ISSN (Print) : 0974-6846
ISSN (Online) : 0974-5645
Indian Journal of Science and Technology, *Vol 11(24), DOI: 10.17485/ijst/2018/v11i24/124315, June 2018*

Ergonomics Estimation and Dimensions of ATM Usage in Pakistan

Muhammad Faheem Rana*, Syed Zagham Naseem, Muhammad Shahzad Sarfraz and Umar Shoaib

Faculty of Computing and Information Technology, Hafiz Hayyat Campus, University of Gujrat, Jalalpur Jattan Road, Gujrat, Pakistan;
Fahimrana123@gmail.com, zagham@gmail.com, shahzad.sarfraz@uog.edu.pk, umar.shoaib@uog.edu.pk

Abstract

Objectives: Currently different models with different dimensions of Automated Teller Machine installed in Pakistan. This research finds problems in existing ATM's dimensions and their suitability will be evaluated by applying ergonomics principles on anthropometric measurement of Pakistan population. **Methods/Statistical Analysis:** We measured the different dimensions of ATMs used in Pakistan and anthropometric measurements of Pakistani people. We will consider the neutral and awkward postures of elbow, shoulder, wrist, spine, neck and back. The last step is to compare the ATM machine's dimensions used in Pakistan and anthropometric measurement of people of Pakistan, apply ergonomic rules in order to reduce the gap between ATM users of Pakistan and ATM machines used in Pakistan. **Findings**: By including all dimensions of ATM's, anthropometric measurements, calculating mean and standard deviation we have come to know that there is a huge difference between dimensions of ATM's currently used in Pakistan and dimensions that are recommended in this paper. This difference leads us to make a standard that is suitable especially for people of Pakistan. **Application**: It is strongly recommended to adopt this standard which is based on anthropometric measurements of Pakistani people.

Keywords: Anthropometric Measurement, ATM Dimensions, Ergonomic Principles, Pakistan

1. Introduction

Automated Teller Machine is considered as the new technology in many developing countries. Today, the latest ATM enable the users to deposit and withdraw cash, pay utility bills and transfer money from one account to other instantly[1]. Thus these machines have become an essential part of markets, banks, workplaces and shopping malls[2]. It plays the dual role in society i.e., reducing per transaction cost and increases customer satisfaction and accessibility to banks[3]. The ATM offers many services i.e., deposit cash, withdraw cash, pay bills, transfer funds from one account to another and deposit cheques using smart cards provided by the banks[4]. These machines will be used more and more and it can be made more effective if the user finds this machine more users friendly and easy to use[5]. Banks are showing deep interest in the development of ATMs because effective use of these will reduce the operations load on banks. The main reason is the fact that the cost of transaction using machine is minimal as compared to the transaction done through the bank involving the employees[6]. Although ATM machines have become very popular and play a vital role in all societies in transformation of cash but it's a bitter reality that there are still many issues i.e., interfaces anthropometric dimensions and ambiguity in menus that needs to

*Author for correspondence

be addressed and resolved for better usability. When a user interacts with ATM different parts of the body are also involved and affected such as shoulder, elbow, hand, wrist, back and neck. The human body measurements vary with respect to gender, age and geographical location[7]. The design of ATMs and the dimensions should be developed in a way that it can be used by all potential users regardless of their gender and age. Developed countries have already defined standards for ATM's but developing countries like Pakistan is unable to adopt this kind of standard yet. In this study, we will evaluate the principles of ergonomics with the help of anthropometric measurements of Pakistani population to analyze the existing infrastructure and availability of ATM machines and make recommendations to enable the users to use ATMs more comfortably. This study also highlights that the ATMs users can be increased by reducing their difficulties, and improving the customer satisfaction.

2. Background

In Pakistan, Habib Bank Limited in Karachi installed the first Automated Teller Machine in 1990. There were around 6757 ATM's installed till June 2013. These numbers increased significantly in next year and there were 8240 ATM's installed till June 2014. These number increased continuously and there were 9597 ATM's installed till June 2015[8]. This yearly increment is shown in the graph (Figure 1). Currently there are thirty-five commercial banks working in Pakistan with 11315 online and 622 offline branches[9]. From the last five years (2011-2015), the growth of e-banking transaction has increased to almost double such as 235 million to 470 million. During the financial year 2014-2015, transactions through automated teller machines were 64% of the total e-banking transactions. The ATM machine transactions are rapidly increasing. These jumped from 1.2 trillion to 3.2 trillion by 2015. The rapid growth is shown in the chart (Figure 2) which shows that the transactions using ATM machine are tripled within five years.

Developed countries have good ratio of ATM's with respect to the population, i.e., there are around 290 ATM's for 100,000 people in South Korea, while 173 ATM machines are installed for 100,000 people in United States and 43 ATM's for 100,000 people in Indonesia but developing countries like Pakistan have only 6-7 ATM's for 100,000 people. As we can see, there is a huge difference between ATMs installed in developed countries and developing countries. According to State Bank of Pakistan, banks will increase the ratio of ATMs around

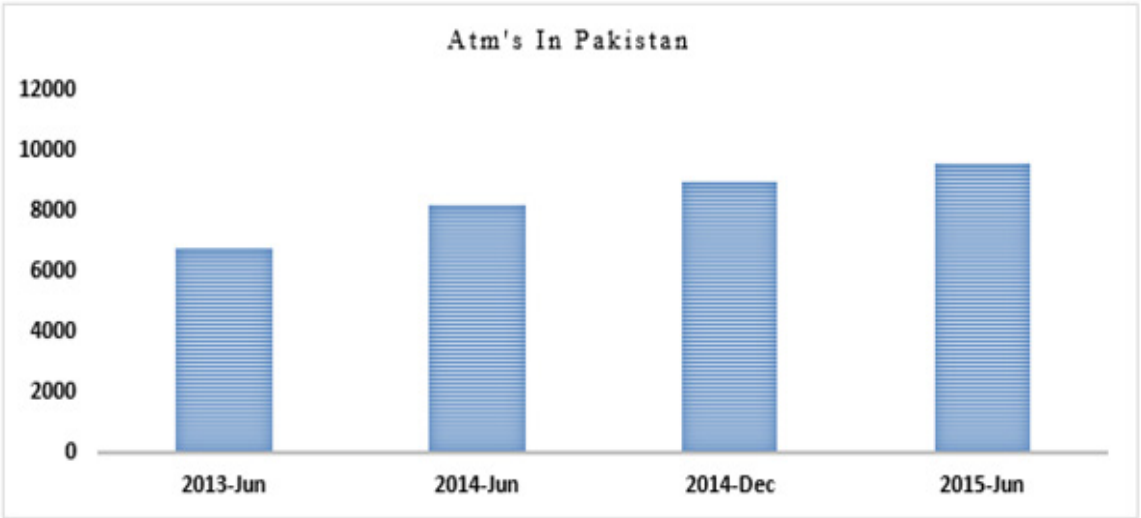

Figure 1. ATM's in Pakistan.

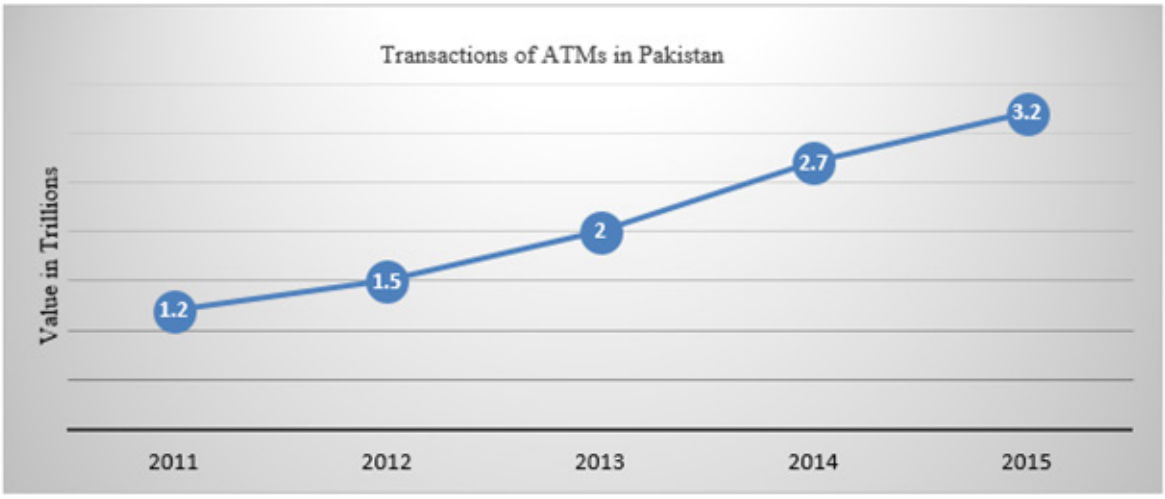

Figure 2. Transactions through ATM's in Pakistan.

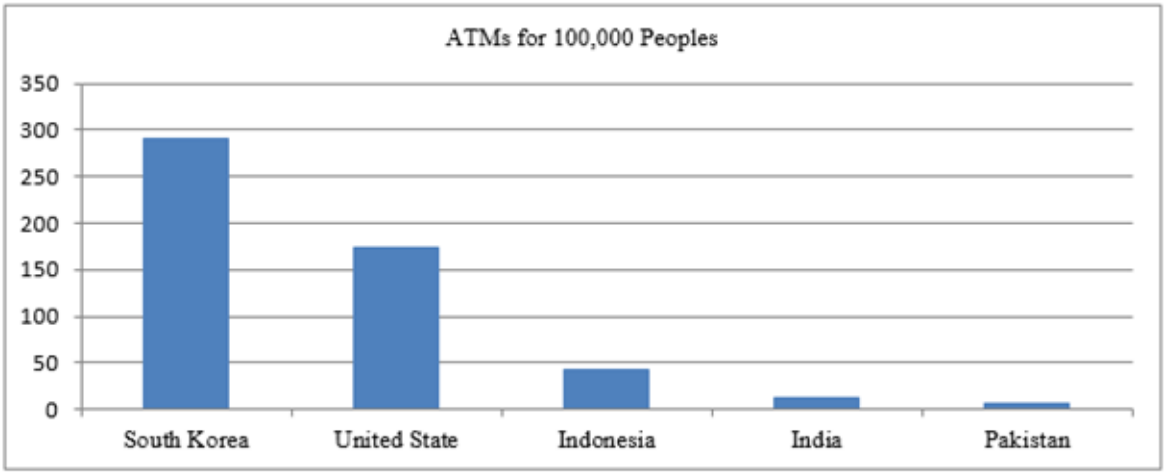

Figure 3. ATM's available in different countries for 100,000 peoples.

8-10 ATMs for 100,000 people till 2018 in order to facilitate ATMs users of Pakistan. The graph (Figure 3) shows the comparison of ATM machines available per hundred thousand people in different countries.

3. Ergonomics

Ergonomics is a science, which is used to design physical environment according to the capabilities of user in order to perform tasks easily. It is also used to reduce the gap between user and environment[10]. The word Ergonomics is derived from Greek words ergon and norms, which means rules of work[11]. Rules and regulations are being adopted in ergonomics so that any job performed by user can be done with comfort and ease. The strategy of Ergonomics keeps users safe from injuries and pain as well as increase the quality of service and enhances the user satisfaction[12,13]. The development in ergonomics is designed with the help of anthropometric measurement i.e., size, shape, weight, physical dynamics and limitation.

Posture is very important, a good posture prevent you to carry extra weight on your neck and spine[14]. If a user sustains an awkward posture for some specific amount of time, it will cause some injury in your neck and spine. According to Organizational Health Unit[15,16], every single inch head moves forward enables more pressure on spine starting from 4.5 kg to 19.8 kg. OSHA said in[17]; work space should be design in a way which will suitable for workers instead of forcefully fit the user in work space. Author in[18] said, it is a branch of science that emphasizes to obtain optimal relationship between humans and systems joints have maximum force and control in natural form therefore reduce the chances of injury. Muscles are supposed to be in neutral posture when they are in resting length as well as joints are naturally aligned[19]. The dimensions of people's body vary with gender, bone structure, length and age. It is a fact that if we consider the same group of people the variations in their bodies are very prominent. If the interface is poorly designed then it will affect the mental system, cardio vascular system and muscular system[20].

The comparison between male heights of different countries, Netherlands stands on top ranking with 6ft or 72-inch average male height where Indonesia stands on last rank with 5.2ft or 62 inches average male height. Average height of Pakistani males is near to 5.7 ft or 67 inches.The comparison of female heights between different countries, Netherlands again stands on first rank with average female height of 5.7 ft or 67 inch, where Bolivian females stood on last in female ranking.

Pakistan stands on 66th position in word ranking of height. The average height of male is 1670mm/65.75 inch[21], and the average height of female is 1587mm/62.48 inch[22], therefore the average height of Pakistani male and female is 1627mm/64.1 inch. If ATM's in Pakistan are designed according to ergonomic standards, it will encourage good posture and minimize injury.

4. Methodology

ATMs standards have already been built in developed countries. The first standard for ATMs was developed by Australia using ergonomics and anthropometric size of their population, later on Khalid Al-Saleh made a standard for ATMs used in Saudi Arabia which is pretty similar to Australians standard but with different ergonomics and anthropometric measurements[23]. One standard is not suitable for different countries because each nation has different anthropometric measurement.

In this research, we are going to design a standard for ATMs used in Pakistan which will be based on anthropometric measurements of people of Pakistan. First of all we measured the different dimensions of ATMs used in Pakistan i.e., Door handle of work space, temperature of work space, height of card slot, screen, key board and the height of receipt printer. After getting the measurements of these dimensions, we will compare these dimensions with anthropometric measurements i.e., average height of male and female, average height of elbow and the average level of eye. We will consider the neutral and awkward postures of elbow, shoulder, wrist, spine, neck and back. The last step was to compare the ATM machine's dimensions used in Pakistan and anthropometric measurement of people of Pakistan, apply ergonomic rules in order to reduce the gap between ATM users of Pakistan and ATM machines used in Pakistan.

4.1 Door Handle

In order to interact with an ATM, we first need to open the door of work space where the machine is actually installed. Height of the door handle does really matters. It helps the users to sustain a good posture to avoid injury. If the height of door handle is too high it may affect the muscles of elbow, shoulder and neck. Users also need to put extra effort to open the door of workspace. On the other hand, if the height of door handle is too low, it may affect the muscles of elbow, shoulder, neck and back. Extra efforts will also be required to open the door with an awkward posture. So, it is very important that door handle should be placed on average height which is neither too high nor too low for the users. According to the ergonomic principles the height of door handle should be near to elbow height of person with zero to hundred mille meter upper variation.

4.2 Work Space Temperature

Temperature of the work space is also very crucial and importance. Sudden change in temperature such as from extreme hot to cold or from extreme cold to hot may harm human health and effect the muscles seriously. Normally the temperature of body is 37^0 C or 98.6 F. Pakistan is a country where temperature raises up to 50^0 C or 122 F in summer and falls to freezing point in winter. The temperature of ATMs work space is very important, especially in summer because sudden change in temperature may cause the muscular problems.

4.3 Card Window Height

The first step after entering the workspace area of ATMs is to insert the card in card window/slot. The position and height of card slot is very important. It must be visible to user clearly in order to insert card. The height of card slot window also matters as if slot is located too high or too low it will frustrate user and may affect shoulder, neck, and back. Ergonomic rule identifies that the height of card slot should be near to elbow height of person with zero to hundred mm/ten cm upper variation.

4.4 Screen Height

The dimensions of display screen are also very important. Good position of screen will not only be easier to see but it also enhances the usability and accessibility of the system and people will be more attracted towards the machines. If position of screen is too high, user may feel difficulty to see the whole screen. If screen is difficult to see, it will also be difficult to operate and may have a deep impact on user neck and spinal cord. On the other hand, if screen is fixed too low it may affect knees, neck, spinal cord and shoulder. The ideal height of screen is three hundred mm/ thirty cm below the eye height of people.

4.5 Keyboard Height

Keyboard is probably the most important thing to interact with for the ATMs. The first step after the insertion of ATM card into card slot is to select native language and enter PIN (Personal Identification Number) in order to authenticate the credentials of the user. After that, user selects his required amount to be withdrawn with the help of keyboard. So the height of keyboard is another important factor while interacting with ATMs. If the height of keyboard is greater or lesser than the actual anthropometric measurements of fifty percent population of the county, it will cause frustration, difficulty to use, may affect wrist, neck, backbone and shoulder. The recommended height of keyboard may be the actual elbow height with zeros to hundred mm/ten cm upward variation.

4.6 Cash Dispenser Height

ATMs are used for many purposes i.e. user may able to withdrawal cash, pay utility bills, transfer funds, deposit cash. Most of the time ATMs are used to withdrawal cash, so the position of cash dispenser is very important to provide ease to the user. The slot of cash dispenser is comparatively wider than card slot and receipt slot. Due to that reason its height and position have a deep impact. The height of cash dispenser should be approximately fifty mm / five cm greater than the actual height of elbow.

4.7 Receipt Printer Height

ATMs are not used only for withdrawal of cash but it also intimate user about the remaining balance of the account.

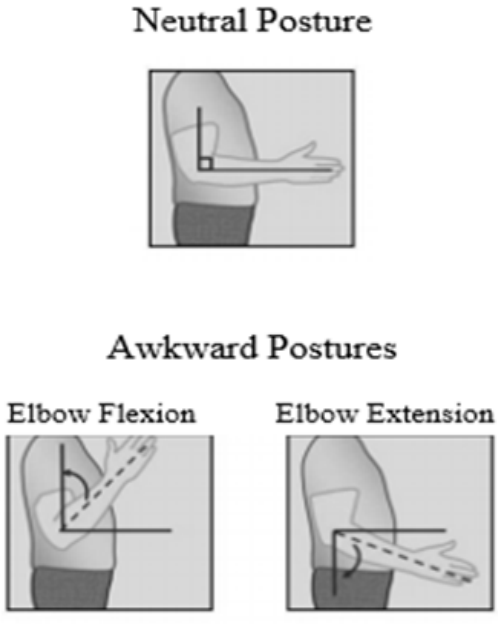

Figure 4. Neutral and awkward postures of elbow[25].

Therefore, the height of receipt printer is also very important. The height of receipt printer should be approximately fifty mm/five cm greater than the actual height of elbow. We can say that the height of cash dispenser and receipt printer should be approximately same in order to provide better services to the customers.

Figure 4 shows the neutral and awkward postures of elbow[24]. Elbow should be in neutral posture if it maintains the right angle with shoulder; on the other hand, there are two types of awkward posture such as elbow flexion and elbow extension. The elbow flexion is an awkward posture in which angle of elbow with shoulder is less then ninety degrees. Elbow extension is an awkward posture in which angle of elbow with shoulder is greater than ninety degrees (right angle).

Figure 5 shows the neutral and awkward postures of shoulder, if the angle between shoulder and elbow is equal to ninety degrees (right angle) the shoulder become in neutral posture. But if the angle of shoulder is not straight with elbow then shoulder is either in flexion or extension mode.

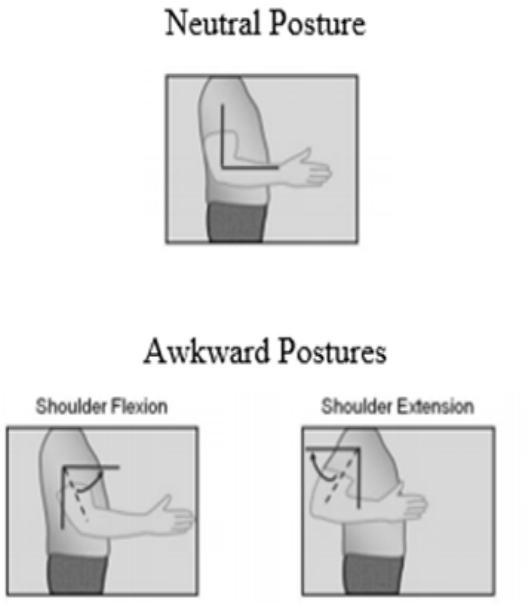

Figure 5. Neutral and awkward postures of shoulder[24].

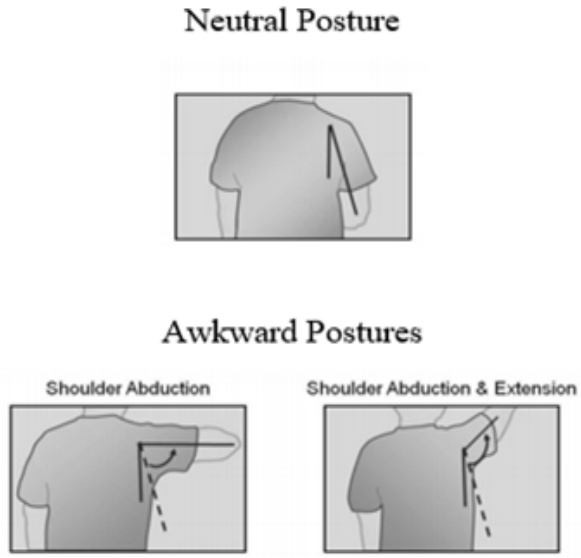

Figure 6. Neutral and awkward postures of shoulder[24].

Figure 6 shows a different angle of shoulder, in this angle shoulder becomes in neutral posture if angle between shoulder and elbow is quite low. As angle of shoulder increases with elbow it will become in awkward

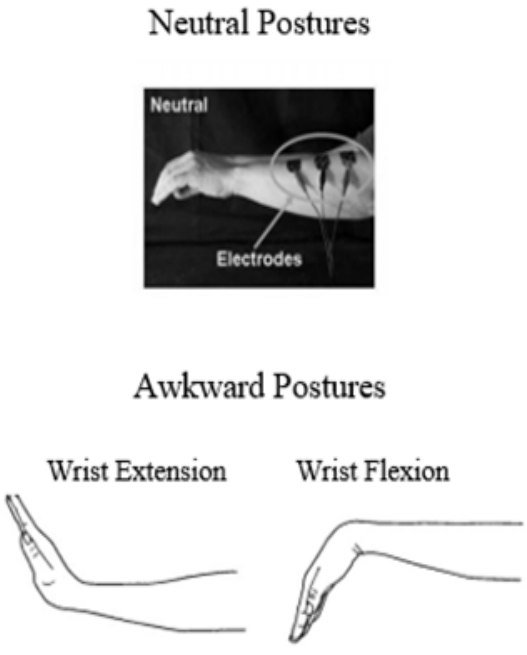

Figure 7. Neutral and awkward postures of wrist[24].

posture called shoulder abduction and if angle increases at maximum it is called shoulder abduction and extension.

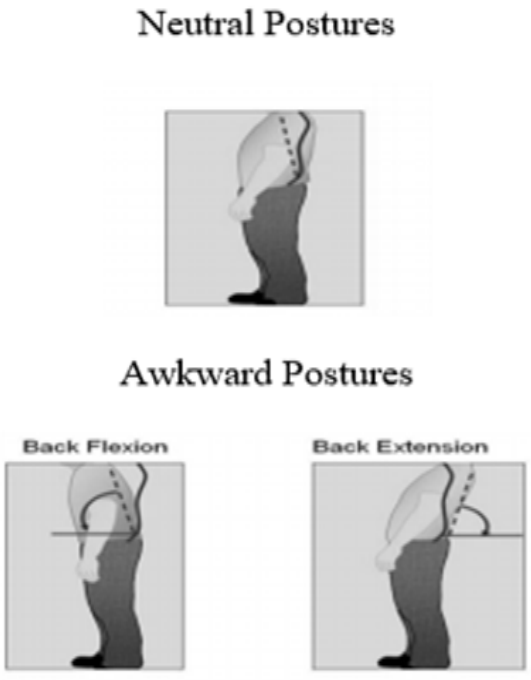

Figure 8. Neutral and awkward postures of back[24].

Figure 7 shows the neutral and awkward posture of wrist, if wrist and hand is in same position we say wrist is in neutral posture. If wrist and hand are not in same position it is called an awkward posture, there are two awkward postures called wrist extension and wrist flexion. In wrist extension the position of hand is upward where as in wrist flexion the position of hand is downward.

Figurer 8 shows the neutral and awkward standing posture, fine posture is very important in order to avoid neck and spine injury, awkward posture put extra weight on spine and neck that may cause injury. The neutral posture of standing is to stand straight so that your spine may able to carry your weight easily. There are two types of awkward postures of standing called back flexion and back extension. In back flexion the angle of neck with back decreases which carry extra weight to spine whereas the in back extension the angle between neck and back increases which also put extra weight to spine.

Figure 9 shows the neutral and awkward posture of back[25]. It is very important to stand in good posture in order to avoid back from injury. Back flexion or extension put extra wait on spinal cord which will cause injury. Spine only carry twelve pounds if the head and back are

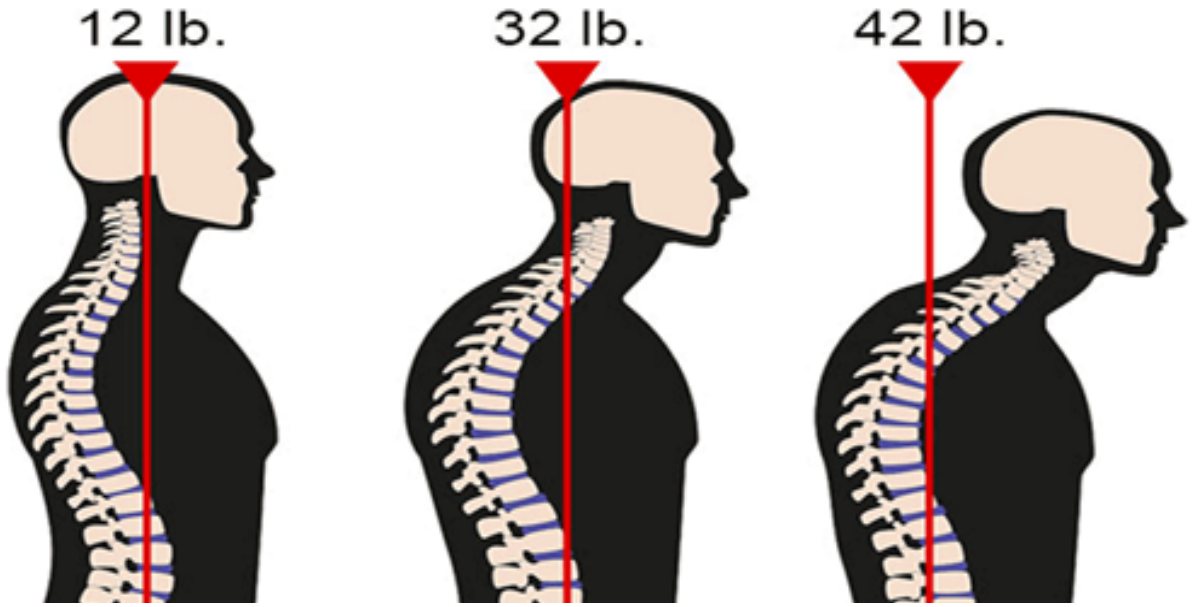

Figure 9. Fine Posture prevents spine and neck to carry extra weight[25].

in same position or we can say in same angle, if a person moves his head one inch to forward the results are unbelievable, he have to carry 32 lb of weight instead of 12 lb. If a person moves head 2 inch forward he has to carry 42 lb.

5. Results and Discussion

Currently there are different machines used in Pakistan i.e., Diebold series and NCR series. Due to privacy issues, we are unable to mention the names of machines therefore used random codes for ATMs from 1 to 5. As the anthropometric measurement of Pakistani people varies from other countries therefore we are unable to apply the same standard.

Table 1 shows the actual dimensions of ATMs used in Pakistan; from these measurements we are able to say that there is a huge difference between the dimensions of ATMs used in Pakistan. The maximum difference between different dimensions are the height of door handle is 1321-991= 330mm/33cm, Height of card slot 1219-1047 =172mm/17.2cm, Height of Screen 1346-1193 = 153mm/15.3cm, Height of keyboard 1190-840 = 350mm/35cm, Height of Cash Dispenser 1037-890 = 147mm/14.7cm, Height of Receipt Printer 1331-900 = 431mm/43.1cm, Temperature of work space 26-21 = 05^0C. After adding all the dimensions of five ATMs we calculate the mean and standard deviation of these dimensions. The massive difference between ATM dimensions used in Pakistan leads us to make a standard that is suitable especially for people of Pakistan. Recommended dimensions for ATMs used in Pakistan are given in Table 2, we have added the anthropometric measurement of Pakistani people, and average measurements of ATMs used in Pakistan and recommended measurement of ATMs by considering anthropometric measurement of Pakistani people.

Table 1. Automated teller machines dimensions used in Pakistan (mm)

Dimensions of ATM	Machine 1	Machine 2	Machine 3	Machine 4	Machine 5	Mean	SD
Door Handle(work space)	991	1270	1321	1092	1193	1173	1334
Card slot height	1219	1047	1120	1200	1099	1137	72
Screen Height	1346	1227	1300	1193	1270	1267	60
Keyboard Height	927	984	1190	1020	840	992	130
Cash Dispenser height	965	1037	1000	922	890	963	59
Receipt Printer Height	1331	900	1047	1121	1200	1119	162
Temperature(work space)	26	24	22	25	21	24	2

Table 2. Automated teller machines recommended dimensions for Pakistan

Dimensions of ATM	**Anthropometric**			**Average**			**Recommended**		
Units	mm's/ K^0	cm's/ F^0	inch's/ C^0	mm's/ K^0	cm's/ F^0	inch's/ C^0	mm's/ K^0	cm's/ F^0	inch's/ C^0
Door Handle (work space)	990	99	38.98	1173	117.3	56.18	1070	1070	42.12
Card slot height	990	99	38.98	1137	113.7	44.76	1060	106	41.73
Screen Height	1510	151	59.45	1267	126.7	49.88	1430	143	56.30
Keyboard Height	990	99	38.98	992	99.2	39.05	1020	102	40.15
Cash Dispenser height	990	99	38.98	963	96.3	37.91	1030	103	40.55
Receipt Printer Height	990	99	38.98	1119	111.9	44.05	1030	103	40.55
Temperature (work space)	300.2	80.6	27° C	297.2	75.2	24 ° C	303.2	86	30° C

Table 2 shows these measurements in millemitres, centimetres and inches. The main purpose of using three units is to achieve more accuracy as mille meter is more accurate and precise whereas the centimetre and inches are mostly understandable to average persons. We can see that the average dimension of door handle of work space is 1173 mm, but anthropometric measurement of people living in Pakistan is 990 mm, the handle of the door should be equal to the elbow height of person with 100mm upward variation, so the recommended dimension in this case is 1070 mm. Height of card window/ slot average is 1137 mm, but anthropometric measurement of this region 900 mm, the recommended card slot height is 1060 mm. The height of screen is one of the most important factors of ATM, the average height is 1267 mm whereas the anthropometric dimension of screen height is 1510 mm, therefore recommend screen height is 1430 mm. Keyboard height is also very crucial, the average height of keyboard is 992 mm, whereas the anthropometric dimension of keyboard height is 990mm/ and recommend dimension is 1020 mm.

The average height of cash dispenser we have recorded here is 963 mm whereas the anthropometric measurement of elbow is 990 mm therefore recommended dimension that we suggest here is 1030 mm as discussed earlier height of cash dispenser should near to elbow height with zero to hundred mille meter upper variation. Height of receipt printer, the average dimension 1119 mm, anthropometric measurement 990 mm, and recommended dimension 1030 mm[26]. Temperature is very crucial and can effect on muscles if changed suddenly, the average temperature of working space of ATMs is 24° C, we recommended the temperature of workspace should be equal to 30° C, if a person travel in a hot sunny day by facing temperature

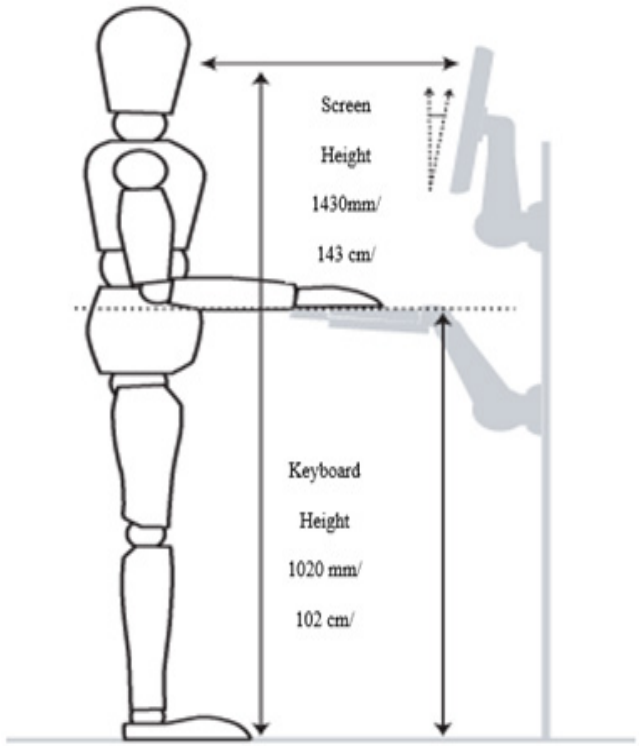

Figure 10. Recommended dimensions[26].

of around 50° C and suddenly enters an ATM work space area where temperature is around 22–24° C may seriously affect muscles. Recommended dimensions are given in Figure 10.

6. Conclusions

Our findings clearly show that there is a huge variation or mismatch between dimensions that are currently used ATMs in Pakistan and dimensions, which are recommended in this research. Based on these results i.e. Door Height of work space 1070mm, Temperature 30°C, Card window height 1060 mm, Screen height 1430 mm, keyboard height 1020 mm, Cash dispenser height 1030 mm, Receipt printer height 1030 mm. We strongly recommend adopting this standard that is based on anthropometric measurements of Pakistani peoples. This research did not cover people with disabilities, i.e., visual impairment, colour blindness and people having hearing disability.

7. References

1. Nuthan K, Nagarathna B, Nayaka S, Rathna V. An automated teller machine: literature review. International Journal of Novel Research in Computer Science and Software Engineering. 2015; 2(1):43–5.
2. Meena R. Automated Teller Machine its benefits and challenges. International Journal of Commerce, Business and Management. 2015; 4(6):1–7.
3. Zhang M, Wang F, Deng H, Yin J. A survey on human computer interaction technology for ATM. International Journal of Intelligent Engineering and Systems. 2013; 6(1):20–9. Crossref.
4. Naseem Z, Saleem Y, Zagham S, Muhammad A, Shafiq M, Saleem M. Analysis of different ATM interfaces in Pakistan to minimize cognitive burden for interaction. Pakistan Journal of Science. 2013; 65(1):73–81.
5. Thatcher A, Shaik F, Zimmerman C. Attitudes of semi-literate and literate bank account holders to the use of Automatic Teller Machines. International Journal of Industrial Ergonomics. 2005; 35(2):115–30. Crossref.
6. Al-Saleh K, Bendak S. An ergonomics evaluation of certain ATM dimensions. International Journal of Occupational Safety and Ergonomics: JOSE. 2013; 19(3):347–53. Crossref. PMid:24034878
7. Pheasant S, Christine MH. Body space: Anthropometry, ergonomics and the design of work. 3rd ed. London, UK: Taylor & Francis; 2005. p. 1–352.
8. Banks offer only seven ATMs for 100,000 adults in Pakistan. Available from: https://www.pakistantoday.com.pk/2014/11/29/banks-offer-only-seven-atms-for-100000-adults-in-pakistan/
9. Statistical look at payment system and retail banking of Pakistan for 2014-15. Available from: https://propakistani.pk/2015/09/07/statistical-look-at-payment-system-and-retail-banking-of-pakistan-for-2014-15/
10. Nina M, Mohammad S. Factors of workplace environment that affect employee's performance: A case study of Miyazu Malaysia. International Journal of Independent Research and Studies. 2013; 2(2):66–78.
11. Te-Hsin P, Kleiner B. New developments concerning the occupational safety and health act. Journal of Managerial Law. 2001; 43(1/2):138–46. Crossref.
12. Valinejad M, Shakiba A, Rasoulijavaheri A. Ergonomics principles and utilizing it as a remedy for probable work related injuries in construction projects. International

Journal of Advances in Engineering and Technology. 2013; 6(1):232–45.
13. Ajala E. The influence of workplace environment on workers' welfare, performance and productivity. The African Symposium: An Online Journal of the African Educational Research Network. 2012; 12(1):141–9.
14. Robertson M, Huang Y, Larson N. The relationship among computer work, environmental design, and musculoskeletal and visual discomfort: Examining the moderating role of supervisory relations and co-worker support. International Archives of Occupational and Environment Health. 2015; 89(7):22–67.
15. Office ergonomics guideline. Queensland: Department of Education Training and Employment; 2013. p. 1–15.
16. Britain G. Ergonomics and human factors at work: A brief guide. UK: Health and Safety Executive; 2014. p. 1–10.
17. Ergonomics: The study of work. U.S. Department of Labour Occupational Safety and Health Administration (OSHA 3125); 2000. p. 1–14.
18. Smith T. Occupational ergonomics: Principles and applications, (Manufacturing Systems Engineering Series); 1997. p. 1–452. PMCid:PMC2125555
19. Hameed A, Amjad S. Impact of office design on employees' productivity: A case study of banking organizations of Abbottabad, Pakistan. Journal of Public Affairs, Administration and Management. 2009; 3(1):1–13.
20. Nunes IL. FAST ERGO_X - A tool for ergonomic auditing and work-related musculoskeletal disorders prevention. Work. 2009; 34(2):133–48. PMid:20037227
21. Average height for men by country. Available from: http://www.averageheight.co/average-male-height-by-country
22. Average female height by country. Available from: www.averageheight.co/average-female-height-by-country
23. Choi SD. Safety and ergonomic considerations for an aging workforce in the US construction industry. Work. 2009; 33(1):307–15.
24. Moore S, Janet K, Lisa S. Practical demonstrations of ergonomic principles. Report of Investigations 9684. Department of Health and Human Services; 2011. p. 1–66.
25. The forward head posture fix listed on its website about muscle that FIXES ugly forward head posture. Trouble Sleeping, Text Neck and Back Pain. Available from: http://forwardheadposturefix.com
26. Workspace planner, find the right position for workstation components. Available from: http://www.chairlines.com/ergonomics-tips-tricks/ergotrons-workplace-planner/