Identification of the Ergonomic Properties of Outdoor Fitness Chest Press Leg press and Pull Chairs Machines with Respect to the Anthropometric Characteristics of Iranian Women

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Abstract

Introduction: Appropriateness of ergonomic properties of outdoor fitness equipment with respect to anthropometric features of their users can reduce risk of injuries. The aim of this study was to investigate the appropriateness of the ergonomic indices of outdoor leg presses, chest presses, and pull chair machines with respect to anthropometric parameters in Iranian female athlete users**. Material and Methods:** 124 Iranian female athletes who used outdoor fitness machines in Iran were recruited. An engineering tape measure and an anthropometric kit were used to measure the dimensions of the chest press, leg press, pull chair machines and also anthropometry of female users. Next, using the anthropometric data and the fitness device standards based on trigonometric calculations, standard anthropometric computational dimensions of devices were obtained. Standard indices of outdoor fitness devices based on athlete's anthropometric data were compared with the dimensions of outdoor fitness machines. A one-sample t-test was conducted on the collected data using SPSS software, version 21. **Results:** Comparison among all calculated ergonomic indices of leg press, chest press, and pull chair machines according to anthropometric features of female users and certain measured indices showed a significant difference (P<0.05), with exception of ergonomic variable of optimal horizontal distance from the back of seat pad to foot plate tip in the leg press machine (P=0.68). According to this significant difference, these devices were not ergonomic in terms of female athletes' anthropometry. **Conclusion:** Based on the findings, ergonomic properties of leg press, chest press, and pull chair outdoor fitness machines did not meet the anthropometric variations in Iranian female users. Given this mismatch could play an important role in the occurrence of musculoskeletal injuries among female users of these devices, this study highlight the necessity of following ergonomic standards in the design and production of fitness equipment.

Keywords: Ergonomics, Anthropometrics, Outdoor Fitness Equipment

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Introduction

Exercise has a valuable effect on population health and the prevention of metabolic disease (1). Exercise and outdoor physical activity are ways that people may participate in socially engaging leisure activities(2). Engaging in public sports, or sports for all, has been shown to be closely related to the health and vitality of society(3).Participation in public physical activity is part of the strategic and comprehensive system of physical education in Iran and aims to ensure health and vitality of all citizens.

Outdoor fitness equipment can create opportunities for everyone to freely exercise in a social environment(4, 5). While use of such equipment may be beneficial with regard to exercise, it also has a potential to cause musculoskeletal injuries (6). Indeed, such devices must be designed with respect to anthropometric characteristics of their users. Designers of these outdoor fitness equipment must take ergonomic and anthropometric factors into account in design and production of equipment (7).

Table 1. Demographic feature of participants

Parameters	Mean (SD)
Age (years)	29.03 (8.13)
Weight (kilograms)	66.08 (12.81)
Height (cm)	164.38 (7.20)
Seat height (cm)	80.59 (2.76)
Acromion height (cm)	134.12 (9.57)
Shoulder-fingertip length (cm)	66.27 (5.04)
Elbow-fingertip length (cm)	42.78 (4.57)
Shoulder-elbow length (cm)	23.48 (5.49)
Forearm length (cm)	25.94 (3.19)
Forearm width cm)	7.44 (1.33)
Knee to hip (seated)	47.88 (6.62)
Calf length (cm)	35.13 (3.93)
Leg length (cm)	23.48 (5.49)

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 measurements of human body(8). Mismatch of anthropometric and ergonomic properties may contribute to musculoskeletal injuries(9, 10). It is noteworthy that body positions of athletes during exercise are completely different. For this reason, the necessity and application of special standards in bodybuilding machines, such as outdoor fitness equipment, have been emphasized. Clarice *et al.* reported that some sports machines in parks not only do not have a standard installation but also are not suitable for both women and men (11). Kassel *et al.*, demonstrated that men are more prone to sports injuries than women while using sports equipment (12). Lack of necessary standards for the installation and mismatch of equipment characteristics with human physical characteristics (men and women) in equipment can reduce user's satisfaction and the effectiveness of movements, thereby causing injuries, complications, and physical abnormalities. Further, manufacturing devices abroad may meet the needs of respective country's population, but those may be incompatible with users in other countries (12). As a result, it should be ensured that sizing of sports equipment is appropriate for anthropometric measurements of people in the community in which it is used. Therefore, the purpose of present study was to examine ergonomic properties of outdoor chest press, leg press, and pull chairs with respect anthropometric characteristics of Iranian female athletes who participated in physical activities for at least 3 times a week.

Material and Methods

In this cross-sectional study, initially 154 healthy women, based on measured sample sizes of previous studies (6, 8, 13) in this field, were invited to participate through announcements posted in city parks of Tehran (Table 1). Inclusion criteria were having no presence of musculoskeletal pain and participating in sports activities using outdoor fitness devices including chest press, leg press, and pull chair machines regularly for at least three times a week. This study was approved by Sport Sciences Research Institute SSRI (IR.SSRC.REC.1399.109). After initial verbal explanation of the research plan, 124 of them agreed to cooperate. An engineering tape measure and an anthropometric kit were used to measure the dimensions of the chest press machine, leg press, pull chairs, and anthropometry of female users. A demographic questionnaire was completed by the participants. The following anthropometric variables were measured for all participants: vertical height from seat pad (seated position), acromion height, forward handle reach, shoulder-elbow length, shoulder-handle length, handle-elbow length, forearm length, forearm width, hip width, hip-knee length, foot plate length, and leg length. Next, using anthropometric data and fitness device standards based on trigonometric functions (mathematical calculations), anthropometric computational data were obtained.

Descriptive statistics (measures of central tendency) were used to describe subjects' demographics (Table 1). Anthropometric data were also checked for normality statistically by Kolmogorov-Smirnov test. One sample t-test was utilized to compare measured anthropometric indices of 124 participated women and standard dimensions of chest press, leg press, and pull chair machines calculated based on trigonometric functions according to real dimensions (Table 2) of these devices. Level of significance was set at 0.05 (P<0.05).

Results

Anthropometric and demographic parameters of participants compared to the standard ergonomic sizes of chest press, leg press, and pull chair machines are shown in Table 1. Results of Kolmogorov-Smirnov test indicated that the distribution of all variables were normal (P>0.05). Mean and optimal standard deviation of devices, adjusted to anthropometric measurements of the participants, were calculated and shown in Table 3.

Table 2. Dimensions of a sample of chest press, pull chair, and leg press machines

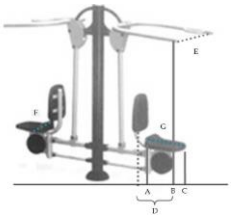
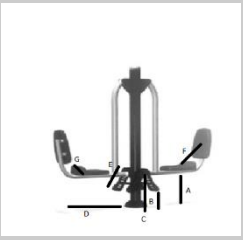
Machine	Dimensions	
Chest press	A: Height of the tip of the backrest (54 cm) B: Seat Height (47 cm) C: Handle height (105 cm) D: Mid handle height (100 cm) E: Horizontal backrest-handle distance (10 cm) F: Horizontal distance between handles (68.5 cm) G: Seat width (27 cm) H: Seat length (35 cm	
Pull chair	A: Seat height (end) (50 cm) B: Handle height (165 cm) C: Seat height (tip) (45 cm) D: Horizontal backrest-handle distance (40 cm) E: Horizontal distance between handles (52 cm) F: Seat width (35cm) G: Seat length (37cm)	
Leg press	A. Seat pad height: (50cm) B. Foot plate tip height: (20cm) C. Foot plate end height: (45cm) D. The horizontal distance from pad to the end of foot plate: (61) E. Foot plate length: (28.5cm) F. Angle between the foot plate and theground: (54°) G. Seat pad width: (27cm)	

Table3. Comparison of calculated standard ergonomic outdoor fitness machines dimensions based on anthropometric measurements of female athletes with certain measured dimension of devices

Parameter	Mean (SD) of outdoor fitness dimension	Mean (SD) of devices dimension	Mean Difference	*P*-value
Chest press (seated chest height) (cm)	2.55 (49.7)	2.05 (60.60)	10.87	0.000
Leg press (Vertical distance from hip on seat pad to the end of foot toes) (cm)	1.37 (25.21)	1.92 (16.86)	-8.35	0.000
Leg press (Horizontal distance from hip on seat pad to the end of foot toes) (cm)	0.42(82.75)	9.86 (81.72)	-1.02	0.068
Pull chair (Horizontal seat-handle distance) (cm)	2.12 (25.78)	4.02 (23.64)	-2.13	0.05
Pull chair (Vertical seat-handle distance) (cm)	4.19 (125.75)	7.03 (118.38)	-7.37	0.01

Comparison between all ergonomic indices of leg press, chest press, and pull chair machines calculated, according to anthropometric features of female users and certain dimension of machines, demonstrated a significant difference (P<0.05) with the exception of the ergonomic variable of optimal horizontal distance from the back of seat pad to foot plate tip in the leg press machine (P=0.68) indicated in Table 3. According to this difference, these devices were not ergonomic in terms of female athletes' anthropometry.

Discussion

The aim of this study was to investigate the appropriateness of ergonomic properties of leg press, chest press, and pull chair machines to anthropometric parameters of female athletes. The results showed ergonomic properties of the exercise machines were not in accordance with anthropometric measurements of the participants. A significant difference was found between ergonomic indices of the chest press machine and the anthropometric measurements of the participants. According to the findings, ergonomic variable of seated chest height in the chest press machine had a significant difference according to theoretical calculated value. Therefore, ergonomic properties of the chest press machine were not appropriate for female participants. This mismatch may result in suboptimal strengthening for these female athletes. The results of this research are consistent with a study (14). Ilbeigi *et al.* concluded that there was a significant difference between the device dimension and anthropometric characteristics of users. The authors concluded that these devices were not ergonomic in relation to anthropometric measurements of male users, thus standardization should be considered (13). This same mismatch may interfere with arm movement when using the chest press machine. The seat to grip distance on the chest press machine was not suitable for anthropometrics of the female athletes in this study. Because of the specifications of the device, the participants in this study could not perform sequential movements or repetitions of the movement. At the start of this movement, female athletes had to open their arms and chest when holding the device handles (horizontal arm extension) and then move their arms back. This wide range of this movement with this equipment can be impossible for these female athletes and also cause injuries to the chest and shoulders. Previous epidemiological studies have confirmed sports injuries such as fractures, sprains, and strains may occur while using park fitness equipment (15-18).

In the present study, the dimensions of the leg press machine were not appropriate for anthropometric measurements of female athletes. The results indicated no significant difference between optimal horizontal distance from beginning of the gluteal region (back of seat pad) to the toe in the leg press machine and anthropometric measurements of the subjects in comparison with calculated standard of outdoor fitness machines. Mohammadi *et al*. concluded that there was a significant difference between horizontal and vertical measurements from beginning of the gluteal region (back of seat pad) to the toe in the leg press of the user and the dimensions of the foot press machine for about 95% of users (14). It can be concluded that horizontal distance from the back of seat pad to the toe on the press is shorter than the usual magnitude and vertical distance is greater than the optimum size for women. The vertical distance from beginning of the gluteal region (back of seat pad) to the toe in the leg press was significantly less than optimal vertical distance from beginning of the foot sole to the toe of women athletes, thereby creating less than optimal angles at the hip and knee joints. Such improper positioning could decrease exercise efficiency and increase the probability of sports related injuries. At last, the comparison between optimal horizontal and vertical distance from seat to handle based on anthropometric measurements of participants also showed that there was a significant difference with the standard calculated indices of the device.

Small size of sample group was a major limitation of present study.. We also did the measurements in one city in Iran. Therefore, since dimension of outdoor fitness machines are different in different parts of country and world, it is better to run related studies all around a country.

Conclusion

This study revealed that ergonomic properties of leg presses, chest presses, and pull chair machines were not well matched to anthropometric parameters of female athletes in Iran. Given that these disproportions may play an important role in the incidence of musculoskeletal injuries, it is suggested that the features allowing adjustability in the design outdoor fitness equipment are included with dimensions of devices accommodating minimum and maximum anthropometric sizes. Designers must be committed to follow rules that govern the human body and ensure the safety and comfort of athletes.

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None

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All authors made substantial contributions to the conception, design, analysis, and interpretation of data.

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