PAPALANI, TRYCICLE FOR SPORT AND REHABILITATION DEVELOPMENT OF PEOPLE WITH CEREBRAL PALSY

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ABSTRACT

Object design can improve rehabilitation and social inclusion for people with Cerebral Palsy, a tricycle for RaceRunner competitions adapted to Mexican and Latin-American cerebral palsy population dimensions and considering their economical and social necessities is developed by an interdisciplinary team leaded by the industrial design school and conformed by physical therapists, management school, end users and their families, and with the support of a Paralympic athlete with Spastic Cerebral palsy. An anthropometric, biomechanical and object design analysis was conducted. This design doesn't only allow Cerebral Palsy people to compete or get physical rehabilitation, also people with reduced mobility or third age are able to use it, enhancing their rehabilitation and social inclusion.

INTRODUCTION

Cerebral palsy (CP) describes a group of permanent conditions limiting movement and posture and causing activity limitation attributed to non-progressive disturbances that occurred in the developing fetal or infant brain. The motor limitations of CP are often accompanied by disturbances of sensation, perception, cognition, communication, and behavior, by epilepsy, and by secondary musculoskeletal problems. (Rosenbaum, 2007:9) Its world incidence rate is 2 to 2.5 per 1000 births (Calzada, 2014). The conditions and needs of each person with CP are different, some require constant caring or assistance or they have different needs regarding posture and balance. When they have enough medical, social and economical support, they can participate in most everyday activities; good rehabilitation or occupational therapy programs can lead them to development of abilities and a good quality of life.

Taking in consideration their ability and/or physical characteristics people with CP are integrated in events like wheelchair races. Early wheelchair races were performed backwards in a seated position; competitors propelled themselves extending their knees and feet with the objective of developing a more efficient movement. In 1989 Connie Hansen and Mansoor Siddiqi, both Paralympic wheelchair race athletes, conducted research with the idea of developing the athletes' physical potential and muscle strength. They changed the position to a frontal semi-standing position. This improved the record time from 38 seconds to 28 seconds in a 100 meters competition. With this proposal the Race Runner concept was born, defined as "Tricycle without pedals with a frontal thorax support plate". The objective is to promote the abilities and capacities of people with CP enabling autonomous movement for faster velocities. In 1995 the Cerebral Palsy International Sports and Recreation Association (CPISRA) started general competitions using the Race Runner device. In 2013 Race Runner competitions became an athletic discipline (Sidiqqi, 2016).

In Mexico this sport is not well known. People with CP usually use hand cycles, an adaptive seated tricycle, the low-rider or the tandem, which are still expensive for most of the population because they are also imported. RaceRunner tricycles are manufactured and sold in North Europe, so the cost in developing countries is too high for people with CP; even though 3 functional sizes and adjustable parts are included, these devices are designed for a European population. The body sizes of the Latin-American population are different and it is difficult to adapt and personalize the tricycles for the needs of individuals.

A Mexican Paralympic athlete with Spastic CP who competes in Europe approached the Trials and Simulators Laboratory of the Universidad Autonoma Metropolitana, campus Xochimilco, which is part of the Industrial Design School, with the purpose of developing a new tricycle that fulfilled the CPISRA specifications and Latin American needs. On his own he had already built 3 tricycles (figure 1.), which were hand made by a blacksmith with the supervision of a student of engineering, but they are heavy, poorly

designed, not well sized and very rigid. The third one can be folded but it still has size and weight problems, and doesn't have a springs or shock absorbers to reduce movement. He traveled with it by airplane and had to pack it in a cardboard TV box, which compromised its integrity.

After the athlete competed in Europe and won

Figure 1 Tricycles built by the Paralympic athlete.

medals, specialized Mexican sport associations like the Sport National Commission (CONADE), local CP schools and institutions were interested in using the tricycle design. Physical therapists and parents believe that promoting this device among athletes or people with mobile disability has a great potential. The athlete hopes to develop affordable accessible tricycles to train athletes with CP and get government support to compete in the international scene.

This project received a university grant with the objective of developing an affordable accessible tricycle hoping that it would be marketable and thus become a self-financed research project that produces income for the university.

For the development of the project an interdisciplinary team was assembled:

1. People with CP and their families: they are key participants for design who convey their needs, concerns and design ideas to the design team.
2. Industrial design school: the designing of the device and the manufacturing of a simulator to test concepts will be done in their industrial workshops to reduce costs.
3. Cerebral palsy sport associations: they will participate by arranging the appropriate athletic spaces for the field trials, loan the three built tricycles for analysis and help recruit potential users for the anthropometrical and biomechanical analysis
4. Occupational and Physical therapists: they will provide medical and biomechanical knowledge to assess the correct postures and use of the tricycle and evaluate the rehabilitation potential of the device.
5. Management school: they will study the financial viability of the product and develop a business model to establish the feasibility of developing a personalized design of the tricycle.
6. Social Service students: They will support the fieldwork and learn through the experience.

METHODS

As part of the industrial design process this project was divided into 3 phases.

Phase 1. User Analysis

The development of the project started with an ethnographic analysis of the CP population and an ergonomic, anthropometrical and biomechanical study of the end users with the objective of developing a comfortable, functional, efficient and safe device. A total of 10 participants with spastic CP age 14 to 50, all able to follow commands and walk with help, accompanied by the primary caregiver (considered a direct user too) were invited to participate in the tryouts of the built tricycles in a 400 athletic track (Figure 2).

Each participant tried each tricycle and was encouraged to do a complete round on the 400m track. Video and photography were taken during the mounting of the tricycle, observation of the primary caregiver activity, the position and adjust needed for the CP user, the posture used during the track running or walking and how they get off the tricycle. After the trial, an open interview was completed with the participant and his caregiver, so their opinions and design recommendations could be taken into consideration.

Figure 2. Track field trials with direct users.

An independent analysis of the Paralympic athlete was done at the laboratory to obtain complete anthropometric data on the participant and the tricycles measurements. Photographs and video were made to assess each individual's posture using a gridded wall (Figure 3). House visits and open interviews were also completed to identify related needs in the design of a competition tricycle, e.g. storage space, transport issues, etc.

Phase 2. Object analysis.

A reverse engineering method was applied to assess the tricycles. The current built tricycles

Figure 3. Laboratory photographic session with the gridded wall.

were photographed and analyzed by physical characteristics like size and weight and design features. With the help of this data and information from the photographs and video a design proposal was completed. The design also addressed the CPISRA specifications for manufacturing a tricycle (CPISRA, 2015):

- Maximum length is 200 cm, Maximum height 95 cm. The frame has one frontal and two back tires. Front tire size 25", Back tire size 27"
- The seat support doesn't have to be the traditional bicycle type. A thorax support plate is needed to provide stability and the body can be tied to a plate, belt or an orthopedic clamp
- The steering handle has to be secured so the athlete can run and maneuver without risk. Hands can be fastened to the handle, if the athlete can operate a brake, it can be included.

Considering the principles of design, which are, ergonomics, form and function, the prototype design will rethink the thorax plate, the seat, the handle and the angles. It will provide three basic sizes: small, medium and large, based in Mexican user percentiles, and also accommodating children, adolescents and third age users. The next phase will include user trials, and a cost analysis. From this, real redesign parameters will be developed. The redesign proposals were completed as scale models and presented to the Paralympic athlete.

Phase 3.

The 3 built tricycles were cleaned, repainted and adjusted; a spring was integrated in the handles so other users can use them for training and competition. The manufacturing of a competition prototype tricycle is in process for the trials in formal competences.

RESULTS

After the Paralympic athlete interview and the general ethnographic research the design needs determined were:

1. Price - The European model is extremely expensive for the Latin-American population, considering the lack of governmental support and low income of most of the families, the price has to be in the bicycle market range.
2. Folding – Considering cars and houses usually used by families with CP members are small or that professional competitions are carried out in different countries or continents and it has to be transported by plane in the bicycle category, fast folding and a resistant case is needed.
3. Weight - Most of the helpers are women, especially mothers, therefore it has to be light so smaller people can carry it easily.
4. Dimensions – The sizes need to be adapted for the Latin-American population.

The research team found that the tricycle is useful for people who have difficulty walking or limited strength so it is not only useful for specialized sports or as a rehabilitation device. It can also be used by people with reduced mobility, amputations and third age. Finally, it can be a device for encouraging family integration with recreational or social activities like bicycle roads or paths.

The physical therapists noticed the sitting position with the weight falling over the seat reduces spastic movements and helps with the postural balance, generating an aerobic activity that substitute for the exercise done with a walker. The internal abductor muscles are not involved but since they are connected with leg flexion and extension from hip to legs, the device permits more movement, allowing people to experience a walking sensation and generating a feeling of freedom and autonomy.

Developing these tricycles will allow users to build up their strength, dexterity, and general physical ability and obtain greater aerobic capacity. It can be used by an athlete or as a rehabilitation or social participation device. It can allow families to do more activities together and also provide a new perspective to people with mobility limitations to enhance capacity and personal development. Due to the characteristics and specific capacities of each user a personalized design is needed. The adaptable

elements should allow the person to maintain a secure position when seating, as well as provide body support and control through a good grip on the handles.

The project will be part of a university business development where the management school is elaborating the financial analysis for its inclusion in local and foreign markets, and will support rehabilitation institutions for its implementation in their physical therapies. The business plan is considering that due to the components and materials, it has to be easy to fix and maintain and replacement parts have to be easy to get. The last two should be found in a bicycle workshop.

As part of the institutional development of the project a name and a graphic image had to be developed, with the intention of having a Mexican identity, considering that the tricycle will be in internationally competitions, the name "Papalani" was chosen. It had to be a name that would be easy to pronounce in any language. Papalani means, "Flying continuously" in Nahuatl, an indigenous Mexican language.

CONCLUSION

The analysis concluded with the idea of designing two different tricycles. The one designed specifically for competition has to be custom made for the athlete's measurements and will be manufactured with duralumin or Columbus and high quality components, racing tires, a personalized thorax support and a travelling airplane case. The university grant will cover the prototype price. The other will be built for rehabilitation and social purposes, considering two basic designs, children and adult, and those will be divided in small, medium and tall, using bicycle and commercial parts

The design of an anthropometric method for the measuring people with CP, a more detailed biomechanical analysis of mounting, sitting and running has to be completed. A seating system and mechanism has to be developed for different kind of users.

The tricycle design and manufacture will not develop a low price product; the management school is looking for options that will be ~~the~~ more suitable for final users so the durability can be guaranteed. Part of the high price of these devices is because it has to be done specifically for each user and its needs, for the rehabilitation and social proposals, the development of a base design with the inclusion of alternative pieces is the best option to reduce costs.

Mexico provides limited governmental support for people with disabilities. Only families with higher incomes can buy foreign rehabilitation devices and technical aids. The development of this market is an emerging area at present. Institutions, universities and manufacturers are combining efforts to develop better designs and more affordable prices. This can serve as a model for other developing economies.

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