A CASE STUDY ON IDENTIFYING THE AESTHETIC VALUES OF LOWER LIMB PROSTHETIC

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ABSTRACT

Prosthesis refers to the artificial extension or equipment that substitutes a missing body part, be it an eye, a nose, a tooth, a facial bone, and even upper or lower body limbs. Aesthetic denotes the value of a property based on its appearance. Application of aesthetic values on prosthesis design adds to its attraction that enhances positivity and increases the psychological acceptance of the "new limb". Nevertheless, investigations that focused on this particular subject matter are in scarcity, especially those that analysed the correlation between aesthetic attraction to devices and their human-likeness. As such, this study conducted a literature review analysis and several semi-structured interview sessions with selected lower limb prosthesis users. The primary objective of this study was to determine the level of aesthetic satisfaction amongst selected local prosthesis users regarding their prosthetic devices. As a result, the study outcomes displayed that males were more satisfied with their prosthesis than the females did. In comparison to the female respondents, the males exerted higher tendency in wearing cosmesis. Apart from that, an amputee who resided at the urban area seemed to be more willingly to wear artificial limb than those who lived in small town. Amputees with lower physical activity level were more likely to choose prosthesis that resembled the normal human limb embedded with realistic details, such as toes and skin colour. Therefore, the study yields bridge the gap in information and add to the existing knowledge concerning aesthetics of prosthesis design, apart from encouraging enhancements for future prosthesis design.

Keywords: *Prosthesis, Aesthetic, Lower Limb, Design*

1.0 INTRODUCTION

The prosthesis is an artificial extension or equipment that replaces a missing body part, which could be an eye, a nose, a tooth, a facial bone, an upper or lower body limbs, and other body parts (Breaky, JW, 1997). The use of prosthetics for example denoted by artificial limbs (prosthesis) replaces the original function of limbs of an individual who suffers from limb misplacement or limb absence in order to enhance one's daily life. Artificial or prosthetic limbs require a special combination of suitable design, material, alignment, and engineering to fulfil the functional needs of the wearer. According to World Health Organization USA, 2004, the lower limb amputations which under the knees become the highest cases happen to the human.

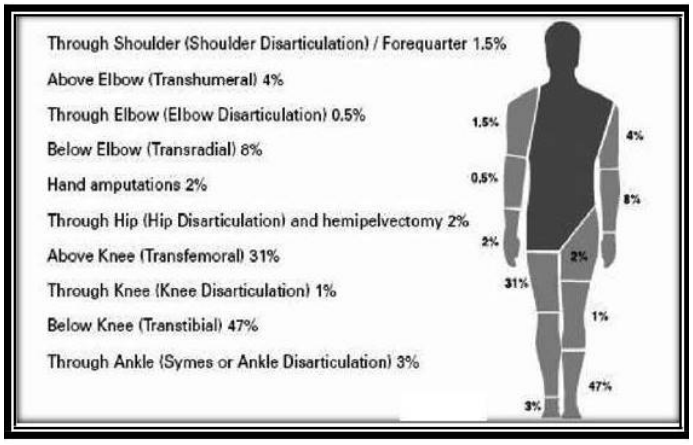

Figure 1: The percentage of limb amputation at all levels. (World Health Organization USA, 2004)

According to Gregory-Dean (1991), the occurrence of lower-limb amputations is significantly higher than upper-limb amputations. Furthermore, amputations are most prevalent among elderly people (Stewart, Jain, & Ogston, 1992). This is because the lower limb amputations are caused by a number of major factors, including congenital limb absence or damaged limb, diseases, and traumatic injury (CE & JA, 2009). Elderly person is always involved with the safety careless and unhealthy life (Stewart, Jain, & Ogston, 1992).

A person suffering from the congenital condition is born with a missing or damaged limb, may require an artificial limb to aid in mobility. Traumatic injuries, on the other hand, may be caused by traffic, industrial and war-related accidents are regarded as major reasons leading to amputation in most of the developing countries. However, in most developed countries, amputations happen mostly due to diseases. Consequently, due to these factors and many other reasons, the demand for prosthetic limbs has risen around the world (Stewart et al., 1992).

In Malaysia, the common reason for the exponentially increasing number of limb amputation is type-2 diabetes according to the Ministry of Health of Malaysia (2015). Although type-2 diabetes is a common factor leading to amputations, other determinants also contribute to the increasing number of amputations. Abdullah & Mey (2011) stated that over the last decade, there has been a rise in the official number of Malaysia citizens registered with disabilities. Accordingly, a total of 258,918 people with disabilities were registered in Malaysia by mid-2009 compared to a mere 69,753 recorded by the Social Welfare Department in 1997. Therefore, quality prosthetic devices are required to cater to the increasing numbers of amputees and to meet patients' satisfaction requirements.

Based on a study by Razak et al (2016), a person who loses mobility and independence due to lower limb amputation faces detrimental impacts. The physical ability, social capability, body image, lifelines and general health of the amputees compared to the normal population is affected upon amputation (Eiser et al., 2001). Other than the physical changes, amputation of a limb can negatively impact the patients' psychology (Horgan & MacLachlan, 2004). In particular, post-amputation, amputees may suffer from stress and depression (Breakey, 1997; Rybarczyk et al., 1992). They may also face tremendous difficulty in accepting their current physical condition due to the absence of certain body parts (Sjödahl, Gard, & Jarnlo, 2004).

In addition to discussing the functionality of prosthetic limbs, the psychological concerns of amputees influenced by the aesthetic value of the prosthesis will also be shown in this study. A previous study indicated that the aesthetic appearance of the prostheses is also considered essential apart from its functionality and comfort in order for prostheses to be accepted by the users (Millstein, Heger, & Hunter, 1986). The aesthetic appearance of the prostheses influences the opinion or acceptance of both the wearers and observers, especially for lower limb prosthetic devices. The self-body performance and psychological satisfaction of the wearer are enhanced by reinforcing the aesthetic quality of the device (Cairns et al., 2014).

This study emphasises the aesthetics quality of prostheses as the use of prostheses affects the psychological satisfaction of lower-limb amputees. Besides highlighting the changes in the physical appearance of prostheses wearers, this study also pinpointed the realism of prosthetic devices attracting visual attention. Furthermore, this study investigated the characteristic of design elements in prosthetics design as a factor for creating visual appeal. In response to that, this paper identified key design elements applicable to the aesthetic design of lower limb prosthetic devices aiming to enhance the prosthetic users' emotional experience by providing a set of guidelines for the improvement of a user-centred data collection approach. The design of methodology is based on a fully qualitative method and semi-structured interviews.

1.1 PROTHESIS DESIGN

Demand for prosthesis were exponentially increased following the onset of the World War I, as when the tremendous amount of injured soldiers came back from the battle field without limbs (Hunter Oatman, 2012). Meanwhile, improvement and development were started to be seen in the field of

prosthesis design. For instance, the artificial arm used during World War I which shows in Figure 2 allowed movement, and different types of attachments applied that gives user more flexibility rather than only replace the misplacement of the body parts with similar shape but rigid objects.

Figure 2: Development of prosthesis design can be seen in different aspects after World War I

The development of prosthesis become better and got improvement in term of colour, material and functionality. In figure 3 shows the evolution of prosthetic limb design from 1800 to 2000. Regardless of the advance technology, wearers still emerge an unbreakable emotional bonding connects with their prosthesis. Thus, in order to enhance the psychological aspect of user experience, this study is aimed to find out the satisfaction of local amputees on their prosthetic devices and the importance placed on contribution of aesthetic appearance of prosthetic to provide useful information for future prosthesis design.

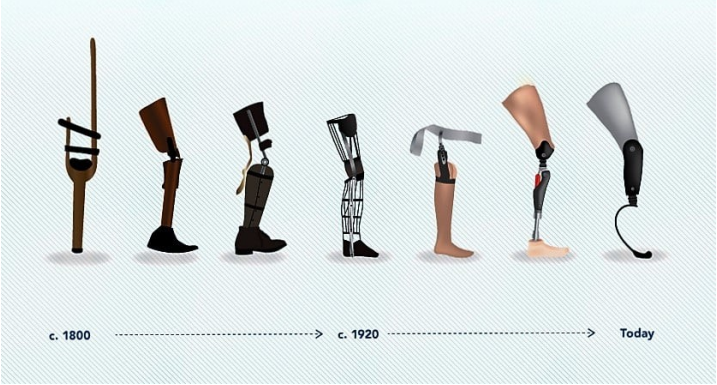

Figure 3: The evolution of prosthetic limb design from 1800 to 2000. (Care Crafters Prosthetics & Orthotics, 2016)

There are few elements will look in prosthesis design. There has listed out certain design elements to be classified in their study which are colour, pattern, fashion and organic components (Sansoni, Wodehouse, McFadyen, & Buis, 2015).

People also look for the material such as wood, metal and plastic. They used to know that metal is a strong material since centuries ago. However, thanks to today's technology, carbon fiber is found stronger than metal steel. According to Zoltek Carbon Fiber Education Group (2000), the strongest carbon fibers are 10 times stronger than steel and 8 times that of aluminium. Further than that, weight of prosthesis is also a big issue that influence user satisfaction. Carbon fiber provides light weight that is 5 times lighter than steel and 1.5 times lighter than aluminium. Biotech Limb and Brace, LCC (2000) has stated out the benefits that carbon technology could bring towards prosthesis design such as: reducing weight, enhancing flexibility, increasing strength as well as increasing durability.

The aesthetic taste could be influenced by different gender. Salkind (1997) argued that boys' and girls' art perception is different because of their psychosocial variables. The male was likely tend to greater levels of graphic complicacy while girls to lower levels of graphic complicacy (Rački, 2015). Similarly, in the study of Savarese and Miller (1979), girls were found more preferred "direct and artistic style artworks." Therefore, male and female got different perception for the aesthetic design value.

1.2 RESEARCH OBJECTIVE

The objectives of this study are to investigate the current satisfaction level of Malaysia prosthesis users with their prosthetic devices. In order to prove that aesthetics quality of prosthesis brings decisive impact toward lower-limb amputees' psychological satisfaction, and the level of appreciation on aesthetic design would be identified in this study. Following the objectives, key aesthetic design elements and characteristics applied on currently used prosthesis in Malaysia which are more appreciated would be found out as well. Furthermore, the outcome of this study is to create a clearer guideline in order to improve prosthesis design development in future. Meanwhile, this guideline may also help prosthesis designer meets the individual needs of amputees in Malaysia.

1.3 LIMITATION OF THE STUDY

Several limitations are worth noting in this study. The target respondents for this study are the lower limb amputees in Malaysia. Since this study investigated a limited number of prosthesis users from different individual characteristics and cultural background, only a small number of respondents were recruited for this study. Next, since this study did not include a complete manufacturing design progress, the pricing and technical details were not considered and investigated in the current study, however, are encouraged to be addressed in future studies.

2.0 RESEARCH METHOD

A semi-structured interview was conducted to gather information and feedback from the recruited participants. During the interview, a set of prosthetic models which were showcased were accompanied by some aesthetic-related questions. The method of research is based on the collection and analysis of non-numerical data, derived from interviews and observations. Through this method, researchers can obtain and gather sufficient, in-depth perspectives targeting people with special needs instead of applying a quantitative method such as questionnaires. Guba and Lincoln (1994) stated that qualitative data collected through interviews can be validated in providing a better understanding of human behaviour which meets the objective of this study

2.1 Participants

Limb For Life (LFL) in Bandar Utama was contacted and has agreed to participate in this study. Four lower limb amputees using prosthesis from LFL consented to participate in this study. The participants recruited for this study were adult men or women of no younger than 13 years old.

3.0 RESULTS AND FINDING

Interview sessions were conducted for 4 prosthesis users who had undergone lower limb amputation. They were from different age group, gender and culture background. Their details are follows:

1. Race: Indian 2 (50%); Malay 1 (25%); Chinese 1 (25%).
2. Gender: Male 3 (75%); Female 1 (25%)
3. Amputation reason: Trauma 1 (25%); Disease 2 (50%); Congenital 1 (25%)

Upon acquiring the approval of the participants, the conversation during the interview was recorded using the researchers' mobile devices. In addition, 3 of the 4 participants agreed for their photos to be

taken with the researcher during and after the interview while the other wanted to remain anonymous. The 2 major themes highlighted from the data collection, include: 1) Aesthetic Satisfaction and 2) Important Design Features.

3.1 Aesthetic Satisfaction

Participant 1 (P1) is not really satisfied with the current aesthetic appearance of the prosthesis as it is still yet to go through cosmesis. P1 feels that his prosthesis looks unstable without cosmetics. In general, prosthesis wearer who receives his/her prosthetic limb from LFL must wear the prosthesis for at least 6 months before proceeding to cosmetic making. This is because once the prosthesis has gone through cosmesis, adjustments cannot be made even if the wearer finds it uncomfortable. Therefore, it is only after 6 months of adaptive phase that the patient can get their prosthesis to be cosmeticised. Regarding the aesthetic quality of the prosthesis appearance, P1 is dissatisfied and the importance level of aesthetic value for P1 is at a medium rank. P1 said:

"For me, the aesthetic quality of my prosthesis is dispensable."

However, he still demanded for a cosmetic limb if possible.

"But it's better if I could have a cosmetic one."

On the other hand, participant 2 (P2) agreed that the aesthetic quality of prosthesis plays an important role in prosthetic design.

"*Yes, it is quite important to have a pleasant looking for prosthesis*"

P2 would be glad to use a cool looking prosthesis. P2 rated his satisfaction on the prosthesis at a high rank, as he thinks that it's satisfying to be able to walk again. P2 is confident to show his ideal prosthesis.

"I'm satisfied to have a leg to walk again, it's enough for me."

Although participant 3 (P3) gave high rates for his satisfaction on the prosthesis, P still encountered discomfort.

"It is good enough for me although it's not comfortable sometimes."

Aesthetic quality is considered important for P3 and appreciated the cool appearance of the device. P3 may be confident to show out his ideal prosthesis.

Lastly, participant 4 (P4), hoped to have a pleasant looking prosthesis if possible. However, functionality is still the prior concern for P4 rather than the aesthetic appeal:

"Well, I think it depends. But functionality is the prior concern for me."

P4 gave a medium-high rank for satisfaction on the prosthesis as P4 is satisfied with its basic use.

"It is good enough for me for basic use since I'm not using it 24 hours."

P4 is satisfied with her current prosthesis as she is able to walk independently now.

3.2 Important Design Features

Some key points emphasised by P1 include the improvement on the material which should be considered essential in prosthesis design.

"Material, my prosthesis I'm using now is quite heavy for me, I hope there is one with light weight and nice looking at the same time"

Moreover, P1 agreed on realism of the prosthesis which influences visual attraction, thus preferred his

prosthesis to be similar to a genuine human limb with realistic colour and details. However, no suggestion was given by P2, but repeatedly mentioned "cool looking" in his statements. P2 also demanded for a sports prosthesis that is stylish and functional that fits his personality. P2 agreed that the realism of the prosthesis influences visual attraction. He prefers his prosthesis to be practical in shape but obviously artificial.

> *"I would choose the one looks prosthetic limb with a practical shape but that is obviously artificial, it looks cool. I'm very active in school, I wish I could have one stylish and functional prosthesis for sport."*

Next, P3 chose colour and pattern as the essential design elements for his ideal prosthesis.

> *"Because these two affect the most on the appearance."*

Besides that, P3 highlighted the durability of the prosthesis that should be improved based on his experience.

> *"More durable, easy maintenance, this prosthesis cannot get wet but I'm active person which mean I sweat a lot, and this will affect the durability of my prosthesis."*

On the other hand, P4 chose colour as the essential design elements of her ideal prosthesis. P4 further suggested that changeable colour would be appreciated to fit her costume.

> *"I think colour affects a lot. If it is changeable then it would be good to fit my outfit."*

P4 agrees that realism of the prosthesis influences visual attraction and would be confident to show off her ideal prosthesis. P4 also preferred her prosthesis to look similar to genuine human limb with practical colour and details. She also suggested that it would be a good choice to have skin colour as one of the options if the colour is changeable.

> *"At this moment, I would choose the one looks similar to a genuine human limb with practical colour and details, but it's so nice if colour skin is one of the options of the changeable colour*."

4.0 CONCLUSION

The data obtained in this study indicated that the aesthetic satisfaction of the local prosthesis users on their current prosthetic device fulfilled the objective of this study. In concern with the prosthetic limb appearance and respondents' opinion or satisfaction, the amputees' prosthesis satisfaction can be improved through prosthetic design which could directly influence the mental health of amputees. In figure 4 shows the guideline framework for the prosthesis design based on the aesthetic satisfaction and design features.

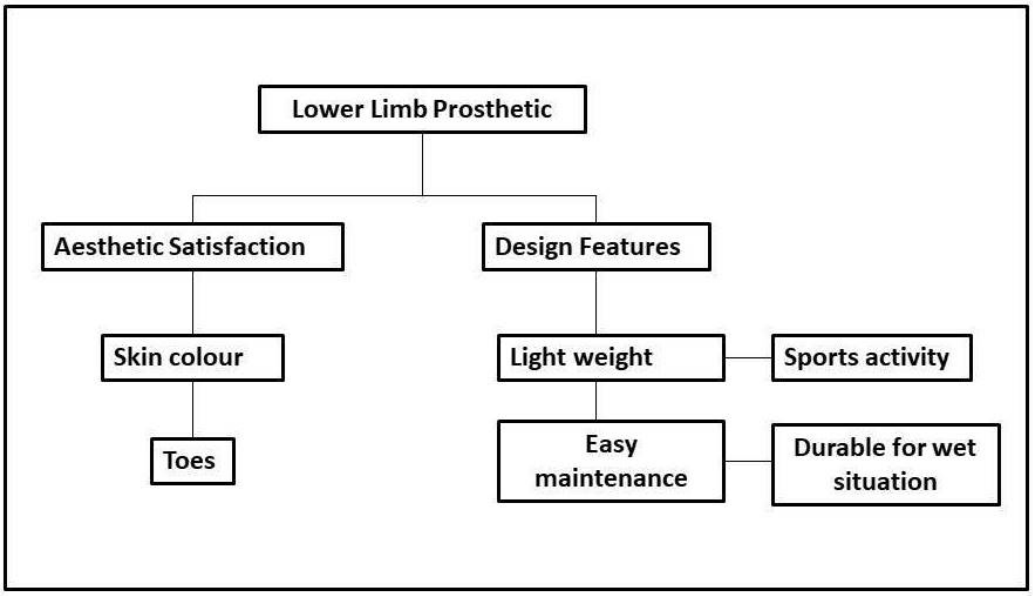

Figure 4: Guideline framework for prosthesis design based on aesthetic satisfaction and design features

For the conclusion, the prosthesis user preferred skin colour and real toes for the aesthetic values. Therefore they feel confidence walk with other normal peoples. They preferred light weight due they can involve with any sports activity or others. They also want the material is easy to maintain. Men are more satisfied with their prosthesis than women. Also, men tend to wear a cosmesis compared to women. Furthermore, it was identified that amputees who live in an urban area are more willing to wear artificial limb than those who live in small towns. Amputees with lower physical activity level are more likely to choose prosthesis that looks similar to normal human limb with realistic detail, such as toes and skin colour. It is hoped that this study can fill the vacancy of information and relevant research on the aesthetics of prosthesis design. Finally, future prosthesis design research can be improved by utilising the important design features that were identified during data collection in the current study.

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