

Ergonomics Analysis for Angiography Arm Board Design

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Abstract

Ergonomics is a process of arranging products, process and systems of the design to fit the people involved with them. For this project, the ergonomics is focusing on shoulder abduction movement for the angiography arm board design. Angiography arm board is an arm resting for peripheral angiogram patients. The shoulder abduction is one of the most crucial ergonomic aspects during the angiography procedure. The aim is to prove the ergonomics standard guide and gaining the best posture for the angiography arm board user. In this project, the arm board design and human model are used in Kinovea software. This software is commonly used for workplace and athlete ergonomics analysis. Besides that, ergonomic standard for shoulder abduction are used as a guide which is concise in a 3 zone from safe to dangerous; 0o to 13o (Green zone), 14o to 37o (Yellow zone) and 38o to 67o (Red zone). The result shows that ergonomic aspect is important for the patient because the angiography procedure can take up to an hour or more. Because of that, neglecting the ergonomic aspect may lead to injuries to the joint or Musculoskeletal Disorders (MSDs). From the simulation, the minimum and maximum angle are 17o and 47o respectively. The arm board maximum angle reaches the danger zone, but can be prevented with adjustment and proper placement. For human analysis, a marking at shoulder and hand part is placed to ease the software detect the movement. The human model analysis is to prove the ergonomics standard. The human analysis is proven with shoulder dislocation in minor changes of 2.65 mm in the green zone. The result gained for yellow zone is 5.03 mm difference from initial which is safe but may lead to discomfort and 12.96 mm difference from initial is gained with red zone.

Keywords: Ergonomics; Angiography Arm Board; Human model; Abduction movement.

1. Introduction

This Ergonomics is a combination of the Greek words of 'Ergon' and 'Nomos' which means work and law. It brings the meaning of consideration of laws into the work when used together. Participatory ergonomics means actively involving workers in developing and implementing workplace changes which will improve productivity and reduce risks to safety and health [1]. It starts to implement in the United States of America (USA) during World War II, when a design of new systems needs a consideration of the people who would be using them [2]. Then, the USA starts the 'Safety First' movement in early 20th century with knowledge development in the sphere of safety, managing, with cost reduction and production efficiency as the key drivers [3]. This causing awareness of the people's physical requirement resulted in discipline of ergonomics. Since then, ergonomics has become important throughout many courses including the sciences. The use of ergonomics concepts and principles started in Malaysia several decades ago and began to increase its popularity when Malaysia becomes one of the new Industrially Developing Countries (IDCs) [4].

Ignoring the guide of ergonomics can cause Musculoskeletal Disorders (MSDs) which are injuries or pain in the human musculoskeletal system, including the joints, ligaments, muscles, nerves, tendons, and structures that support limbs, neck and back.

Safety and ergonomics are both human factors sciences. Both play an important role in the success of a design or task. They can work synergistically to enhance each other, improving safety and

productivity and reducing employer costs [5]. Malaysian Social Security Organization (SOCSO) reported an increase of MSDs with 77 cases in 2008 and plumped to 708 cases in 2015. The changes each year are about 12.6% to 90% increased. The increase also caused by the development of local industries [6].

There are many crucial factors before creating the new design. The factor includes the information about the tools, machines, tasks, processes and human factors/ergonomics (HFE). Maintainability design is a major concern in the product design process. These factors can ensure the service, dependability, reduce the life cycle cost of the product, and improve comfort during maintenance. HFE considered in maintainability design, but most designers have difficulties in incorporating ergonomics information about human operators into their designs [7]. There are many information regarding ergonomics for designers to use, but no proper information for the angiography arm board. Ergonomics plays important part to ensure comfort and prevent unnecessary injury, such as MSDs or over-pressure posture. The new design for the angiography arm board needs to be suitable for every type of angiography patient and easy to use by medical personnel. Other than that, the material of the design has to be light, durable and can allow x-ray vision through.

The design has to be in spaces where it won't block the operators. Therefore, the designers have to take measure of the distance between Doctors operation and angiography arm board parts to avoid any collision or blocking. The distance also important, it doesn't get in a way of angiography equipment.

The tools used to analyze and test the ergonomics of the angiography patients are goniometer, Kinovia software and video recorder. The goniometer can be used to measure the angle of an object in precise angular position. Other alternatives are to use iPhone application that can calibrate and measure the movement by strap-ping phone on the upper arms. However, goniometer will be more reliable. The movement then will be recorded using video recorded and uploaded to Kinovia software for analysis. The results of the patient's analysis also will be compared to the standard value of ergonomics guide. For this project, we will focus on analyzing the ergonomics for shoulder abduction. The guide also prepared the specific angle of the movement.

2. Material and Method

2.1. Angiography Arm Board Design

The angiography arm board as shown in Fig. 1 below will be analyze using the Kinovea software and proven its ergonomics quality. It needs to be adjusted at substantially horizontal and planar support on which the arm is stabilized.

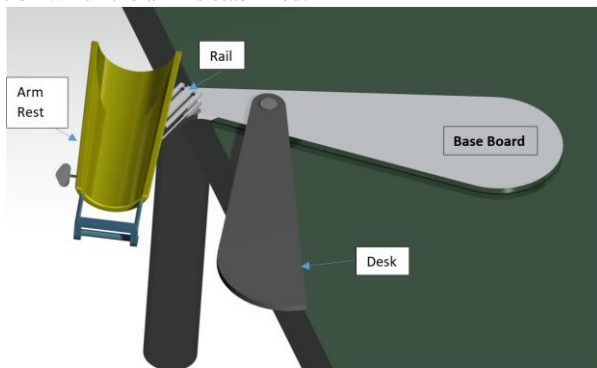


Fig. 1: The angiogram arm board design.

2.2. Kinovea Software

The ergonomic analysis uses Kinovea Software for Windows operating system. This software is free and open for everyone. It is commonly used for athletes and designed to prevent any muscle injuries. Posture pattern can be easily identified with the software as shown in Fig. 2. The process for analysis requires a model to recreate the movement of the shoulder abduction. The model's moving components will be marked with bright sticker to easy observation using high definition cameras. A tripod is used to prevent any error for analysis. After that, the recorded sample is uploaded to Kinovea software. The software prepares the necessary tools to read the angle of the arm and to identify the differences of movement. It also have coloring options to differentiate the element of the analysis. Besides that, there is an editing option to trim away unnecessary footage and speed control for the recording.

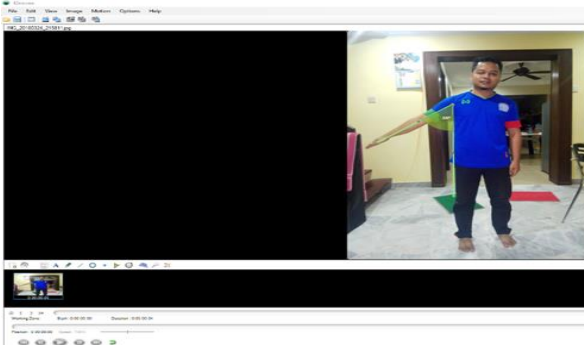


Fig. 2: Kinovea software analysis sample.

2.3. Standard Ergonomics Peripheral Movement

There are studies of human movement limits on every part of moving parts that are compiled into single book. The arm move-

ment is specifically prepared by Center for Ergonomics University of Michigan in effort to help Ford Motor Company and United Auto Workers (UAW) in 1980 [8]. The standard angle of the movement is used as a guide for this study. The purpose of the movement limitations is to pre-vent any unnecessary risk of injuries. The factors affecting repeti-tive tasks include user's muscle strength, amount of force required, and type of task [8].

The movement for this study is shoulder abduction and shoulder extension as shown in the Fig. 3 below. This guidance applies to the concept generation of the design. The colored zone green, yellow and red for every joint motion represent from least risk for danger as shown in Fig. 3 and Table 1 below. The Green and yellow zone are safe in most cases. Red and Gray (Beyond red) need to be avoided. If the motion is in the red and gray at repetitive times, the person will be exposed to the risk of musculoskeletal disorders (MSDs) [8].

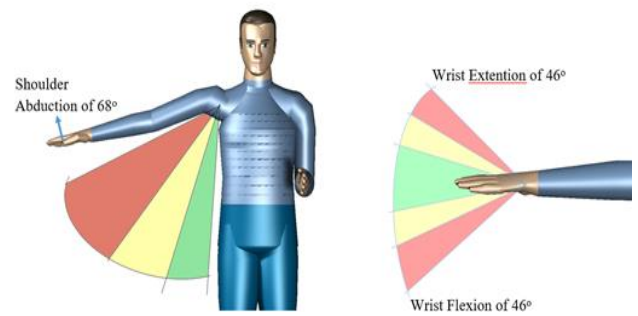


Fig. 3: The standard ergonomics guide.

Table 1: Zone of the Ergonomics range.

Color	Zone
Green	0
Yellow	1
Red	2
Beyond Red	3

2.4. Human Model

There are studies of human movement limits on every part of moving parts that are compiled into single book. The arm movement is specifically prepared by Center for Ergonomics, University of Michigan. The standard angle of the movement is used as a guide for this study. The purpose of the movement limitations is to prevent any unnecessary risk of injuries. The factors affecting repetitive tasks include user's muscle strength, amount of force required, and type of task [8]. The process of calibrating the human model



Fig. 4: The calibration process of the analysis.

2.5. Recording Device

The recording device used is a latest version smartphone with high quality camera that is capable to capture and record the detail of the model from Fig. 4 above. A tripod is used to help with stabilization and prevent any shaking as shown in Fig. 5 below. After recording, the footage is uploaded to the computer to test with Kinovea software.



Fig. 5: Smartphone setup.

3. Results and Discussion

The minimum angle of the arm board design is estimated 17° . The estimation is based on the point of the shoulder and the angle where the arm rest (Yellow design) does not block the table (gray) as shown in Fig. 6. This shows the design is in the yellow zone as shown in Fig. 3. The zone is safe and within recommended limits from ergonomics standard. 1.

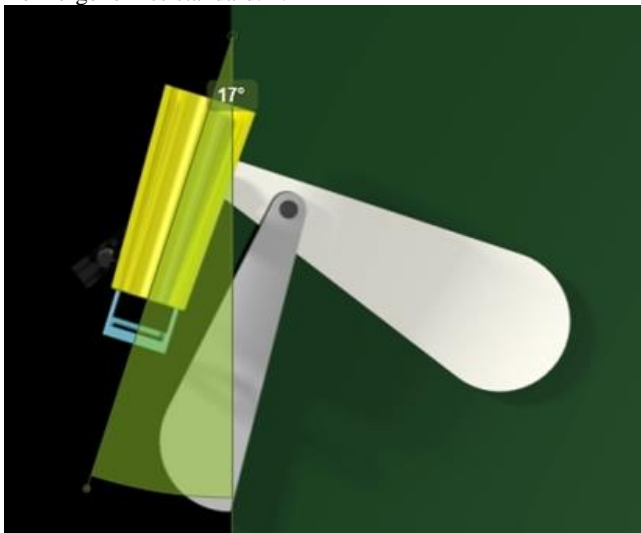


Fig. 6: Minimum angle of the angiography arm board design

Fig. 7 shows the maximum angle estimation. The angle reached 47° which is more than recommended angle from Fig. 3. This is to show the design range capabilities.

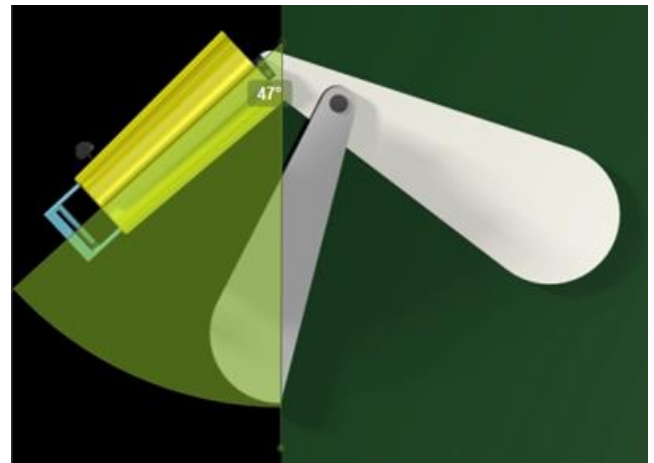


Fig. 7: Maximum angle of the angiography arm board.

Based on the result shown in Fig. 8 and 9, the colouring marking is used. The blue colour is the initial spot and the green colour is the first movement. The movement is 13° away from the body. The result gained is 10 px from initial. It is about 2.65 mm shoulder movement when converted. The error margin is very small proving that proving the ergonomics standard.

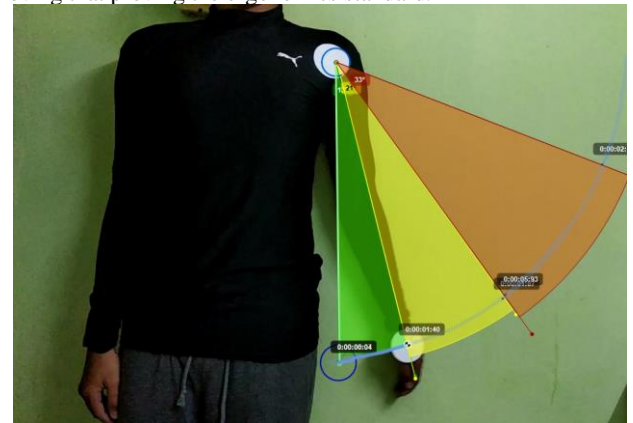


Fig. 8: Maximum angle of the angiography arm board.

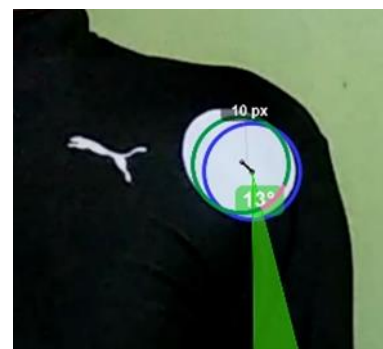


Fig. 9: Result for 13o shoulder abduction.

Fig. 10 shows the result of 34° shoulder abduction. The result gained is 5.03 mm (19 px) difference from the initial. Almost twice from the green zone. This is considered as beware zone. The zone is still safe, but it is not recommended because it is near to the danger zone. The longevity in this position may result in discomfort.

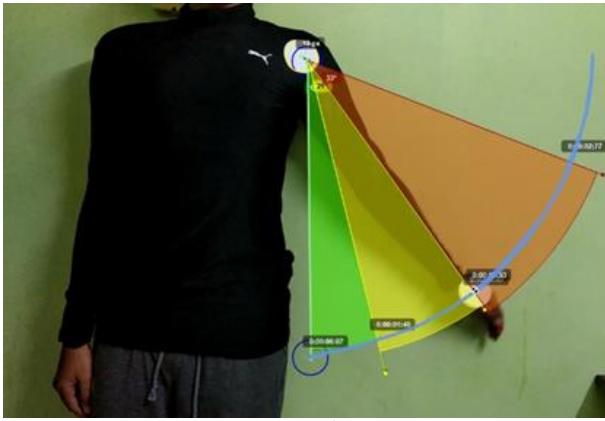


Fig. 10: Movement for 34° shoulder abduction

From Fig. 11, the movement is 67° away from the body. The results are almost 2.5 times as the safe zone from 34° angle. The difference from the initial is 12.96 mm. This is a danger zone where longevity could result in MSDs. This zone is dangerous for the angiography patients.

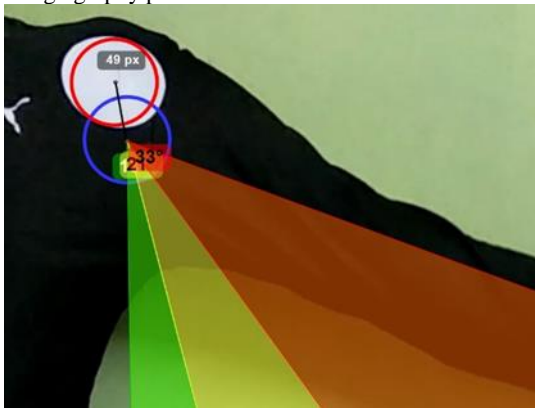


Fig. 11: Movement for 34° shoulder abduction

4. Conclusion

In conclusion, this project was developed in order to improve the angiography arm board design. All the objectives stated are achieved successfully. The first objective is to prove the standard of the ergonomics value. The standard are proved through analysis which have been done for shoulder abduction. Then, the second objective is to gain a good posture for angiography arm board design. From here, the angle range is chosen for the application of the angiography arm board design.

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References

- [1] B-L. Robin, "Participatory Ergonomics: Evidence and Implementation Lessons", *Applied Ergonomics* (2018).
- [2] S. Gavriel, "Handbook of Human Factors and Ergonomics", John Wiley & Sons, Inc., 4th Edition (2012).
- [3] Georgios, "Center for Risk and Safety in the Environment (CE-RISE)", European University Cyprus (2017).
- [4] H. S. Loo and R. Stanley, "Ergonomics Issues in Malaysia", Science Publications (2012).

- [5] O. R. Abdul, "Investigation of Work-Related Musculoskeletal Disorders in Malaysian Metal Stamp-ing Industry Using RULA Method", 8th Confer-ence & Exhibition on Occupational Safety and Health (COSH) (2005).
- [6] Md. Z. Raemy and M. R. Jafri, "Financial Impact and Causes of Chronic MSD Cases in Malaysia Based on SOCSO Claims Record", *Advances in Intelligent Systems and Computing* (2018).
- [7] Z. Dong, C. Jiayu and Lv. Chuan, "A method for integrating ergonomics analysis into maintainabil-ity design in a virtual environment", *International Journal of Industrial Ergonomics*, Vol 54, Pg. 154-163 (2016).
- [8] O. Scott and T. Erin, "Ergonomics and Design A Reference Guide". Allsteel Inc. (2006).