Iranian Journal of Ergonomics | ISSN: 2345-5365

Original Article

Conceptual design of an ergonomic desk converter using anthropometric data of Iranian community

Arezoo Sammak Amani[1], Mohammad Amin Mououdi[2], Morteza Mahdavi [3*], Fariba Ghaempanah[2]

1- MSc student, Department of Occupational health and safety engineering, faculty of health, Mazandaran University of Medical Sciences, Mazandaran, Iran
2- MSc, Department of Occupational health and safety engineering, faculty of health, Mazandaran University of Medical Sciences, Mazandaran, Iran
3- MSc student, Department of Occupational health and safety engineering, faculty of health, Tehran University of Medical Sciences, Tehran, Iran

Article Info

Received: 2021/9/15
Accepted: 2021/11/23
ePublished: 2022/2/2

Use your device to scan and read the article online

Corresponding Author
Morteza Mahdavi
MSc student, Department of Occupational health and safety engineering, faculty of health, Tehran University of Medical Sciences, Tehran, Iran
Email:
MortezaMahdaviH@gmail.com

ABSTRACT

Background and Objectives: For many employees, students and "Behind the desk jobs", most of the daily work is done while sitting on a chair and behind a desk. This happens while many studies are associating long-term sedentary posture with musculoskeletal and cardiovascular diseases, etc. The aim of the present research is to design a tool that helps to change the working posture of people who work at sedentary workstations from sitting to stand-sit posture.

Methods: The measurements needed to design a desk converter were extracted from the existing anthropometric data of Iranian community between the ages of 6-19 and 20-60 for both sexes, using 4 anthropometric parameters of elbow (to floor) height sitting, eye height sitting, elbow height standing and eye height standing. These values were used to obtain the difference between the required work surface of the hand while sitting and standing (keyboard position) and the difference of the required work surface of the eye while sitting and standing (display position). In order to calculate the range of height alteration of this tool, 5th percentile of women and 95th percentile of men were used.

Results: The desk converter constitutes two parts, 1. Top surface (meant for monitor) and 2. the keyboard tray. The difference in the height of these two surfaces was calculated 12cm. The maximum height of the desk converter (adjustable range) for both age groups was 68cm due to changes in sitting and standing elbow height. The width and depth of the desk are set at 90 by 50cm, and the keyboard and mouse surface, with a width equal to the desk's and a depth of 20cm, creates a sufficient and comfortable space for users.

Conclusion: It is envisioned that by using this tool and changing the posture of individuals from an entirely sitting posture to standing and sitting alternation, a contribution to the reduction of musculoskeletal, cardiovascular, diabetes and cancer problems can be made.

Keywords: Desk converter, Sit-stand posture, Workstation, Anthropometric Engineering.

How to Cite This Article:

Arezoo Sammak Amani, Mohammad Amin Mououdi, Morteza Mahdavi, Fariba Ghaempanah. Conceptual design of an ergonomic desk converter using anthropometric data of Iranian community. Iran J Ergon. 2021; 9 (3) :104-120.

Extended Abstract

Background and Objectives

Most office workers and "behind the desk jobs" spend most of their time sitting in a chair, performing the day-to-day tasks assigned to them, which will have consequences for them. Biswas *et al*. found that the destructive effects of prolonged sitting are not related to exercises and it exerts its destructive impact independently, and exacerbate the dangers of long sitting habits [1]. Van Der Berg *et al*. in a study on prolonged sitting and various diseases found that sitting for more than one hour increased the risk of developing type 2 diabetes by 22% and the risk of developing metabolic syndrome by 39% [2]. Nana Keum *et al*., in a similar study in 2015 found a link between prolonged sitting and colon cancer which Morris *et al*. in the same field confirmed their findings [3, 4]. Lawrence introduced sitting as a risk factor for hemorrhoids [5]. At the Pennington Biomedical Research Center, studies by Katzmarzyk *et al*. on 7,278 men and 9,735 women aged 18-90 and their follow-up for 12 years found a direct relationship between increased sitting time and increased mortality (for various reasons) and cardiovascular disease (CVD) [6]. Tigbe *et al*. also revealed a relationship between prolonged sitting and coronary artery disease (CAD) [7]. Prolonged sitting and obesity, according to Hobbs, are some of the reasons for the rapid growth of varicose veins [8]. Studies by Bontrup *et al*. also, found an association between low back pains (LBP) and prolonged sitting [9]. Ali *et al*. also reported the association of prolonged sitting with low back pain in employees of Dhaka City Bank in Bangladesh [10]. In a survey of employees and those with office work, Parry and Straker found that 81.8% of employees spend their time in a sitting position, which this high percentage increases the expressed risks in these individuals [11]. Healy *et al*. showed that having time to rest in the middle of a long sitting work (which involves moving the whole body, such as getting up) has a positive effect on the body's metabolic markers. For some reasons stated in various studies, on the risk of prolonged sitting and the positive effects of refusing to long periods sitting, this work posture, i.e. long period sitting, requires intervention [12]. According to a meta-analysis of 12 studies by Agarwal *et al*., sitting-standing workstations are suitable for reducing low back pain [13]. However, due to anthropometric engineering knowledge that warns us of variation of body dimensions, no detailed study has been done on the design of this product for Iranians. Therefore, this study aimed to design a desk converter to change the inappropriate posture and long sitting periods of employees in a sedentary posture to a standing posture, To both move the whole body and potentially reduce problems such as cancer, diabetes, cardiovascular problems, hemorrhoids, varicose veins, etc., in addition to preventing musculoskeletal disorders in people.

Methods

In this study, the design was conducted for two age groups of 6-19 and 20-60 in order to obtain sufficient information for different age groups and comprehensiveness of study. The data for the age group of 6-19 and 20-60 were obtained from the studies of Mehrparvar *et al*. [16-14] and Joneidi *et al*. [17], respectively. In this study, the anthropometric dimensions required to conceptualize the product include the height of the sitting eye, sitting elbow, standing eye, and standing elbow, which were obtained from the mentioned studies [14-17]. The appropriate height of the work surface according to ISO 14738 is 50th percentile of elbows (for fixed work surface). This standard also expresses this value as an average of 95th percentile and 5th percentile [18]. The product we are trying to design is an adjustable work surface, so it follows this standard; because the desk converter must be designed to provide a wide range of dimensions to support very short and very tall users. To extract the following dimensions, the 5th percentile of women (for the younger ones) and the 95th percentile of men (for the older ones) were used:

Sitting elbow height; 2- Standing elbow height; 3- Sitting eye height; 4- Standing eye height; 5- {(sitting eye height)- (sitting elbow height)}; 6- {(standing eye height)- (standing elbow height)}; 7- {(standing eye height)- (sitting eye height)}; 8- {(standing elbow height)- (sitting elbow height)}. The required changes for the screen placement were obtained by eye height, and the required changes for the keyboard placement were obtained by elbow height. In addition, the monitor width was obtained by examining the screen width of the different screens (considering the placement of two screens on a converter) and evaluating external models. Depth and width of the keyboard trey were also obtained by examining the depth and width of the keyboards available in the market and the required minimum amount.

Findings

Dimensions for the 6-19 age group have been shown in Table 1 and Figure 1 and Figure 2, and the dimensions for the 20-60 age group have been shown in Table 2 and Figure 3 and Figure 4.

Table 1. Extracted dimensions for 6 to 19 years old population (the data have been shown in Figure 2)

DIMENSION	5th percentile of female (cm)	5th percentile of male (cm)
Eye height	105	166
Sitting eye height	80	128
Elbow height	69	112
Sitting elbow height	44	73
Height difference between sitting and standing eyes	25	38
Height difference between sitting and standing elbow	25	39
Height difference between sitting elbow and eyes	36	55
Height difference between standing eyes and elbow	36	54

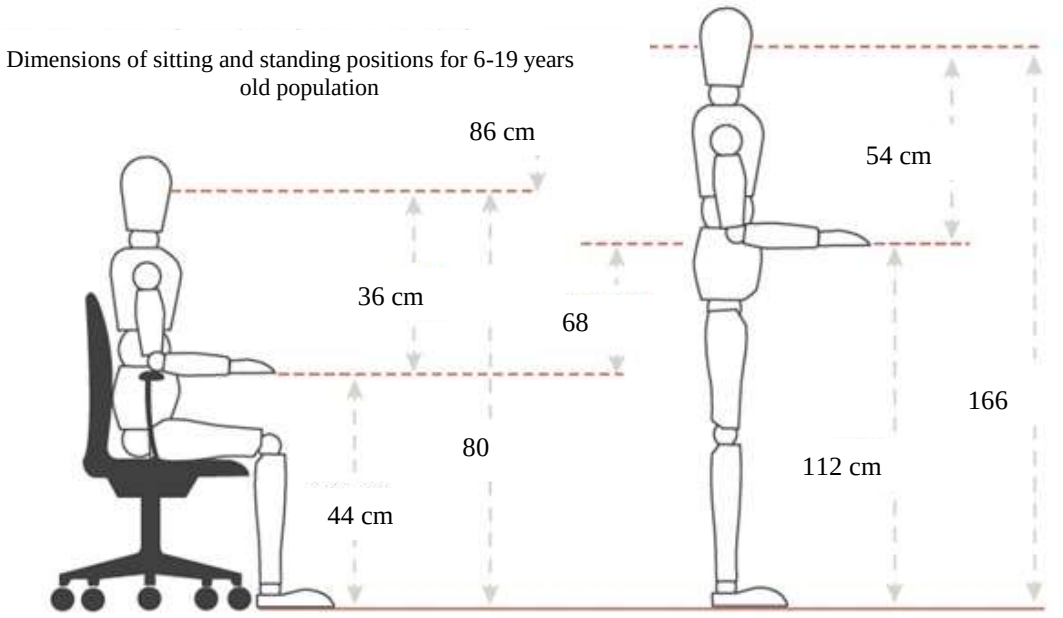


Figure 1. Extracted dimensions for 6 to 19 years old population [14-16]

Table 2. Extracted dimensions for 20-60 age group (these data have been shown in Figure 4)

Dimension	5th percentile of female (cm)	5th percentile of male (cm)
Eye height	137	173
Sitting eye height	101	135
Elbow height	92	119
Sitting elbow height	51.5	81
Height difference between sitting and standing eyes	36	38
Height difference between sitting and standing elbow	40.5	38
Height difference between sitting elbow and eyes	49.5	54
Height difference between standing eyes and elbow	45	54

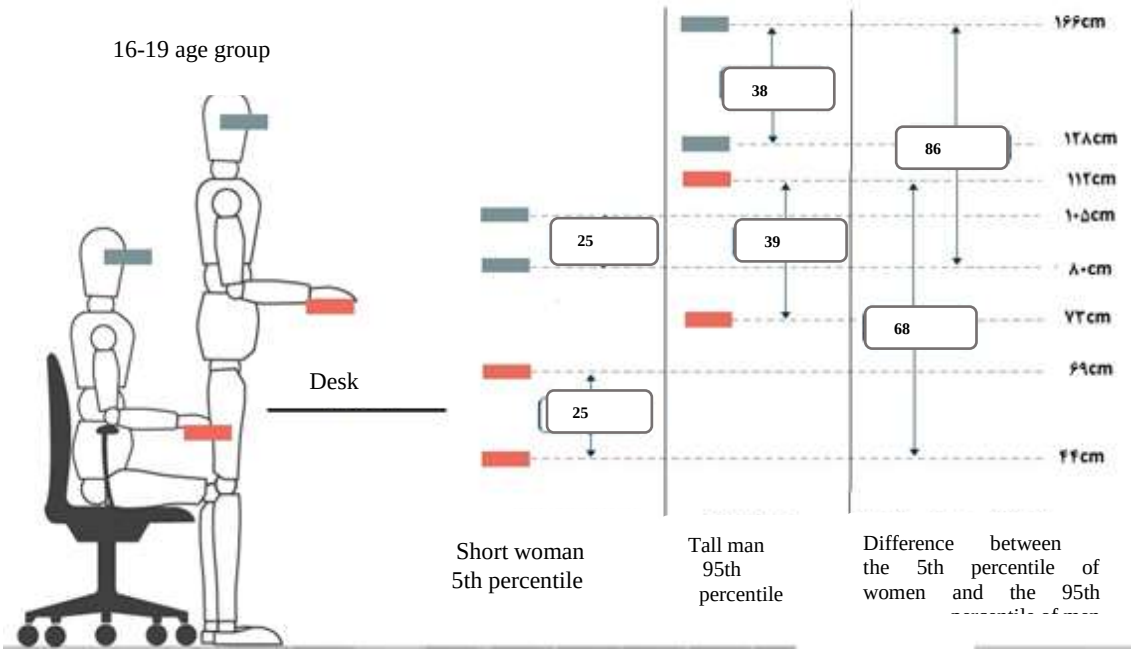


Figure 2. Comparison of differences in extracted dimensions for 16-19 age group [14-16]
Red marks show sitting and standing elbow height, and gray marks show sitting and standing eye height)

The dimension of sitting and standing positions for 20-60 age

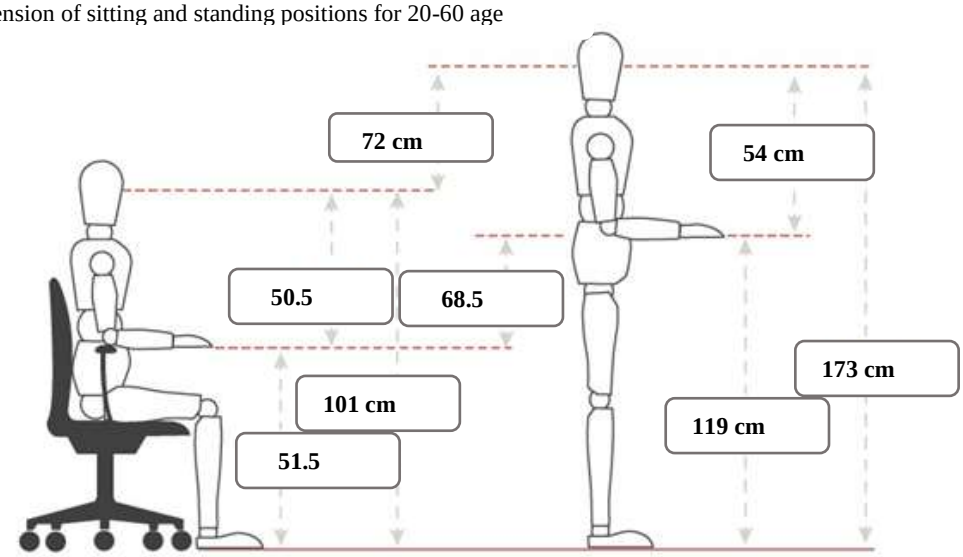


Figure 3. Extracted dimensions for 20-60 age group[17]

A distance of 12 cm between the keyboard and the table was considered by examining the different desks and keyboard trey used in the market. The keyboard also has the ability to adjust height (vertical distance from the display trey) and change the negative slope so that the wrist can be placed in a proper posture. keyboard tray shares the width of desk converter and has a depth of 20cm to create a depth of 20cm create a comfortable position for users (Table 3). By examining the routine dimension of the monitor (Table 4), the width and the depth were considered 90 cm and 50 cm, respectively, so that the user could use two monitors simultaneously. In addition, the ability to rotate the display trey 180 degrees allows other people to see the monitor.

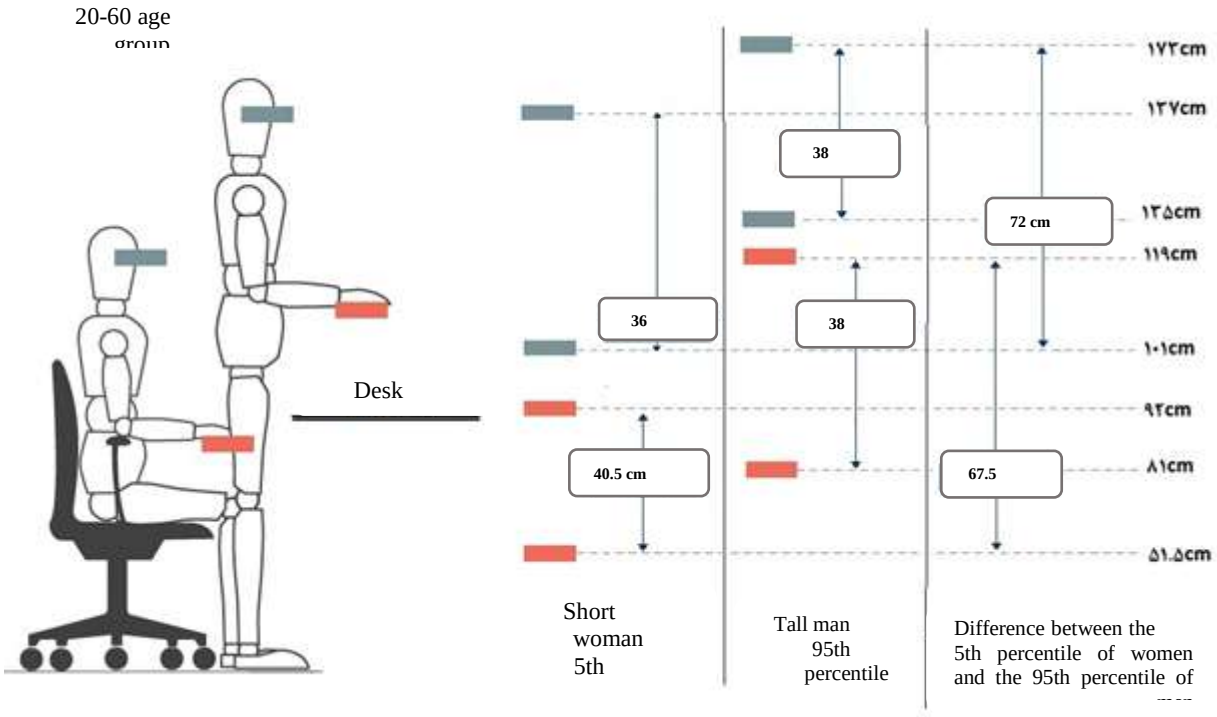


Figure 4. Comparison of differences in extracted dimensions for 20-60 age group [17]

In addition, the average height of the screens is 37.41 cm. To check the height of the display trey, its maximum height was considered so that the standing eye height with the 95th percentile would be equal to the upper surface of the screen. According to this study, the 95th percentile of eye height was obtained for the two age groups of 166 and 173 cm.

These values were subtracted from the monitor mean height of 37.41 cm and 78 cm height for the desk surface for the people (the height of the desk is usually between 75 and 80 cm). The maximum height for the monitor was 50.59 and 57.59, respectively. Height difference for sitting and standing elbow height was 68 cm for both age groups (Figure **5**-Figure **6**-Figure **7**-Figure **8**). The maximum height of the desk converter (adjustable range) for both age groups was 68 cm, considering the values and the fact that the adjustment range obtained from the change in elbow height covers needed amount for the eye..

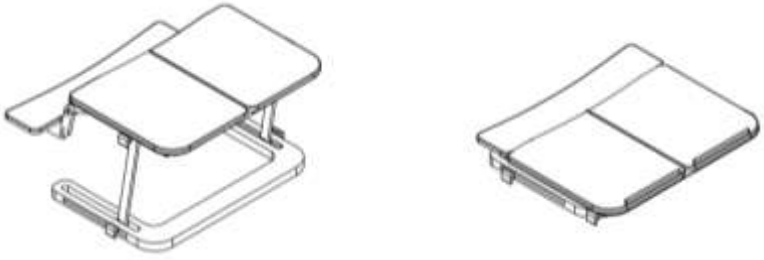
Table 3. List of best-selling keyboards available in the market and their dimensions

Keyboard			
Row	**Model**	**Dimensions** (mm)	**Width** (mm)
1	Microsoft Sculpt Ergonomic	225×534×45	540
2	Beyond Model BK-7100 RGB	432×127×23	432
3	Beyond Model BK-3880	439×125.8×29.5	439
4	Wireless Tesco TKM 7020W	21×137×445	445
5	Green Model GK403 Gaming	30×217×480	480

6	Green Model GK601-RGB Gaming	36×153×455	455
7	Beyond Model BK-7100w	432×127×26	432
8	Green Model GK303	25×185×435	435
9	Tesco TK 8021L with Persian keyboard	42×220×470	470
10	Tesco TK8011	30×180×475	475
11	Tesco TK8020 with Persian keyboard	23×146×447	447
12	XP-Product Model XP-9500B	450×150×30	450
13	Repo Model N1850S with Persian letters	440×150×30	440
14	Wireless PowerMedia Model KBM-6122W	416×140×20	416
15	XP-Product Model XP-8000B	130×400×20	400
16	Green GK401 with Persian letters	27×129×440	440
17	Sadita SKM-1655 with Persian letters	20×140×440	440
18	XP-Product Model XP-8200B	150×420×20	420
19	Sadita Model SK1500 with Persian letters	20×220×480	480
20	Sadita Model SK-1700 with Persian letters	140×440×20	440
21	Tesco Model TK 8026 with Persian letters	26 × 175 × 437	437
22	Telsa Wireless Keyboard & Mouse Model KM1917	25 × 120 × 380	380
23	XP-Product Model XP-8100B	150 x 420 x 20	420
24	Variety Wireless Keyboard & Mouse Model V-KB6114CV	415. 140.16	415
25	Green Model GK402 with Persian letters	20 × 150 × 450	450
26	Logitech cable K120 with Persian letters	23.5 × 155 × 450	450
27	A 4tech keyboard & mouse Model FSTYLER F1010	455 x 153 x 36	455
28	a 4tech Model Q100 Gaming	460 × 170 × 30	460
29	Wireless Keyboard & mouse HAVIT Model KB610GCM	150 x 400 x 10	400
30	Logitech Model G213 Gaming	33 × 218 × 428	425
31	D-Net Model DT-993	30 × 140 × 440	440
32	Microfire Model KB-8158	440 x 160 x 10	440
33	Philips Model SPK8274	450 x 162 x 25	450
34	Beyond Model BK-7100w	432 x 127 x 26	432

Table 4. List of best-selling keyboards available in the market and their dimensions

Name	**Dimensions** (mm)
GPlus model GDM-225JN (22 inches)	286×35×486
X-Vision XT2210H (21.5 inches)	377×503×192
Asus VP2228HE (21.5 inches)	513×373×199
Samsung C24F390 (24 inches)	547×418×206
Asus VC239H (23 inches)	533×383×19.55
BenQ GW2270H (21.5 inches)	505×400×189
LG 24MP68VQ (24 inches)	542×416×187
X-Vision XL2020AI (19.5 inches)	465×360×135
LG Model 20MK400AB (19.5 inches)	181.9×366.5×163.8
Samsung Model C27F591FDM (27 inches)	614×362×142
Mean height	37.41



a **b**

Figure 5. Conceptual design of ergonomic desk converter; a) at minimum height; b) at maximum height

Figure 6. Workstation without using a desk converter

Figure 7. Ergonomic desk converter at minimum height

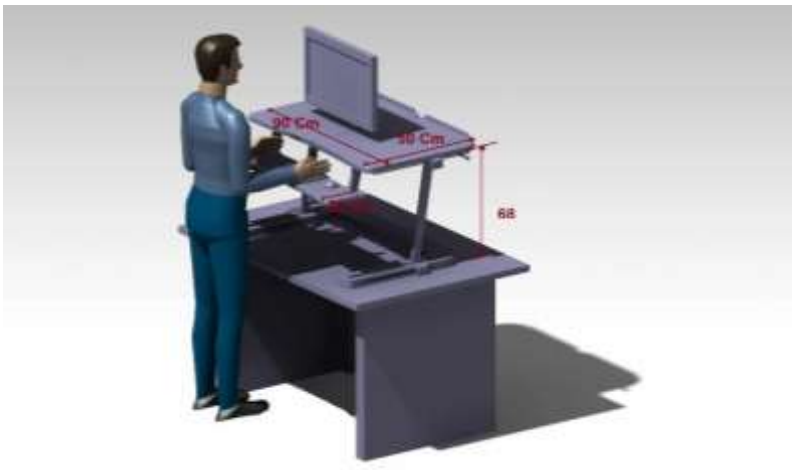


Figure 8. Ergonomic desk converter in user mode

Discussion

According to previous studies, in addition to musculoskeletal problems in the upper and lower back and lower back, prolonged sitting causes many problems. During several attempts to correct the posture, the root cause of the risk factor was observed i.e. the elimination of prolonged sitting. The researchers found that standing and sitting

postures had to be changed alternately during work. This posture change from sitting to standing (and vice versa) significantly reduces musculoskeletal disorders, cancer, diabetes, cardiovascular problems, hemorrhoids, varicose veins, etc. Considering the average sitting rate of administrative staff per day, the problems caused by prolonged sitting, and the lack of an Iranian model of this product, the need for its design was felt. To date, plans have been implemented to improve the problems of desk workers with some strengths and weaknesses; however, the musculoskeletal problems of employees and other office workers have not improved significantly.

Studies in this area are as following:

The American patent "USD719767S" named "Table / Desk" registered in 2014 is a desk converter; however, the problems of using a laptop or computer and the need for height differences between the monitor and the keyboard have not been considered [19]. Another American invention called the "Height Adjustable Desk System And Method" is an adjustable table and not usable for desk users [20]. Another registration by Daniel Flaherty named "Adjustable desktop platform" numbered "US8671853B2" is a height-adjustable desktop. This design is also not considered for users who use computers, and there is no place for the keyboard, and the position of the hand and neck angle during the use of computers and laptops; so it causes musculoskeletal problems [21]. Similar models do not have the key parts of the design, such as being native, the ability to adjust the height and negative slope of the keyboard, monitor rotation, and so on.

Table 5. Comparison of designed model dimensions and different converter models available in the market (dimensions in centimeters)

Model	The designed model in this artic	Model	Model WorkFit-T2	Model WorkFit-T
Maximum heigh	68	48.2	45.5	50.8
Depth	50	59.7	40.2	61
Keyboard depth	20	20.6	23	13.3
Desk width	90	81	78.6	89

In a study by the Centers for Disease Control and Prevention (CDC), Pronk *et al*. performed tests on desk converters and found that converters could lead to a 54% reduction in neck and upper back pain [22]. This study showed the positive effects of desk converters on spirit, energy levels, and feelings of health and comfort using desk converters of Ergotron company. The dimensional differences of the Iranian model designed by this article and some of the company's models have been shown in Table 5 [23].

Conclusion

The design of an indigenous desk converter was performed using the Iranian community in this study. It is predicted that the mentioned problems will be reduced using the converter, in addition to changing the posture of people from a full sitting position (long sitting) to an alternating position between two standing and sitting postures. We suggest that more research be performed on the desk converter in different groups of the human population such as the disabled, children, pregnant women, the elderly, etc., based on anthropometric characteristics.

On the other hand, the production and evaluation of usability and convenience of this product require several studies by researchers.