A new design approach of user-centered design on a personal assistive bathing device for hemiplegia
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Designers of assistive device develop and produce assistive device. If the process is a “Black Box process” which is only valid with the designer or expert, the experience of the project cannot be systemized. Therefore, the objective of this study is to build a standardized design procedure specific for assistive devices. The selection of the Assistive Technology Device prioritizes on user ability, environment needs and the objective; providing design procedure based on User-Centered Design. The aim of UCD is to include the user in the complete design procedure to enhance the practicality of the product, enabling the product to fulfill the needs of the user. This study bases the four criterion of UCD as the fundamental structure of the research; exploring the implementation of new assistive device product design methods into an UCD structure, providing standardized assistive device design procedure.

The design goal must be understood before the design begins, the man (user), machine (assistive device) and link (environment) must be understood. The field of business management often applies the SWOT analysis, using one’s subjective and objective conditions to analysis one’s market position. This study applies SWOT on Assistive Technology procedure providing new assistive device to design conceptual development method. This method is mainly applied in the field of assistive device design, providing a specific analytical method on a specific assistive device. Therefore, this study names this method as “Assistive Device SWOT (AD-SWOT)”.

The first stage is to understand user traits. The subject of this study is a 72 years old female with a diagnosis of being a L’t hemiparesis due to R’t MCA infarction patient. The subject suffers from slight paralysis and coordination problems; she can also grab devices with a big handle for her daily activities. It is observed that the subject often results in the slanting of the body due to applying excessive power on the assistive device; this lack of balance creates the potential of tripping. The perceptual ability of the subject is evaluated in this stage and the evaluations find that the subject has a normal perception; without the influence of a slight synergy she is able to produce complete actions. This discards the influence of synergy on this study. The physical ability is then evaluated, including the joint’s range of motion and muscle strength.
The second stage undergoes the community, technological and environmental analysis of the assistive device; integrating user traits from the first stage. The strengths of the subject are identified as the right upper limb, range of motion of the upper limb shoulder joint being able to extend to shoulder-height, upper limb elbow, range of motion of the wrist joint performed well and the complete muscle strength of the left and right lower extremities. The weakness is that the upper limb cannot be lifted above shoulder, upper limb cannot extend to lower extremity, and range of motion of the lower extremity is too low. The opportunities are tasks (the back, popliteal, leg and foot) that cannot be performed personally are completed with the help of the assistive device, using the assistive device can induce the user to perform independently and is helpful in rehabilitation of the subject. The threats are the operating action which causes the user’s imbalance, exertion of sudden force and the resulting of the change of blood flow.

The third stage is defining design standards, providing concrete design references for designers in the next stage. This stage summarizes the above described research and study, providing concrete design goals, design limits and design development standard for this study. Firstly, the assistance of cleaning the back and lower limb is defined as the goal. Apart from the functions of the device, the operation design of the device must also take into consideration the muscle strength of the hand. Secondly, based on data gained from physical element analysis, and the motion characteristics of a patient suffering from stroke, the device should be limited and formulated as:

1. The assistive device design of a stroke patient should aim at “keeping balance” as the main consideration, keeping the balance of the body.
2. The patient requires the support of the upper limb while sitting down.
3. Although the focus is emphasized on the affected side, the safety of the healthy side should also be considered to keep the balance of the patient.
4. With the support of the lower limb, the movable area of the upper limb will be extended.

Finally, using the three developmental directions of weakness and opportunities, strengths and opportunities and strengths and threats, the standard of formulating assistive device design development is applied as the conceptual development direction.

The fourth stage consists of the concept design and prototype production. This stage aims at the bathing needs of the user – the back, lower limb cleaning devices. 12 concepts are developed through the application of concept development rules. Secondly, patients suffering from neurological diseases are taken into consideration. Based on “design limitation principles”, concept selection takes place. The total score is calculated and four conceptual principles are produced, specifying requirements. Lastly, design concepts are developed through sketches. After requirement specification, sampling of products takes place. The assistive device of this study consists of three parts: a board for cleansing of the back, foot cleaning device (also support bathing straps to undergo various cleaning actions) and co-operating with the single-sided elastic bathing belt which is used on the problem of weak left side muscle.

The fifth stage is the evaluation based on the user; the device is sampled and given for individual use. The first time it is used, the experiment controller guides the subject and only afterwards is the subject permitted to undergo training of the device operation. The duration of the training is one week. After the subject has used the device for one week, the experiment controller agrees on the participation of the subject with the evaluation and the actual usage is videoed. The usage of the device consists of two parts, the first being the evaluation of execution abilities and the second part focusing on the evaluation of the device efficiency. The evaluation plan is as follows:
1. Execution ability evaluation: the experiment controller observes how the subject showers and evaluates the subject’s ability to carry out the required actions.

2. Efficiency evaluation: this phase of the experiment evaluates whether the product can complete cleaning actions that cannot be completed independently.

While the subject cleans with the provided device, observation and analysis are made. The back, popliteal, leg and foot of the subject cannot be cleansed properly due to the range of motion of the body. Therefore, the above seven parts are marked with red paint and after the subject have showered, stills of the video are analyzed to observe the degree of cleansing of the seven parts. Furthermore, the same experimental steps take place the following day, the subject showers with the absence of the devices, the same procedure of observing the seven parts takes place. The subject showed a better cleaning result on the knee, popliteal and leg compared to existing assistive devices.

When comparing postures of using existing assistive devices and assistive devices from this study, the result shows that the posture of using assistive device from this study has an obvious difference from existing devices. There is no difference on the neck and right upper limb. But it provides a stabilizing and straightening effect on the shoulder and body, which would otherwise have resulted in a big range of motion due to actions from the healthy side. It even applies on the left upper and lower limbs that are neglected, using the balance of the affected side and healthy side, in addition to the interconnection of the assistive device, amplifying the maximum physical ability of the patient, and reaching the objective of cleaning the patient’s whole body independently. The assistive device of this study not only provides support for subjects not able to perform independently, but also uses the affected and healthy side of the patient effectively, enhancing the rate of using the affected side instead of relying on the healthy side.

After the training, the subject uses the assistive device independently for one week. The experiment controller conducts a satisfaction interview on the subject and the feedback of the user will be applied on the modification of the device. In the interview on the user, the subject showed a high satisfaction and affirmation on its assertiveness, but commented on the lack of familiarity with the device, resulting not being able to completely cleanse the red marks mentioned in the experiment (the left feet being most obvious). She feels that she needs practice time.

In order to formulate credibility, the device is provided to another stroke patient. The experiment selects a candidate that also suffers from a left-side paralysis. After an evaluation on the range of motion of the joint and muscle strength, an 84 years old male candidate is chosen as case study 2. The physical ability analysis shows that the left lower limb joint range of motion performed the worst, the upper joint range of motion performed normally; the right muscle strength (upper and lower limb) performed normally, the left lower muscle strength performed worse. Through interviews and physical movement ability of the subject, case study 2 did not have the lower limb strength to sit on a bathing chair and the body cannot bend with the resulting difficulty of cleansing the lower limb. In this stage red marks were painted on the subject before the shower, the subject took shower independently with this assistive device; then the effectiveness of the product on different subjects were compared.

The assistive device of this study applies assistive device design development procedures to complete the design and development of the assistive device, enabling the assistive device designer to enlighten the concept and provide experiences for future designers to help more users.