

## **The Ergonomic Properties of Outdoor Fitness Equipment with Respect to the Anthropometric Characteristics of Iranian Women: A Case Study of Chest Press Machine and Pull Chairs**

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### **ABSTRACT**

*Anthropometrics is an important area in ergonomics. Perhaps the main reason for physical injuries in fitness training is anthropometrically and ergonomically non-standard equipment. The purpose of the present research is to identify the ergonomic properties of outdoor chest press machine and pull chairs with respect to the anthropometric characteristics of Iranian women. Certain anthropometric indices of 140 women as well as the dimensions of chest press machine and pull chairs were measured. Then, the dimensions of these machines were evaluated taking into account the related percentiles and the position of body on the machines. The results showed that there is a significant difference between the horizontal hip-handle distance and the dimensions of the bench press machine for the 95<sup>th</sup> percentile of female users ( $p < 0.05$ ). However, the difference was not significant for the vertical hip-handle distance ( $p = 0.85$ ). There was also a significant difference between the horizontal and vertical hip-handle distance and the dimensions of the pull chairs for the 95<sup>th</sup> percentile of female users ( $p < 0.05$ ). Moreover, in both machines, there was a significant difference between the hip width and the seat width and between the popliteal height and seat height for the 95<sup>th</sup> percentile of female users ( $p < 0.05$ ). Based on the findings, it can be concluded that the horizontal seat-handle distance in the chest press machine is small for the female users and that the vertical distance is appropriate. It was also revealed that the horizontal and vertical seat-handle distance in the pull chairs is too large for the female users. The results of the present research suggest the mismatch between the dimensions of the chest press machine and the pull chairs and the anthropometric characteristics of Iranian women, thus highlighting the necessity to follow ergonomic standards in design and production of fitness equipment.*

**Keywords:** Ergonomics, anthropometrics, outdoor fitness equipment

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### **INTRODUCTION**

Sport has taken different forms throughout human history. History has proven that civilized nations have always considered the essential role of sports and have employed it as a means for educating the youth and preparing them to face personal and social problems. Nowadays countries are paying increasing attention to sport [1].

Movement is one of the essential characteristics of human beings and an important factor for their development and health [2].

The contemporary century is, without doubt, the age of inactivity and mechanical life, when human activities are mostly done by machines and physical activity has decreased among people. Outdoor fitness equipment can create opportunities for everyone to freely exercise in a social environment. It must be noted that this activity can be both beneficial and detrimental, for these equipment may cause musculoskeletal damages, pain in the joints, and cardiac diseases. Indeed it is of utmost importance that these devices be designed with respect to the characteristics of the users [3,4]. Designers must be committed to follow the rules that govern human body and must guarantee the safety and comfort of the users. They must take ergonomic and anthropometric factors into account in the design and production of the equipment [5,6].

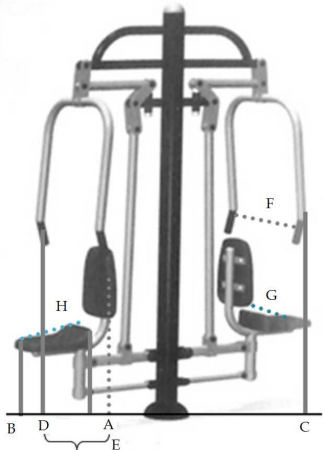
Ergonomics is the science of designing equipment that fits the human body, its movements, and its cognitive abilities. Anthropometry, on the other hand, is a subject in ergonomics that deals with the measurement of human body. Perhaps one of the main reasons for injuries is disregard to anthropometric and ergonomic standards that correspond to the dimensions, size, and even the culture and behavior of Iranian people [7,8]. The purpose of the present research is to examine the ergonomic properties of outdoor chest press machine and pull chairs with respect to the anthropometric characteristics of Iranian women. This study will show whether there is a proper correspondence between the anthropometric data (related percentiles) and the dimensions of these machines. In many advanced countries, the issue of correspondence of equipment is rather old, since they are perfectly familiar with the effect of bad body postures on health and design and build equipment with respect to the characteristics of the population. In Iran, studies have merely focused on the suitability of classroom seats for students. Thus, no similar research was found in this regard and it was not possible to compare the results with those of previous research.

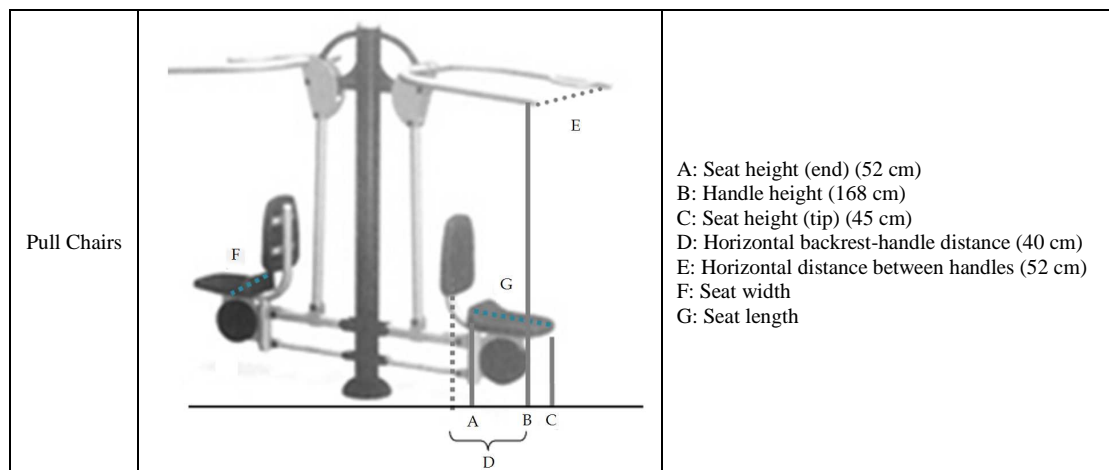
## MATERIALS AND METHODS

In this cross-sectional case study, the population consists of all Iranian women as well as 35 brands of outdoor fitness equipment. The sample includes 140 female volunteers and the sample equipment includes the chest press machine and the pull chairs (Arya Inc., Iran). An engineering tape measure and an anthropometric kit were used for measuring the variables of the research, i.e. the dimensions of the chest press machine and the pull chairs and the anthropometry of female users. Also a demographic questionnaire and a survey were used for data collection. Thus, the anthropometric table was completed with nine variables: shoulder height (seated position), forward handle reach, shoulder width, shoulder-elbow length, shoulder-handle length, handle-elbow length, hip width, hip-knee length, and popliteal height. Descriptive statistics (measures of central tendency and normality of distribution of variables) were used for describing the subjects' personal characteristics and research variables (anthropometric data) and one-sample t-test was used for hypothesis testing. All the operations were done in Excel 2007 and SPSS 16.

In this research, the required parts of the chest press machine and the pull chairs were measured using a plummet. The dimensions of machines are presented in the table below.

**Table 1: The dimensions of the chest press machine and the pull chairs**

Machine	Figure	Required Dimensions
Chest Press		A: Height of the tip of the backrest (54 cm) B: Seat Height (47 cm) C: Handle height (95 cm) D: Mid handle height (100 cm) E: Horizontal backrest-handle distance (10 cm) F: Horizontal distance between handles (68.5 cm) G: Seat width H: Seat length (35 cm)



## RESULTS

The majority of female users of outdoor fitness equipment were older than 50 (37.1%) of whom 50.5 percent engaged in hiking as well as fitness training. About 31.4 percent of the sample had been using the equipment for one to three years and 28.6 percent of the sample used the equipment for maintaining physical health. The anthropometric characteristics of the female users are presented in Table 2.

Table 2: Mean, standard deviation, 5<sup>th</sup> percentile, 95<sup>th</sup> percentile, and the normality test (N = 70)

Position	Variable	Mean $\pm$ SD (cm)	5 <sup>th</sup> Percentile	95 <sup>th</sup> Percentile	Kolmogorov-Smirnov Test	P-Value
Seated	Shoulder Height	58.48 $\pm$ 3.86	52.55	65	0.892	0.403
	Forward Handle Reach	66.64 $\pm$ 3.51	61	73	0.548	0.925
	Shoulder Width	40.30 $\pm$ 2.35	36	44.72	1.010	0.259
	Shoulder-Handle Length	57.02 $\pm$ 3.84	50.55	63	0.677	0.749
	Shoulder-Elbow Length	32.65 $\pm$ 3.09	27	38.72	0.987	0.284
	Elbow-Handle Length	32.08 $\pm$ 2.34	26	36.45	1.001	0.269
	Hip Width	38.89 $\pm$ 2.82	34.27	44.5	0.917	0.369
	Hip-Knee Length	45.37 $\pm$ 3.53	38.1	49	1.098	0.179
	Popliteal Height	41.19 $\pm$ 3.21	35.77	46.45	0.756	0.617

Table 2 shows the mean and standard deviation of some anthropometric characteristics of the female users of outdoor fitness equipment as a part of Iranian women population. Also the results of Kolmogorov-Smirnov test indicate that the frequency distribution of all the variables is normal ( $P > 0.05$ ).

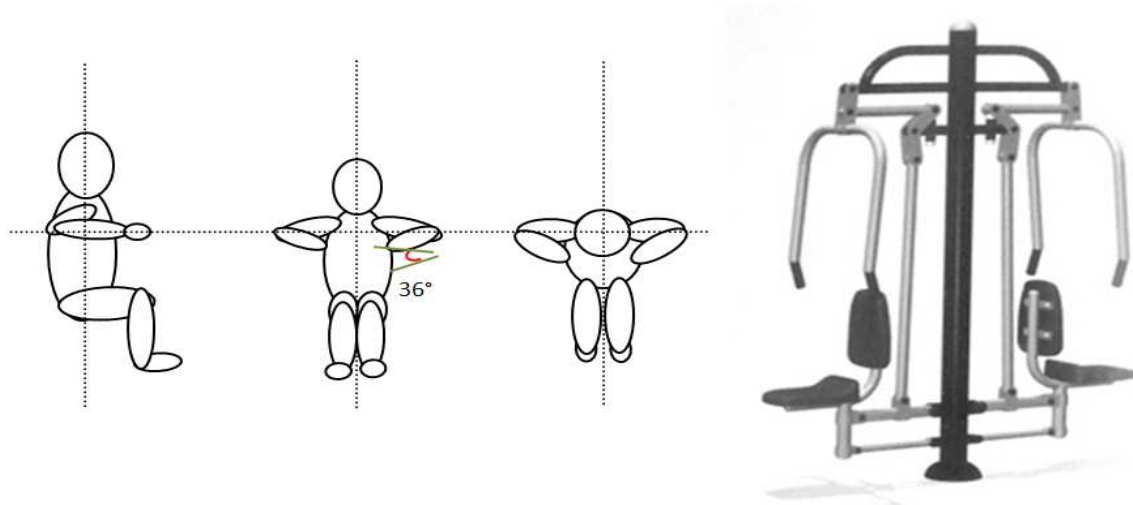


Figure 1: The desirable position of the body on the chest press machine

### The chest press machine

The chest press machine is very suitable for novice users, for there are no concerns for maintaining balance of the weights or barbells. In chest press, the upper body is straightened and the handles are a little away from shoulders and along the middle of the chest [9, 10]. Since elbow plays a significant role in this movement and since some studies have reported the ROM of shoulder in flexion to be 140 to 145 degrees [11,12], the mean elbow angle is 144 degrees, where the handles are almost positioned against the acromion. The best position on the chest press machine is shown in Figure 1.

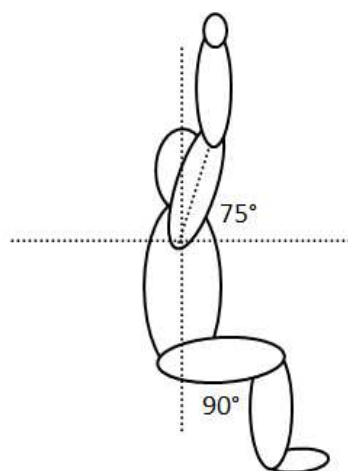
**Table 3: Position of the body on the chest press machine and the results of one-sample t-test**

Variables	5 <sup>th</sup> Percentile	50 <sup>th</sup> Percentile	95 <sup>th</sup> Percentile	SD	5 <sup>th</sup>	t-value 50 <sup>th</sup>	95 <sup>th</sup>	5 <sup>th</sup>	P-value 50 <sup>th</sup>	95 <sup>th</sup>
Horizontal scapula-handle distance	23.41	28.55	34.55	3.05	66.6	50.9	88.55	0.001	0.001	0.007
Horizontal backrest-handle distance		10								
Vertical hip-handle distance	36.8	40.94	45.5	2.7	-5.6	-0.19	-0.74	0.03	0.85	0.51
Vertical seat-handle distance		41	46	-						
Popliteal Height	35.77	41.19	46.45	3.21	-17.2	-9.9	4	0.003	0.001	0.057
Seat Height		47		-						
Hip-Knee Length	38.1	45.37	49	3.53	1	21.51	13.69	0.42	0.001	0.001
Seat Length		35		-						
Hip Width	34.27	38.9	44.5	2.8	20	35.2	144.5	0.002	0.001	0.001
Seat Width		27		-						

The data in Table 3 shows that there is a significant difference between the horizontal scapula-handle distance of Iranian women and the horizontal seatback-handle distance of the chest press machine ( $P < 0.05$ ); there is no significant difference between the vertical hip-handle distance and the vertical seat-handle distance ( $P > 0.05$ ), but this difference is significant for the 5<sup>th</sup> percentile of the users ( $P < 0.05$ ); there is a significant difference between the seat height and the popliteal height of the female users ( $P < 0.05$ ), but this difference is not significant for the 95<sup>th</sup> percentile ( $P = 0.057$ ); there is a significant difference between the hip-knee length and seat length ( $P < 0.05$ ), but this difference is not significant for the 5<sup>th</sup> percentile ( $P = 0.42$ ); and there is also a significant difference between the hip width of Iranian women and the seat width of the chest press machine ( $P < 0.05$ ).

### The Pull Chairs

Since the shoulder joint plays the most important role in this movement and since some studies have reported the ROM of shoulder in flexion to be 130 to 180 degrees [17], the desirable angle for the users is 165 (Figure 2).



**Figure 2: The desirable position of the body on the pull chairs**

**Table 4: The position of the body on the pull chairs and the results of one-sample t-test**

Variables	5 <sup>th</sup> Percentile	50 <sup>th</sup> Percentile	95 <sup>th</sup> Percentile	SD	5 <sup>th</sup>	t-value 50 <sup>th</sup>	95 <sup>th</sup>	5 <sup>th</sup>	P-value 50 <sup>th</sup>	95 <sup>th</sup>
Horizontal scapula-handle distance	13.84	18.11	23.29	2.69	-80.27	-68.07	27.30	0.001	0.001	0.023
Horizontal backrest-handle distance		40								
Vertical hip-handle distance	114	124.2	134.2	6.36	-10.28	1.57	4.56	0.001	0.121	0.137
Vertical seat-handle distance		123		-						
Popliteal Height	35.77	41.19	46.45	3.21	-17.2	-9.9	4	0.003	0.001	0.057
Seat Height		45		-						
Hip-Knee Length	38.1	45.37	49	3.53	1	21.51	13.69	0.42	0.001	0.001
Seat Length		35		-						
Hip Width	34.27	38.9	44.5	2.8	20	35.2	144.5	0.002	0.001	0.001
Seat Width		27		-						

The data in Table 4 shows that there is a significant difference between the horizontal scapula-handle distance of Iranian women and the horizontal backrest-handle distance in the pull-chairs ( $P < 0.05$ ); there is no significant difference between the vertical hip-handle distance and the vertical seat-handle distance ( $P > 0.05$ ), but this difference is significant for the 5<sup>th</sup> percentile of the users ( $P < 0.05$ ); there is a significant difference between hip width and seat width ( $P < 0.05$ ); there is a significant difference between seat height and popliteal height ( $P < 0.05$ ), but this difference is not significant for the 95<sup>th</sup> percentile ( $P = 0.42$ ); there is also a significant difference between the hip-knee length of Iranian women and the seat length of the pull chairs ( $P < 0.05$ ), but this difference is not significant for the 5<sup>th</sup> percentile ( $P = 0.42$ ).

## DISCUSSION

The purpose of the present research was to identify the ergonomic properties of outdoor chest press machine and pull chairs with respect to the anthropometric characteristics of Iranian women. Thus, the anthropometric data and the dimensions of the machines were evaluated. The results showed that the horizontal backrest-handle distance in the chest press machine is short for average Iranian women, but the vertical seat-handle distance is suitable. The possible reason for the difference is that the machine is not standard, since people need to have excessive horizontal arm extension for reaching the handles of the machine. The height of the seat of this machine is long for average Iranian women and its length is appropriate. Moreover, the seat width is short for Iranian women. Considering these findings, it is recommended that users push the handles slightly forward and then begin the exercise.

Also the ergonomic properties of the pull chairs was identified and compared with the anthropometric characteristics of Iranian women. The results showed that the horizontal backrest-handle distance and the vertical seat-handle distance in the pull chairs are large for the female users. The reason for this difference could be due to non-standard design of the machine, since the users need to bend forward in order to reach the handles. The seat distance is also high for the users, but seat length is suitable. Moreover, the seat width is short for the female users.

All these differences can also be associated to individual differences, small number of studied samples, and the single-gender approach of this research. We can recommend users to seat slightly away from the backrest so as to easily reach the handles, otherwise they may bend forward and this will put much pressure on their spine. These findings are consistent with similar studies carried out on the leg press machine and elliptical glider, for these studies have shown the differences between the dimensions of the fitness equipment and the anthropometric characteristics of the users.

## CONCLUSION

Considering the findings, it is recommended that the overall height of the chest press machine be reduced by 10 cm and the horizontal backrest-handle distance of the machine be increased by 25 cm. Preferably, the seat width can be increased by 18 cm (Figure 3).

Also considering the results, it is recommended that the horizontal backrest-handle distance in the pull chairs be reduced by 26 cm and the height of the handles be reduced by 19 cm. It is better to change these distances by making changes in the seat of the machine in order to maintain the leverage capability of the pull chairs. It is also recommended that the seat height be reduced by 10 cm and the seat width be increased by 17 cm (Figure 4).

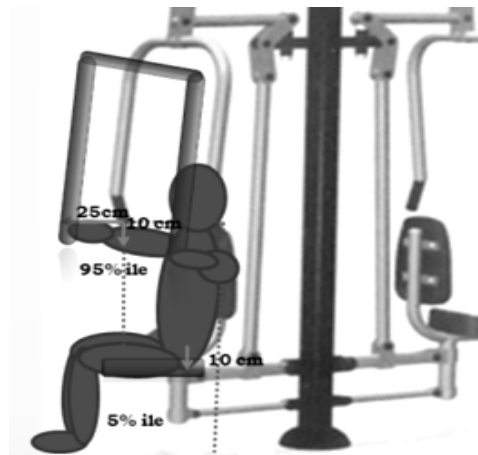


Figure 3: The desirable dimensions of the chest press machine for Iranian women

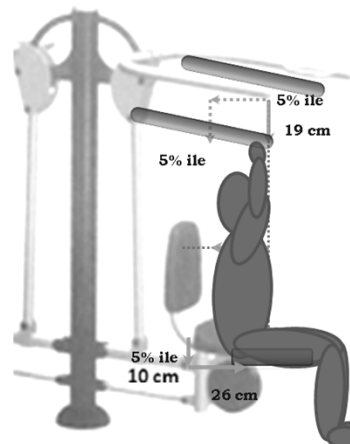


Figure 4: The desirable dimensions of the pull chairs for Iranian women

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