# A Prototype Development of Anti-Hunchback Device

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ABSTRACT

*The spine is a part of our body which is very important but often neglected. Sometimes because of our own mistakes, the damage or injury in the spine will cause a variety of problems that have to be borne. Therefore, the objective of this research is to develop a device that is able to warn by triggering people about the position of the spine body if the hunch exceed the critical level by vibration. This device is environmentally friendly and small in size. In the process of making 'Anti Hunchback Device', observations have been made against those who tend towards the hunchback problems. Taking data from the user by questionnaire and using product design and development method to produce this device. This device will be a useful solution to address the problem of bone bent at an early stage of the spine disease, restoring a healthy posture health care for the long term and also save money from health spending for the foreseeable future.*

**Keywords:** *Spine, Anti hunchback device, Product design & development, hunchback/kyphosis and Prototype development*

## Introduction

Hunchback also known as round back or kyphosis is an illness condition in which the spine in the upper back has an excessive curvature. Normally the

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upper back or thoracic region of the spine is supposed to have a slight natural curve and also most of people have some degree of curvature in their spine. Also, hunch occurs when this natural arch is larger than normal. Sometimes hunch doesn't cause any symptoms besides than regular back curve and it is just a slight hunch. However in some cases, the condition causes tiredness, back pain, stiffness and tenderness of the spine. In a long-term period this can lead to serious damages to the spine such as abnormality curved back, excruciating back pains, difficulty breathing and eating, fatigue, and tendering of spine. Therefore, in order to prevent this illness became more dangerous, a comprehensive solution need to be taken to prevent at the early stages of the symptoms. Nowadays, there are many existing spine alignment products in the market. Hunchback device is a new method solution to overcome this issue so that users easily wear without any complicated installments. It applies towards every person that experience with first stage of hunch problem and user friendly among all types of ages.

This research will focused on anti-hunchback device where the function is towards human upper back. This is a new alternative device to correct posture of human upper back due to hunchback/kyphosis [1]-[3]. According to research by American Academy of Orthopedic surgeons, there are many method of hunch posture treatment [4, 5]. For example by using support strap, posture tracker, thoracic and spine brace. Eventually, it requires a longer time and adjustment for proper installment and also contains lack of comfort ability. One the other hand, anti-hunchback device has the easier and faster method compared to these products. Besides it is also include comfort and high wear ability which also easy to assemble within time frame. By comparing with other existing products, this device is also stresses upon natural alter which excluded support force from any element. It is cheaper, comfortable, ergonomic and easy to wear.

## Literature Review

Literature review is a significant process of evaluate the research information. The sources of literature review are obtained from the journals, books, and electronics resources. All of the information is based on historical medical data, manufacturing method and past studies that related to this product. Therefore, it has covers on the study of hunch back/kyphosis evaluation, design tools, fabrication and prototyping.

### Hunchback/Kyphosis

Hunchback or kyphosis refers spinal deformity that looks like a forward-curved posture of the head, upper back or thoracic spine. It forms when the neck spine shift forward and get misaligned [6]. Generally, most people have some degree of curvature in their spine. However, a curve more than 45 degrees is considered excessive. The worsening condition of the curvature

can lead to high risk of disease. Hunchback formation can be contributed by several things. This is labelled as high level of hunch posture.

There are several spine illnesses which cause such as osteoporosis, posture, injury, Paget's disease of the bone congenital kyphosis, spinal cancer, arthritis and Scheuermann's disease. In general situation, there are a number of reasons that it occur towards most people which related with poor posture. This is one of the most likely reasons for developing a hyper kyphosis. Our thoracic curve generally increases as we get older.

Average curve for children is 20 to 25 degree, where for adults, increases over 30 degrees and females generally have a greater curve than males, particularly after age 40. Woman 50-60 years old, the average kyphosis is around 40 degree and (33 degree for men). Women 75 to 80 years old, the average is 50 degree. So for middle-aged people, a curve greater than 40 degree and in older people a curve over 50 to 55 is considered to be excessive. This is termed hyper kyphosis [7]. Figure 1 show the types of postural position and figure 2 show the type of improper standing position.

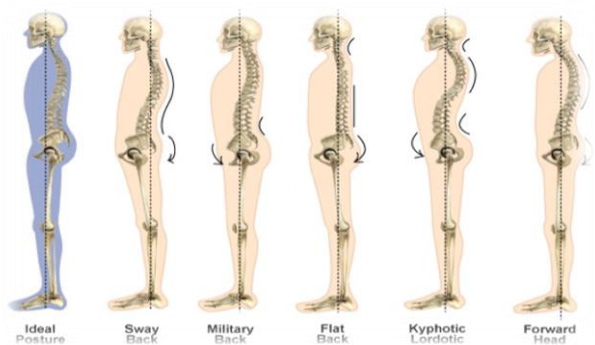


Figure 1: Types of Common Postural Problems

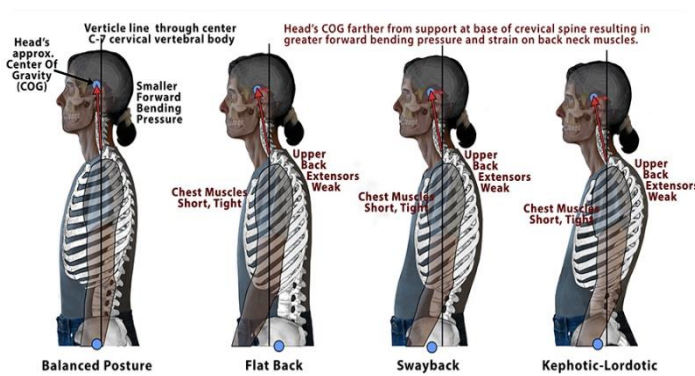

Figure 2: Types of Improper Standing Posture

Hyper kyphosis can result from conditions such as osteoporosis or thinning bones, and fractures of the vertebrae that result from thin bones. However, research has found that two thirds of people with hyper kyphosis do not have spinal fractures. There are several suspected causes for development of this spinal deformity when vertebral fractures are not present. Hyper kyphosis may result from poor habitual posture, muscle weakness, degenerative disc disease, ligament degeneration, or hereditary factors [8].

Ergonomics plays essential part in daily activities. It can be determine the level of safety and health as consumption. In this anti-hunchback system, it involves working posture between neck and upper back. The exact location would be at the point of C7 and T1. It is the connection between cervical spine and thoracic spine which hold the significant posture of human hunch. This is also the flexible point where the mobility of the neck and upper body plays the direction of hunch angle. The device angle sensor will be placed at the spine intersection point of C7 and T1 and will be penetrated by two flexible arm containing with 7V D.C. motor vibrator upon skin at the both sides of shoulder in the T3 thoracic region. This is due to nearest location to the T1 because it is the critical spot which hunch occurs.

By using the concept from the posture brace, this device acts as a guide for correct alignment of the muscles in the shoulders and neck, upper and lower back. Besides, this relieves pressure on the neck, shoulders, back and abdominal muscles which leads to reduced pain and discomfort. It is also vastly reduces the chances of injury. They also can be used as a preventative measure to avert any injury or to develop good posture habits. In posture brace description, it should never be worn frequently or for long periods of time as they may cause weakening of the muscles due to lack of their use resulting in worsening of symptoms and posture problems but in this case anti-hunchback device can be worn over long period of time without any restrictions as this works as reminder to correct posture by user itself. The conceptual model of the relationship between thoracic upper back and anti-hunchback device are shown in figure 3.

Figure 3: The Conceptual Model

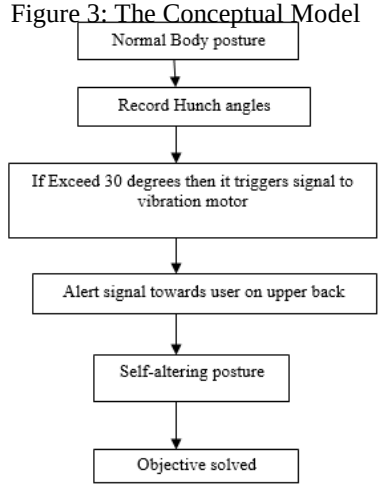


Figure 4: Conceptual of the Relationship between Angle Posture and Anti-Hunchback Device

## Methodology

Methodology is the crucial part where this is the first phase of implementation the research. It is start from concept development, detail design, manufacturing process & assembly and testing.

### Concept Development

Questionnaire survey have been conducted. Data about customer needs are obtained by sending out questionnaire to consumers. These methods were involved 100 public respondents which consists of male and female customer, office worker, driver and student. Sketch has been made to explain in detail about this product. The objective to have questionnaire survey is to deliver the information about this new product and to identify potential customer who manage to apply this product with satisfactory requirements. The results of the questionnaire survey will be able to identify customer's requirement need and will be used as a tool data in making this product. Based on survey results (figure 5), it show that the percentage of use frequency of poor hunch posture by the respondents. Respondents were from a wide range of ages, genders and jobs. Among those who experienced with back posture very often for posture is 24% and who often having posture is 53%. There is 23% of respondents does not use hunch regularly. This shows

the level of posture problem is common among people. The right pie chart shows that 41% of the respondents already use back support product.

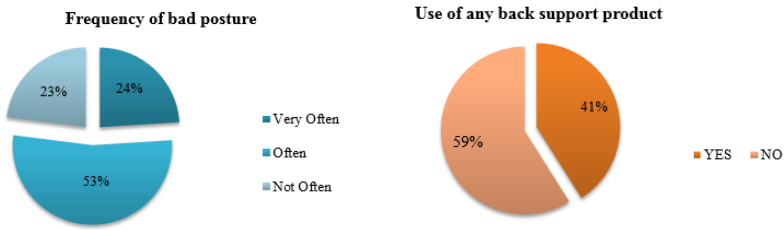


Figure 5: Chart of Respondents with Frequency of Bad Posture and Use Back Support Product

The mission statement to produce a new anti-hunchback device that will ease people posture while sitting and standing still at indoor/outdoor activities. This is because the concept of this product is to trigger vibration signal where it can identify by human posture angle. The terms of attachment is plain simple where is can be easily attach by using its hook and function as plug and play device. Hence, this anti-hunchbacked device can be wear without of specific setting or assembly and this can reduce wearing time. An addition to that, it also light in weight, portable and easy to maintain so that it will ease to bring anywhere. Figure 6 below show the mission statement that will guide the entire decision making.

| | |
|---|---|
| Product Description | · This product can attach and grip to human neck and function as hunch indicator<br>· Simple design and light in weight<br>· Plug and play concept |
| Key Business Goals | · Develop a product that can be used to alter human posture with an affordable price<br>· The result is to reduce human hunch in early stage before it goes in to critical stages |
| Primary Market | · Office worker<br>· Drivers<br>· Student<br>· Travellers |
| Secondary Market | · Hospital-hold<br>· House (family)<br>· Outdoor activities |
| Assumptions and constraints | · New product platform for easily handling<br>· Easy to operate/maintenance<br>· Need to be clean after used<br>· Device should tightly grip to avoid fall |
| Stakeholders | · Purchasers and users<br>· Manufacturing operations<br>· Service operations<br>· Distributors and resellers<br>· Office workers<br>· Drivers<br>· Student<br>· Travelers<br>· Household |

Figure 6: Mission Statement of Anti-Hunchback Device

Quality Function Deployment-QFD is a useful and structured tool that helps to translate both spoken and unspoken customer requirements into key business deliverables. At this stage all the information gather from the survey will transform to business deliverables by using QFD method. After that concept generation stage will take place. Concept generation method is used in order to get the best alternative to produce the best quality and creative product. Other than that, this is the best strategy to start a new product with successful by following customer need. Concept selection is the process of evaluating concept with respect to customer needs and other criteria has been done. Next, compare the relative strengths and weakness of the concept. Lastly, one or more concepts have been selected for further investigation, testing and development. All these flow must be completed before fabrication stage. Table 1 resulting based on survey, most of respondents satisfied with this product and they really wanted to try this anti-hunchback device.

Table 1: Customer Requirements Consideration

| No. | Item | Specification |
|---|---|---|
| 1. | User Friendly | - safe design<br>- light in weight<br>- compact design |
| 2. | Functionality | - easy to flexible<br>- easy to operate and maintenance<br>- easy to wear |
| 3. | Durability | - good quality<br>- simple function |
| 4. | Low Cost | - affordable price |

There have 4 (four) design sketches concept for this research. Refer figure 7 and figure 8 for sketches explanation. All these sketches concept is made by followed customer need. The best concept will be choose based on concept screening and scoring method. In scoring process, focus has been put on the differences relatives to the concept screening. In the screening concept, classification has been made based on criteria that already listed on need statement. Screening concept is to define which the most suitable design that can satisfy the customer and the scoring stage is to make the choice of the best design. To make the decision, concept scoring used to help making a good decision.

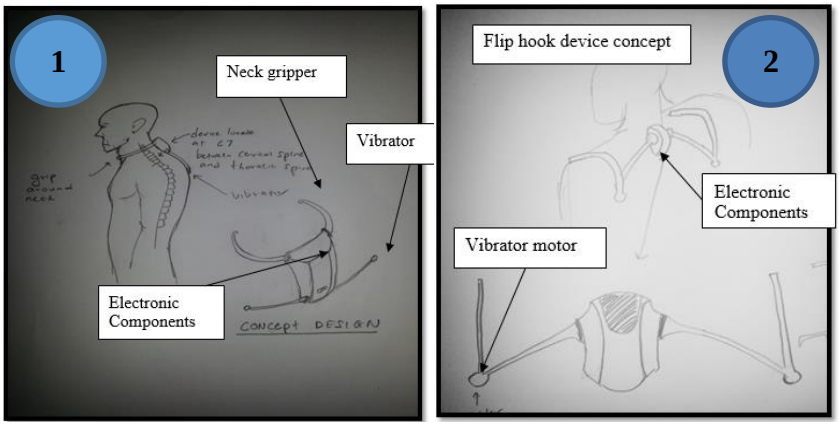


Figure 7: Design Sketches Concept 1 & 2

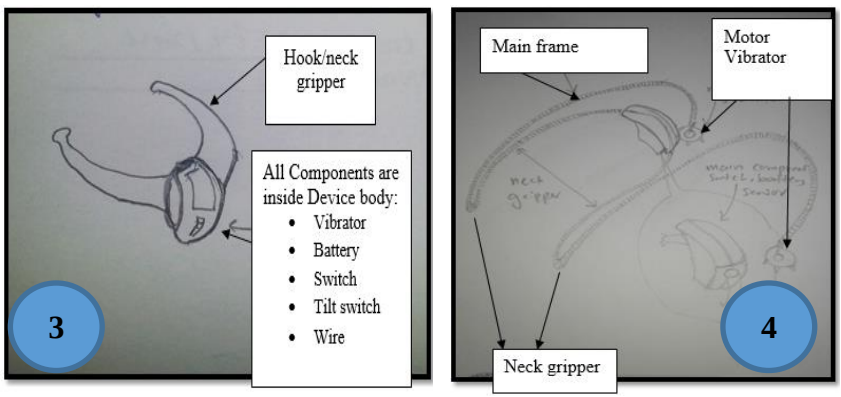


Figure 8: Design Sketches Concept 3 & 4

Figure 9 below show the final design concept. The concept has been selected and described by sketches based on customer consideration. Although each concept nominally satisfied the key customer need, the best concept still need to be choose. Firstly, the process of evaluating concept with respect to customer needs and other criteria has been done. Next, compare the relative strengths and weakness of the concept. Lastly, one concept have been selected for further investigation, development and testing.

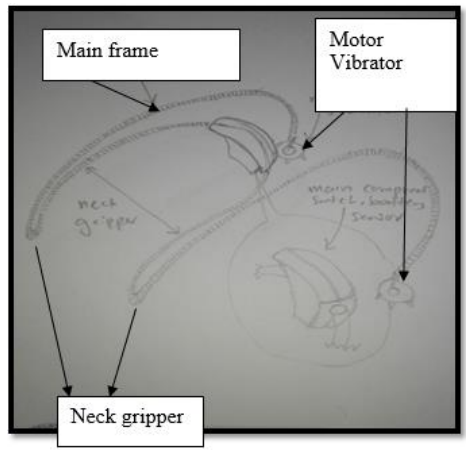


Figure 9: Final Design Concept Sketches (Concept 4)

## Detail Design

This product consists of 6 main part which is cover 1 & 2, battery, vibration cap, main frame and screw as shown in figure 10. Others part such as red wire, blue wire, motor vibrator, angle sensor and switch are directly purchase from electronic hardware. Figure 11 show the design of circuit diagram the device system. Figure 12 and figure 13 show bill of materials and assembly drawing of the device.

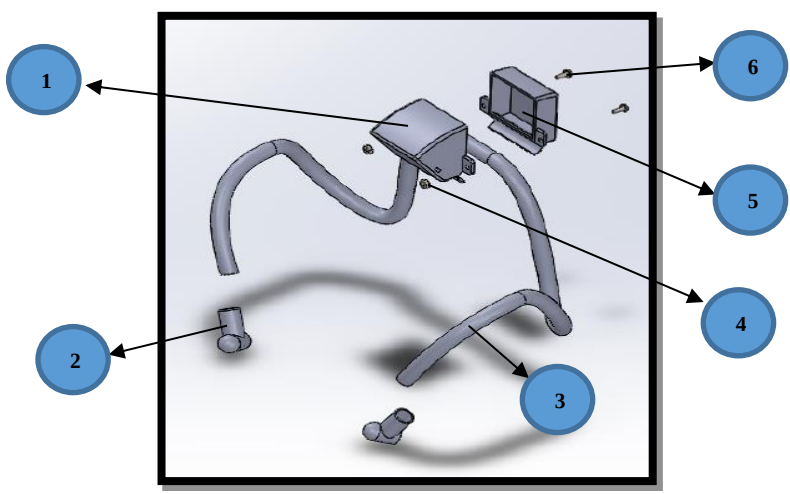


Figure 10: Exploded View of Anti-Hunchback Device

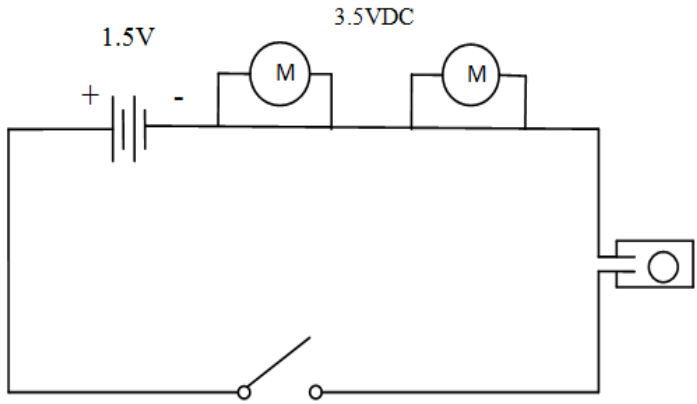


Figure 11: Circuit Diagram of Device System

| ITEM NO | PART NO | QUANTITY |
|---|---|---|
| **1** | Part 1 : Cover 1 | 1 |
| **2** | Part 2: Vibration Cap | 2 |
| **3** | Part 3: Main Frame | 1 |
| **4** | Part 4: Battery | 3 |
| **5** | Part 5 : Cover 2 | 1 |
| **6** | Part 6 : Screw | 2 |

Figure 12: Bill of Materials

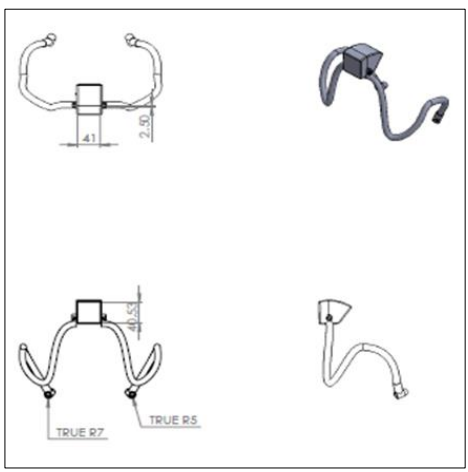


Figure 13: Assembly Drawing of Anti-Hunchback Device

## Prototype Development

Prototype development process begin from rapid prototyping development, the part assembly process together with the electrical component, and then the prototype will be attached to the respondent during testing process. Prototyping is the design verification phase of Product Development that used to demonstrate or verify aspects of a design. Figure 14,15 & 16 below clearly explain how this device being developed and process involved.


Figure 14: Electronic Parts Assembly Process

Prepare the wire frame as the backbone of the device. Shape of the design by using neck as indicator and flex into the desired shape. Prepare the wire both blue and red. The diameter used is 1 mm and tighten the wire along the frame. It is light in weight and suitable for this compact device. Tape the wire to tidy the path and point out the end to both side to solder. Motor vibrator that used in this research is 1.5-3.7 dc Flat Vibration Motor. Solder the main part of the component to make sure the solder point is strong. Tidy up all components by using wire tape to minimize space and strengthen the solder connection point. The crucial part is when applying tape at motor and sensor system. Solder at the main sensor system which intersect the long wire and sensor system. Tidy up the wire to easily recognize the wire location and minimize space. Next, solder at slide switch and battery according to circuit diagram. Afterwards, tighten the wire with tape and duct tape as it firmly grip and cut out any slide and movement. This is the main sensor system wiring

which require good taping to avoid any movement from solder point as in weaken the spot due to many move during action. After that, integrate the PVC wire pipe for finishing at the main frame besides cover up the wire it is also as aesthetic wise. After several amount of testing, the hunch angle is leverage to 30 degrees during hunch which as it has -30 during straight position. Final hunchback physical system appears to be like this without head and vibrator cover.

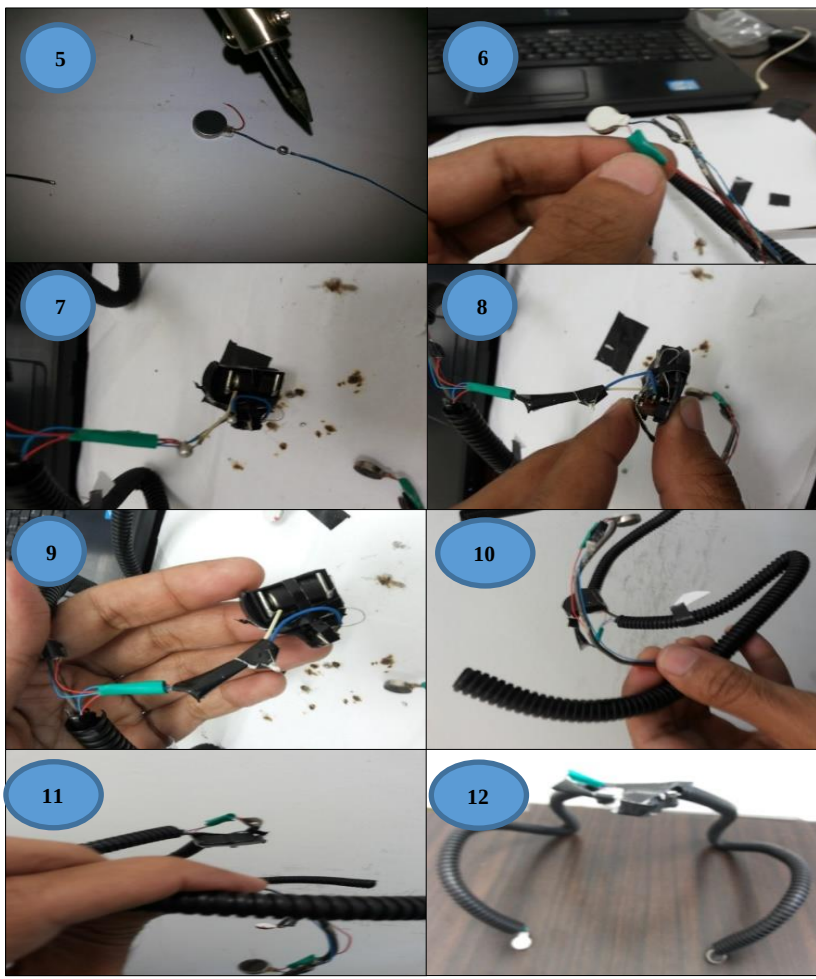


Figure 15: Electronic Parts Assembly Process

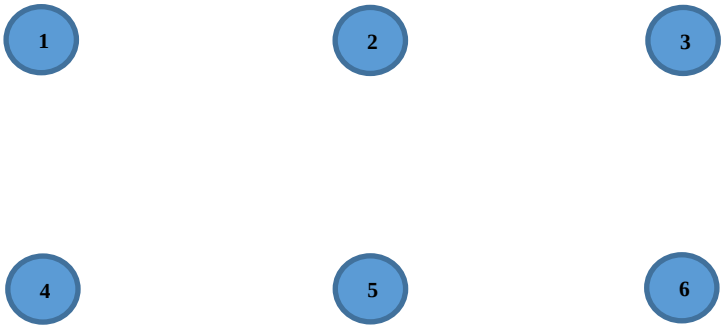


Figure 16: Rapid Prototype Printing and Component Installation Process

Before used the rapid prototype machine, the drawing from solidwork software need to transfer to the V2.12 UP! Software. After finish transferring the drawing, need to wait the ABS filament being melt. The magnet is installed in same level to the ABS filament to make the origin point. The process is start and the time to finish the chassis part is about 3 hours in total. The device finish is quite good but there is some defect occur at the edge due to very small dimension. For assembly process, firstly, insert a component platform. This is the base of the component to be placed. Next, install the battery, sensor and switch Place the component according to desired place. After that, make sure the tape wire is tightly wrapped the solder point and the wire. Lastly, assemble all the part which includes top and bottom cover, screw, and motor pad into the main frame.

## Testing

This phase will discussed the testing result of anti-hunchback device. The data were obtained by questionnaire and interviews from student and office worker. The specific information includes frequency of poor posture, usability of support product, commercialization and response. Figure 17 below show the final product specification detail and ready for testing process. In order to evaluate testing to user, Usability testing is a technique that used in user-centered towards for the interaction design. This can be seen as an irreplaceable usability practice, since it gives direct input on how real users use the system.

Figure 17: Anti-Hunchback Device

Prototype Usability Testing was conducted in three different stages which include normal posture, hunch posture and after use the product with 5 times trial. Then the candidates will evaluate the post-study usability form for their response based on criteria.

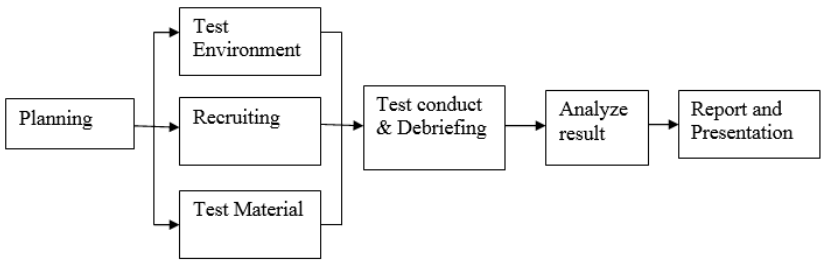


Figure 18: Usability Test Methodology

Product Familiarization and Test was conducted to provide information and handling of the device. Volunteer may able to hold, operate, wear and receive the function. The test location was held at Factory 3, FTK, UTeM. There are 3 types of test methodology includes primary posture, average hunch and after used the device. This device is tested upon volunteer who has hunch posture in the early stage.

| **Normal posture** | **Average Hunch posture at desk after 30 min** | **After use Anti-Hunchbacked Device** |
|---|---|---|
|  |  |  |

Figure 19: Usability Testing on the functional Anti-Hunchback Device

## Result and Discussion

The result data is based on the familiarizations and post-questionnaires which obtained by survey and test volunteer. The data then conducted into graphical to enhance understanding and counter measure was taken to improve the design and system according to feedback. The prototype are well function and volunteer respondent are very satisfied with this product. After testing process, Post-Study Test Questionnaire Usability Question (PSSUQ) have been done in order to measures user perceived satisfaction with a product or system. Obtaining an overall satisfaction score is done by averaging the four sub-scales of Device System Quality (the average of items 1-6), Function Quality (the average of items 7-12), and Design Quality (the average of items 13-16). The PSSUQ is highly reliable among the user. Based on the figure 20

below, the highest rating is the safety followed by design system while the lowest rating is portability. Besides, there are some occurrences during the testing due to stability of the vibrator and compact factor. The other difficulties show average result on 4 and 5. Many positive responses received after the usability testing method. Quantitative test also have been made. This test is measured by sum of defect occur during testing process. The frequency taken by volunteer to test was 5 times trial It is to measure the success rate of the function to ensure the result run clean. There are some error occur during the test which may due to technical difficulties inside the component.

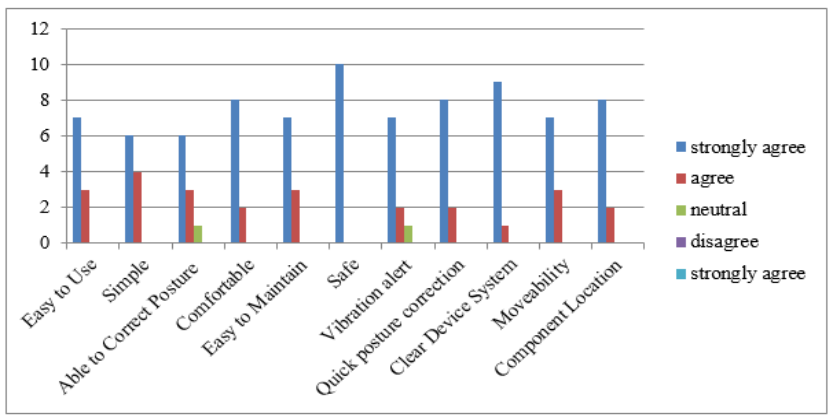


Figure 20: PSSUQ Feedback Result from The Volunteer

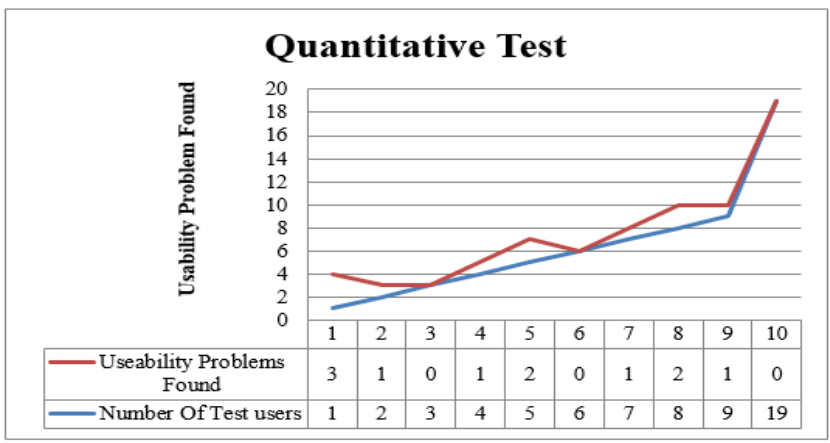


Figure 21: Amount of Defect Occur During Test 5 Times Per Trial

## Conclusion

In this modern century, as technologies take over the world, sophisticated traditional job become much easy and less of movement required. They are lot of tendencies working with sitting position such as in the office. As consequences, they subconsciously have first stage of hunch. Aftermath of this illness will slowly consume their health such as stress, causes digestive issues, poor breathing, back shoulder and neck pain, tension headaches and Scheuermann's disease. To avoid this health injury occur, Anti-Hunchback device are designed to eliminate this risk to those future spine ill.

The aim of this research is avoid people hunch during their activity doesn't matter where the incident occur. As the result obtained, the final device prototype is successfully completed and achieved the main objective. The studies about the method to produce design, finish product and the materials needed to make this product have done well. The result quite positive despite several problems arise when the study was conducted. Among these are the problems to choose a suitable design to place towards human upper back.

Moreover, based on the aim of this research which to find out the best design and to reduce hunch, there are some procedure have been done. The questionnaire survey has been distributed by using surveymonkey.com and also manually. With the 100 respondents who are willingly to answer this questionnaire survey, the customer need was obtained. Therefore, some concepts have been designed before the best design has been chosen. The difficulties during designing occurred while considered on how to place the components, material and cover design. During the manufacturing process, there are some technical difficulties and resistance occurred. Solder wire did not proper cover up the whole pin which it takes long time to proper layer it until become strong point. Besides, the top cover design required long time to select due to toughness, balance and flexibility. Filament Rapid Prototype (RPD) is malfunction for long time which needs to hold the project and for the smaller size cover it used LBM machine. This manufacturing and finishing process took quite a time and patience to complete. Finally, this device has been successfully develop and it is based on the customer needs.

For future work, this device can be suggested to develop with a multi-function health benefit. The clamp factor is adjustable and layered with comforted cushion around the neck. In can be develop with apps and the angle meter can be diagnosed inside mobile phone. It can also trigger the body temperature; change from vibration to heat and noise. Besides, to make it handy, the device are able to flip and enough in a pocket. Apart from that, the material used can also change to the better material which more tough and durable. The main alter is the clamp force and also clip to avoid it from fall during activities.

## Acknowledgement

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