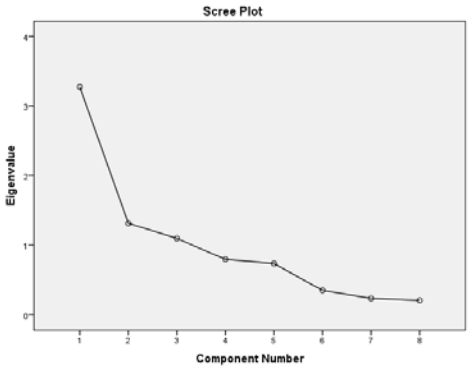

Figure1: Diagram representing eigenvalues

4. DISCUSSION AND CONCLUSION

The results that have been derived from factor analysis of administrative workers anthropometric measurements that appeared in component matrix were rotated by Varimax method. By examination of the total variance and the rotated component matrix in Table 4, it's obvious that there are three principle factors explained 71.062% of variance between variables that can be named as the length, width and height of administrative workers workplace.

Table 5. Rotated Component Matrix[a]			
	Component		
	1	2	3
Foot length in mm	-.030	-.057	.750
Standing Height in mm	.457	.275	.735
Sitting Height in mm	.187	.195	.774
Lower Leg Length in mm	.850	.166	.143
Upper Leg Length in mm	.723	-.050	.178
Shoulder Width in mm	.222	.860	.110
Hip Breadth in mm	.046	.922	.117
Arm length in mm	.679	.411	-.003
Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.[a]			
a. Rotation converged in 5 iterations.			

As can be seen from table 5 and Figure 2 the first factor is length of administrative workers in x direction that is formed by variables: Lower leg length in mm with factor loading 0.850, Upper leg length in mm with factor loading 0.723 and Arm length in mm with factor loading 0.679. The second factor in y direction called width of administrative workers work place consist of the following variables: Shoulder width in mm with factor loading 0.860 and Hip breadth in mm with factor loading 0.922. The third factor is in z direction interpreted as height of administrative workers workplace and composed from these variables: Standing height in mm with factor loading 0.735, Sitting height in mm with factor loading 0.774 and Foot length in mm with factor loading 0.750.

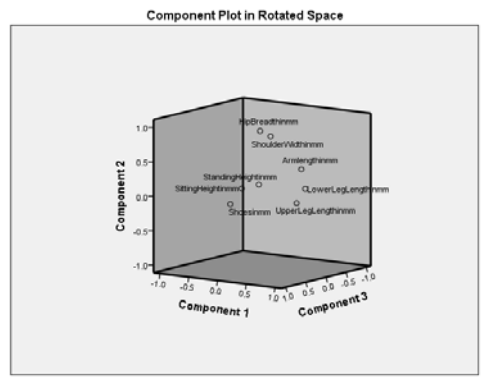

Figure 2: Diagram representing component plot in rotated space

Finally it can be concluded that in administrative workers workplace design, the three factors extracted by factor analysis can describe the most important anthropometric measurements in three dimension space as seen in component plot in rotated space diagram. This finding of work can be used in further research to determine the right design of administrative workplace. Further studies will be performed as continuation of this preliminary study in aim to study the problem on larger sample size.

Table 3. Correlation matrix									
		Foot length in mm	Standing Height in mm	Sitting Height in mm	Lower Leg Length in mm	Upper Leg Length in mm	Shoulder Width in mm	Hip Breadth in mm	Arm length in mm
Correlation	Foot length in mm	1.000	.382	.261	.063	.146	.014	.103	.127
	Standing Height in mm	.382	1.000	.695	.544	.385	.404	.335	.366
	Sitting Height in mm	.261	.695	1.000	.316	.200	.286	.214	.167
	Lower Leg Length in mm	.063	.544	.316	1.000	.421	.271	.243	.595
	Upper Leg Length in mm	.146	.385	.200	.421	1.000	.289	.051	.269
	Shoulder Width in mm	.014	.404	.286	.271	.289	1.000	.707	.390
	Hip Breadth in mm	.103	.335	.214	.243	.051	.707	1.000	.384
	Arm length in mm	.127	.366	.167	.595	.269	.390	.384	1.000

Table4: Total Variance Explained									
Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3.275	40.932	40.932	3.275	40.932	40.932	2.002	25.019	25.019
2	1.315	16.432	57.364	1.315	16.432	57.364	1.904	23.805	48.824
3	1.096	13.698	71.062	1.096	13.698	71.062	1.779	22.238	71.062
4	.795	9.934	80.996						
5	.734	9.177	90.172						
6	.348	4.356	94.528						
7	.233	2.912	97.440						
8	.205	2.560	100.000						
Extraction Method: Principal Component Analysis.									

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