# A PRELIMINARY DESIGN OF A LACTATING CHAIR: AN ERGONOMICS APPROACH

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# A PRELIMINARY DESIGN OF A LACTATING CHAIR: AN ERGONOMICS APPROACH

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We certify that the project entitled "*(A Preliminary Design of A Lactating Chair: An Ergonomics Approah)"* is written by (*Mohd Faiz Bin Zulkifli*) We have examined the final copy of this project and in our opinion; it is fully adequate in terms of scope and quality for the award of the degree of Bachelor of Engineering. We herewith recommend that it be accepted in partial fulfillment of the requirements for the degree of Bachelor of Mechanical Engineering.

(  )

Examiner  Signature

## Student Declaration

I declare that this thesis “A Preliminary Design of A Lactating Chair: An Ergonomics Approach” is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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**To my beloved family**

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# LIST OF ABBREVIATIONS

| | |
|---|---|
| MSD | Musculoskeletal Disorder |
| ASTM | American Society for Testing and Materials |
| CAD | Computer-aided drafting |
| CAE | Computer-aided engineering |
| FE | Finite element |
| 2-D | Two dimension |
| 3-D | Three demension |

## ABSTRACT

This project investigates the effect of position applied during breast feeding to the mothers. Most of the mothers prefer to breastfeed their babies while sitting and they tend to have back pain or other pains because of there is no chair in the market specialize in that purpose. Aware of that, this project is being conducted in order to enhance the existence chair in the market to fix the mother's body posture and to reduce the possibility of Musculoskeletal Disorder (MSD) which is related to pains at certain part of the bodies such as back pain due to wrong body posture while doing works. The design was sketched based on the review on past researches and studies done on designs of ergonomics chair. This project would be applied SolidWork software to design the lactating chair as the design can be 3-D drawn. A survey using questionnaire is also being conducted in order to collect the data related to the design of the chair. The design is then simulated using Finite Element Analysis software. This process will involve the critical parts only where most of the loads applied such as on the headrest, backrest, seat and also the base. From the analysis of the questionnaire, the answers show that most of the mothers agreed with the features included in the design of the lactating chair. The analysis of the design using Finite Element Analysis software shows that the selection of steel ASTM A-36 is the best material for the main frame of the chair as there are only small displacements on the critical parts when acted with forces.

# ABSTRAK

Projek ini mengkaji kesan posisi yang diamalkan semasa penyusuan dada terhadap para ibu. Kebanyakan ibu- ibu lebih cenderung untuk menyusui anak mereka dalam keadaan duduk dan mereka berpotensi untuk mendapat sakit belakang atau kesakitan lain disebabkan tiada kerusi yang khusus di dalam pasaran bagi tujuan tersebut. Menyedari kewujudan masalah ini, projek ini dijalankan bertujuan untuk menambahbaik kerusi sedia ada di pasaran untuk menjadikannya lebih selesa dengan bentuk badan ibu yag menggunakannya dan pada masa yang sama mengurangkan potensi "Musculoskeletal Disorder (MSD)" yang dikaitkan dengan kesakitan di sesetengah bahagian badan seperti sakit belakang berikutan posisi badan yang tidak betul ketika melakukan sesuatu kerja. Lakaran kerusi itu dihasilkan berpandukan kepada kajian terhadap penyelidikan yang telah dibuat sebelum ini mengenai kerusi yang ergonomiks. Projek ini akan menggunakan perisian "SolidWork" untuk melakar lukisan kerusi menyusu tersebut. Ini kerana perisian tersebut mampu menghasilkan lukisan tiga dimensi. Satu tinjauan umum menggunakan soalan- soalan yang telah disediakan dijalankan untuk mendapatkan data- data berkaitan lakaran kerusi menyusu tersebut. Lakaran itu kemudiannya akan diuji menggunakan perisan "Finite Element Analysis". Ini akan hanya melibatkan sesetengah bahagian yang kritikal sahaja di mana kebanyakan beban dikenakan seperti bahagian kepala, belakang, tempat duduk dan juga tapak kerusi menyusu itu. Daripada analisis soalan- soalan yang telah diedarkan, jawapan- jawapan yang diberikan menunjukkan ibu- ibu tersebut bersetuju dengan bahagian- bahagian yang terdapat pada kerusi menyusu itu. Analisis lakaran pula yang menggunakan perisian "Finite Element Analysis" menunjukkan penggunaan besi ASTM A-36 adalah bahan terbaik sebagai rangka utama kerusi menyusu tersebut disebabkan hanya sedikit perubahan berlaku pada struktur bahagian- bahagian kritikal kerusi menyusu tersebut apabila dikenakan daya.

# CHAPTER 1

# INTRODUCTION

## 1.1 INTRODUCTION

Breast feeding is one of the easiest ways for mothers to express their love to their babies but the reality of modernization had been a wall that stop the love that born from such a simple life movement. Most of the mothers involved with careers that require them to spend more time on it and grow their babies with formula milk. They also tend to bottle-feed their babies as they easily get tired and pains due to the variety of wrong position while breast feeding. There is no specific chair or furniture that focused on such a function. Breast feeding is not as easy as it seen. There are several problems that need to be encountered to get a successful breast feeding process. A successful breast feeding process meant that the baby will get enough amount of milk per session and the mother will not feel the pains that can occur during the process.

A common pain that related to this situation is Musculoskeletal Disorder (MSD). The pain is related to the damage or defect happen to any parts of the mother's body especially the thoracic area which is at the back side body part of the mother. This could happen if the mother does not practice the right position during breast feeding. This pain can be a permanent pain if there is no action or research taken to help mothers in increasing the level of comfort while breast feeding. Those actions can be summarized to be the change in the way of seating or in other words the design of chair used by the mother to breast feed her baby.

Most of the chairs in the market do not applied the real concept of ergonomics. And even there are many studies have been done in designing chair with ergonomics approach, but yet the suitable chair for the application of breast feeding mothers is still not being considered. An ergonomics chair for the mother should be created to reduce the pain faced by the mother and also to consider the comfort of the baby.

Aware of this problem, this project is being conducted in order to enhance the existence chair in the market to fix the mother's body posture and reduce the possibility of MSD. A suggested design of an ergonomics chair for mothers will be carried out after the analysis of survey data of selected mother has finished. The design would then be simulated using Finite Element Analysis. The purpose of this simulation is to identify the distribution of forces on the critical parts and predict the possible failure that could happen.

## 1.2 OBJECTIVES

The objectives of this study are:

1. To design a lactating chair with ergonomics approach using SolidWorks.
2. To simulate designed lactating chair using Algor.

## 1.3 SCOPE OF THE STUDY

Without yet considering unforeseeable problems that might crop up later, these are the exclusions and the things known but not attempted to solve:

1. The developed lactating chair is only a basic idea or at preliminary stage and is not readily functional as a commercial product.

## 1.4 PROJECT ASSUMPTION

This thesis is based on certain assumptions:

1. Respondents for the survey questionnaire are Malaysian woman who had experience in breast fed their babies which considerate to give the most accurate results.
2. The design of the lactating chair which includes the extra features considered ergonomics according to previous journals and will only be approved if there is fabrication and being validated by ergonomics experts.
3. The analysis using Algor software is considered precise in determining the maximum load that can be applied on the critical parts of the design based on previous journals and researches.

## 1.5 PROJECT BACKGROUND

This project is to solve the Musculoskeletal Disorder (MSD) among mothers who expressed their breast milk in sitting position. Currently, there are few studies have been done for such a function. We are going to design a lactating chair that will do this by adapting the ergonomics criteria. In doing this, we are going to tackle some of the problems associated with the MSD. Other problems are not tackled in the duration of this project.

## 1.6 THESIS ORGANIZATION

This thesis is consisting of 5 chapters and was organized as follow. For each chapter, there are subtopics in it.

In Chapter 1, the introduction consists of describing breast feeding process in real life applications, problems in breast feeding process and introduces the idea of the project. In addition, this chapter also discusses on objectives of study, scopes of study,

project assumptions, project background and also the overall thesis organization distributed by each chapter.

Chapter 2 discusses on ergonomics history and also pillar of ergonomics. Besides that, the previous studies and researches on ergonomics chair and related aspects also included. The sources for the literature review are library books and journals.

Chapter 3 is about methodology of the research design. This includes all the methods used to complete this thesis such as data collection method, sampling design, survey instruments and other particular procedures. For the data collection method, this project applied the method of questionnaires and the data collected would be analyzed to co-relate to the objective of this project. Justification on each of questions in the questionnaire set also stated in this chapter.

Chapter 4 will discuss on analysis of collected data from questionnaire. Each of the answer include in the questionnaire will be analyzed and the data will be used in designing the ergonomics lactating chair. The design using SolidWork software will be based on the comparison with previous studies with some extra features in order to achieve the objective of the project. This chapter will also discuss on the reasons of every features included in the design of the lactating chair. The suggested specifications for the design also being discuss in this chapter. The analysis of the specifications will use the Algor software focusing on the critical parts of the design.

Chapter 5 will discuss on the achievement of the study and also the recommendation on the whole project for the use in the future task.

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 INTRODUCTION

The purpose of this chapter is to gather and revised on useful information from journals, books and articles that relate to this thesis especially in ergonomics aspect. The body of this chapter consists of four sections. Firstly, this chapter will focus on the history of ergonomics and also the principle of ergonomics. Secondly, this chapter discuss on the previous studies on Musculoskeletal Disorder (MSD). Thirdly, this chapter will cover on designs of chairs used in previous researches and the models available in the market. Next, this chapter will focus on researches on the designs of survey. After that, we will go through past readings on anthropometry data. Lastly, this chapter will focus on few reading on Computer Aided Design (CAD) software as well as ALGOR software. The sources for literature review are library books, journals from established databases such as Science Direct and Scopus, articles, past researches, internet search engine and observation process. All of the references attached at the end of this chapter.

## 2.2 ERGONOMICS

### 2.2.1 History of Ergonomics

Ergonomics came about as a consequence of the design and operational problems presented by technological advances in the last century. It owes its development to the same historical processes that gave rise to other disciplines such as industrial engineering and occupational medicine (Bridger, 2003)

Christensen (1987) points out that the importance of a "good fit" between humans and tools was probably realized early in the development of the species. As the example, the selected of pebble tools and made scoops from antelope bones in a clear display of selecting/creating objects to make tasks easier to accomplish. After World War II, the focus of concern expanded to include worker safety as well as productivity. Research began in a variety of areas such as:

i. Muscle force required to perform manual tasks
ii. Compressive low back disk force when lifting
iii. Cardiovascular response when performing heavy labour
iv. Perceived maximum load that can be carried, pushed or pulled

According to Lehto and Buck, the field got its name in summer of 1949 when a group of interests' individuals assembled in Oxford, England to discuss the topic of human performance. The group consists of anatomists, physiologists, psychologists, industrial medical officer, industrial hygienists, design engineers, work study engineers, architects, illuminating engineers, and anyone who is concerned some aspect of human performance. Then it is decided that they would coin new word ergonomics, which couples *ergos*, the greek word for work and *nomos*, meaning natural laws. Sometime later, the term human factors were coined in U.S for a society of similar purpose.

### 2.2.2 Definition of Ergonomics

Ergonomics came from the words that have many definitions that we can derive to know what textually the ergonomics. But the definition that has been use worldwide is actually from the International Ergonomics Association (2000). Table 2.1 shows the many definitions of ergonomics.

**Table 2.1:** Definition of Ergonomics

| No. | Author/ Resources | Year | Definition |
|---|---|---|---|
| 1 | International Ergonomics Association | 2000 | Ergonomics (or human factors) is the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimize human well-being and overall system performance |
| 2 | Scott Openshaw and Erin Taylor | 2006 | Ergonomics is a science focused on the study of human fit, and decreased fatigue and discomfort through product design. Ergonomics applied to office furniture design requires that we take into consideration how the products we design fit the people that are using them. |
| 3 | S.N.Cenghalur, S.H.Rodgers, T.E.Bernard | 2006 | Ergonomics is a multidisciplinary activity striving to assemble information on people's capacities and capabilities and to use that information in designing jobs, products, workplaces and equipment |

By the definition, we can conclude that ergonomics is actually a science discipline to obtain working environment that is fit for people to work. It is also making the job to be fit to the worker. That is why it is stated in definition that ergonomics is also designing jobs and work related material. It also means that we are creating a job that basically does not affect the human health.

### 2.2.3 Principles of Ergonomics

Over the past few decades a number of basic principles have emerged from the field of ergonomics. While many of these principles may appear simple, one should not underestimate the power of new fundamental ideas applied systematically. In their basic form, these principles must follow in order that the design work can be fit to the worker. The principles are comfort, safety, ease of use, aesthetics and productivity/ performance (Dul and Weerdmesster, 2001).

For the first principle is comfort. It's known to be one of the desired criteria in designing a product. People in the world today always want the comfortable in all things. It's being the first elements when their want to choose something that related to their body. The comfortable environment when performing tasks tends to motivate the works to work hard. Furthermore, it can relax the workers and release the stress that can cause ergonomics failure among the workers. The environment in which work is performed can directly and indirectly affect not only the comfort and health of people, but also the quality and efficiently of the work being done (MacLeod, 1994).

The next principle is safety. Safety is very important since it is an element that everyone is looking for when performing a task. Ergonomics promotes safety in designing the task for workers. Job that is safe is relevant and practical to be used in the world. Safety also includes the working environment and also the working tools. It is important that work areas be designed with enough space to both get the task done and have easy access to everything needed. So, the safety of our body to do the task is completely save without any dangerous because there is no any obstruction between a person and the items needed to accomplish the task. For working tools, they need to be safe to be handled. That is why a lot of tools that move around is been equipped with

safety measurements. Some tools for example the lathe machine is equip with emergency stop button and also automatic emergency stop button. The emergency stop button is important in case something bad happen and the machine needs to stop immediately.

The other principles are ease to use. These principles basically related with the working accessories and tools equipment. To make it easy, we must keep tools or everything in easy reach. Long reaches can strain the body and make work more difficult, plus waste time. An easy way to make tasks more user-friendly is to keep frequently used items such as knobs, switches, tools and parts within easy reach. Basically, different of jobs required different type of tools but one thing that is must consider and it is almost same for all tolls is the fact that it needs to be ease of use.

The fourth principles are aesthetics. Aesthetics of beauty is commonly about things like clothes, cars, houses and many more. All people like things that is beauty and being beautiful. Something that is beauty has the elements that people like. The elements will make people feel comfortable and suitable to use it. Due to the fact beauty thing is wanted in the world, ergonomics implement this part for the needs to produce jobs that can be fit to the workers. Aesthetics values or beauty are usually associated with tools that are related to the job. Even chair needs to be aesthetics in order for it to be selling as well as to be like. Making the workplace full of aesthetics value will cause the workers feels less stress when doing job. It can also be thought as psychology measure in attracting one's interest.

The last but not least, productivity and performance are also one of the ergonomics principles. Productivity is correlated with performance. We can say the performance is directly proportional to the productivity. Performance of a workers lies within the working aspects including the ergonomics itself. In order to produce productivity and performance, ergonomics will design job that will be fit to the workers according to the basic needs.

From all the principles that have state above, it's very important to ensure that the worker will produce good result in their work if all the principles are combined in a single task. It does also can avoid the worker from injuries and disease such as MSD and many more. From the research that has been done, this principle is very good to known to be effective in solving problems of ergonomics at work. Table 2.2 shows the recent study of ergonomics.

**Table 2.2:** Recent Study of Ergonomics

| Year | Title | Author | Content |
|---|---|---|---|
| 2002 | Does ergonomic equal safety | Jonathan Tyson | Revise the connection of ergonomics and safety. |
| 2006 | Ergonomic experiment for thumb keyboard design | Xiong Yunfei | Study on how to improve the already made products. implement ergonomics principle on the product. |
| 2007 | Ergonomics: Making the job fit | Laura Hill | Ergonomics usage in designing jobs for workers. |
| 2007 | The effects of job performance on effectiveness | Emin Yahya | Evaluate performance on effectiveness, team working benefits of improving performance. |
| 2008 | Vibration reduction of pneumatic percussive rivet tools: Mechanical and ergonomic design approaches | John C Cherng, Mahmut Eksioglu, Kamal Kizilaslan | Solve ergonomics problem using Taguchi method, increase workers performance using ergonomics principle. |

## 2.3 MUSCULOSKELETAL DISORDER (MSD)

The design of tools and workspaces can have a profound effect on the posture of the body. Of particular interest is the posture of the shoulders, elbows and wrists and its relation to pathological musculoskeletal changes. Musculoskeletal disorder**,** means a

broad range of conditions of varying degree associated with the upper extremities (hand and arm) such as inflammation or trauma mostly of the tendon, muscle-tendon junction or surrounding tissue; inflammation of tissue of the hand, compression of the peripheral nerves serving the upper limb, and include temporary fatigue, stiffness of the muscles comparable to that unaccustomed exertion.

Brogmus et al. (1996) analysed trend in MSD from the 1980s to the 1990c using data from the Liberty Mutual group workers' compensation claims and US Bureau of Labor Statistics. The analysis of both data sets confirmed a steady increase in cases and claim, with MSD rising from 1% of the total claims in 1986 to 4% in 1993.

The MSD is actually a class of disorders that basically amount of wear and tear on the tissue surrounding the human joints. Every joint in the body can potentially affect, but the lower back and the upper limbs are the areas of most concern. MSD also because of having the repetitive work and also lifting. This causes fatigue and failure among the human tissue. (D.Macleod, 2006). This means that working style that involve movement and repetitive work are potentially causing MSD. This is because the body is doing the same task the same way and the affected area would be the same. When an area is been subjected to the same force everyday , the area would become less efficient due to the fatigue experience by the body. For example, the hand when it is subjected to the same force every day will become weak. A person might also experience pain and also soreness around the effected area.

Every year it has people that have reported in case of MSD. That means, the percentage of workers to get MSD is higher. When the workers get MSD, it can affect the productivity and efficiency. MSD may progress in stages from mild to severe.

i. **Early stage:** Aching and tiredness of the affected limb occur during the work shift but disappear at night and during days off work. No reduction of work performance.
ii. **Intermediate stage**: Aching and tiredness occur early in the work shift and persist at night. Reduced capacity for repetitive work.

iii. **Late stage:** Aching, fatigue, and weakness persist at rest. Inability to sleep and to perform light duties.

**Table 2.3:** Outlines Occupational Risk Factors and Symptoms

| Disorders | Occupational risk factors | Symptoms |
|---|---|---|
| Tendonitis/tenosynovitis | Repetitive wrist motions<br>Repetitive shoulder motions<br>Sustained hyper extension of arms<br>Prolonged load on shoulders | Pain, weakness, swelling, burning sensation or dull ache over affected area |
| Epicondylitis (elbow tendonitis) | Repeated or forceful rotation of the forearm and bending of the wrist at the same time | Same symptoms as tendonitis |
| Carpal tunnel syndrome | Repetitive wrist motions | Pain, numbness, tingling, burning sensations, wasting of muscles at base of thumb, dry palm |
| DeQuervain's disease | Repetitive hand twisting and forceful gripping | Pain at the base of thumb |
| Thoracic outlet syndrome | Prolonged shoulder flexion<br>Extending arms above shoulder height<br>Carrying loads on the shoulder | Pain, numbness, swelling of the hands |
| Tension neck syndrome | Prolonged restricted posture | Pain |

MSD of muscles, tendons and nerves are a major cause of lost work in many labour-intensive industries. Occupational risk factors include continual repetition of movements, fixed body positions, forces concentred on small parts of body, and lack of sufficient rest between tasks. Prevention must aim at eliminating the repetitiveness of work by proper job design. The strategies of preventive if it is not possible we must consider several things such as good workplace layout, tool and equipment design, and proper work practice.

Preventive and control measures, in order to be truly effective, require significant involvement on the part of the workers, their representatives, and management to improve occupational health and safety. Table 2.4 shows the recent study on MSD.

**Table 2.4:** Recent Study on Musculoskeletal Disorder

| Year | Title | Author | Content |
|---|---|---|---|
| 2007 | Posture and muscle activity of pregnant woman during computer work and effect of an ergonomic desk board attachment | Genevieve A.Dumas, Tegan R. Upjohn, Alain Delisle, Karine Charpinteir, Andrew Leger, Andre Plamondon, Erik Salazar, Michael J.McGrath. | Comparing posture and muscle activity in the back and upper extremity of late pregnancy and non pregnant controls. The research also evaluate the effect of concave desk board on the back and upper extremity of woman in late pregnancy. |
| 2008 | Effects of ergonomics-based wafer-handling training on reduction in musculoskeletal disorders among wafer hanlders | Hsin-Chieh Wu, Hsieh-Ching Chen, Toly Chen. | MSD effect on workers, Judge whether MSD prevention is worth or not in a certain job area. |

**Table 2.4:** Continued

| | | | |
|---|---|---|---|
| 2008 | Comparing dynamic and stationary standing postures in an assembly task | Venkatesh Balasubramaniam, K. Adalarasu, Rahul Regulapati | Study MSD among factory assembly line workers. Effect of MSD to the productivity |
| 2008 | Force in measurement in field ergonomics research and application | Stephen Bao, Peregrin Spielholz, Ninica Howard, Barbara Silverstein. | Explain the effect of pulling/pulling, lifting, pinch and power gripping, measure force when performing task. |
| 2008 | Physiological and perceptual responses in male Chinese workers performing combined manual materials handling tasks | Kai Way Li, Rui-feng Yu, Yang Gao, Rammohan V. Maikala, Hwa-Hwa Tsai. | Study the repetition task that the workers experience. The research also considering the effect of time expose to the task perform and the relation to MSD. |

## 2.4 CHAIR

### 2.4.1 History of chair

The chair is a symbol of civilization. It was probably the first type of furniture created that means not just to provide support off the ground, but to convey status and authority (Schwartz et al., 1968). Images of early chairs can be found in the records of ancient civilizations. In Egypt, the chair changed very little for several thousand years – typically it was pictured with a low seat and slightly reclining back; examples of thrones and folding stools also exist in these records: the throne being very architectural in form, while the stool was often adorned with animal carvings. Both of objects were a symbol of authority, the throne was associated with the regalia of the pharaohs and the stool was provided for travelling dignitaries. Figure 2.1 shows the Egyption chairs.

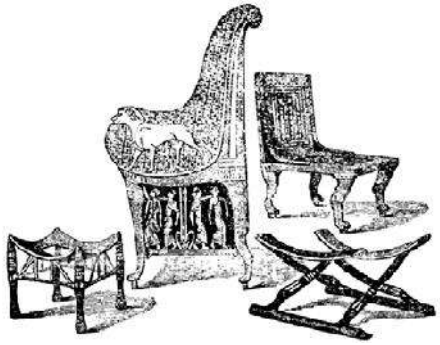


**Figure 2.1:** Egyptian Chairs

**Source:** Master of Flemalle (Robert Campin, 1427)

The first aesthetically significant chair form was created in ancient Greece. The *klismos* was a graceful, symmetrical chair which became a prototype of designs that reappeared throughout the centuries of chair design that follow ("Klismos", 2005).

Roman styles borrowed heavily from the Greeks, and the *klismos* continued to be reinvented. Like the Egyptians, the Romans also had a folding stool, *sella-curulis,* which conveyed authority and status (Ramsay, 1875). The *sella-curulis* continued to be used in the middle-ages by both civil and religious dignitaries ("Timeline of art history", 2000-2005).

Gothic and Romanesque art illustrate the influence of architecture on chair design in the famous *Merode Altarpiece* painted by the Master of Flemalle (Robert Campin) in 1427. The bench-like chairs in this image are not for dignitaries, but were typical of common domestic interiors. Figure 2.2 shows *Merode Altarpiece.*

**Figure 2.2:** *Merode Altarpiece*

**Source:** Master of Flemalle (Robert Campin, 1427)

During the Renaissance, the design of the *klismos* and the *sella-curulis* type chairs were revived and were transformed into the Savonarola chair. The *Savonarola* chair was an x-shaped stool with the addition of a back constructed entirely in wood (Akintilo, 2001).

**Figure 2.3:** Renaissance *Savonarola* chair

**Source:** Master of Flemalle (Robert Campin, 1427)

The Renaissance also saw the embellishment of a previously simple chair type – the wood side chair called the *sgabello* was covered with ornate carvings by craftsmen. In the Renaissance, the decoration and form were not as integrated as they were in the ancient world (Schwartz et al., 1968). Figure 2.4 shows the Renaissance *Sgabello* chair.

**Figure 2.4:** Renaissance *Sgabello* chair

**Source:** Master of Flemalle (Robert Campin, 1427)

### 2.4.2 Chair Design

As we can see, there are a lot of designs of chair available in the market. Most of the designs based on the creativity of the designer. The best design of chair is base on the human body measurements. The chair must fit to the user not the user must fit to the chair.

The Business and Institutional Furniture Manufacturer's Association (BIFMA) have suggested the design of the chair. The suggested as a guideline are based on the Natick military studies using $5^{th}$ to $95^{th}$ percentile females and females. The suggested BIFMA measurements are illustrated in Table 2.5. Figure 2.5 shows Measurements from BIFMA guidelines used for ergonomic chairs.


**Figure 2.5:** Measurements from BIFMA guidelines used for ergonomic chairs

**Table 2.5:** Specific BIFMA chair design guideline measurements

| | Specifications | | | |
|---|---|---|---|---|
| | | Measurement | BIFMA Guideline | Allsteel Sum Chair |
| Seat Height | A | Popliteal height + Shoe allowance | 15.0” – 19.9” | 15.0” − 22.25” |
| Seat Depth | B | Buttock-popliteal length – Clearance allowance | No deeper than 16.9” (fi xed) 16.9” included (adjustable) | 15.0” − 18.0” |
| Seat Width | C | Hip breadth, sitting + Clothing allowance | No less than 18” | 18.0” |
| Backrest Height | D | None | At least 12.2” | 24.0” |
| Backrest Width | E | Waist breadth | 14.2” | 16.0” |
| Backrest Lumbar | F | None | Most prominent point 5.9” – | Infi nite through ht. |

**Table 2.5**: Continued

| | | | | |
|---|---|---|---|---|
| | | | 9.8” from seat pan, in and out 1 | of back (AutoFit™ technology) |
| Armrest Height | G | Elbow rest height | 6.9” – 10.8” 7.9” – 9.8” | 7.0” − 11.0” |
| Armrest Length | H | None | None | 10.5” |
| Distance Between Armrests | I | Hip breadth, sitting + 18” (fi xed) 16.5” − 19.0” Armrests Clothing allowance | 18” (fi xed) 18” included (adjustable) | 16.5” − 19.0” |

The chair should be designed according to physiology for comfort, so the chair design should include such elements as follows:

i. Seat height

Seat’s height means a distance from ground to seat. The seat designed too high will strain muscles of legs and leave them stiff and sore, if the height of seat is so high that our feet lost contact with ground, and then muscles of our back also could be hurt. Of course lower seat is not healthy which can result in straining muscles of back and humpback. In summation, the height of seat should be designed to be higher than the length of calf (the length of shin is added to the thick of shoes) a little.

ii. Seat depth

Seat depth is a distance from front to its back which is designed to insure buttocks are supported all over. Moreover, the front of seat should not extend too much not to strain calf, which also be left a distance from it to relax calf. Seat’s depth can be designed about 450 mm in size.

iii. Seat width

Seat width should hold the whole buttocks and one can adjust sitting posture in an easy manner. Those chairs which connect with each other are designed to the width as shoulders; a popular width about 530mm can meet 95 percent of people. The chair for dining is wider with about 600 to 680 mm in size.

iv. Chair back

Chair back is a central key ergonomic element in chair design whose form and degrees are of importance for sitting posture and normal spine. Body's trunk is supported by chair's back, scapula and lumbar are major stress parts.

v. Chair arms

Chair arms can be used to compact seats and support ones with hand, especially for those who act inconveniently, the arms are very important to support their bodies when they get up from their chairs, they also can divide seriate chairs into solo seats.

vi. Chair feet

It's very important to keep balance for chair, so chair feet are design for five to avoid sliding and falling on the ground.

**Table 2.6:** Recent Study of chair

| Year | Title | Author | Content |
|---|---|---|---|
| 2003 | Introduction of Ergonomics: Chair design | R.S.Bridger<br>Para Barbara,<br>Daniella y Angelo | -Study about design of chair based on workplace station and ergonomics approach |

**Table 2.6:** Continued

| | | | |
|---|---|---|---|
| 2005 | The Beauty of Fit: Proportion and Anthropometry in Chair Design | Caroline Kelly | -Explanation about the chair and what is relation of the chair with ergonomics and anthropometry |
| 2006 | Ergonomics and Design<br>A Reference Guide | Scott Openshaw, Allsteel<br>Erin Taylor, Allsteel | -Study about ergonomics and anthropometry<br>-tells the criteria of chair and what the best measurement of chair |

## 2.5 Design Surveys

One of the methods to collect data for this study is by conducting a survey. This section will relate on how to design a proper surveys that will lead to a better information gather. This section will focus more on questionnaire as it will be used for this study.

### 2.5.1 Definition of Surveys

Based on Martyn Denscombe (2007), the word ‘surveys’ can be defined as ‘to view comprehensive and in detail’. In another word surveys also can be defined as specifically to the act of ‘obtaining data for mapping’. As the summary, survey is a research strategy that can be used in order to obtain useful information.

### 2.5.2 Type of Surveys

Surveys came in a wide variety of form depending on researcher aim and discipline background. Most common type of surveys that been used were (Denscombe, 2007):

i. Postal Questionnaire

Involve sending 'self-completion' questionnaire through post. This generally involves a large-scale mailing covering wide geographical area. Usually there is no any personal contact between the researcher and the respondent.

ii. Internet Surveys

Provides a fast and also cheap alternative compared to other type of survey when it comes to collecting survey data (Couper, 2000). Survey can be conducted via three ways which is an email questionnaire, questionnaire sent with an email as attachment and a web-based questionnaire

iii. Face-to-face Interviews

Face-to-face survey involves direct contact between the researcher and the respondent. This contact can be made through researcher approach such as go to the factory and called operator for an interview.

iv. Telephone Interviews

Involve of contacting the respondent via telephone. However this method is rarely used for researcher as it was felt that contacting people by phone led to a biased sample.

### 2.5.3 Stage of a Survey

Generally, there are 5 stage of a survey which are survey design and preliminary planning, pretesting, final survey design and planning, data collection and lastly data coding, data-file construction, analysis and final report (Czaja and Blair, 2005).

First stage of a survey consists of several steps. First step is to decide the goals of the research and determine how best to accomplish them within the available time and resources. Next step is to decide the respondent. It is important to choose the right respondent as it will affect the data from the surveys. After that, start designing a questionnaire. This step consists of decide type of question that need to be asked (behavior, attitude or knowledge question) and also the type of demographic information that we need. Time and money available should be put into consideration in designing a survey.

Second stage of a survey is pretesting. Start with drafting the questionnaire. Question for the questionnaire can be borrowed from other researcher. After finished drafting the questionnaire, pretesting should be done. Important of this pretesting is to know the level of understanding of the respondent for each question in the questionnaire.

Third stage of a survey is final surveys design and planning. The pretest result should be used to improve questionnaire.

Fourth stage of a survey is data collection. During this stage, researcher needs to monitor the result of the sampling and data collection activities and begin coding data file preparation.

Fifth stage of a survey is data analysis and final report. Data gather from questionnaire need to be analyzed and change into useable information.

### 2.5.4 Designing Questionnaire

This section will be a guideline in designing questionnaire for this study. There are several things need to be focused on designing a questionnaire (Sharon L. Loh ,1999):

i. Decide what is the purpose of the questionnaire
ii. Test the questionnaire before taking the survey
iii. Keep the question simple and clear
iv. Use specific question instead of using general question
v. Relate question with concept of interest
vi. Decide whether to use open or closed question
vii. Avoid question that prompt or motivate respondent to answer according to your answer
viii. Used force-choice, rather than agree/disagree question
ix. Ask only one question in each question
x. Pay attention to question order-effect

## 2.6 Anthropometry data

Due to the limited source on Malaysian anthropometry data, the anthropometry data of the southern Thai population is used. This research was done by Jaruwan Klamklay, Angoon Sungkhapong, Nantakrit Yodpijit and Patrick E. Patterson on 2006. Table 2.7 and Table 2.8 shows the anthropometry data of the male southern Thai population and the anthropometry data of the female southern Thai population.

**Table 2.7**: Anthropometry data of the male southern Thai population, aged 18–25 years ($n$= 100)

| | Dimension[a] | Mean | S.D. | 1st percentile | 5th percentile | 50th percentile | 95th percentile | 99th percentile |
|---|---|---|---|---|---|---|---|---|
| 1 | Weight (kg) | 61.85 | 8.57 | 46.00 | 49.95 | 60.42 | 75.42 | 86.06 |
| 2 | Stature | 171.94 | 5.15 | 161.99 | 164.60 | 170.92 | 181.25 | 184.60 |
| 3 | Eye height | 160.21 | 5.01 | 151.73 | 153.60 | 159.28 | 169.07 | 172.35 |
| 4 | Shoulder height | 140.67 | 11.74 | 99.14 | 135.56 | 141.30 | 149.44 | 154.06 |
| 5 | Elbow height | 109.18 | 8.75 | 98.83 | 102.40 | 107.78 | 119.54 | 151.03 |
| 6 | Hip height | 84.96 | 4.09 | 76.03 | 77.88 | 84.55 | 91.25 | 95.61 |
| 7 | Knuckle height | 74.19 | 10.13 | 64.79 | 69.00 | 73.07 | 79.23 | 83.86 |
| 8 | Fingertip height | 63.21 | 4.87 | 55.44 | 59.17 | 63.18 | 69.06 | 71.08 |
| 9 | Sitting height | 90.16 | 3.41 | 83.01 | 85.30 | 89.95 | 95.30 | 100.90 |
| 10 | Sitting eye height | 78.01 | 3.37 | 70.69 | 72.69 | 78.13 | 83.04 | 84.57 |
| 11 | Sitting shoulder height | 60.63 | 2.68 | 53.66 | 56.16 | 60.82 | 65.31 | 66.52 |
| 12 | Sitting elbow height | 25.11 | 2.58 | 19.05 | 21.47 | 25.05 | 28.85 | 30.84 |
| 13 | Thigh thickness | 14.21 | 1.46 | 11.10 | 11.90 | 14.18 | 17.10 | 17.40 |
| 14 | Buttock–knee length | 58.52 | 2.45 | 53.43 | 54.95 | 58.40 | 61.91 | 64.25 |
| 15 | Buttock–popliteal length | 48.23 | 3.95 | 43.85 | 45.02 | 48.42 | 51.78 | 54.02 |
| 16 | Knee height | 52.81 | 2.29 | 47.86 | 48.62 | 52.85 | 56.07 | 59.11 |
| 17 | Popliteal height | 43.04 | 1.56 | 39.66 | 40.64 | 43.02 | 45.51 | 46.18 |
| 18 | Shoulder breadth (bideltoid) | 43.24 | 2.26 | 38.10 | 39.63 | 43.12 | 46.94 | 49.27 |
| 19 | Shoulder breadth (biacromial) | 40.45 | 1.99 | 35.96 | 37.28 | 40.25 | 43.85 | 44.77 |
| 20 | Hip breadth | 34.34 | 5.48 | 29.80 | 30.82 | 33.77 | 36.89 | 39.52 |
| 21 | Chest (bust) depth | 19.85 | 1.92 | 14.73 | 16.68 | 19.90 | 22.59 | 25.63 |
| 22 | Abdominal depth | 20.90 | 2.43 | 16.00 | 17.52 | 20.98 | 24.45 | 26.97 |
| 23 | Shoulder–elbow length | 35.97 | 1.46 | 32.70 | 33.46 | 35.93 | 38.21 | 39.47 |
| 24 | Elbow–fingertip length | 47.12 | 1.63 | 44.00 | 44.70 | 47.00 | 50.24 | 50.64 |
| 25 | Upper limb length | 77.12 | 4.12 | 70.16 | 72.92 | 77.02 | 82.57 | 83.54 |
| 26 | Shoulder–grip length | 66.55 | 2.73 | 61.52 | 62.65 | 66.47 | 71.44 | 72.05 |
| 27 | Head length | 18.99 | 0.73 | 17.59 | 17.93 | 18.92 | 20.04 | 20.70 |
| 28 | Head breadth | 15.78 | 0.56 | 14.60 | 14.86 | 15.80 | 16.70 | 17.03 |
| 29 | Hand length | 19.11 | 7.16 | 16.80 | 17.13 | 18.40 | 20.30 | 21.49 |
| 30 | Hand breadth | 8.22 | 0.35 | 7.40 | 7.66 | 8.25 | 8.87 | 8.90 |
| 31 | Foot length | 25.35 | 0.99 | 23.29 | 23.63 | 25.42 | 26.90 | 27.20 |
| 32 | Foot breadth | 9.80 | 0.54 | 8.73 | 8.97 | 9.75 | 10.67 | 11.07 |
| 33 | Span | 174.28 | 13.88 | 107.32 | 166.35 | 175.15 | 187.73 | 190.85 |
| 34 | Elbow span | 90.07 | 3.14 | 84.43 | 85.72 | 89.90 | 95.71 | 96.51 |
| 35 | Vertical grip reach (standing) | 204.73 | 12.51 | 170.51 | 195.95 | 204.65 | 217.17 | 220.61 |
| 36 | Vertical grip reach (sitting) | 124.78 | 14.51 | 115.42 | 117.63 | 124.02 | 132.92 | 177.06 |
| 37 | Forward grip reach | 73.66 | 4.70 | 64.41 | 68.00 | 73.78 | 80.34 | 81.63 |

**Table 2.8** Anthropometry data of the female southern Thai population, aged 18–25 years (*n*= 100)

| | Dimension[a] | Mean | S.D. | 1st percentile | 5th percentile | 50th percentile | 95th percentile | 99th percentile |
|---|---|---|---|---|---|---|---|---|
| 1 | Weight (kg) | 49.90 | 7.59 | 38.00 | 40.95 | 48.07 | 64.22 | 72.11 |
| 2 | Stature | 157.94 | 5.32 | 146.36 | 149.44 | 157.98 | 167.18 | 169.48 |
| 3 | Eye height | 146.29 | 5.15 | 135.73 | 137.41 | 146.03 | 155.09 | 158.57 |
| 4 | Shoulder height | 129.71 | 4.94 | 119.91 | 122.73 | 129.43 | 139.19 | 142.30 |
| 5 | Elbow height | 99.02 | 6.15 | 90.63 | 92.25 | 98.65 | 105.19 | 117.82 |
| 6 | Hip height | 78.36 | 4.08 | 69.76 | 72.62 | 77.90 | 85.67 | 87.27 |
| 7 | Knuckle height | 68.26 | 3.03 | 61.99 | 63.55 | 68.40 | 73.00 | 74.20 |
| 8 | Fingertip height | 59.08 | 2.89 | 51.97 | 54.56 | 59.22 | 63.11 | 65.38 |
| 9 | Sitting height | 83.70 | 5.00 | 77.22 | 79.39 | 84.00 | 88.43 | 91.01 |
| 10 | Sitting eye height | 72.97 | 2.93 | 66.12 | 68.76 | 73.27 | 76.75 | 80.55 |
| 11 | Sitting shoulder height | 56.50 | 4.35 | 47.13 | 52.33 | 56.25 | 61.24 | 66.83 |
| 12 | Sitting elbow height | 23.12 | 2.06 | 18.96 | 20.02 | 23.07 | 26.04 | 27.21 |
| 13 | Thigh thickness | 12.01 | 1.03 | 10.27 | 10.62 | 11.87 | 13.84 | 14.90 |
| 14 | Buttock–knee length | 54.54 | 2.51 | 49.87 | 50.96 | 54.30 | 59.38 | 60.37 |
| 15 | Buttock–popliteal length | 46.43 | 2.22 | 42.73 | 43.39 | 46.12 | 50.69 | 52.07 |
| 16 | Knee height | 48.13 | 2.16 | 43.96 | 44.70 | 47.77 | 51.77 | 53.74 |
| 17 | Popliteal height | 40.17 | 1.41 | 36.66 | 38.13 | 40.08 | 42.90 | 43.24 |
| 18 | Shoulder breadth (bideltoid) | 38.75 | 1.96 | 35.24 | 35.83 | 38.57 | 41.88 | 44.67 |
| 19 | Shoulder breadth (biacromial) | 35.19 | 1.59 | 31.76 | 32.60 | 35.22 | 37.74 | 38.64 |
| 20 | Hip breadth | 36.15 | 2.18 | 32.36 | 33.18 | 35.65 | 39.91 | 41.15 |
| 21 | Chest (bust) depth | 19.95 | 1.67 | 17.52 | 17.83 | 19.70 | 23.35 | 24.22 |
| 22 | Abdominal depth | 18.45 | 1.70 | 15.23 | 16.20 | 18.30 | 21.76 | 23.34 |
| 23 | Shoulder–elbow length | 33.36 | 1.64 | 30.03 | 30.80 | 33.17 | 36.24 | 37.12 |
| 24 | Elbow–fingertip length | 42.57 | 3.52 | 38.93 | 39.36 | 41.92 | 45.77 | 47.31 |
| 25 | Upper limb length | 69.71 | 3.18 | 63.26 | 64.72 | 69.30 | 75.24 | 76.35 |
| 26 | Shoulder–grip length | 59.56 | 2.78 | 53.83 | 55.53 | 59.53 | 64.54 | 66.57 |
| 27 | Head length | 17.97 | 0.64 | 16.57 | 16.96 | 17.93 | 18.97 | 19.20 |
| 28 | Head breadth | 14.95 | 0.58 | 13.70 | 14.00 | 14.95 | 15.87 | 16.20 |
| 29 | Hand length | 16.61 | 0.73 | 15.20 | 15.46 | 16.57 | 17.84 | 18.10 |
| 30 | Hand breadth | 7.26 | 0.34 | 6.50 | 6.57 | 7.30 | 7.77 | 7.87 |
| 31 | Foot length | 22.68 | 0.94 | 20.50 | 21.05 | 22.78 | 24.00 | 24.57 |
| 32 | Foot breadth | 8.63 | 0.47 | 7.46 | 7.93 | 8.63 | 9.47 | 9.63 |
| 33 | Span | 157.41 | 6.86 | 143.96 | 146.97 | 155.60 | 169.46 | 172.50 |
| 34 | Elbow span | 81.17 | 3.35 | 74.97 | 76.02 | 80.55 | 87.31 | 88.24 |
| 35 | Vertical grip reach (standing) | 187.12 | 9.56 | 170.96 | 176.16 | 187.53 | 201.47 | 208.29 |
| 36 | Vertical grip reach (sitting) | 114.81 | 10.86 | 101.75 | 106.76 | 113.38 | 122.63 | 153.57 |
| 37 | Forward grip reach | 68.45 | 3.28 | 62.91 | 63.60 | 67.77 | 74.13 | 78.37 |

## 2.7 CAD Software

CAD is an acronym for Computer Aided Design which means the usage of computer technology to aid in the design and any particularly drafting of a part or product, including entire buildings. Drafting can be done in two dimensional (2D) or three dimensional (3D). There are plenty of CAD software available in the market. Each of that has its own advantages and disadvantages. For this section, two CADs software will be discussed and compared. CAD software that will be discussed is SolidWorks and AutoCAD.

### 2.7.1 Solidworks

SolidWorks is a parasolid-based solid modeler, and utilizes a parametric feature-based approach to create models and assemblies. SolidWorks was developed by Solid Work Cooperation and now a subsidiary of Dassault Systèmes, S. A. (Vélizy, France).Core product for this software includes tools for 3D modeling, assembly, drawing, sheetmetal, weldments, and freeform surfacing. By using SolidWork, 2D drawing can be easily converted to 3D drawing and vice versa. SolidWork also support numerous of extension file such as IGS file, DWG file etc.

### 2.7.2 AutoCAD

Same with SolidWork software AutoCAD is CAD software application for 2D and 3D design and drafting. This software was developed and distributed by Autodesk Inc. AutoCAD. AutoCAD is basic CAD software and easy to use for those with limited experience in using CAD software. 3D drawing in this software quite difficult to archive.

### 2.7.4 Comparison for CAD software

Each of the CAD software has its own advantage and disadvantages. Table 2.9 shows the comparison for the selected CAD software. The comparison will based on certain criteria which are availability of the software, function of the software, supported import and export file type and knowledge on that particular software.

**Table 2.9:** Comparison for the selected CAD software

| CAD software | Function | Benefits | Disadvantages |
|---|---|---|---|
| SolidWorks | Drafting in 3D and 2D | • Can easily convert 3D to 2D and vice versa.<br>• Can easily modified the drawing.<br>• Can create simulation on design (how its work).<br>• Support IGS file which is file that export to finite Element Analysis software. | • High performance computer need to run this software.<br>• Previous version of SolidWorks file not compatible with newer version of SolidWorks file. |

**Table 2.9:** Continued

| | | | |
|---|---|---|---|
| AutoCAD | Drafting in 3D and 2D | • Medium performance computer need to used this software.<br>• Drawing can be easily modified.<br>• AutoCAD functionality to specific fields such as AutoCAD Architecture and AutoCAD Electrical. | • Difficult to draw in 3D.<br>• Whole must be drawn in as it not support assembling drawing function.<br>• Not support simulation function. |

## 2.8 Analysis Software

Analysis is important for this study as it is related to the machine life time. For this study, Finite Element method will be used to analyze the part. Only critical part will be analyzed because of the percentage of critical part to fail is higher than the other part. There are many softwares that can be used to analyze using finite element method such as Algor, Cosmos Xpress etc. For this study, finite element analysis will be run through Algor software.

## 2.9 Conclusion

Ergonomics design is related to the principle of ergonomics. To design an ergonomics chair, the principle of ergonomics needs to be followed. Besides relying on literature review to get data for ergonomics design, conducting a survey is also a proper way to get the data.

## 2.10 Summary

The selection of a suitable chair is a critical step in preventing health problems in people who work in a sitting position. With the ergonomics approach, sitting is viewed as a specific, specialized activity which is influenced by the way that a sitting person interacts with the working environment. If you are a person who would like to maintain Ergonomic seating while working at the computer workstation, then you should be considering the following instructions:

i. Ensure that your hands, wrists, and forearms are in a row, straight, and almost parallel to the floor.
ii. Ensure that your head and torso are in-line with head slightly bent forward, facing towards the front, and balanced.
iii. Ensure that your shoulders are at ease with upper arms hanging normally at the sides of your body.
iv. Ensure that your elbows are close to your body and bent between 90 and 110 degrees.
v. The feet should be either supported by a footrest or should be relaxing on the floor.
vi. While leaning back or sitting in a vertical position, ensure that your back is supported fully with firm hold on the lumbosacral area.
vii. Your seat should be well padded in order to support your hips and thighs.
viii. Ensure that your knees and hips are in almost the same height with your feet slightly forward.

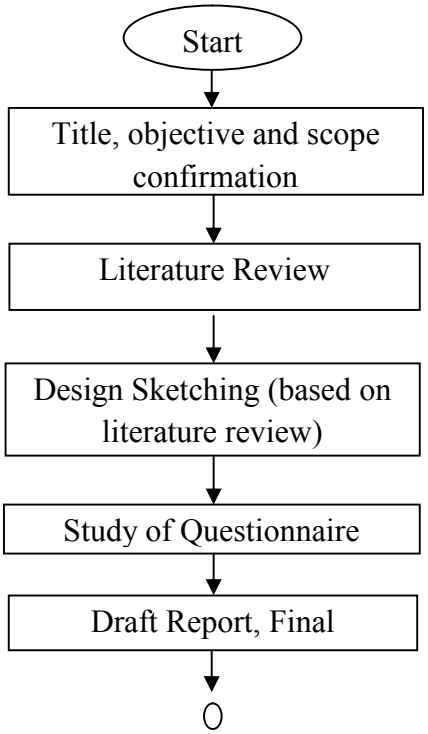
Human's physiology structure also must be considered into chair design as well as chair's using situation, which calls for different design focus. So the design process for chair should be finished by combining theory, mended data with practice under practical problems.

# CHAPTER 3

# METHODOLOGY

## 3.1 INTRODUCTION

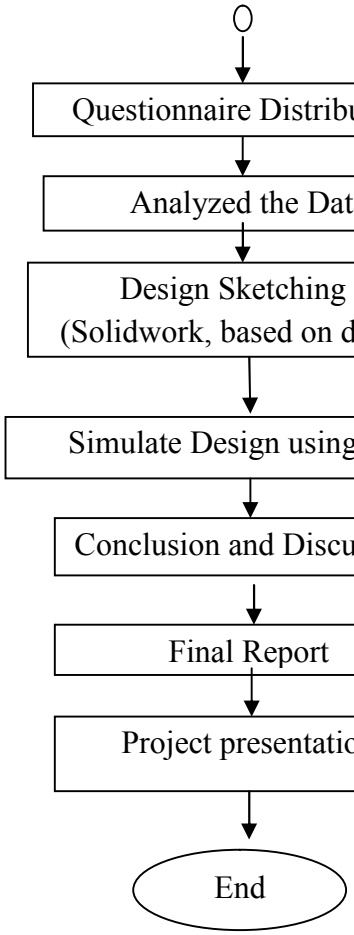
The objective of this chapter is to discuss the methodology applied along this project including collecting data process and simulation process of selected critical parts of the ergonomics lactating chair design. This chapter also explains about justification of every aspect in each process. The project's flow chart is shown in figure 3.1.




(3.1)

**Figure 3.1**: Flow Chart of the project

**Figure 3.1**: Continued




The project begins with the confirmation of the title, objectives and scopes of the project with the supervisor. Then, the project proceeds with literature review where the discussion is focusing on the past researches and studies done on designs of ergonomics chair in order to be applied in designing an ergonomics lactating chair and also focusing on Musculoskeletal Disorder (MSD). Based on the review, the design is sketched. But yet the design is depending on the response on the questionnaire. Next is the study of the questionnaire. The questionnaire is drafted based on the related parts that affect the design of the lactating chair. After that, the draft report and the final presentation 1 are continuing. The draft report included three chapters which are introduction, literature review and the methodology. The questionnaires then distributed to the selected correspondences. The questionnaire is important in designing the features of the ergonomics lactating chair and also determines the level of awareness of the

correspondences to application of ergonomics lactating chair and the effect of not using ergonomics chair. After analyzed the data gained from the questionnaires, the design process again takes part. This design is based on the data and also the theory. Next is the simulation which will use the Algor™ software. This process will involve the critical parts only where most of the loads applied such as on the headrest, backrest, seat and also the base. This process then continues with the conclusion and discussion. In this process, the problems and recommendations will be included for the future study. The flow chart ends with the final report and the project presentation.

## 3.2 Design Sketching Method

This project will use the SolidWorks software in the design process. This software is used to sketch the design in the 3-D with the dimensions. The software is used because it has many benefits that contribute to this project. This software works faster through unmatched performance and ease-of-use, including familiar Windows® functions like drag-and-drop, point-and-click, and cut-and-paste. With SolidWorks software, design data is 100% editable, and relationships between parts, assemblies, and drawings always stay up-to-date.

The parts have to be assembled to view the actual shape of the designed product. With the SolidWorks, the assembly process becomes easy. We can refer to other parts directly and maintain relationship between the parts when creating new parts. Besides that, we can view assemblies in full motion with dynamic assembly motion and observe the interaction of moving components with dynamic collision detection and clearance.

This design process has two stages where the first stage is the sketching process based on the literature review. After review of the previous designs and some ergonomics criteria done, the design is sketched. The functionality is described in the previous chapter. The second stage is when the collected data from the questionnaire is analyzed. The stage will also combine the criteria that were found in the previous chapter in the literature review and the opinion from the consumer will also be included in designing the ergonomics lactating chair.

We can conclude that the design process is the critical process. The stage needs to have a proper planning and observation on the current designs of chairs available in the market The theory applied should be considered in order to achieve one of the functions of the ergonomics lactating chair itself which is to avoid the problem such as MSD.

## 3.3 Data Collection Method

All of the data must be collected and analyzed so that reliable information is gathered to reach the project's objectives. Data collected is very important for this project to identify the best design of an ergonomics lactating chair. Thus, the appropriate and reliable method in collecting data must be implemented in order to obtain accurate reading. There are two types of collecting data from the workers which are interviews and questionnaire.

Nemeth (2004) stated that Thomas Malone (1996) considers questionnaires and interviews helpful tools to obtain opinions, attitudes and preferences of those who have experience in a situation such as the hands-on use of experiment. This two methods can be used to obtain data from the workers.

Human factors research relies on the use of questionnaire to collect a variety of data in the development process (Nemeth, 2004). This means that questionnaire is more reliable from the interviews. Few advantages of using questionnaire compared to interviews has been listed by Nemeth(2004) by taking from Salvendy and Carayon (1997): their ease of use, their facility as a tool to collect quantitative data, their relatively low cost and the potential to collect information from any respondents who may be in separate locations and organizations.

Questionnaire is a research instrument consisting of a series of questions and other prompts for the purpose of gathering information from respondents. That way, more data you got more accurate results can be taken. Questionnaires have advantages over some other types of surveys in that they are cheap, do not require as much effort

from the questioner, and often have standardized answers that make it simple to compile data.

Interviews are a way to get in-depth and comprehensive information. They involve one person interviewing another person for personal or detailed information. Personal interviews are very expensive because of the one-to-one nature of the interview. Typically, an interviewer will ask questions from a written questionnaire and record the answers. Sometimes, the questionnaire is simply a list of topics that the research wants to discuss with an industry expert. Personal interviews are generally used only when subjects are not likely to respond to other survey methods.

### 3.3.1 Mail and Self-administered Questionnaires

In this type of survey, questionnaires are sent directly to respondents and it is by far and cheapest type of survey (Neuman, 2000). In this past, this type of survey was conducted primarily via the postal system, but with improvements in technology and the availability of email and the World Wide Web, questionnaires can now be administered electronically. This type of survey can therefore enable the targeting of very large samples either locally or over much wider geographical areas. This type of survey also offers the greatest level of anonymity, as there is no direct contact with respondents. This lack of direct contact also has the added advantage of eliminating interviewer bias (Neuman, 2000).

This type of survey is still the most popular and convenient method for model testing and refinement. In this instance, this method was selected as it satisfied the criteria relating to the need to target a large, geographically dispersed sample, in a very limited period.

### 3.3.2 Telephone Interview

Telephones interviews are another popular type of survey and may be thought of as a compromise between mail surveys and face-to-face interviews and therefore combine many of the advantages of each type (Sekaran, 2000). First in the list of

disadvantages is the fact that a high percentage of the population can be reached by telephone and this almost guarantees an intermediate response (Neuman, 2000). However, this also presents the possible disadvantage that it may not always be convenient for the target to respond to questions. Naturally, this type of survey tends to be more expensive than a mail survey. In addition, the interview periods must be short as it may not be convenient or cost effective to hold long interviews over the telephone.

### 3.3.3 Face-to-Face Interviews

This type of survey has the distinct advantage of providing the highest response rate compared to the other two types. In addition, this type of survey has all advantages of telephone interviews and with the added advantage of allowing for longer interview periods. This feature therefore provides the opportunity to ask all types of questions including very complex questions that could not otherwise be asked in a brief questionnaire. Further, the face-to-face interview is the only survey type that allows the interviewer to observe both the respondent in their element and their reactions to the question posed (Neuman, 2000). However, this type does have the disadvantage of having the highest cost, particularly with the large samples, in that interviews may need to be conducted by a number of researchers who may require to be paid some form of allowances.

From the research, this project used the questionnaires method. Questionnaire design is one of most critical stages in the research process (Zikmund, 2000). Good questionnaire design should focus upon three areas that were summarized in the table 3.1 (Sekaran, 2000). The principles are included the wording of the questions, the principle of measurement and general appearance of the questionnaire. Table 3.1 shows the principles related to questionnaire.

**Table 3.1:** The Principles Related to Questionnaire

| Areas | Descriptions |
|---|---|
| 1. The wording principles of the questions. | These principles relate to biases resulting from respondents' responses and the questionnaire itself. Consistent with these principles, the following factors were considered during the development of the questionnaire used in this study:<br>• The questionnaire used simple language to approximate the understanding level of the respondents.<br>• Closed questions with alternative answers were chosen as they help the respondents to make a quick answer.<br>• The purpose of each question was scrutinized to minimize unnecessary questions. |
| 2. The principle of measurement. | These principles are concerned with reliability and validity of data to be analyzed. Considering that the development of the questionnaire was based on principles of suggested above, combined with the use multi item scales, the 143 questionnaire used in this study could increase reliability and validity of the collected data (Pedhazur and Schmelkin, 1993). |
| 3. General appearance of the questionnaire. | An attractive and neat questionnaire with appropriate instruction, and a well arrayed set of questions and response alternatives will facilitate the respondents in understanding and answering the questions. However, the general appearance of the questionnaire is not an important aspect in this study, because the study employed structured interview for the data collection. |

### 3.3.4 Survey Instrument

This subchapter is about the study of the questionnaire of this project. The format of the questionnaires is a format consisting of 4 section with 17 items on ergonomics studies. The questionnaires will distribute to mothers because this project is focusing on the women who are breastfeeds their babies. Below is the subchapter included the justification of the questionnaires. The data should be collected for the purpose of analysis and helping in develops an ergonomics lactating chair.

#### 3.3.4.1 Justification of the Questionnaire Constructs

The questionnaires included multi items and variables. Section one contains two items of consumer's information, while section two contains 7 items of breastfeed details. Section three is body posture details consists of 5 items. Then, section four consists of three items on level of comfort for mothers during breast feeding process. This study focuses on three sections that are section B, C and D which will help to give the information for the improvement for the future design. The overall layout of interest in the questionnaire is shown in table 3.2.

**Table 3.2**: Overall layout for the questionnaire

| Section | Variable | Items |
|---|---|---|
| A | Correspondent Details | 3 |
| B | Breastfeed Details | 7 |
| C | Body Posture Details | 5 |
| D | Design Details | 25 |
| E | Comforts Details | 3 |
| | **TOTAL** | **43** |

#### 3.3.4.1.1 Section B

This section contains 7 questions. All questions in this section required the respondents to answer the question in the space provided. The 7 items are shown in table 3.3.

**Table 3.3:** Section B

| No. | Items | Justification |
|---|---|---|
| 1 | Duration for nursing | To know the time provided for breastfeed activities. |
| 2 | Plan to breastfeed | To know the time planning for mothers to breastfeed. |
| 3 | Side of breast used for breast feed | To know which side is frequently be used during breast feed. |
| 4 | Baby sleeping during breast feeding | To know whether the mother wait for the baby to sleep or not. |
| 5 | Time taken for the baby to sleep | To know the duration taken for the baby to sleep during the process. |
| 6 | Activities during breast feeding | To know what the mother usually do during the process. |
| 7 | Position used during breastfeed activities | To know the best position during breastfeed for example, sit, lay and stand. |

#### 3.3.4.1.2 Section C

This section included 5 questions related to the information for the design process. The questions required the respondents to circle their answers according to scale that being shown. The justification is shown in table 3.4.

**Table 3.4:** Section C

| No. | Items | Justification |
|---|---|---|
| 1 | Position during the breast feed | To know the posture during breastfeeding gives the respondents back pain (one of the causes of musculoskeletal disorders). |
| 2 | The regular position for each breast feed process | To know the regular posture during the breastfeeding. |
| 3 | Sitting recommended for breast feeding process | To know how many respondents using this posture during the activities. |
| 4 | Posture | To gather information whether if the posture is the factor that leads to MSD. |
| 5 | Arm position | To know the best position during breastfeeding. |

#### 3.3.4.1.3 Section D

This section consists of 25 questions accordingly to their own classification of parts. The aim is to determine the desired features of the correspondences in designing the ergonomics lactating chair. The justification is shown in table 3.5.

**Table 3.5:** Section D

| Part | No. | Items | Justification |
|---|---|---|---|
| **Headrest** | 1 | Existence of headrest | To know the preferences of having a headrest. |
| | 2 | Material for headrest | To know the type of material for the headrest. |
| | 3 | The function of headrest | To know the function of the headrest in giving comfortability. |
| | 4 | The shape of headrest | To know whether the U shape is preferable. |

**Table 3.5:** Continued

| | | | |
|---|---|---|---|
| | 5 | The shape and design of headrest | To know whether flat shape with wave texture is preferable. |
| **Backrest** | 1 | The material for the layer | To know the type of material for the cushion. |
| | 2 | The addition of air ventilation layer | To know whether air ventilation layer helping in removing heat from the backside of body. |
| | 3 | The addition of nano-technology fiber | To know the preferable of having thye fiber in increasing level of comfort. |
| | 4 | The existence of side wing | To determine the side wing give more support or not. |
| | 5 | The function of the backrest | To know whether the backrest can maintain the back at straight position or not. |
| | 6 | The function of the backrest | To know whether the backrest can absorb the shape of the back of the body. |
| | 7 | The height of the chair | To know the dimension for the height of the chair. |
| **Seat** | 1 | The layer of the seat | To know the best material for the layer of seat. |
| | 2 | The existence of spring layer in the cushion | To know whether spring layer is needed to absorb the shape of the buttock. |
| | 3 | The function of the seat | To know whether the seat can fully support the buttock or not. |
| | 4 | The cleanliness of the cushion | To know whether the layer that is easy to clean is preferable or not. |
| | 5 | The existence of temperature controller | To determine the needed of the temperature controller for heat removal. |
| **Armrest** | 1 | The function of the armrest | To know the function of the armrest to support the arm. |
| | 2 | The position of the armrest | To know the best position for the armrest. |
| | 3 | The design of the armrest | To know the best design for the armrest. |
| | 4 | The level of the armrest | To know the best level for the armrest. |
| **Base** | 1 | The size of the base | To know the dimension for the base for stability. |
| | 2 | The existence of spring | To know the needed for spring |

**Table 3.5:** Continued

| | | |
|---|---|---|
| | | in order to have a little swing. |
| | 3 | The weight of the chair | To know the best weight for the chair. |
| | 4 | The existence of footstep | To know the need for a footstep. |

#### 3.3.4.1.4 Section E

This section consists of three questions with the aim of information about the level of comfort felt by the mother during breast feeding process. The justification is shown in table 3.6.

**TABLE 3.6:** Section E

| No. | Items | Justification |
|---|---|---|
| 1 | Uncomfortable things during breast feeding process | To know the types of uncomfortable things during breast feeding process. |
| 2 | Action taken to increase the comfort level while breast feeding | To know the actions taken in order to increase the level of comfort during the process. |
| 3 | Suggestion of features to be added | To know the suggestions of features to be added in the design. |

## 3.4 Analysis Method for Questionnaires

The analysis for the questionnaires will be completed using the Microsoft Excel. Microsoft Excel is a spreadsheet-application written and distributed by Microsoft for Microsoft Windows and Mac OS X. It features calculation, graphing tools, pivot tables and a macro programming language called VBA (Visual Basic for Applications). It has been the most widely used spreadsheet application available for these platforms since version 5 in 1993. The software is suitable used in analyzed the data for the questionnaires. There are some benefits using the software which are it can keep record, the data can be displays using the graphs and to perform the calculations automatically.

## 3.5 The Simulation Testing

For the simulation process, this project will use the Algor™. The process involved the critical part only in order to predict its limitation due to the applied forces. This software is a computer simulation technique for modeling and analyzing the effects of mechanical loads and thermal stresses applied to a part and/or material used in a product or system. Algor™ or Finite Element Analysis (FEA) is a powerful method for identifying areas of stress concentration that are susceptible to mechanical or thermal failure before manufacturing and testing begin, thereby providing valuable information during product or system design and development, and reducing or eliminating the costs associated with materials scrap and rework. FEA has been used to analyze mechanical systems ranging in size from a portion of a microcircuit chip to a large space antenna. Therefore, we can determine the value of the maximum pressure that can be applied on the critical parts of the lactating chair.

## 3.6 Summary

This chapter is the description of the methodology that is applied during the project. It concludes every aspect of the application including the research design and the data collection methods which is questionnaires and a brief description of alternatives methods. This chapter also discusses on reasons for every method that is not being chosen.

# CHAPTER 4

# RESULTS AND DISCUSSION

## 4.1 INTRODUCTION

This chapter will discuss and focuses on the analysis of the results collected from the questionnaires that have been distributed among the 25 correspondents which all of them are mothers and have experience in breast feeding and also apart from that, we would also discuss on the analysis on the selected part of the design of the lactating chair using Algor software. The analysis of the answers from the questionnaires is important in order to improve the preliminary design of the lactating chair. The variations of answers from the selected correspondents will be evaluated using the features in Microsoft Excel to see the distribution of answers. Meanwhile, for the design, it will be analyzed and simulated using Algor software to determine the maximum distribution of forces that can be applied on the selected part of the lactating chair.

## 4.2 ANALYSIS OF QUESTIONNAIRES

The questionnaires have 5 sections labeled as A, B C, D and E. Each of the section consists of few questions and classified according to the sub- sections. The questionnaires do includes the correspondents' details, breastfeed details, body posture details, design details and also the comfort details and there would be pie chart representing the distribution of data for every sub- question.

### 4.2.1 Descriptive Statistics for section A (Correspondents' Details)

For the Section A, the questions focus on the details information of the correspondents. Table 4.1 shows the distribution of demographic factors of the correspondents such as their ages, weights and also their working status.

**Table 4.1:** Distribution of Demographic Factors

| Demographic | Category | Frequency | Percentage (%) |
|---|---|---|---|
| Age | 20-25 | 1 | 4 |
| | 26-30 | 5 | 20 |
| | 31-35 | 11 | 44 |
| | >35 | 8 | 32 |
| Weight | <40 | 1 | 4 |
| | 40-50 | 16 | 64 |
| | >50 | 9 | 36 |
| Working | Yes | 19 | 76 |
| | No | 6 | 24 |

#### 4.2.1.1 Correspondent's Age

From the first question, the result shows that the 44% or majority of the correspondent's age is in the range of 31- 35 years old followed by 32% of the above 35 years old, 20% of the 26- 30 years old range and finally 4% of the 20- 25 years old range. Figure 4.1 shows the percentage of the correspondent's age according to the range as stated in the questionnaire.

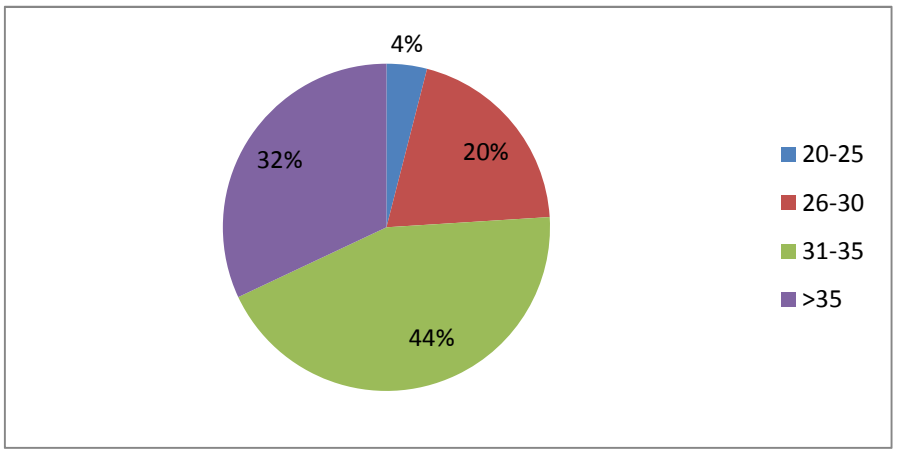



**Figure 4.1:** Correspondent's age

#### 4.2.1.2 Correspondents' Weight

For the next question, it shows that 61% of the correspondents are in 40-50 kg range followed by 35% of above 50 kg and 4% of below 40 kg. All of this weight data are important as it related to the analysis of maximum force that can be applied on the design of lactating chair. Figure 4.2 shows the percentage of the correspondent's weight.

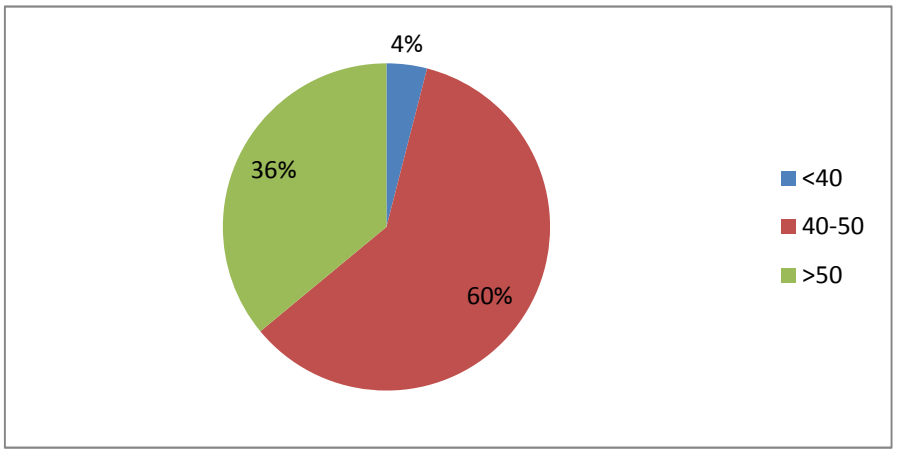



**Figure 4.2:** Correspondents' weight

#### 4.2.1.3 Correspondents' Working Activity

The third question for this section would determine the number of the working and not working mothers. The work activity does affect the breast feeding activity due to lack of time. From this question, it shows that 76% of the correspondents is working while the rest are not working. Figure 4.3 shows the percentage of correspondent's working activities.

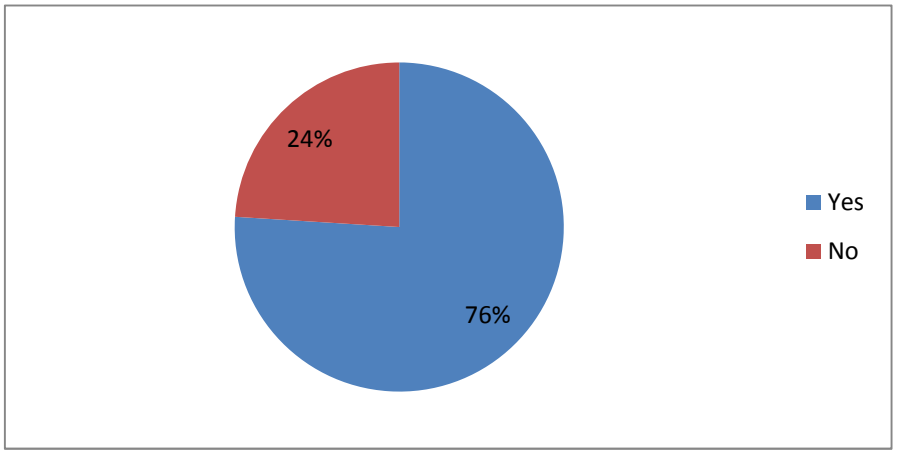



**Figure 4.3:** Correspondent's working activities

### 4.2.2 Descriptive results for section B ( Breastfeed Details)

For the section B, the correspondents need to answer to the questions on their breastfeed details. Table 4.2 shows the distribution of breastfeed details activities of the correspondents.

**Table 4.2:** Distribution of breastfeed details activities

| Question | Item | Frequency | Percentage (%) |
|---|---|---|---|
| B1 | 1-2 hours | 13 | 52 |
| | 2-3 hours | 11 | 44 |
| | 3-4 hours | 1 | 4 |
| | >4 hours | 0 | 0 |

**Table 4.2:** Continued

| | | | |
|---|---|---|---|
| B2 | 1day- 1 year | 6 | 24 |
| | 1 year- 1½ year | 16 | 64 |
| | 1½ year- 2 year | 3 | 12 |
| | >2 year | 0 | 0 |
| B3 | Right side | 0 | 0 |
| | Left side | 0 | 0 |
| | Equal side | 25 | 100 |
| B4 | Yes | 10 | 40 |
| | No | 15 | 60 |
| B5 | <1 hour | 9 | 36 |
| | 2- 3 hour | 1 | 4 |
| | >3 hour | 0 | 0 |
| B6 | Reading | 10 | 40 |
| | Watching television | 11 | 44 |
| | Listening to music | 3 | 12 |
| | Others | 1 | 4 |
| B7 | Stand | 0 | 0 |
| | Sit | 22 | 88 |
| | Lay | 3 | 12 |

#### 4.2.2.1 Nursing in 24 hours

For the first question in this section, it asks about the period of nursing in 24 hours done by the correspondents. It shows that 52% of the correspondents have 1- 2 hours period of nursing in 24 hours. 44% of them have 2- 3 hours period of nursing and 4% being lucky to spend 3- 4 hours to do their nursing with their baby. This situation happen because of most of the correspondents are working and do not have the opportunity to do the nursing longer. Figure 4.4 shows the percentage of the period of nursing spent by the correspondents.

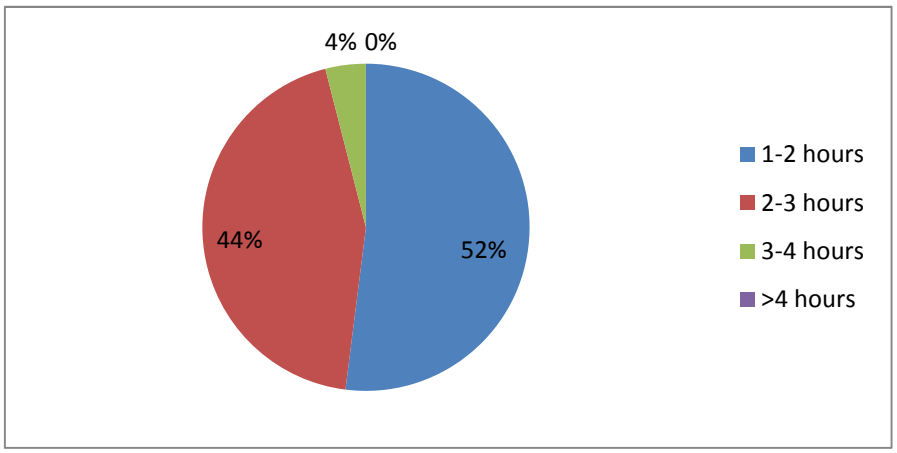



**Figure 4.4:** Nursing in 24 hours

#### 4.2.2.2 Plan of duration to breastfeed

The next question is about the period of time planned by the correspondents for them to breastfeed their babies. This plan related to size of family, the career of the mother and also the use of formula milk. The biggest portion which is 64% of them planned to breastfeed for 1 year- 1 ½ year, next would be the period of 1 day- 1 year with 24%, then 1 ½ year- 2 year with 24% and none planned for more than 2 years. Figure 4.5 shows the percentage of period planned by the correspondents to breastfeed their babies.

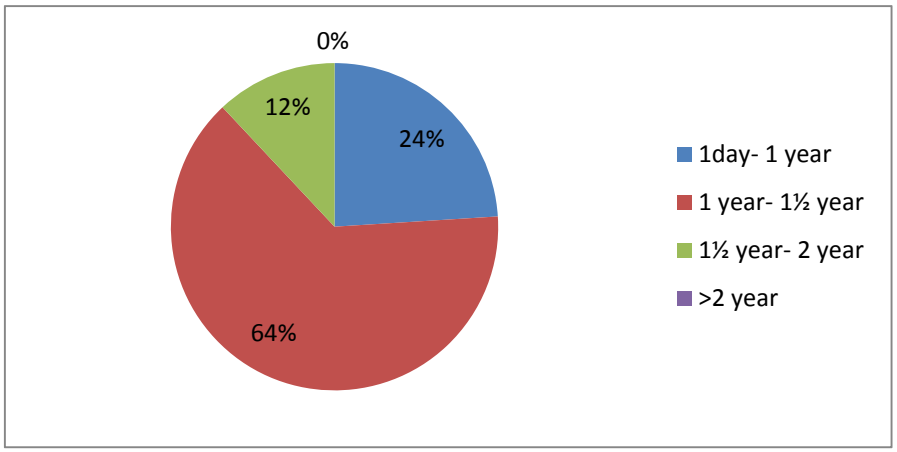



**Figure 4.5:** Time planned for breastfeed

#### 4.2.2.3 Side of breasts frequently used during breastfed

This question focuses on the side of breast used during breast feeding. All of the correspondents responded to equal side of breasts used. This meant that the lactating chair need to be designed to have both armrests to support the correspondents arm while breast feeding as the features will be a platform for the mother to lay their arms while holding their babies. Figure 4.6 shows the percentage of the side of breasts used by the correspondents to breastfeed their babies.

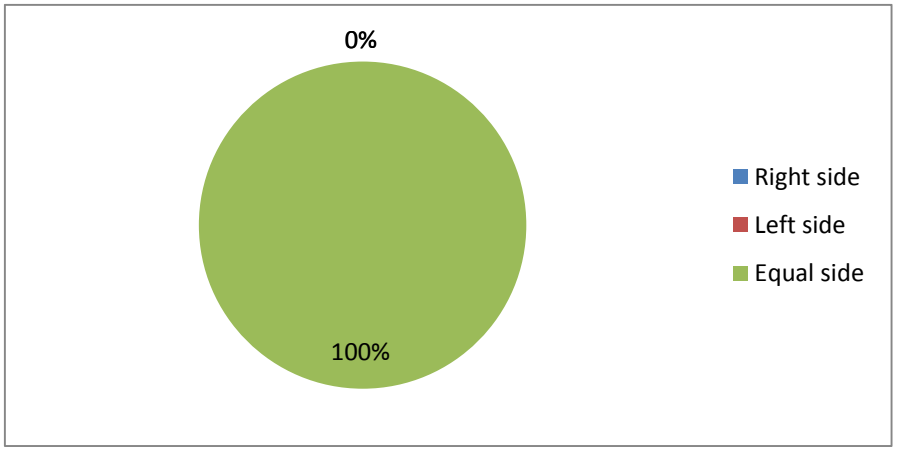



**Figure 4.6:** Side of breast used to breastfeed

#### 4.2.2.4 Wait for the baby to sleep during breast feeding

This questions will determine whether the mothers wait for their babies to sleep or not while breast feeding. From the question it shows that 60% form the correspondents do not wait for their babies to sleep as they finished breast feeding when the babies stop milking. Meanwhile 40% of them do wait for the babies to sleep and if that is the routine, the design of the chair has to be fixed with something that can allow the mothers to have a little swing in order to make it easier and faster for the baby to sleep. Figure 4.7 shows the percentage of correspondents who wait and do not wait for the babies to sleep while breastfeeding.

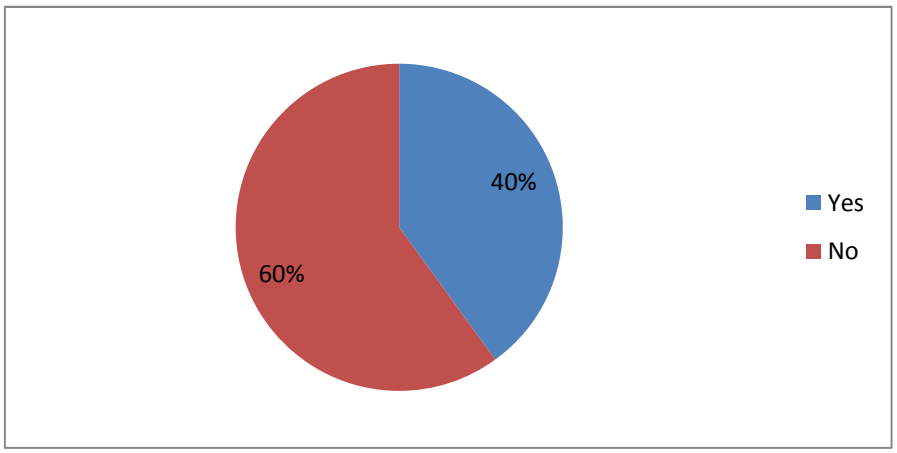



**Figure 4.7:** Correspondents waiting for the babies to sleep

#### 4.2.2.5 Time taken for the baby to sleep

The next question is about the time taken for the baby to sleep. This questions only be answered by the correspondents who say yes to the previous questions asking whether they wait for their babies to sleep or not during breast feeding. From the question it shows that 90% of the correspondents agree that their babies take less than 1 hour to get slept and the rest take about 2-3 hour to get slept. Figure 4.8 shows the percentage of time taken for the baby to sleep.

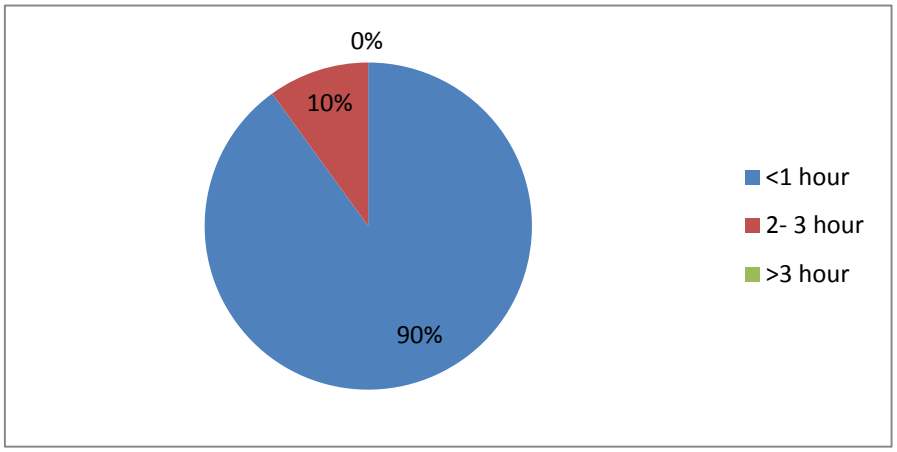



**Figure 4.8:** Time taken for baby to sleep

#### 4.2.2.6 Activity during breast feeding process

This question is about the activity done by the correspondents during the breast feeding process. From the question it shows that 44% of the correspondents prefer to watch television during breast feeding, 40% spend time reading, 12% listen to musics and 4% refer to other activities. Figure 4.9 shows the percentage of activities during breast feeding.

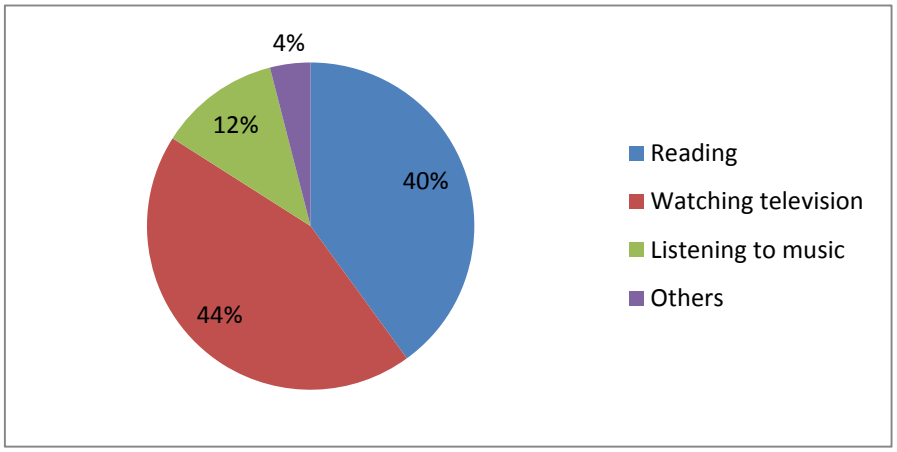



**Figure 4.9:** Activities during breast feeding

#### 4.2.2.7 Position during breast feeding

This question is asking on position applied by the correspondents while breast fed their babies. These position will determine the level of MSD faced by them. 88% of them breastfed their babies while sitting and the rest breastfed while laying. This has shown the importance of designing a specific chair with ergonomics approach for lactating purpose as majority of them prefer to sit in order to breastfed. Figure 4.10 shows the percentage of positions applied during breast feeding.

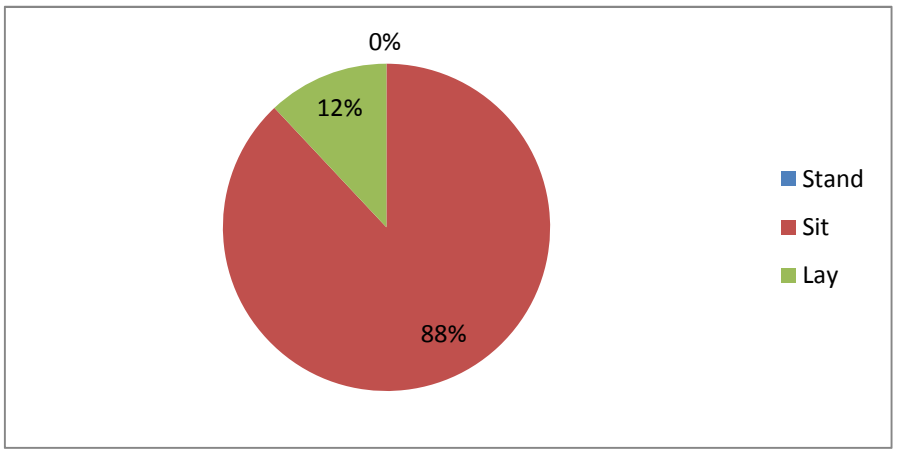



**Figure 4.10:** Positions during breast feeding

### 4.2.3 Descriptive answers for section C (Body Posture)

For the Section C, the correspondents need to answer to questions related to their body postures. Table 4.3 shows the distribution of body posture details of the correspondents.

**Table 4.3**: Distribution of body posture details

| Section/Part | Question | Strongly disagree | | Disagree | | Unsure | | Agree | | Strongly agree | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | N | % | N | % | N | % | N | % | N | % |
| C | 1 | 1 | 4 | 0 | 0 | 0 | 0 | 16 | 64 | 8 | 32 |
| | 2 | 0 | 0 | 2 | 8 | 2 | 8 | 21 | 84 | 0 | 0 |
| | 3 | 0 | 0 | 1 | 4 | 2 | 8 | 14 | 56 | 8 | 32 |
| | 4 | 0 | 0 | 3 | 12 | 7 | 28 | 14 | 56 | 1 | 4 |
| | 5 | 0 | 0 | 0 | 0 | 6 | 24 | 18 | 72 | 1 | 4 |

#### 4.2.3.1 Back pain during breast feeding

The first question in this section is about the existence of back pain as one of the MSD symptoms as the result of the position applied during the breast feeding process. 64% of them agreed that the position during the breastfed gives them back pains, 32% strongly agreed with the statement and 4% strongly disagreed with the statement. This has shown that we need to design an ergonomics chair in order to reduce the possibility of having back pains. Figure 4.11 shows the percentage of correspondents who having backpain during breast feeding.

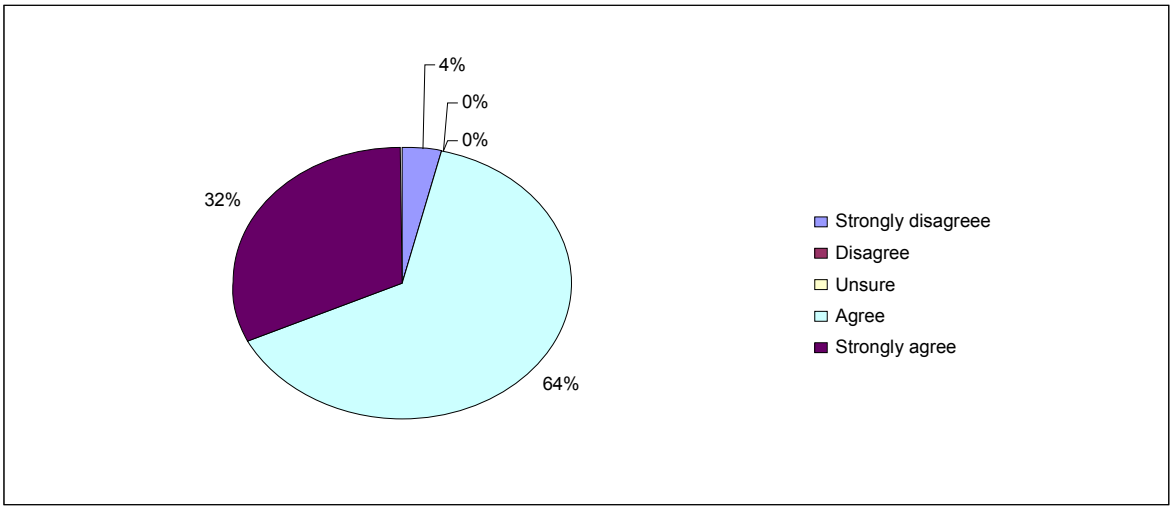



**Figure 4.11:** Correspondents having backpain during breast feeding

#### 4.2.3.2 Same position during each breast feeding

The next question is asking whether the correspondents use the same position during breast feeding or not. From the collected data, 84% of them agree that they use the same position during each breastfeeding process. 8% of them are unsure or might forgot whether they use the same position or not and also 8% of them disagree thay they use the same position. The same position used related to the level of comforts they had and if they keep on using the same position, it is a sign of they are comfort with it. Figure 4.12 shows the percentage of the same position applied during breast feeding.

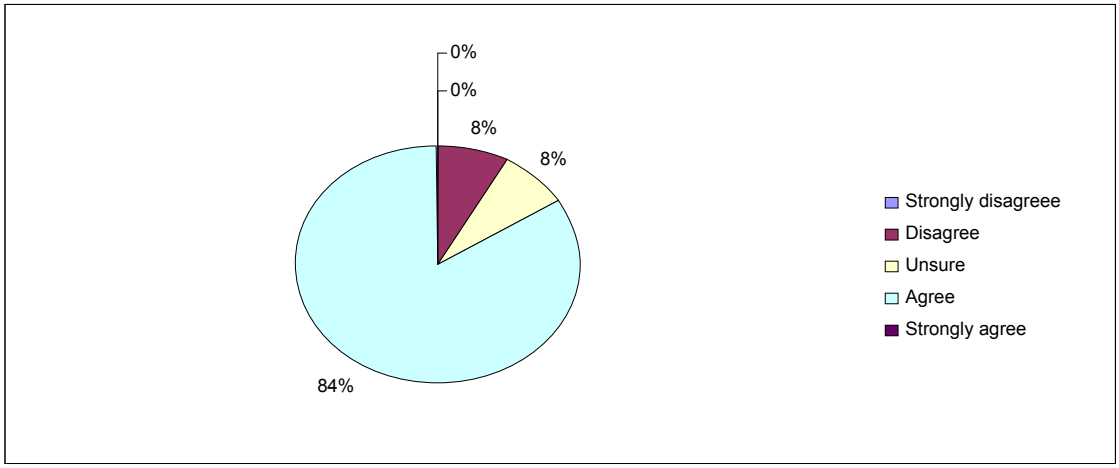



**Figure 4.12:** Same position during breast feeding

#### 4.2.3.3 Sitting is the best position for breast feeding

The next question is about sitting is the best position for breast feeding. The answers from the question shows that 56% of the correspondents agree that sitting is the best position. Meanwhile, 32% of them are strongly agree that sitting is the best position, 8% is unsure and only 4% disagree with the statement. This has shown that the sitting is very preffered by the correspondents and this show the needs of an ergonomic chair to fulfill their preferences. Figure 4.13 shows the percentage of sitting as the best position during breast feeding.

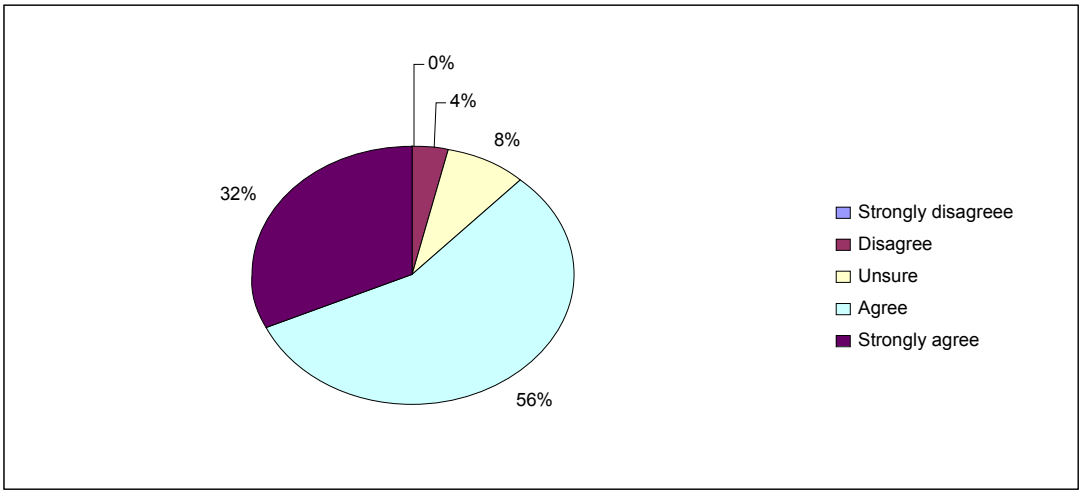



**Figure 4.13:** Sitting as the best position

#### 4.2.3.4 Body needs to be bent during breast feeding

The next question is about whether the body need to be bent during breast feeding or not. The answers shows that 56% of the correspondents agree that they need to bent at least a little bit in order to make the process smoother. Besides that, 28% of them is unsure whether they bent or not, 12% disagree and 4% strongly agreed. Figure 4.14 shows the percentage of bending the body during breast feeding.

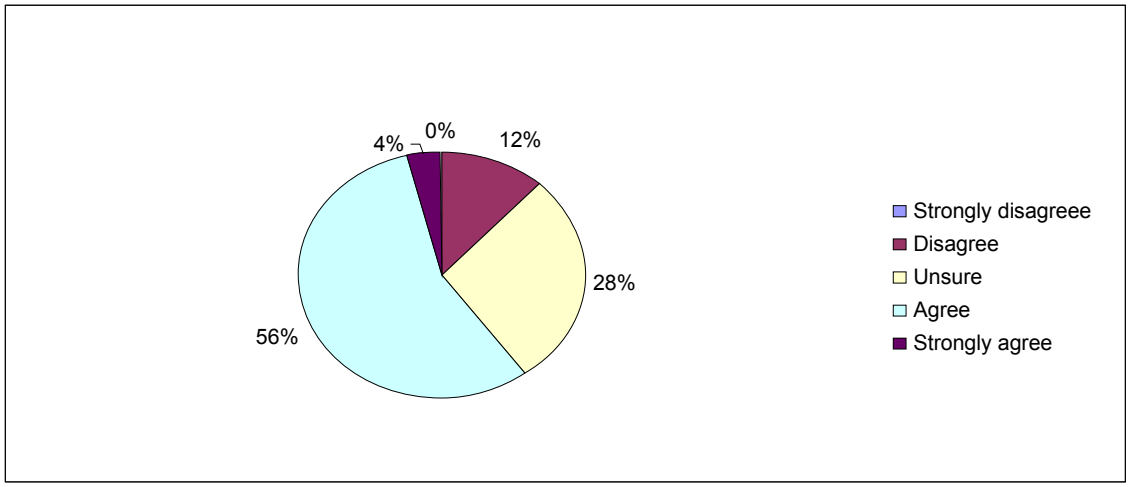



**Figure 4.14:** Bending the body during breast feeding

#### 4.2.3.5 Arm in rest position during breast feeding

The next question is about whether the arms of the correspondents located between 100- 110° or in rest position during breast feeding process. The answers show that 72% agree that they rest their arm while breastfed, 24% is unsure and 4% strongly agreed with the statement. Figure 4.15 shows the percentage of having arm in rest position during breast feeding.

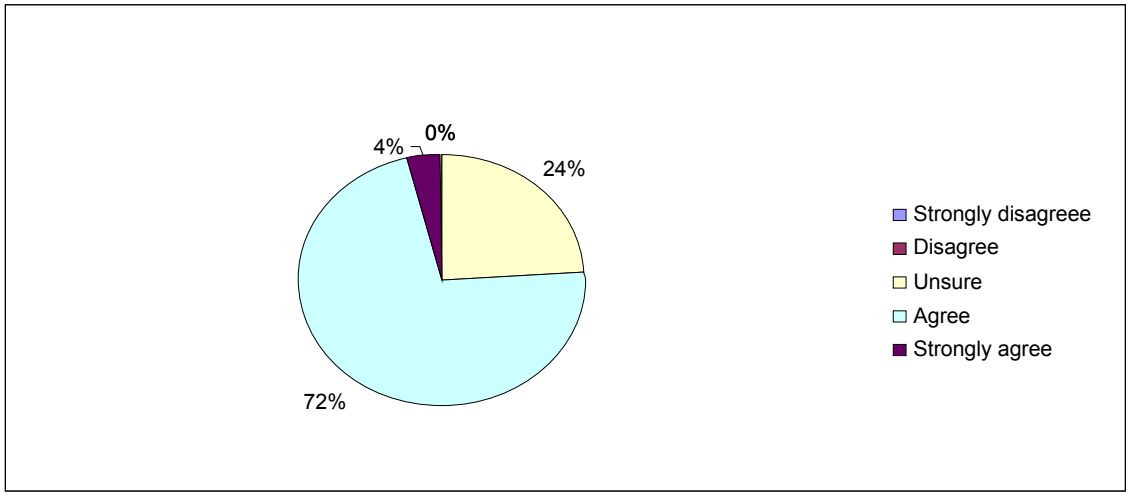



**Figure 4.15:** Arm in rest position during breast feeding

### 4.2.4 Descriptive answers for section D1 (Design for headrest)

For the section D1, the correspondents need to answer to questions related to design for the headrest. Table 4.4 shows the distribution of design of headrest details.

**Table 4.4:** Distribution of design of headrest details

| Section/Part | Question | Strongly disagree | | Disagree | | Unsure | | Agree | | Strongly agree | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | N | % | N | % | N | % | N | % | N | % |
| D/Headrest | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 13 | 52 | 12 | 48 |
| | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 16 | 64 | 9 | 36 |
| | 3 | 0 | 0 | 0 | 0 | 1 | 4 | 15 | 60 | 9 | 36 |
| | 4 | 0 | 0 | 2 | 8 | 16 | 64 | 5 | 20 | 2 | 8 |
| | 5 | 0 | 0 | 1 | 4 | 5 | 20 | 17 | 68 | 2 | 8 |

### 4.2.4.1 Existence of headrest

The next question is about the existence of the headrest is prefered or not by the correspondents. 52% of them agree that the design should include headrest in it and 48% of them strongly agreed with it. This has shown the needed of a headrest for them to lay their heads and get a support at the part. Figure 4.16 shows the percentage of correspondents's feedback about the existence of headrest in the design of the lactating chair.

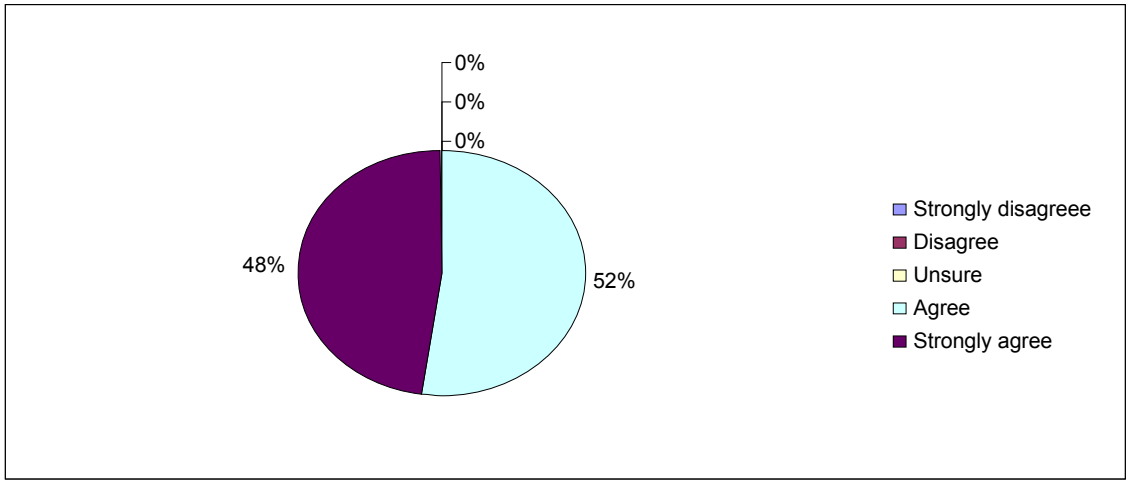



**Figure 4.16:** Existence of headrest

### 4.2.4.2 Headrest is made of soft cushion material

The next question is about the material for the headrest which is soft cushion material. This will ensure that it can give high level of comfort for the users. The answer shows that 64% of the correspondents agree that the headrest should be made of soft cushion material. The statement become stronger with 31% of them strongly agree with it. Figure 4.17 shows the percentage of preferences of the correspondents towards headrest which is made of soft cushion.

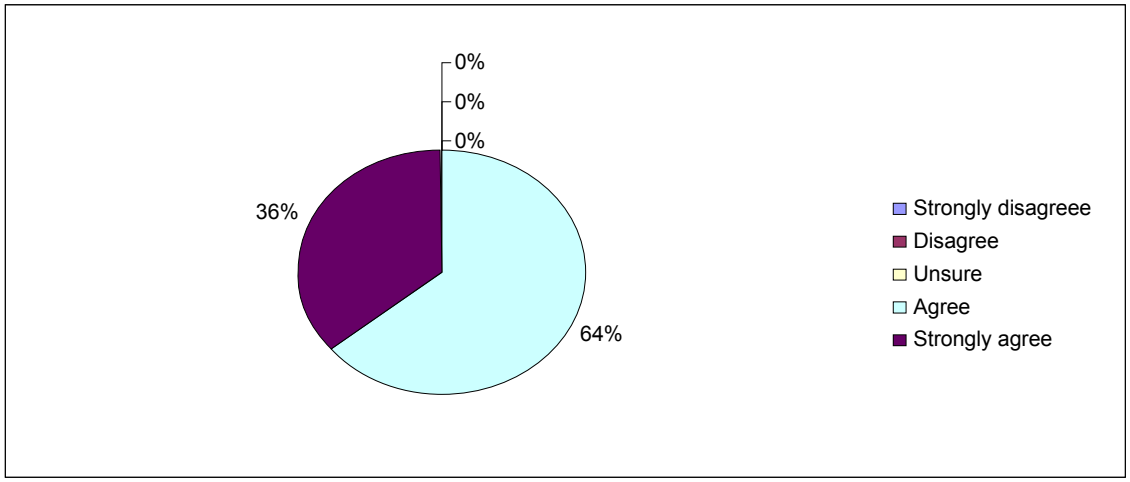



**Figure 4.17:** Headrest made of soft cushion

### 4.2.4.3 Headrest is fully support the back of the head

The next question is about whether the headrest is going to give a full support to the back of the head or not. The data shows that 60% of the correspondents agree that they will have full support at the back of the head with the help of the headrest. 36% of correspondents strongly agree with the statement and only 4% of them being unsure with the function of the headrest. Figure 4.18 shows the percentage correspondents's feedback on the function of the headrest which is to fully support the head.

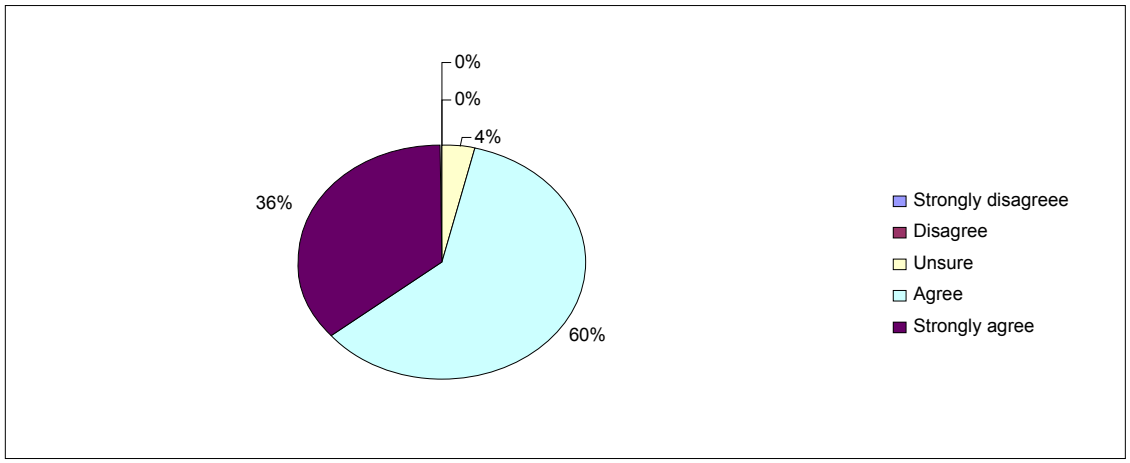



**Figure 4.18:** Headrest fully support the head

#### 4.2.4.4 Headrest is in U- shape

The next question is about the design of the headrest which is in U- shape covering from the left side ear to the ear on the other side. The answers shows that 64% of the correspondents unsure with the design as they might feel that it will limit the movement of their head. 20% of them agree with the use of the shape, 8% strongly agreed with the shape and also 8% disagree with the use of the shape. Figure 4.19 shows the percentage of preferences of the correspondents to the headrest with U- shape.

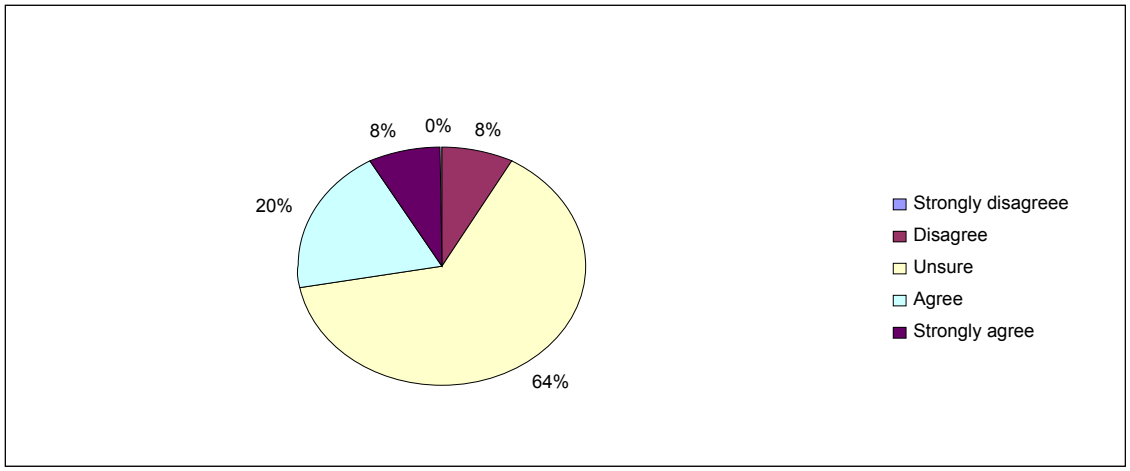



**Figure 4.19:** Headrest in U- shape

#### 4.2.4.5 Headrest in flat shape

The next question is about the design of the headrest which is in flat shape like an ordinary headrest with addition of wave texture that will absorb the shape of the head. The answers shows that 68% of the correspondents agree with the flat shape headrest as it is simpler but promises higher level of comforts. 20% of them is unsure with use of the shape, 8% strongly agreed with the shape and 4% strongly disagreed with the use of the shape. Figure 4.20 shows the percentage of preferences of the correspondents to the headrest with flat shape.

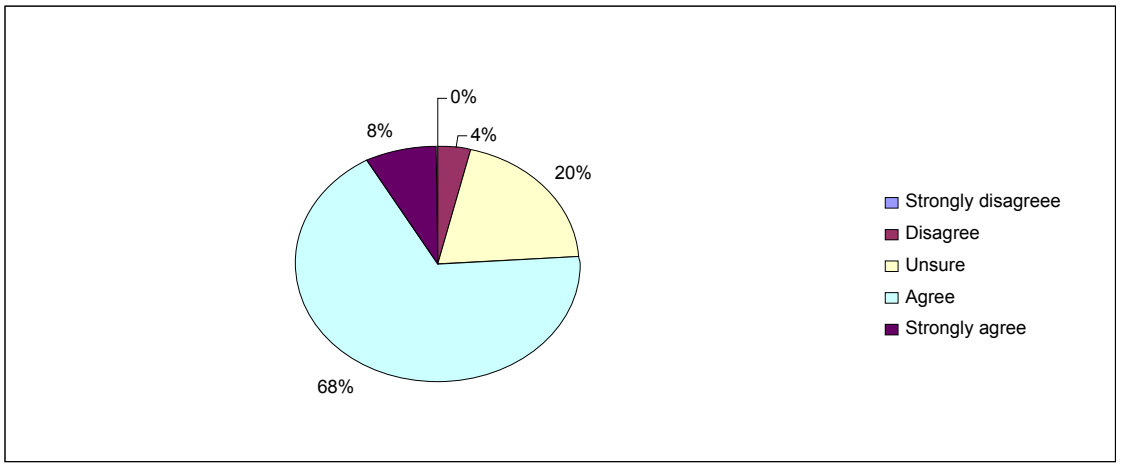



**Figure 4.20:** Headrest in flat shape

### 4.2.5 Descriptive answers for section D2 (Design for backrest)

For the section D2, the correspondents need to answer to questions related to design for the backrest. Table 4.5 shows the distribution of design for backrest details.

**Table 4.5:** Distribution of design for backrest details

| Section/Part | Question | Strongly disagree | | Disagree | | Unsure | | Agree | | Strongly agree | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | N | % | N | % | N | % | N | % | N | % |
| D/Backrest | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 14 | 56 | 11 | 44 |
| | 2 | 0 | 0 | 1 | 4 | 1 | 4 | 14 | 56 | 9 | 36 |
| | 3 | 0 | 0 | 0 | 0 | 3 | 12 | 17 | 68 | 5 | 20 |
| | 4 | 0 | 0 | 1 | 4 | 1 | 4 | 22 | 88 | 1 | 4 |
| | 5 | 0 | 0 | 0 | 0 | 4 | 16 | 18 | 72 | 3 | 12 |
| | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 15 | 60 | 10 | 40 |
| | 7 | 0 | 0 | 0 | 0 | 3 | 12 | 19 | 76 | 3 | 12 |

#### 4.2.5.1 Backrest is layered with soft cushion material

The first question of this section on the design of the backrests is about the using of soft cushion material for the backrest itself. This will ensure that it can absorb the shape of the back. The answer shows that 56% of the correspondents agreed that the backrest should be layered with soft cushion material. The statement becomes stronger with 44% of them strongly agreed with it. Figure 4.21 shows the percentage of preferences of the correspondents towards backrest which layered with soft cushion.

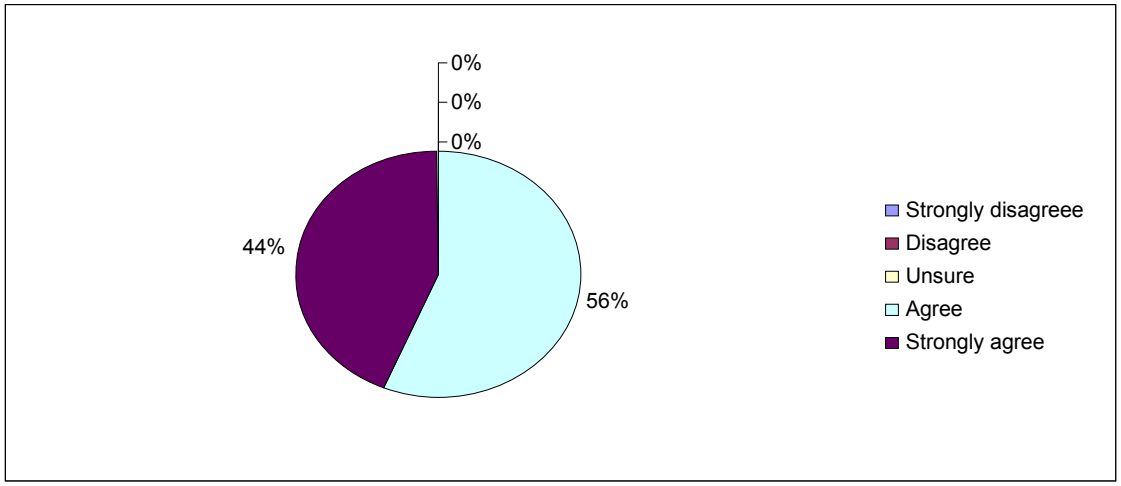



**Figure 4.21:** Backrest layered with soft cushion

#### 4.2.5.2 Backrest's cushion has air ventilation layer

The next question is about the addition features of air ventilation layer at the backrest part. This features will enable the air trapped between the surface of the backrest and the back of the body being circulated. The answer shows that 56% of the correspondents agreed with use of the layer. This becomes stronger when 36% of them strongly agreed with it. 4% of them unsure and also 4% of them disagree with use of the layer. Figure 4.22 shows the percentage of preferences of the correspondents towards backrest which has air ventilation layer.

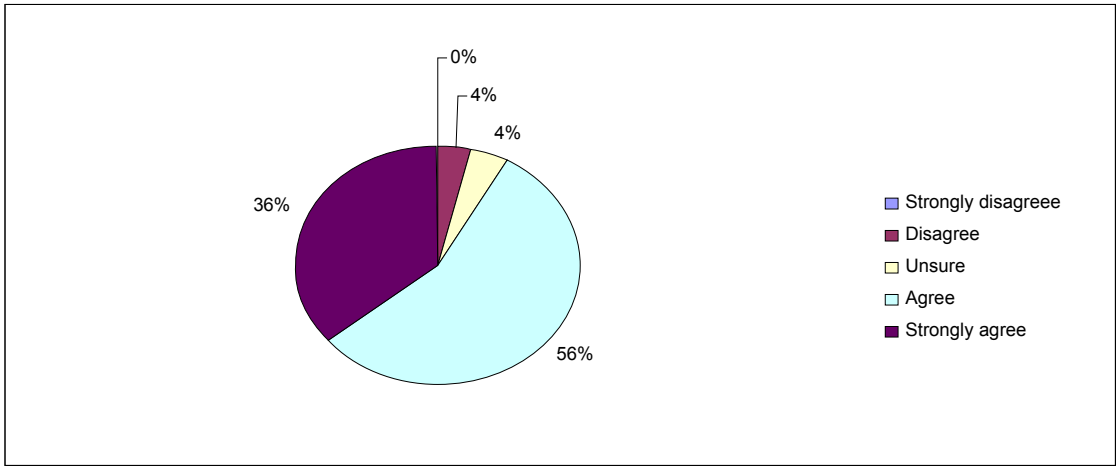



**Figure 4.22:** Backrest has air ventilation layer

### 4.2.5.3 Backrest layered with nano- technology fiber

The next question is about the addition features of nano- technology fiber at the backrest part. This features will increase the air ventilation at the surface on the backrest. The answers shows that 68% of the correspondents agreed to the addition of the fiber. This becomes stronger when 20% of them strongly agreed with it. Only 12% of them unsure on the purpose of using the fiber. Figure 4.23 shows the percentage of preferences of the correspondents towards backrest which has nano- technology fiber.

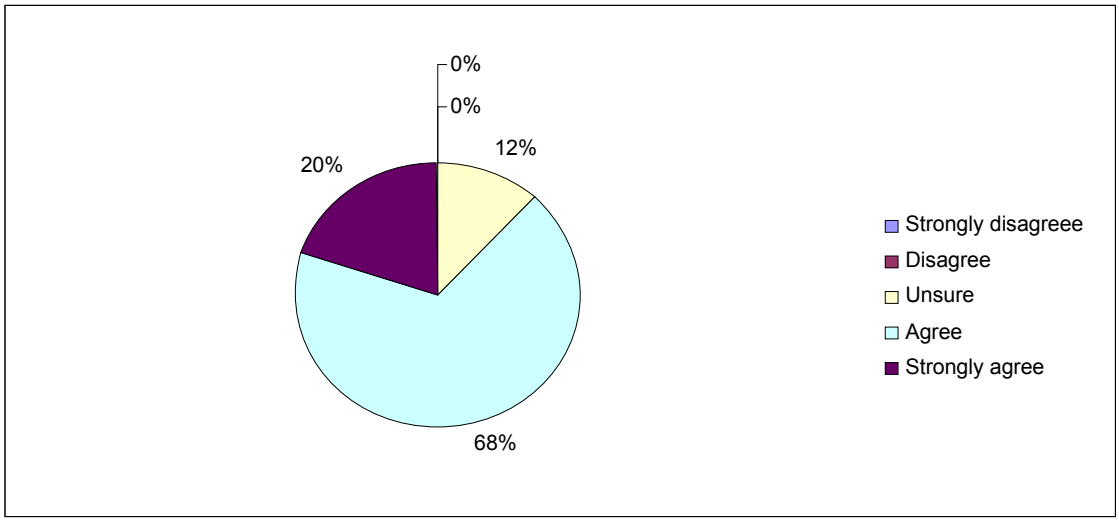



**Figure 4.23:** Backrest layered with nano- tech fiber

#### 4.2.5.4 Backrest has side wing to give more support

The next question is about the backrest having side wings to give more support to the user and will hold the side of the body. The answer shows that 88% of the correspondents agreed to the existence of the side wings. 4% of them strongly agreed with it, 4% is unsure and 4% of them disagree with the side wings. Figure 4.24 shows the percentage of preferences for backrest which has side wings.

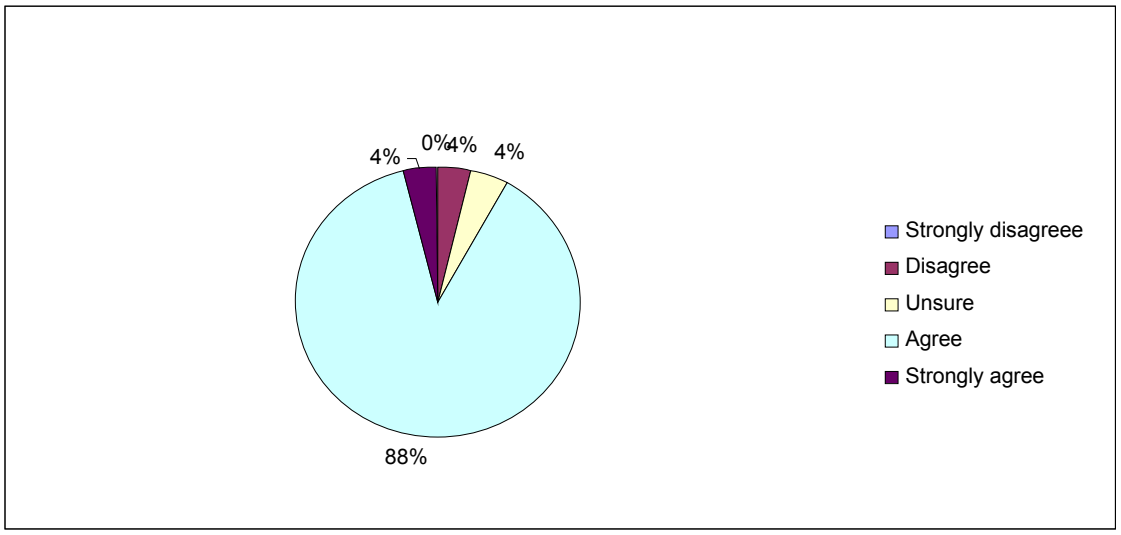



**Figure 4.24:** Backrest has side wings

#### 4.2.5.5 Backrest can maintain the back at 90° position

The next question is about the function of the backrest in maintaning the back at 90° position. This is important to avoid the user from having MSD due to inproper backrest that is fail to maintain the spine at straight position. From the data collected, 72% of the correspondents agreed to the function of the backrest, 12% strongly agreed and 16% of them are unsure. Figure 4.25 shows the percentage of the correspondent's feedback towards the function of the backrest which is can maintain the back of the body to be straight.

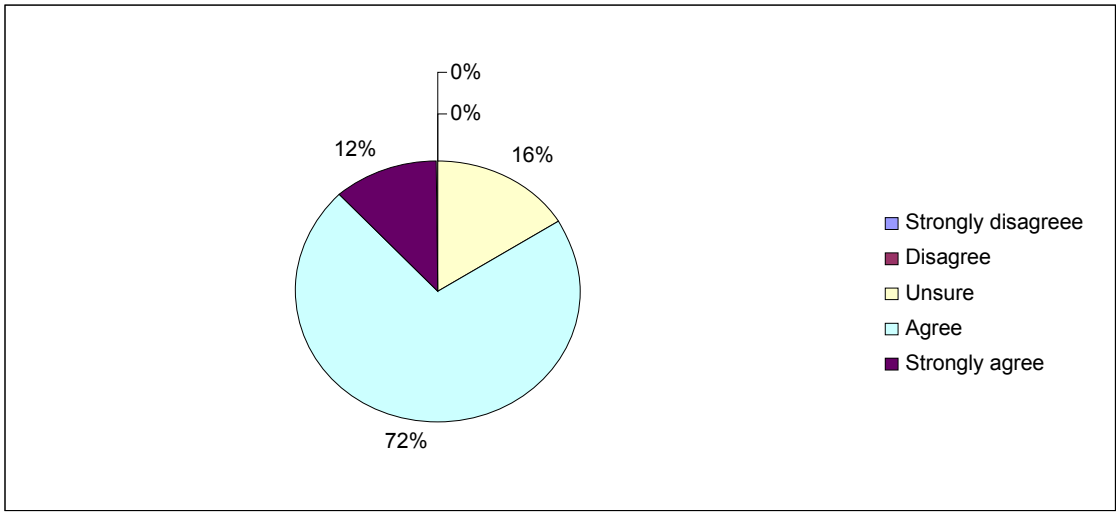



**Figure 4.25:** Backrest can maintain the body to be straight

### 4.2.5.6 Cushion can absorb the shape of the back

The next question is about the cushion can absorb the shape of the back. This is important as the cushion will reshape according to the shape of the back but at the same time maintaning the back at a straight position. From the data, 60% of the agreed with function of the cushion. And this statement proven to be important as 40% of them strongly agreed with it. Figure 4.26 shows the percentage of the feedback towards the function of a cushion which is can absorb the shape of body.

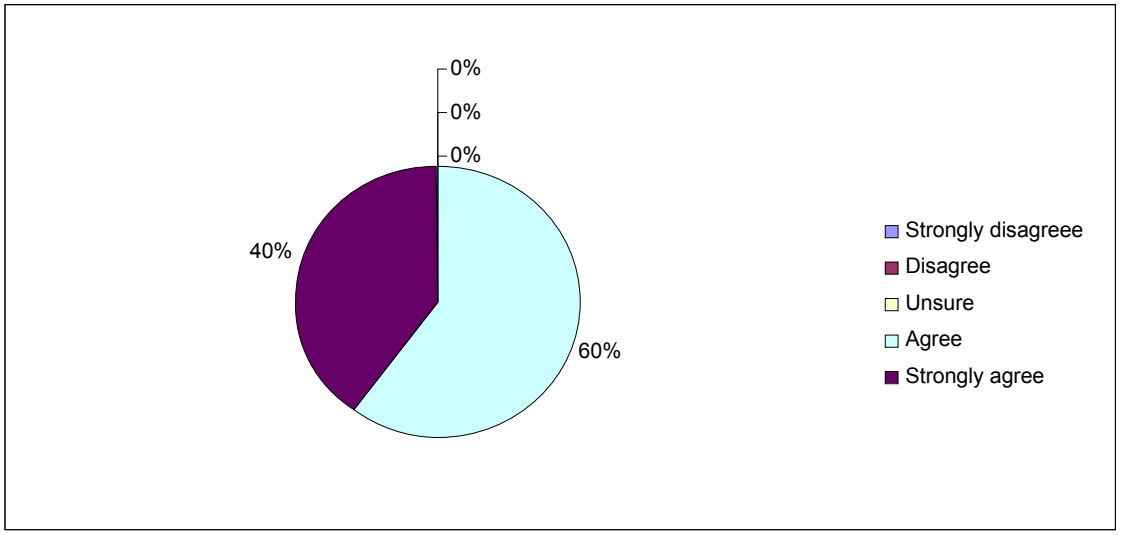



**Figure 4.26:** Cushion can absorb the shape of body

### 4.2.5.7 Height of the chair is equal to the length from toe to head

The next question is about the height of the chair. It supposed to be equal to the length measured from the toe to the head when we sit on a chair. From the answer, 76% agreed with the dimension of measurement, 12% strongly agreed and 12% unsure of it. Figure 4.27 shows the percentage of the question asks about the height of the chair equal to length of toe to head.

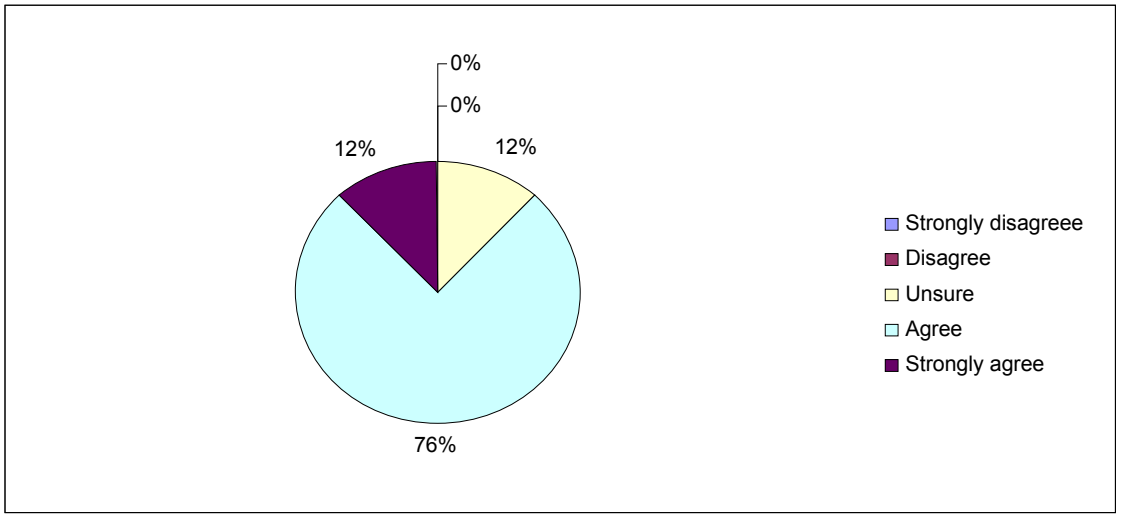



**Figure 4.27:** Height of the chair equal to length of toe to head

### 4.2.6 Descriptive answers for section D3 (Design for seat)

For the section D3, the correspondents need to answer to questions related to design for the seat of the lactating chair. Table 4.6 shows the distribution of design for seat details.

**Table 4.6**: Distribution of design for seat details

| Section/Part | Question | Strongly disagree | | Disagree | | Unsure | | Agree | | Strongly agree | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | N | % | N | % | N | % | N | % | N | % |
| D/Seat | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 8 | 32 | 17 | 68 |
| | 2 | 0 | 0 | 1 | 4 | 2 | 8 | 18 | 72 | 4 | 16 |
| | 3 | 0 | 0 | 0 | 0 | 1 | 4 | 18 | 72 | 6 | 24 |
| | 4 | 0 | 0 | 0 | 0 | 1 | 4 | 18 | 72 | 6 | 24 |
| | 5 | 0 | 0 | 2 | 8 | 6 | 24 | 15 | 60 | 2 | 8 |

#### 4.2.6.1 Seat is layered with thick and soft cushion

The first question of this section on the design of the seat is about the using of thick and soft cushion material for the seat. This will ensure that it can absorb the shape of the buttock and cope with the weight of the body. The answer shows that 68% of the correspondents strongly agreed that the seat should be used those type of cushion. It seems to be certain to use the type of the material for the seat as 32% agreed with it. Figure 4.28 shows the percentage of preferences of having seat which is layered with soft cushion.

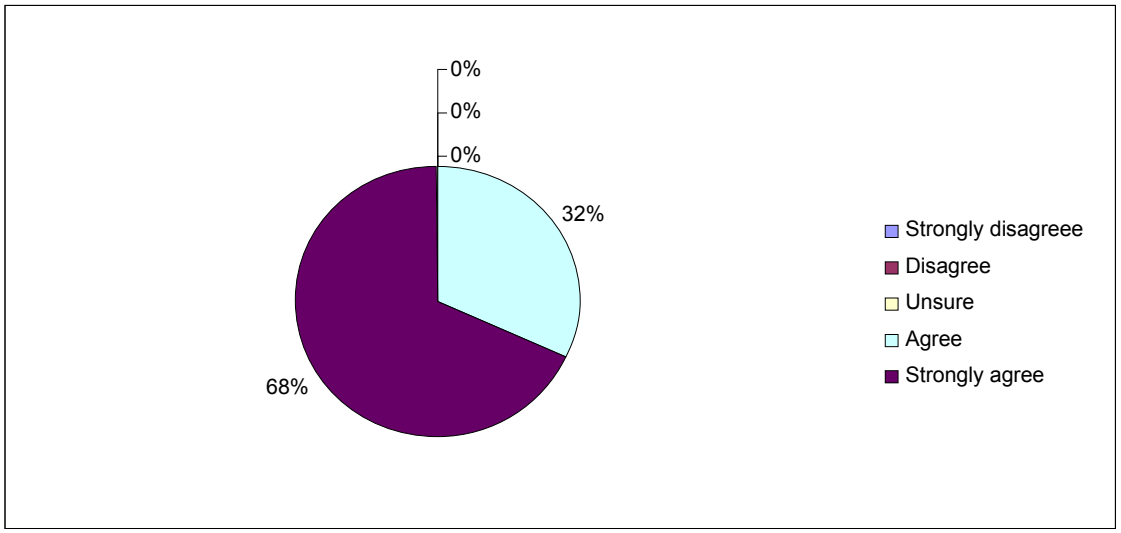



**Figure 4.28:** Seat is layered with soft cushion

#### 4.2.6.2 Seat has spring layer

The next question is about the addition of spring layer in the seat. The purpose of having the spring layer is to absorb the shape of the buttock effectively. The answer shows that 72% of the correspondents agreed with the addition of the spring layer. 16% of them strongly agreed, 8% unsure and 4% of them disagree with the use of the spring layer. Figure 4.29 shows the percentage of preferences of having a seat which has spring layer.

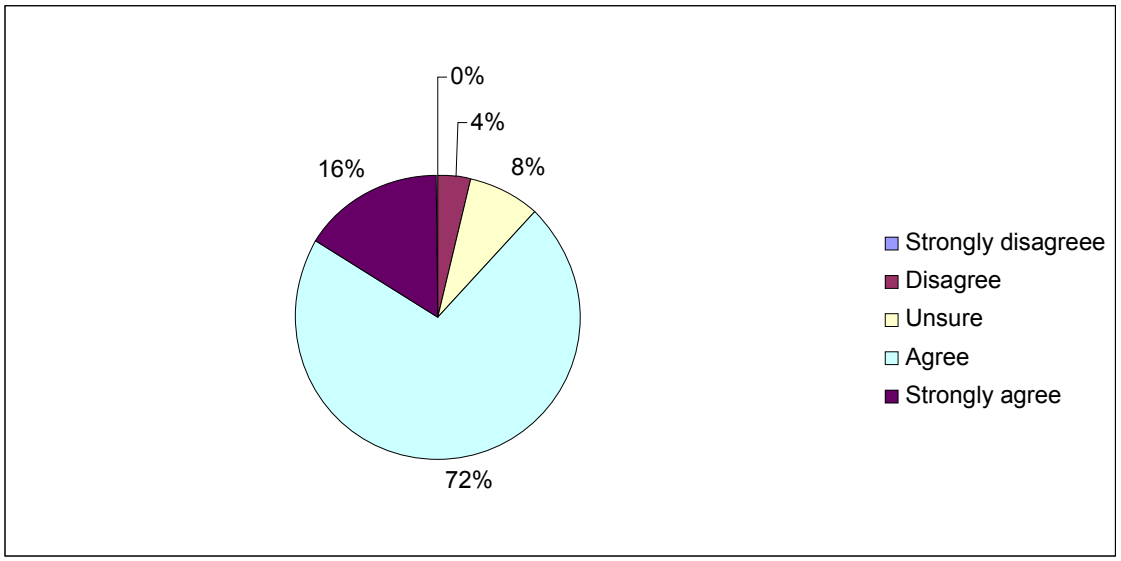



**Figure 4.29:** Seat has spring layer

#### 4.2.6.3 Seat can fully support the buttock

The next question is about whether the seat is going to give a full support to the buttock or not. The data shows that 72% of the correspondents agreed that they need a seat that can fully support their buttock as it is one of the most important part in having a chair. 24% of correspondents strongly agreed with the statement and only 4% of them being unsure with the function of the seat. Figure 4.30 shows the percentage of the feedback towards the function of a seat which is can fully support the buttock.

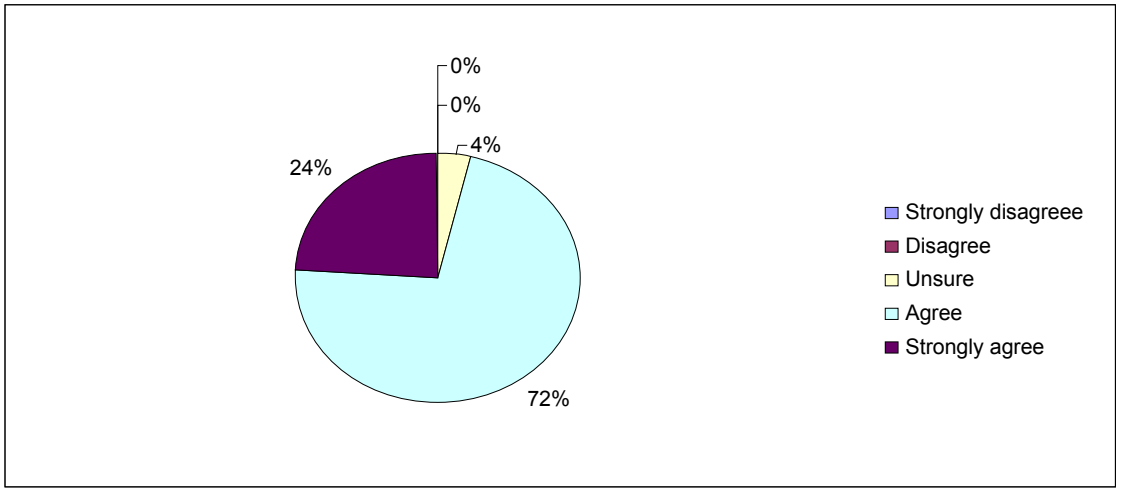



**Figure 4.30:** Seat fully support the buttock

#### 4.2.6.4 Seat's cushion is easy to clean

The next question is about the seat's cushion is easy to be cleaned. This is related to the type of material used for the outer layer of the seat. It will be easy to clean if the material can cope with water and at the same time do not absorb it. The data shows that 72% of the correspondents agreed that they need a chair with a seat that is easy to be cleaned in case if there is spills of any fluid such water and also any other mess. 24% of them strongly agreed with the statement and only 4% unsure about it. Figure 4.31 shows the percentage of preferences of having a seat's cushion which is easy to be cleaned.

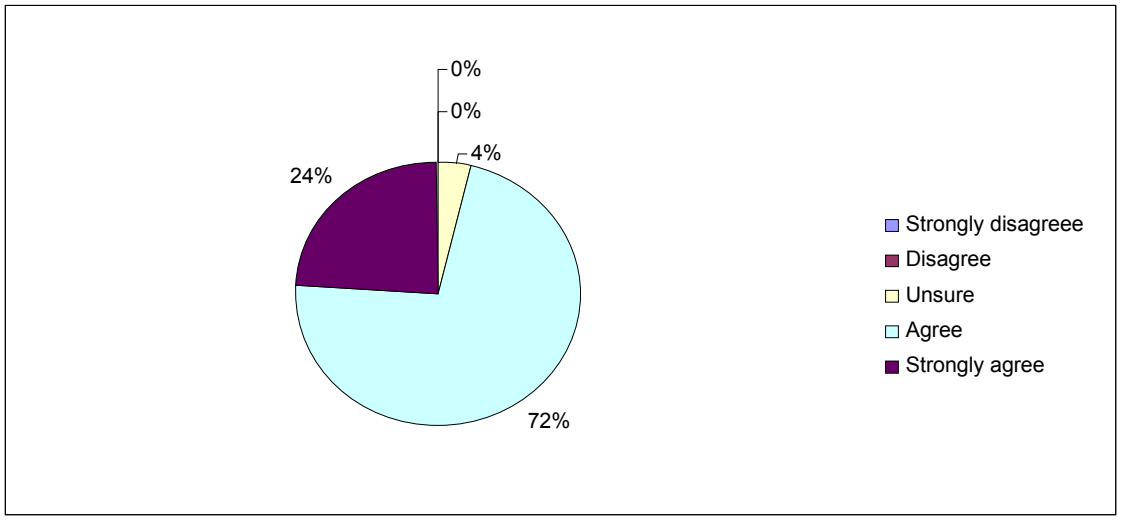



**Figure 4.31:** Seat's cushion easy to be cleaned

#### 4.2.6.5 Seat has a temperature controller for heat removal

The next question is about the extra features added to the chair which is the temperature controller device fix under the surface of the seat. The function is to remove the heat produced underneath the buttock while seating and especially if the heat gathered together around the area it will make the user feel uncomfortable. From the data, 60% agreed with the addition of the features, 24% unsure, 8% strongly agreed and 8% disagreed with it. Figure 4.32 shows the preferences of having a seat which has a temperature controller.

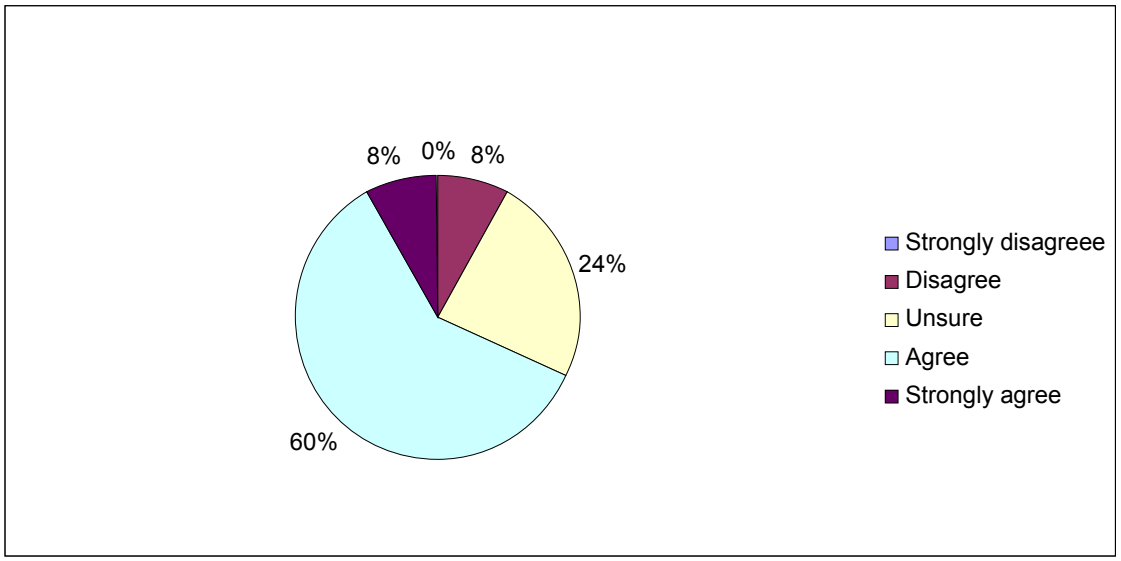



**Figure 4.32:** Seat has temperature controller

### 4.2.7 Descriptive answers for section D4 (Design for armrest)

For the section D4, the correspondents need to answer to questions related to the design of armrest for the lactating chair. Table 4.17 shows the distribution of design for armrest details.

**Table 4.7:** Distribution of design for armrest details

| Section/Part | Question | Strongly disagree | | Disagree | | Unsure | | Agree | | Strongly agree | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | N | % | N | % | N | % | N | % | N | % |
| D/Armrest | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 15 | 60 | 10 | 40 |
| | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 19 | 76 | 6 | 24 |
| | 3 | 0 | 0 | 0 | 0 | 3 | 12 | 16 | 64 | 6 | 24 |
| | 4 | 0 | 0 | 0 | 0 | 4 | 16 | 19 | 76 | 2 | 8 |

#### 4.2.7.1 Existence of armrest

The next question is about the existence of armrest is prefered or not by the correspondents. 60% of them agreed that the design should include armrest in it and 40% of them strongly agreed with it. This has shown the needed of a armrest for them to lay their hands and get a support at the part especially while holding their babies. Figure 4.33 shows the percentage of feedback of the correspondents towards the existence of armrest in the design of the lactating chair.

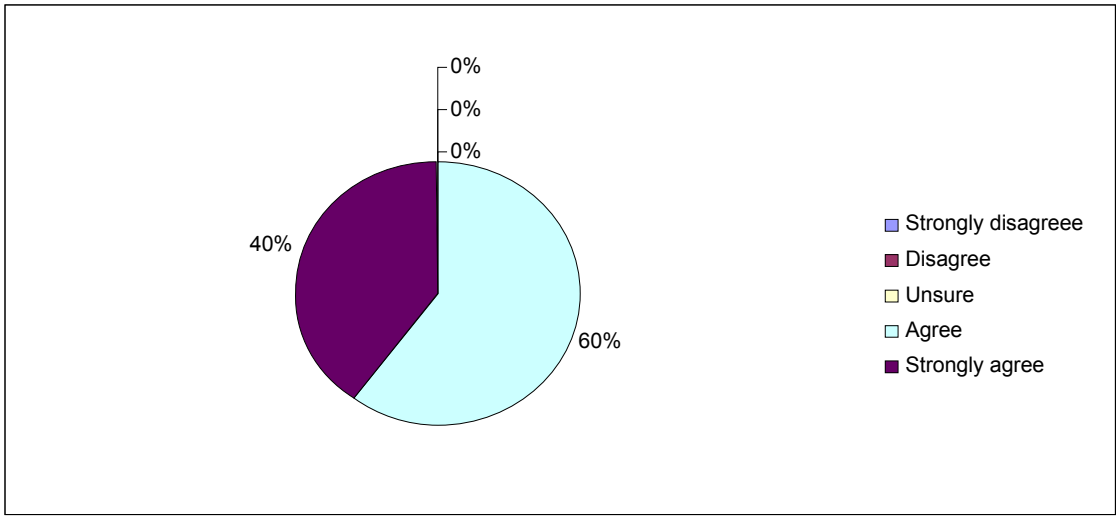



**Figure 4.33:** Existence of armrest

#### 4.2.7.2 Armrests are at both side of chair

The next question is about the armrests being located at the both side of the chair to support both of the arms as analyzed before, 100% of the correspondents used both side of the breasts so both of the arms would be used to hold the baby repeatingly. The answer shows that 76% of the correspondents agreed with the armrest located at the both side of the chair and 24% of them strongly agreed with it. Figure 4.34 shows the percentage of preferences of having the armrest at the both side of the chair.

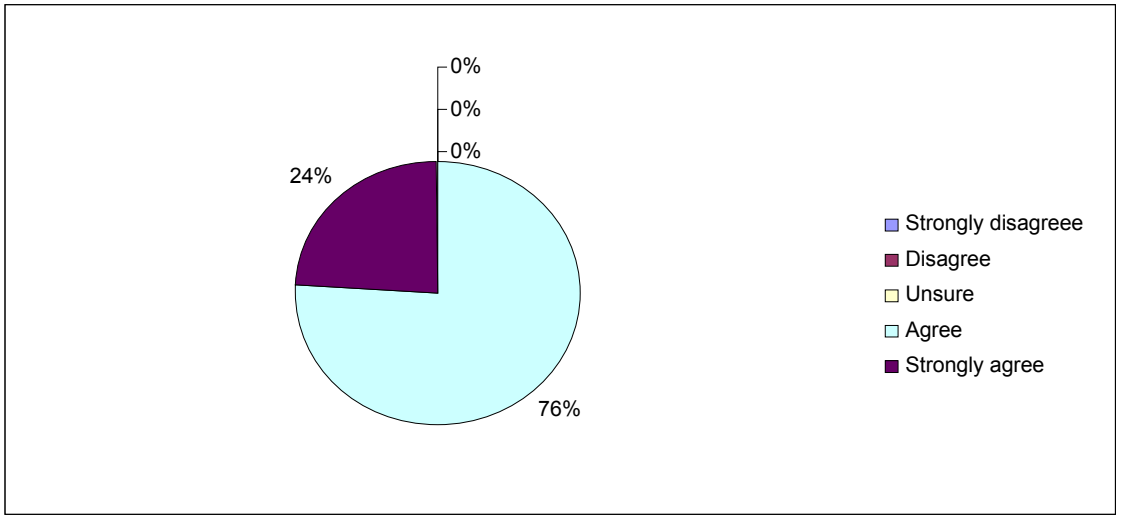



**Figure 4.34:** Armrest at the both side of chair

### 4.2.7.3 Armrest is layered with soft cushion material

The next question of this section is about the using of soft cushion material for the armrest. This will increase the level of comforts and reduce the tense of holding the baby for a long period of time while breast feeding. The answer shows that 64% of the correspondents agreed that the armrest should be layered with soft cushion material. The statement becomes stronger with 24% of them strongly agreed with it while only 12% of them unsure with it. Figure 4.35 shows the percentage of preferences of having the armrest layered with soft cushion.

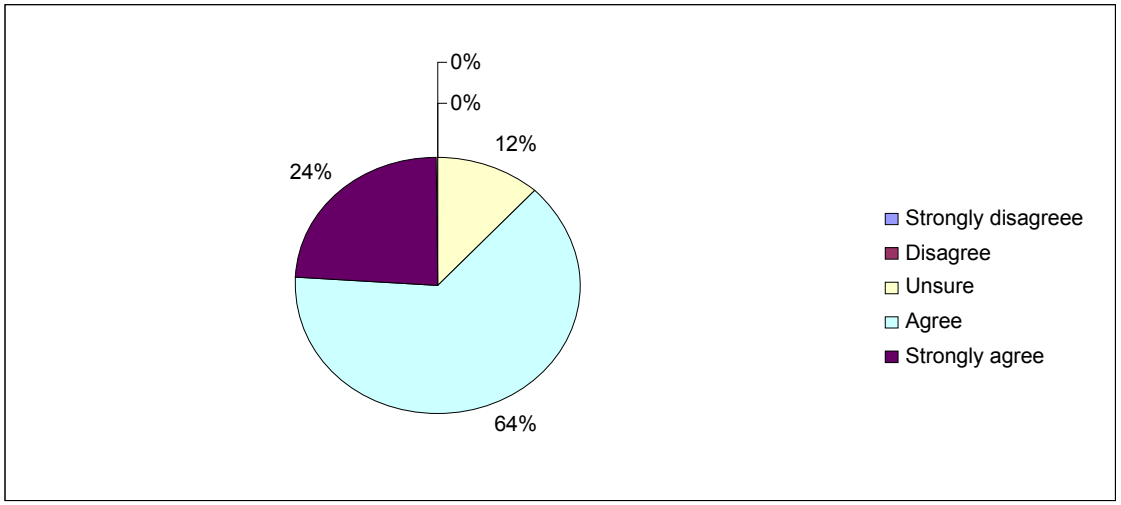



**Figure 4.35:** Armrest is layered with soft cushion

#### 4.2.7.4 Armrest is at the level of 90° of the arm

The next question is about the armrest located at the level of 90° of the arm or perpendicular to the arm. This is because we want to avoid the user from bent their arms to much while holding the baby as it might be tiring and can bring to MSD when the arm is not properly supported. The answer shows that 76% of the correspondents agreed with the level of the armrest, 16% of them unsure and 8% of them stronlgy agreed with the statement. Figure 4.36 shows the percentage of feedback towards armrest condition which is perpendicular to the arm while breast feeding.

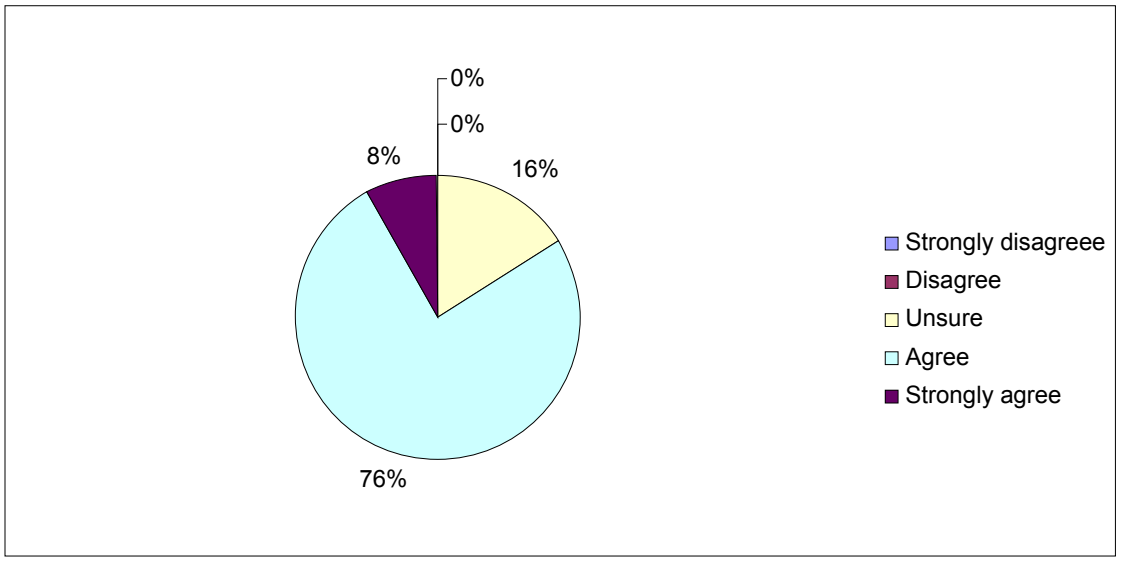



**Figure 4.36:** Armrest is perpendicular to arm

### 4.2.8 Descriptive answers for section D5 (Design for base)

For the section D5, the correspondents need to answer to questions related to design for the base of the lactating chair. Table 4.8 shows the distribution of design for base details.

**Table 4.8:** Distribution of design for base details

| Section/Part | Question | Strongly disagree | | Disagree | | Unsure | | Agree | | Strongly agree | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | N | % | N | % | N | % | N | % | N | % |
| D/Base | 1 | 0 | 0 | 1 | 4 | 1 | 4 | 15 | 60 | 8 | 32 |
| | 2 | 0 | 0 | 0 | 0 | 2 | 8 | 19 | 76 | 4 | 16 |
| | 3 | 0 | 0 | 0 | 0 | 2 | 8 | 12 | 48 | 11 | 44 |
| | 4 | 0 | 0 | 11 | 44 | 3 | 12 | 10 | 40 | 1 | 4 |

#### 4.2.8.1 Base wide for stability

The next question is about the wide of the base for stability. As we know biggest area of base would promised higher stability as it can cope with more loads. From the answer, 60% of the correspondents agreed that they want a wide base for their chair. 32% of them strongly agreed with it while 4% of them unsure and 4% disagreed. Figure 4.37 shows the percentage of feedback of the correspondents towards a wide base.

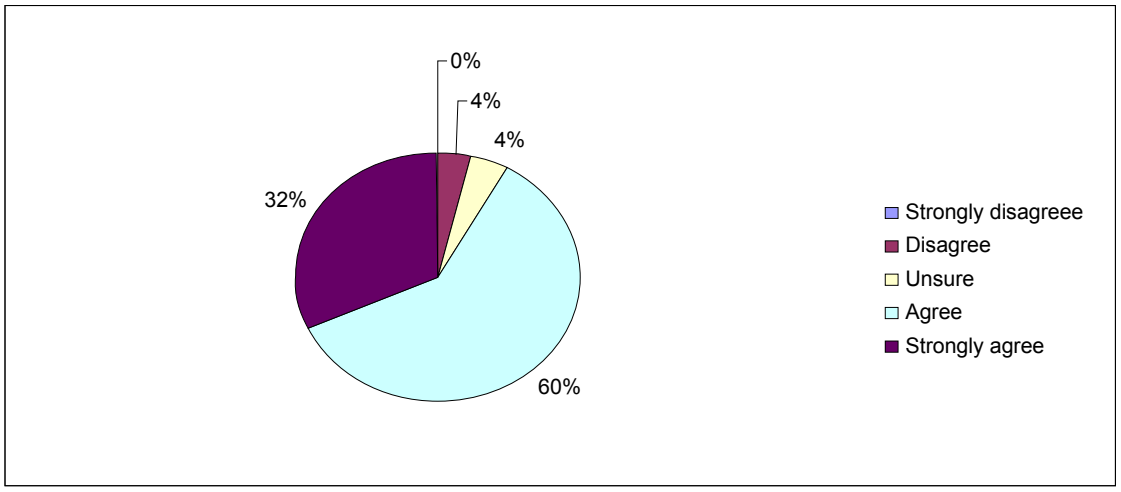



**Figure 4.37:** Base is wide

#### 4.2.8.2 Spring for a little swing

The next question is about the use of spring for the mothers to make a little swing and make the process of the baby to sleep faster and easier. The spring would be located between the seat and the base. Before this, the analysis show that 40% of the correspondents do wait for their babies to get slept and 90% of the babies takes about less than 1 hour to get slept. This process would be easier with the help of the spring. From the data of this question, 76% agreed with the use of the spring, 16% strongly agreed and only 8% of them unsure with it. Figure 4.38 shows the percentage of having spring for a little swing.

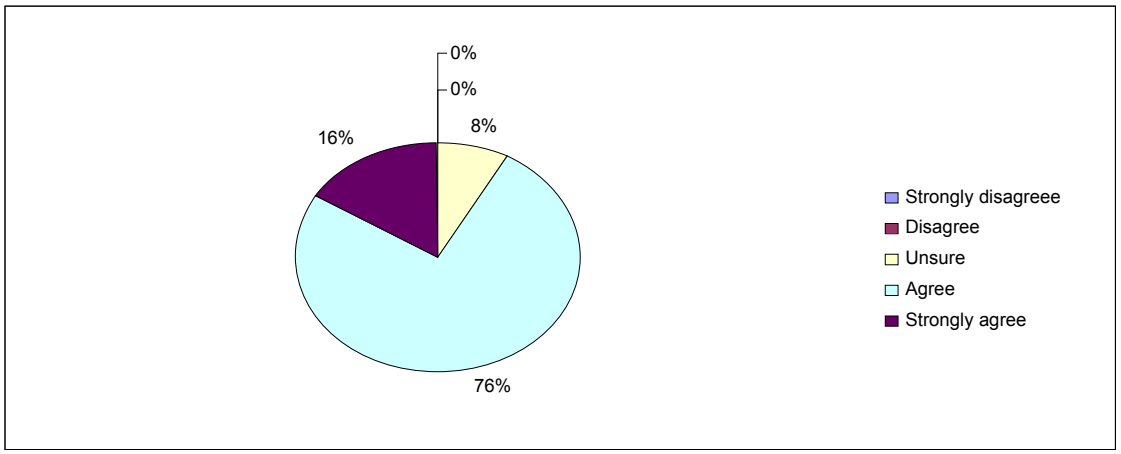



**Figure 4.38:** Spring for little swing

### 4.2.8.3 The chair is lightweight and easy to carry

The next question is about the weight of the chair and also the mobility of it. The chair would use lighter material for the frames and this would make it lightweight and easy to be carried. This is important in order to reduce the load of works for the mothers to manage besides taking care of their babies. 48% of them agreed that they need a lightweight chair and this is supported by 44% of them who strongly agreed with it. Only 8% of them unsure about using a lightweight chair and they might not think of removing the chair anywhere. Figure 4.39 shows the percentage of having a lightweight chair.

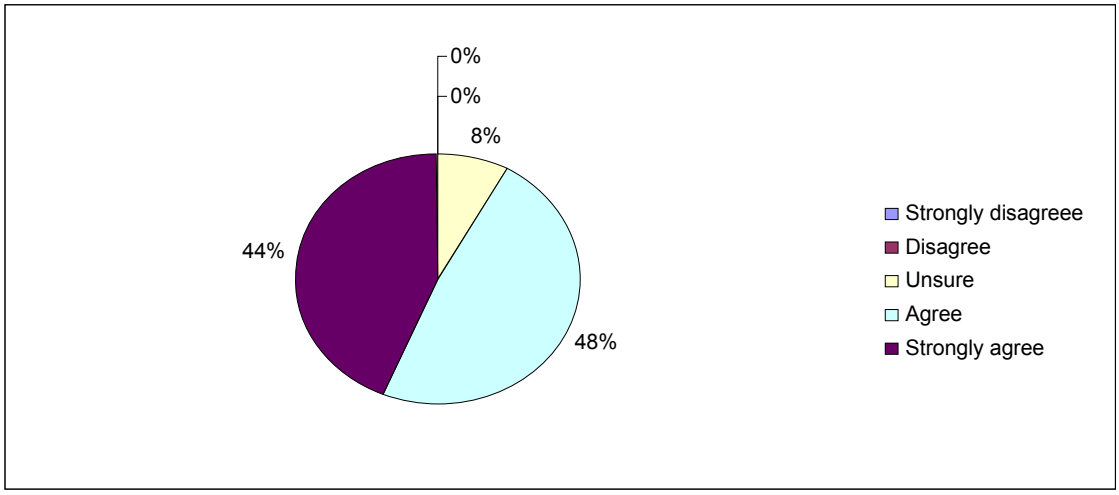



**Figure 4.39:** Chair is lightweight

#### 4.2.8.4 The base has a footstep

The next question is about the existence of footstep on the base itself. The footstep is for the mothers to put their footts on while breast feeding. This will ensure that they would be totally supported with comforts starting from their foots until their heads. From the answer, 44% of them disagreed with it and they prefer their foots to be free without any holder that might limit their movements. 40% of them do agreed, 12% unsure and only 4% strongly agreed with the use of the footstep. Figure 4.40 shows the percentage of having a footstep at the base.

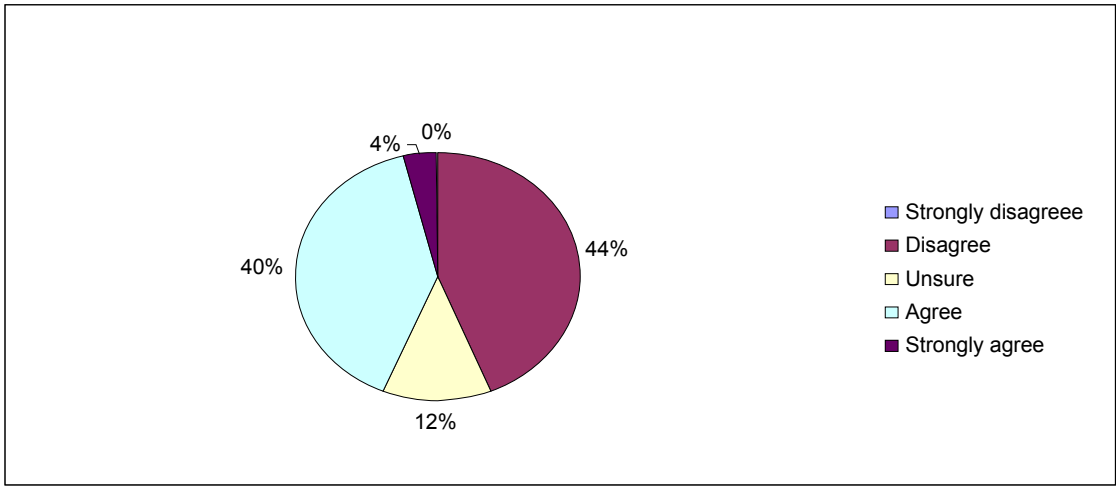



**Figure 4.40:** Base has footstep

### 4.2.9 Descriptive answers for section E (Comfort details)

For section E, there are three questions asking on uncomforatble things happen during the breast feeding process, things done to increase the comfort level while breast feeding and also suggested features that the correspondents want to add if there is a chair specialized in breast feeding process. Table 4.9 shows the variety of answers for each questions.

**Table 4.9**: Distribution of answers for comfort details

| No. | Question | Answers |
|---|---|---|
| 1. | Uncomfortable things during breast feeding process. | Back pain, tiring, sleepy and pain at the arm. |
| 2. | Things done to increase the comfort level while breast feeding. | Use pillows, adjust the position and do activities such as listen to music and watching television. |
| 3. | Suggested features for lactating chair. | Mp3, adjustable fan and controller to move the chair. |

From the collected answers responded by the selected mothers, it has shown that back pain which is one of the MSD symptoms occurred while breast feeding and also pain at the arm and feel tiring. This is because of inproper position applied while breastfed and there is no specific chair with ergonomics approach in the market. The correspondents need to use the pillow to cover their back and also the babies and also need to adjust their position frequently.

## 4.3 ANALYSIS OF DESIGN OF LACTATING CHAIR

The design of the lactating chair is based on the previous studies and also related researches. The design has 5 critical parts which is the headrest, backrest, seat, armrest and the base. Figure 4.41, 4.42, 4.43 and 4.44 shows the isometric view, top view, side view and front view of the design.

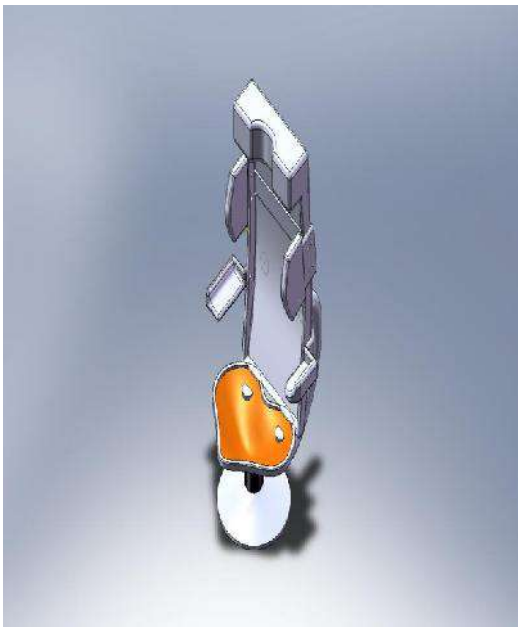


**Figure 4.41:** Isometric view

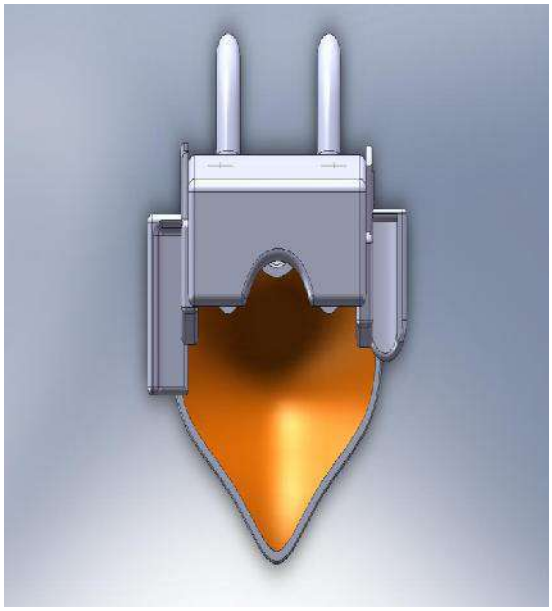


**Figure 4.42:** Top view

**Figure 4.43:** Side view

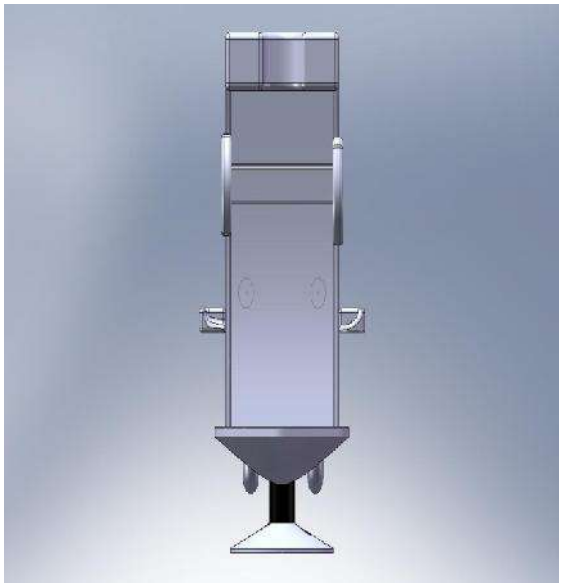


**Figure 4.44:** Front view

The analysis of the design is simulated using Algor software to determine the maximum load that can be applied on the critical parts of the design. Table 4.10 shows the properties of Steel (ASTM - A36) which is the material used in the analysis as the main frame.

**Table 4.10:** Properties of Steel (ASTM- A36)

| | |
|---|---|
| Material Description | Structural Steel |
| Mass Density | 0.0000000078548 N·s²/mm/mm³ |
| Modulus of Elasticity | 199950 N/mm² |
| Poisson's Ratio | 0.29 |
| Shear Modulus of Elasticity | 77221 N/mm² |
| Thermal Coefficient of Expansion | 0.0000117 1/°C |

### 4.3.1 Design analysis using Algor software (Seat)

For the seat of the lactating chair, the load applied on it would be the total of weight of the mothers plus with the baby's weight. The weight of the mother is considered according to the range of weights asked in the questionnaire and the average weight of the baby is 19.62 N. In the analysis of the seat part, the base of the chair is fixed at all direction and all of the forces is located onto the surface of the seat. Figure 4.45 shows the load which applied onto the seat.

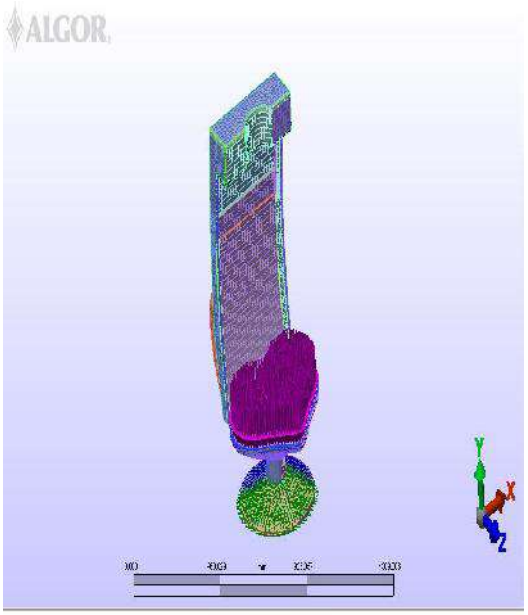



**Figure 4.45:** Load applied onto seat

For the first range of weight of the mother which is the average is 392.4 N. The total of load is 412.02 N. After being analyzed, the maximum value is 0.3026 N/mm$^2$. This indicates that only small value of stress applied on the seat and this could reduce the displacement of the structure of the seat thus make it long lasting. Figure 4.46 shows 412.02 N of force applied onto the seat.

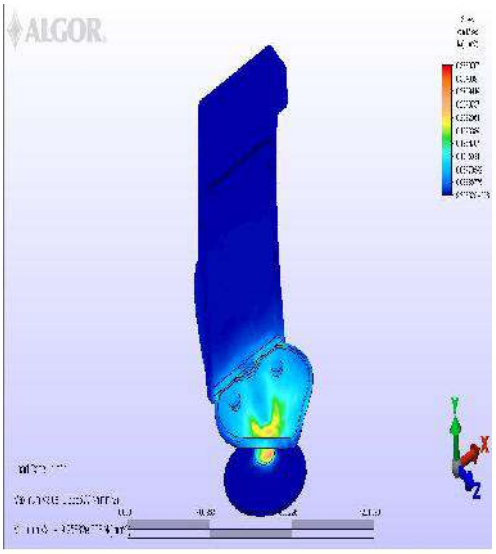



**Figure 4.46:** 412.02 N

For the second range of weight of the mother which is the total of load is 461.07 N. After being analyzed, the maximum value is 0.3387 N/mm$^2$. The maximum stress is still small and the material selected can withstand the load. Figure 4.47 shows 461.07 N of force applied onto the seat.

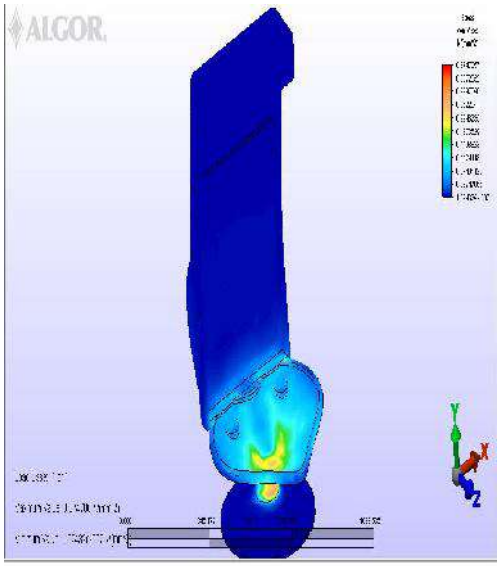



**Figure 4.47:** 461.07 N

For the third range of weight of the mother which is the total of load is equal to 510.12 N. After being analyzed, the maximum value is 0.3747 N/mm$^2$. The highest load for the analysis of the seat which is 510.12 N still has a small stress on the seat structure and the displacement of the structure is also small.

### 4.3.2 Design analysis using Algor software (Headrest).

For the headrest part, the base is still fixed at all direction and the force is located onto the surface of the headrest. There are two values of load selected to be applied onto the headrest part which is 10 N and 50 N. This is because all of the weight of the correspondents focus on the body so the force acted by the head could be as small as 10 N and the maximum can be 50 N. Figure 4.48 shows the load applied onto the headrest.

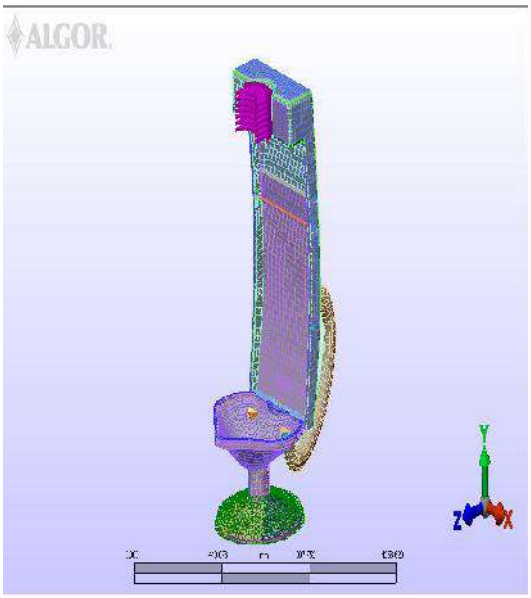



**Figure 4.48:** Load applied onto the headrest

The first one is 10 N. The maximum value that can be applied is 0.6996 N/mm$^2$. It shows that the maximum force acted on the headrest produce small displacement in the structure of the frame at the seat part and also very small at the headrest. Figure 4.49 shows 10 N of force acted on the headrest.

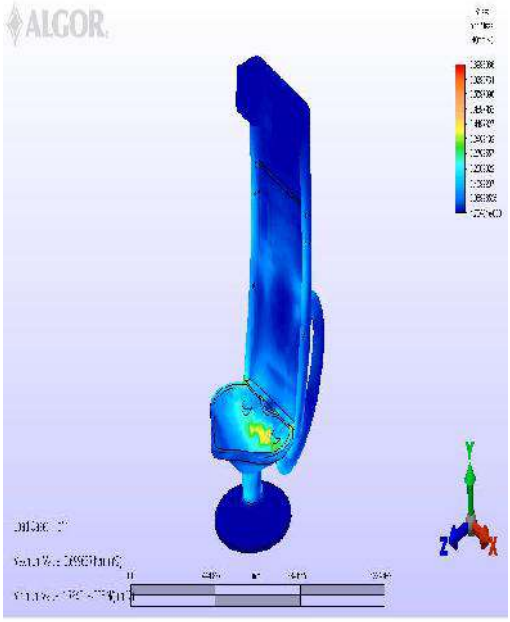



**Figure 4.49:** 10 N

For the second value of load selected to be applied is 50 N. The maximum value that can be applied is 1.7491 N/mm$^2$. Figure 4.50 shows 50 N of force acted on the headrest.

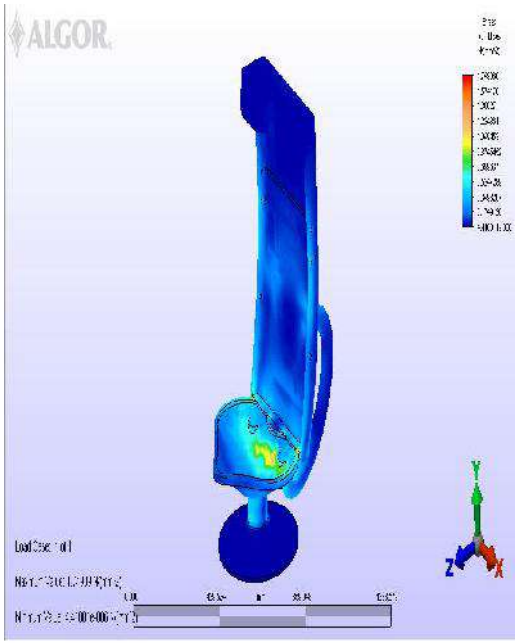



**Figure 4.50:** 50 N

### 4.3.3 Design analysis using Algor software (Armrest).

Armrest is important for the mother to lay their hands while breastfeeding the babies and while holding the babies at the level of their breast. For the armrest part, there are three value of load to be applied on the part itself as the load produced by the hand of the correspondents would be mostly the weight of the baby where he/ she is supported. The first one is 10 N. After being analyzed, the maximum value that can be applied is 0.3250 N/mm$^2$. This shows that only small stress occurred on the surface of the armrest and do not affect the structure. Figure 4.51 shows 10 N of force acted on the armrest.

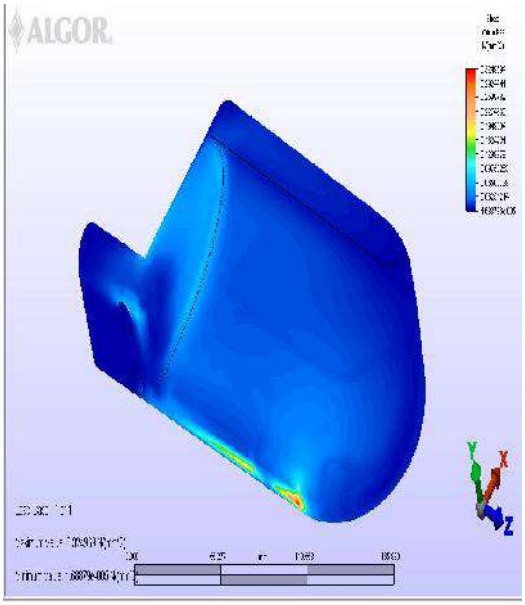



**Figure 4.51:** 10 N

The second value is 20 N. After being analyzed, the maximum value that can be applied is 0.6500 N/mm$^2$. The stress occurred on the surface of the armrest when being acted with 20 N is also small and the structure has a very small displacement in the structure. Figure 4.52 shows 20 N of force acted on the armrest.

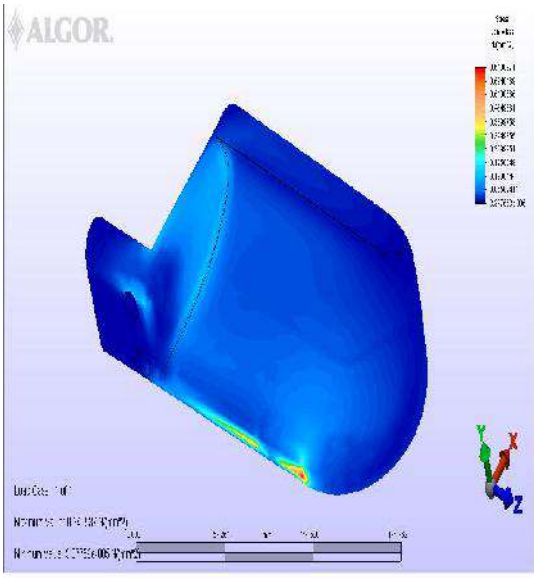



**Figure 4.52:** 20 N

The third value is 30 N. After being analyzed, the maximum value that can be applied is 0.9749 N/mm$^2$. The stress on the surface when being acted with 30 N is larger but yet not affected the structure as the displacement shown only at the edge of the armrest. Figure 4.53 shows 30 N of force acted on the armrest.

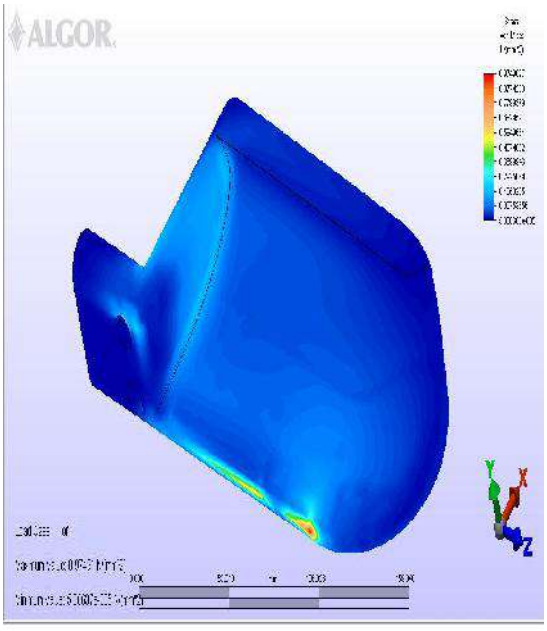



**Figure 4.53:** 30 N

### 4.3.4 Design analysis using Algor software (Backrest)

The backrest is the major part that support the back of the mother. The analysis done with 50 N which is the maximum force that can be produced by the correspondent's body. This is because the biggest force is acted mostly onto the seat. After being analyzed, the maximum value that can be applied is 3.3104 N/mm$^2$. Figure 4.54 shows 50 N acted on the backrest.

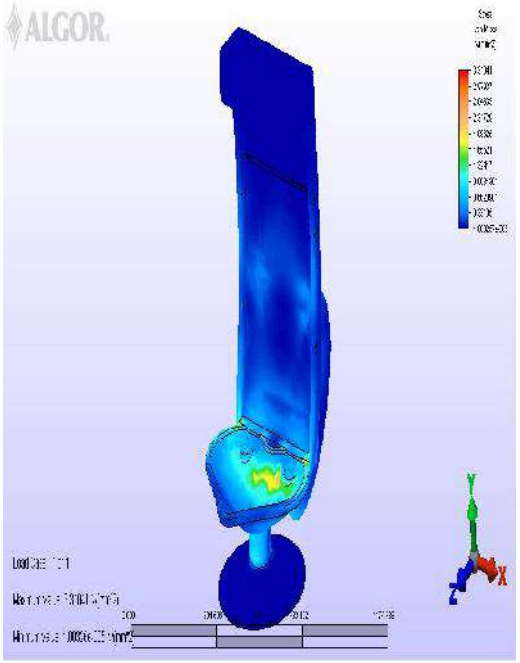



**Figure 4.54**: 50 N

## 4.4 SUMMARY

From the analysis of the questionnaire, we can conclude that the correspondents agreed with the suggested features in the design of the lactating chair such as the headrest, armrest, backrest, seat and also the base. For the analysis of the design using Algor software, we can conclude that the use of steel ASTM A-36 as the main frame is approved to have only a little displacement and can cope with high force applied on it.

# CHAPTER 5

# CONCLUSION

## 5.1 INTRODUCTION

This is the final chapter which will conclude on the overall process involved in this project. This include the stages of planning process made for this project, the finding of past researches related to this project, the method applied and also the results gained. Conclusion also is made on the problems encountered during the process of conducting the project. This chapter also will have proposed recommendations for the future work in order to improve the project itself. The recommendations is proposed as the solution based on the problems occurred along the project was carried out.

## 5.2 Project Conclusion

As the conclusion, we have succeeded in achieving the objective of this project which is to design a lactating chair with ergonomics approach using SolidWorks and to simulate the designed lactating chair using Algor. The overall perception of this project is good and considered to be the best starting point for the idea of having the real lactating chair. There were a few problems happened and unable the design to be fabricated but yet, the design is still can be accepted as the preliminary idea of the lactating chair. The responds from the correspondents for the questionnaire has shown that the demand on the lactating chair is high for its features and ergonomics approach applied.

## 5.3 RECOMMENDATION AND FUTURE WORK

### 5.3.1 Facilities

Based on the progress of the project that had been done, so many things in facilities aspect can affect the flow of the project itself. The moving of Faculty of Mechanical Engineering to Pekan campus has seen some of technical problems occurred due to power supply problem where the most of the machines can't be run and this has affect the whole project as this project required fabrication of prototype in order to be validated. This project supposedly using the Rapid Prototyping machine or sand casting machine for the purpose of fabrication but it can't be proceed due to the stated problem previously. So the faculty has to take an aggressive action in coping with this problem as the machines would also be used by the students in the future for their projects and also inform the students earlier if the machines still can't be used so that they can find alternative ways such as outsource the process by using the machine available at the outside of UMP.

### 5.3.2 Student Budget

The project could be proceeding with fabrication only if we outsource the process due to the unable of using the machines at the faculty laboratory. This will require the students to spend their own money for the purpose and it will highly cost as the process will use high- technology machines for Rapid Prototyping. There should be an instant budget provided by the faculty to the students at first and the students would be attaching the bills of overall cost used in the final report as the proof. Precise planning of the work progress will ensure that the project can be done in a shorter time. With systematic system and good time management, the students can also give more time to focus on other subject.

### 5.3.3 Survey using Questionnaire

The correspondents for the survey should be increased to make the results more precise and reliable. The time given for the survey is limited so the faculty should give an earlier date for the project to be started. The survey also should be done on the mothers throughout the country to get a specific range of data used for the design of the chair. There should also be a survey on Malaysian mothers' anthropometry data as it is better to use our local people's data than other country's people.

### 5.3.4 Future Work

Due to some problems that occurred and being stated previously, this project is unable to be fabricated and this is important as only with fabrication, the design can be validated by ergonomics experts and approved to be an ergonomics design. For the future work, the design should be fabricated in order to make it easier to be validated and also the idea would be clearer. Any distraction during the project should be detected earlier or being informed by responsible party for alternative action. The survey also should be more specific in order to get better results for the design of the chair.

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APPENDIX A

Faculty of Mechanical Engineering
Universiti Malaysia Pahang
Lebuhraya Tun Razak, 26300 Gambang,
Kuantan, Pahang Darul Makmur

# SURVEY QUESTIONNAIRES

**Design and Development of Ergonomics Lactating Chair: An Ergonomics Approach**

This questionnaire seeks some information about the information, the perception and the opinion about the ergonomics design on lactating chair. Your answers will be kept anonymous, so please be candid in your response. Your input is very important to our research. All the responses will be maintained in strictest confidence. Your kindness is much appreciated.

A. CORRESPONDENT DETAILS

In this part we want to know general information about you. Please fill in the space provided.

Age : ☐ 20-25 ☐ 26-30 ☐ 31-35 ☐ >35

Weight (kg) ☐ < 40 ☐ 40- 50 ☐ > 50

Working : ☐ Yes ☐ No

B. BREASTFEED DETAILS

This part will provide us about your breastfeed activities. Please answer the questions in the space given.

1. How many nursing in 24 hours?
   - ☐ 1-2 hours
   - ☐ 2-3 hours
   - ☐ 3-4 hours
   - ☐ > 4 hours
2. How long do you plan to breastfeed?
   - ☐ 1 day – 1 year
   - ☐ 1 year – 1 ½ years
   - ☐ 1 ½ years – 2 years
   - ☐ > 2 years
3. Which side of your breasts frequently used during breast fed?
   - ☐ Right side
   - ☐ Left side
   - ☐ Equal side (Both)
4. Do you wait for the baby to sleep during breast fed?
   - ☐ Yes, (please proceed to the question no. 5)
   - ☐ No, (please proceed to question no.6)

5. How long the baby usually takes time to sleep?

☐ <1 hour
☐ 2 to 3 hours
☐ >3 hours

6. What you usually do during breast feeding process?

☐ Reading
☐ Watching television
☐ Listening to music
☐ Others (State): _____

7. What position do you prefer during breast fed?

☐ Stand ☐ Sit ☐ Lay

C. BODY POSTURE DETAILS

In this section, we want to know the posture and your position while breastfeeding your baby. Please circle your answer according to the scale below.

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Strongly disagree | Disagree | Unsure | Agree | Strongly agree |

1. Your position during the breastfeed gives you back pain. 1 2 3 4 5
2. Your position is same during each breastfeeding process. 1 2 3 4 5
3. Sitting is the best position during the breastfeeding process. 1 2 3 4 5
4. The body needs to be bent during the breastfeeding process. 1 2 3 4 5
5. The arm should be located between 100 - 110° or in other words, arm is in rest position. 1 2 3 4 5

D. DESIGN DETAILS

In this section, we want to know your preference in the design of a lactating chair. Please circle your answer according to the scale below.

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Strongly disagree | Disagree | Unsure | Agree | Strongly agree |

**Headrest**

1. There is a headrest for you to lay your head 1 2 3 4 5
2. The headrest is made of soft cushion material 1 2 3 4 5
3. The headrest is fully support the back of your head 1 2 3 4 5
4. The headrest is in U shape covering from your ear-to-ear 1 2 3 4 5
5. The headrest is in flat shape with wave texture 1 2 3 4 5

**Backrest**

1. The backrest is layered with soft cushion material 1 2 3 4 5
2. The backrest's cushion has air ventilation layer 1 2 3 4 5
3. The backrest is layered with nano-technology fiber 1 2 3 4 5
4. The backrest has side wing to give more support to your body 1 2 3 4 5
5. The backrest can maintain your back at 90° position 1 2 3 4 5
6. The cushion can absorb the shape of your back 1 2 3 4 5
7. The height of the chair is equal to the length from your toe to your head when you sit on a chair 1 2 3 4 5

**Seat**

| | | | | | |
|---|---|---|---|---|---|
| 1. The seat is layered with thick and soft cushion material | 1 | 2 | 3 | 4 | 5 |
| 2. The seat has spring layer in the cushion | 1 | 2 | 3 | 4 | 5 |
| 3. The seat can fully support your buttock . | 1 | 2 | 3 | 4 | 5 |
| 4. The seat's cushion is easy to clean | 1 | 2 | 3 | 4 | 5 |
| 5. The seat has a temperature controller for heat removal | 1 | 2 | 3 | 4 | 5 |

**Armrest**

| | | | | | |
|---|---|---|---|---|---|
| 1. The chair has armrest to support your arm while breastfeeding | 1 | 2 | 3 | 4 | 5 |
| 2. The armrests are at the both side of the chair | 1 | 2 | 3 | 4 | 5 |
| 3. The armrest is layered with soft cushion material . | 1 | 2 | 3 | 4 | 5 |
| 4. The armrest is at the level of 90° of your arm | 1 | 2 | 3 | 4 | 5 |

**Base**

| | | | | | |
|---|---|---|---|---|---|
| 1. The base of the chair is wide for stability | 1 | 2 | 3 | 4 | 5 |
| 2. There is a spring which enable you to a have a little swing | 1 | 2 | 3 | 4 | 5 |
| 3. The chair is lightweight and easy to carry | 1 | 2 | 3 | 4 | 5 |
| 4. The base has a footstep | 1 | 2 | 3 | 4 | 5 |

E. COMFORTS DETAILS

1. What kind of uncomfortable things happen during your breast feeding process?
   ……
   ……

2. What do you do to increase the comfort level while breast feeding?
   ……
   ……

3. If there is a chair specialized in breast feeding process, please state what kind of suggested features you want to add.

……
……

We sincerely appreciate your time and cooperation. Please check to make sure that you have not skipped any questions. Thanks you.

APPENDIX B

Descriptive answers for questionnaire section A

| Demographic | Category | Frequency | Percentage |
|---|---|---|---|
| Age | <20 | 5 | 15 |
| | 21-29 | 24 | 70 |
| | 30-39 | 5 | 15 |
| | 40-49 | 0 | 0 |
| | 50> | 0 | 0 |
| Gender | Male | 24 | 69 |
| | Female | 11 | 31 |
| Hours work per day | <3 | 7 | 18 |
| | 4-6 | 8 | 20 |
| | 7-9 | 24 | 62 |
| | >10 | 0 | 0 |
| Years of working | <1 | 10 | 29 |
| | 2-3 | 14 | 40 |
| | 4-6 | 4 | 11 |
| | 7-9 | 1 | 9 |
| | >10 | 10 | 11 |

APPENDIX C

Descriptive answers for questionnaire section B

| No of question | Strongly disagree | | Disagree | | Unsure | | Agree | | Strongly Agree | |
|---|---|---|---|---|---|---|---|---|---|---|
| | N | % | N | % | N | % | N | % | N | % |
| 5 | 1 | 3 | 2 | 5 | 9 | 26 | 16 | 46 | 7 | 20 |
| 6 | 1 | 2 | 4 | 11 | 4 | 11 | 21 | 57 | 5 | 19 |
| 7 | 1 | 3 | 4 | 12 | 6 | 17 | 13 | 37 | 11 | 31 |
| 8 | 3 | 9 | 6 | 17 | 6 | 17 | 11 | 31 | 9 | 26 |
| 9 | 2 | 6 | 4 | 11 | 3 | 9 | 11 | 31 | 15 | 43 |
| 10 | 0 | 0 | 2 | 6 | 2 | 6 | 17 | 48 | 14 | 40 |

APPENDIX D

Descriptive answers for section C

| No of question | Strongly disagree | | Disagree | | Unsure | | Agree | | Strongly Agree | |
|---|---|---|---|---|---|---|---|---|---|---|
| | N | % | N | % | N | % | N | % | N | % |
| 11 | 1 | 3 | 1 | 3 | 2 | 6 | 18 | 51 | 13 | 37 |
| 12 | 1 | 3 | 3 | 9 | 6 | 17 | 11 | 31 | 14 | 40 |
| 13 | 2 | 6 | 3 | 8 | 9 | 26 | 15 | 43 | 6 | 17 |
| 14 | 1 | 3 | 4 | 11 | 10 | 29 | 18 | 51 | 2 | 6 |
| 15 | 0 | 0 | 9 | 26 | 9 | 26 | 14 | 40 | 3 | 8 |
| 16 | 2 | 6 | 5 | 14 | 7 | 20 | 18 | 51 | 3 | 9 |
| 17 | 1 | 3 | 16 | 46 | 8 | 23 | 6 | 17 | 4 | 11 |
| 18 | 3 | 8 | 15 | 43 | 7 | 20 | 8 | 23 | 2 | 6 |

APPENDIX E

Descriptive answers for section D

| No of question | Strongly disagree | | Disagree | | Unsure | | Agree | | Strongly Agree | |
|---|---|---|---|---|---|---|---|---|---|---|
| | N | % | N | % | N | % | N | % | N | % |
| 19 | 1 | 3 | 4 | 11 | 3 | 9 | 18 | 51 | 9 | 26 |
| 20 | 2 | 6 | 5 | 14 | 10 | 28 | 10 | 29 | 8 | 23 |
| 21 | 1 | 3 | 4 | 11 | 5 | 14 | 18 | 52 | 7 | 20 |
| 22 | 2 | 6 | 4 | 11 | 7 | 20 | 15 | 43 | 7 | 20 |
| 23 | 1 | 3 | 7 | 20 | 7 | 20 | 13 | 37 | 7 | 20 |
| 24 | 0 | 0 | 6 | 17 | 8 | 23 | 13 | 37 | 8 | 23 |
| 25 | 0 | 0 | 1 | 3 | 5 | 14 | 14 | 40 | 15 | 43 |
| 26 | 2 | 6 | 4 | 11 | 12 | 34 | 9 | 26 | 8 | 23 |
| 27 | 1 | 3 | 8 | 23 | 10 | 29 | 13 | 37 | 3 | 8 |

| Demographic | Category | Frequency | Percentage (%) |
|---|---|---|---|
| Age | 20-25 | 1 | 4 |
| | 26-30 | 5 | 20 |
| | 31-35 | 11 | 44 |
| | >35 | 8 | 32 |
| Weight | <40 | 1 | 4 |
| | 40-50 | 16 | 64 |
| | >50 | 9 | 36 |
| Working | Yes | 19 | 76 |
| | No | 6 | 24 |

Distribution of breastfeed details activities

| Question | Item | Frequency | Percentage (%) |
|---|---|---|---|
| B1 | 1-2 hours | 13 | 52 |
| | 2-3 hours | 11 | 44 |
| | 3-4 hours | 1 | 4 |
| | >4 hours | 0 | 0 |
| B2 | 1day- 1 year | 6 | 24 |
| | 1 year- 1½ year | 16 | 64 |
| | 1½ year- 2 year | 3 | 12 |
| | >2 year | 0 | 0 |
| B3 | Right side | 0 | 0 |
| | Left side | 0 | 0 |
| | Equal side | 25 | 100 |
| B4 | Yes | 10 | 40 |
| | No | 15 | 60 |
| B5 | <1 hour | 9 | 36 |
| | 2- 3 hour | 1 | 4 |
| | >3 hour | 0 | 0 |
| B6 | Reading | 10 | 40 |
| | Watching television | 11 | 44 |
| | Listening to music | 3 | 12 |
| | Others | 1 | 4 |
| B7 | Stand | 0 | 0 |
| | Sit | 22 | 88 |
| | Lay | 3 | 12 |

Distribution of body posture details

| Section/Part | Question | Strongly disagree | | Disagree | | Unsure | | Agree | | Strongly agree | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | N | % | N | % | N | % | N | % | N | % |
| C | 1 | 1 | 4 | 0 | 0 | 0 | 0 | 16 | 64 | 8 | 32 |
| | 2 | 0 | 0 | 2 | 8 | 2 | 8 | 21 | 84 | 0 | 0 |
| | 3 | 0 | 0 | 1 | 4 | 2 | 8 | 14 | 56 | 8 | 32 |
| | 4 | 0 | 0 | 3 | 12 | 7 | 28 | 14 | 56 | 1 | 4 |
| | 5 | 0 | 0 | 0 | 0 | 6 | 24 | 18 | 72 | 1 | 4 |

Distribution of design of headrest details

| Section/Part | Question | Strongly disagree | | Disagree | | Unsure | | Agree | | Strongly agree | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | N | % | N | % | N | % | N | % | N | % |
| D/Headrest | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 13 | 52 | 12 | 48 |
| | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 16 | 64 | 9 | 36 |
| | 3 | 0 | 0 | 0 | 0 | 1 | 4 | 15 | 60 | 9 | 36 |
| | 4 | 0 | 0 | 2 | 8 | 16 | 64 | 5 | 20 | 2 | 8 |
| | 5 | 0 | 0 | 1 | 4 | 5 | 20 | 17 | 68 | 2 | 8 |

Distribution of design for backrest details

| Section/Part | Question | Strongly disagree | | Disagree | | Unsure | | Agree | | Strongly agree | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | N | % | N | % | N | % | N | % | N | % |
| D/Backrest | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 14 | 56 | 11 | 44 |
| | 2 | 0 | 0 | 1 | 4 | 1 | 4 | 14 | 56 | 9 | 36 |
| | 3 | 0 | 0 | 0 | 0 | 3 | 12 | 17 | 68 | 5 | 20 |
| | 4 | 0 | 0 | 1 | 4 | 1 | 4 | 22 | 88 | 1 | 4 |
| | 5 | 0 | 0 | 0 | 0 | 4 | 16 | 18 | 72 | 3 | 12 |
| | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 15 | 60 | 10 | 40 |
| | 7 | 0 | 0 | 0 | 0 | 3 | 12 | 19 | 76 | 3 | 12 |

Distribution of design for seat details

| Section/Part | Question | Strongly disagree | | Disagree | | Unsure | | Agree | | Strongly agree | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | N | % | N | % | N | % | N | % | N | % |
| D/Seat | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 8 | 32 | 17 | 68 |
| | 2 | 0 | 0 | 1 | 4 | 2 | 8 | 18 | 72 | 4 | 16 |
| | 3 | 0 | 0 | 0 | 0 | 1 | 4 | 18 | 72 | 6 | 24 |
| | 4 | 0 | 0 | 0 | 0 | 1 | 4 | 18 | 72 | 6 | 24 |
| | 5 | 0 | 0 | 2 | 8 | 6 | 24 | 15 | 60 | 2 | 8 |

Distribution of design for armrest details

| Section/Part | Question | Strongly disagree | | Disagree | | Unsure | | Agree | | Strongly agree | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | N | % | N | % | N | % | N | % | N | % |
| D/Armrest | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 15 | 60 | 10 | 40 |
| | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 19 | 76 | 6 | 24 |
| | 3 | 0 | 0 | 0 | 0 | 3 | 12 | 16 | 64 | 6 | 24 |
| | 4 | 0 | 0 | 0 | 0 | 4 | 16 | 19 | 76 | 2 | 8 |

Distribution of design for base details

| Section/Part | Question | Strongly disagree | | Disagree | | Unsure | | Agree | | Strongly agree | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | N | % | N | % | N | % | N | % | N | % |
| D/Base | 1 | 0 | 0 | 1 | 4 | 1 | 4 | 15 | 60 | 8 | 32 |
| | 2 | 0 | 0 | 0 | 0 | 2 | 8 | 19 | 76 | 4 | 16 |
| | 3 | 0 | 0 | 0 | 0 | 2 | 8 | 12 | 48 | 11 | 44 |
| | 4 | 0 | 0 | 11 | 44 | 3 | 12 | 10 | 40 | 1 | 4 |

Distribution of answers for comfort details

| No. | Question | Answers |
|---|---|---|
| 1. | Uncomfortable things during breast feeding process. | Back pain, tiring, sleepy and pain at the arm. |
| 2. | Things done to increase the comfort level while breast feeding. | Use pillows, adjust the position and do activities such as listen to music and watching television. |
| 3. | Suggested features for lactating chair. | Mp3, adjustable fan and controller to move the chair. |

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# SURVEY QUESTIONNAIRES

**Design and Development of Ergonomics Lactating Chair: An Ergonomics Approach**

This questionnaire seeks some information about the information, the perception and the opinion about the ergonomics design on lactating chair. Your answers will be kept anonymous, so please be candid in your response. Your input is very important to our research. All the responses will be maintained in strictest confidence. Your kindness is much appreciated.

A. CORRESPONDENT DETAILS

In this part we want to know general information about you. Please fill in the space provided.

Age : ☐ 20-25 ☐ 26-30 ☐ 31-35 ☐ >35

Weight (kg) ☐ < 40 ☐ 40- 50 ☐ > 50

Working : ☐ Yes ☐ No

B. BREASTFEED DETAILS

This part will provide us about your breastfeed activities. Please answer the questions in the space given.

1. How many nursing in 24 hours?

☐ 1-2 hours
☐ 2-3 hours
☐ 3-4 hours
☐ > 4 hours

2. How long do you plan to breastfeed?

☐ 1 day – 1 year
☐ 1 year – 1 ½ years
☐ 1 ½ years – 2 years
☐ > 2 years

3. Which side of your breasts frequently used during breast fed?

☐ Right side
☐ Left side
☐ Equal side (Both)

4. Do you wait for the baby to sleep during breast fed?

☐ Yes, (please proceed to the question no. 5)
☐ No, (please proceed to question no.6)

5. How long the baby usually takes time to sleep?

| | |
|---|---|
| ☐ | <1 hour |
| ☐ | 2 to 3 hours |
| ☐ | >3 hours |

6. What you usually do during breast feeding process?

| | |
|---|---|
| ☐ | Reading |
| ☐ | Watching television |
| ☐ | Listening to music |
| ☐ | Others (State): _____ |

7. What position do you prefer during breast fed?

☐ Stand ☐ Sit ☐ Lay

C. BODY POSTURE DETAILS

In this section, we want to know the posture and your position while breastfeeding your baby. Please circle your answer according to the scale below.

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Strongly disagree | Disagree | Unsure | Agree | Strongly agree |

1. Your position during the breastfeed gives you back pain. 1 2 3 4 5
2. Your position is same during each breastfeeding process. 1 2 3 4 5
3. Sitting is the best position during the breastfeeding process. 1 2 3 4 5
4. The body needs to be bent during the breastfeeding process. 1 2 3 4 5
5. The arm should be located between 100 - 110° or in other words, arm is in rest position. 1 2 3 4 5

D. DESIGN DETAILS

In this section, we want to know your preference in the design of a lactating chair. Please circle your answer according to the scale below.

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Strongly disagree | Disagree | Unsure | Agree | Strongly agree |

**Headrest**

1. There is a headrest for you to lay your head 1 2 3 4 5
2. The headrest is made of soft cushion material 1 2 3 4 5
3. The headrest is fully support the back of your head 1 2 3 4 5
4. The headrest is in U shape covering from your ear-to-ear 1 2 3 4 5
5. The headrest is in flat shape with wave texture 1 2 3 4 5

**Backrest**

1. The backrest is layered with soft cushion material 1 2 3 4 5
2. The backrest's cushion has air ventilation layer 1 2 3 4 5
3. The backrest is layered with nano-technology fiber 1 2 3 4 5
4. The backrest has side wing to give more support to your body 1 2 3 4 5
5. The backrest can maintain your back at 90° position 1 2 3 4 5
6. The cushion can absorb the shape of your back 1 2 3 4 5
7. The height of the chair is equal to the length from your toe to your head when you sit on a chair 1 2 3 4 5

**Seat**

| | | | | | |
|---|---|---|---|---|---|
| 1. The seat is layered with thick and soft cushion material | 1 | 2 | 3 | 4 | 5 |
| 2. The seat has spring layer in the cushion | 1 | 2 | 3 | 4 | 5 |
| 3. The seat can fully support your buttock . | 1 | 2 | 3 | 4 | 5 |
| 4. The seat's cushion is easy to clean | 1 | 2 | 3 | 4 | 5 |
| 5. The seat has a temperature controller for heat removal | 1 | 2 | 3 | 4 | 5 |

**Armrest**

| | | | | | |
|---|---|---|---|---|---|
| 1. The chair has armrest to support your arm while breastfeeding | 1 | 2 | 3 | 4 | 5 |
| 2. The armrests are at the both side of the chair | 1 | 2 | 3 | 4 | 5 |
| 3. The armrest is layered with soft cushion material . | 1 | 2 | 3 | 4 | 5 |
| 4. The armrest is at the level of 90° of your arm | 1 | 2 | 3 | 4 | 5 |

**Base**

| | | | | | |
|---|---|---|---|---|---|
| 1. The base of the chair is wide for stability | 1 | 2 | 3 | 4 | 5 |
| 2. There is a spring which enable you to a have a little swing | 1 | 2 | 3 | 4 | 5 |
| 3. The chair is lightweight and easy to carry | 1 | 2 | 3 | 4 | 5 |
| 4. The base has a footstep | 1 | 2 | 3 | 4 | 5 |

E. COMFORTS DETAILS

1. What kind of uncomfortable things happen during your breast feeding process?
   ……

2. What do you do to increase the comfort level while breast feeding?
   ……

3. If there is a chair specialized in breast feeding process, please state what kind of suggested features you want to add.
   ……

We sincerely appreciate your time and cooperation. Please check to make sure that you have not skipped any questions. Thanks you.