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ANTHROPOMETRIC DIMENSIONS AND THE HEIGHT OF THE WORKING SURFACE FOR WORK IN A STANDING POSITION

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ABSTRACT

In order to establish the optimum height of the working surfaces of machines and working benches for males working in a standing position, the relevant anthropometric dimensions were used as the starting base. Using as sample 203 males, of an average age of 29, twelve relevant longitudinal anthropometric variables were measured, and the obtained data were statistically elaborated.

On the basis of the analysed results of this investigation, and taking into consideration the current ergonomic principles established for certain working positions, and especially for a standing working position, the optimum heights for certain types of work are defined as well as the optimum heights of the working surfaces of machines and working benches for males working in a standing position. The necessity is pointed out of providing a foot grid or some other raised support for workers with shorter longitudinal dimensions in order to improve and adjust their relation to the actual height of the machines and working surfaces.

In modern industry, efforts have been made to ensure the adjustment of work to the human being, i.e. to improve to a maximum the "man-machine" system. The object of this is to increase work productivity by improving the economy of body activities and by limiting fatigue and the undesirable effects of the work strain on the health of the worker, while increasing safety at work and thus humanize labour itself. Therefore in designing machines and work benches, the respective morpho-functional characteristics of man and the rationality of working postures and sequence of movements should be taken into consideration in order to adjust accordingly the actual measures of machines and work benches as well as the display of controls and commands and other implements.

Despite the fact that the standing work posture, compared to the sitting one, requires a greater static effort which consequently causes a greater energy consumption and other undesirable effects, there are cases when it cannot be avoided due to the peculiarities of the working process. The undesirable effects of the standing work position, can be limited by ensuring that the working surfaces of machines and work benches have optimum height.

Various previous studies have pointed out that the anthropometric measures of potential workers and the muscular force involved should be taken as the starting basis in order to determine the optimum height of the working surfaces of machines and work benches at which work is carried out in a standing position[3,5,6].

Anthropometric data should be obtained by measuring potential workers within the population they belong to in order to achieve reasonable effects[2]. The aim of this paper is to find the optimum height of the working surfaces of machines and work benches for work in a standing position based upon the anthropometric measurements of the population which is likely to use the equipment.

SUBJECTS AND METHOD

Using as sample 203 males, of an average age of 29, twelve longitudinal anthropometric variables were measured: stature, eye height, shoulder height, elbow height, knuckle height, height of hip, foot length, bimetacarpal distance, horizontal grasping reach-metacarpal, overhead reach-metacarpal, elbow to metacarpal distance and sternum to metacarpal distance. All anthropometric measures were taken in subjects in a standing position, using the method recommended by Damon and co-workers[1]. The data obtained by the measurements were statistically elaborated, and mean ($\overline{X}$), standard deviation (S.D.), coefficient of variation (CV%), and 5th and 95th percentile were computed. The correlation coefficient (r) of all measurements taken was also calculated.

RESULTS

The basic descriptive statistical parameters ($\overline{X}$, S.D. CV%) as well as the 5th and 95th percentiles of the anthropometric variables are shown in Table 1. Since

TABLE 1
Anthropometric measurements of standing posture (cm).

N	Measurement	$\overline{X}$	S.D.	CV%	Percentile	
					5th	95th
1.	Stature	174.56	5.44	3.12	166.20	184.20
2.	Eye height	163.08	5.36	3.29	154.10	173.70
3.	Shoulder height	144.78	5.15	3.56	137.00	154.40
4.	Elbow height	110.81	4.44	4.01	103.70	118.00
5.	Knuckle height	77.21	4.01	5.19	70.40	84.70
6.	Height of hip-iliospinal	102.33	4.43	4.33	95.90	109.60
7.	Foot length	26.68	1.08	4.05	24.90	28.40
8.	Bimetacarpal distance	153.50	7.23	4.71	141.20	165.50
9.	Horizontal grasping reach-metacarpal	67.39	3.15	4.67	62.80	73.60
10.	Overhead reach-metacarpal	211.40	7.95	3.76	199.40	227.50
11.	Elbow to metacarpal distance	33.60	2.36	7.02	30.20	37.70
12.	Sternum to metacarpal distance	56.36	4.16	7.38	50.40	63.20

TABLE 2
Correlation coefficients.

No	Measurement	1	2	3	4	5	6	7	8	9	10	11	12
1.	Stature	1.00	0.97	0.95	0.90	0.71	0.82	0.63	0.65	0.73	0.88	0.48	0.45
2.	Eye height		1.00	0.94	0.89	0.70	0.82	0.62	0.65	0.73	0.87	0.49	0.45
3.	Shoulder height			1.00	0.93	0.78	0.84	0.60	0.62	0.71	0.86	0.43	0.47
4.	Elbow height				1.00	0.85	0.76	0.58	0.53	0.58	0.78	0.44	0.38
5.	Knuckle height					1.00	0.63	0.40	0.24	0.30	0.58	0.10	0.21
6.	Height of hip-iliospinal						1.00	0.57	0.60	0.72	0.76	0.36	0.34
7.	Foot length							1.00	0.49	0.53	0.57	0.41	0.28
8.	Bimetacarpal distance								1.00	0.77	0.66	0.58	0.48
9.	Horizontal grasping reach-metacarpal									1.00	0.76	0.56	0.51
10	Overhead reach-metacarpal										1.00	0.49	0.49
11.	Elbow to metacarpal distance											1.00	0.36
12.	Sternum to metacarpal distance												1.00

the basic statistical parameters indicate the means and the variability extent of the applied anthropometric measures of the surveyed sample and thus cannot serve as a basis for a maximum improvement of the "man-machine" system, the values of the 5th and 95th percentiles are used. As a starting basis for establishing the optimum heights of the working surfaces of machines and work benches for work in a standing position in accordance to the existing ergonomic principles, the anthropotechnical coordination should cover 90% of the surveyed persons within the range of 5th and 95th percentile.

Coefficients of the correlation (r) of anthropometric variables are shown in Table 2. All coefficients equal to or greater than 0.14, are considered statistically significant at a level of $P = 0.05$, and equal to or greater than 0.18 at a level of $P = 0.1$[4].

DISCUSSION

While all shown anthropometric variables are important to a smaller or greater degree for the design of machines and work benches, of particular importance for determining their optimum height for work in a standing position is the elbow height. Investigations have shown that the optimum height of the working surface is 10–15 cm below the elbow height; as a rule, the measures of tall workers should be taken into consideration while adjusting the height for shorter ones by raising the floor (using grids or platforms)[3]. As the value of the elbow height for 90% of measured workers lies between 103.70 and 118.00 cm, plus the average clothing increment of 2 cm for shoes, the height of the working surface should be 105 cm (118 + 2 − 15 cm).

One other factor to be taken into consideration refers to the criterion of the level of the muscular force involved, and in accordance with it the height of the working surface should be corrected. In cases when most of the performance requires a considerable muscular effort (lifting heavy parts; strong downward pressure) the working height should preferably be lower (90–95 cm), while for precise work the working surface should be higher (105–110 cm). The static effort of the arm muscles can be reduced by providing supports for the elbows and the forearms (if the nature of the work permits it) which should be adjustable and suited to the individual requirements of the workers. The static muscular strain of the back and the legs can be diminished by intermittent use of a high, adjustable working chair.

The remaining anthropometric variables which define the working area, can be used as the basis for determining the other parameters of machines and working benches such as the display of commands, controls, tools and other implements. The results obtained by this study allow the conclusion that the location of commands on the vertical panel should be between the height of the working surface of the machine and 137.00 cm above the floor (value 5th percentile shoulder height). If it is necessary to locate the commands beside the machine, the lowest value of this range should not be lower than 84.70 cm (value 95th percentile knuckle height). This range (84.70–137.00 cm) is the optimum working area on the vertical panel and covers 90% of the surveyed population of

workers. The coordination is facilitated to a certain degree by the fact that the elbow height, as a basis for determining the optimum height of machines and working benches, has statistically significant, positive and mainly high correlations.

CONCLUSION

The results obtained by this study allow the conclusion that the optimum height of the working surface of machines and work for males in a standing position is 105 cm, considering the measured elbow height of the surveyed population. Depending upon the type of work to be performed and the muscular force involved, the working heights should be between 90 and 110 cm, as determined by the anthropometric measures of taller persons, while for shorter persons it is advisable to use a foot-grid or a platform for individual adjustment. Whenever the working operation permits it supports for the forearms and seats for temporary use should be provided which considerably diminish the static muscular strain.

In addition to a well coordinated height of the working surfaces of machines and working benches it is necessary to coordinate the remaining dimensions to the respective anthropometric measures of workers. This will ensure that the working operations are executed in a comfortable body posture and at an optimum visual distance of the working area and result in a higher work productivity, less fatigue and improved safety at work.

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