Adaptive Hydrotherapy Wetsuit: User-Centred Design Approach

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PolyU UoA 38

Adaptive Hydrotherapy Wetsuit - User-Centred Design Approach

Descriptor

This research took a user-centred design approach to develop a hydrotherapy wetsuit prototype for people with limited mobility. Flotation devices for rehabilitation are generally too bulky and require special machines to fasten and remove the device from the patient. Furthermore, they tend to impair the wearer's movement as they ride up over the wearer's shoulders, or are too cumbersome to allow sufficient limb movements. Consequently, this not only creates difficulty for physiotherapists to administer effective hydrotherapy, but it also renders hydrotherapy less cost-effective as it requires a minimum of two physiotherapists to ensure the patient's safety. Consultations with physiotherapists and patients with impaired leg movements were conducted, and a total of 53 floatation patents was reviewed and buoyant materials were tested. Subsequently, a series of hydrotherapy wetsuit prototypes were designed and developed to achieve two hydrotherapy positions in the water, an upright position and a supine position, whilst limiting the physiotherapists' assistance. Two distinctive features of the adaptive hydrotherapy wetsuit, adjustability and user-operated adaptability, were to improve hydrotherapy effectiveness while increasing cost-efficiency. First, maneuverability is improved by a snug fit provided by two pairs of adjustable side buckles and an adjustable crotch panel, which prevents patients from capsizing in the water. Second, its user-operated flexibility is achieved by pulling the cord from the front to move the corresponding the movable foam panels in the back, which enables wearers to change between two hydrotherapy positions in the water. This reduces the number of required physiotherapists from two to one. The adaptive hydrotherapy also provides the wearer with maximum comfort through an ergonomic design and skin friendly fabrics.

Research outputs includes a silver medal from the 43rd International Exhibition of Inventions of Geneva (2015), a journal publication (2016), a patent (pending since 2015) and two commercial fairs (2015 & 2016).

Contents

Kristina Shin

Kristina Shin is an underwear designer. Kristina Shin‘s research interests are 1) design for quality of life (e.g., mastectomy bra and prosthesis design & hydrotherapy device design) and 2) design for cultural visual identity.

Research Questions

The research project sets out to investigate:

1. How to incorporate user-centred design approach into a hydrotherapy wetsuit design?

2. How to enhance the comfort of the hydrotherapy experience?

3. How to improve the hydrotherapy efficacy whilst enhance the cost-efficiency?

Research Outputs

1 patent, 1 international award, 1 journal publication, 2 medical fairs

Patent

- **Adaptive Hydrotherapy Wetsuit** (CN105983169A) Pending
  Filed on 10 March, 2015 to Chinese patent office

International award

- **Silver medal:** 43rd International Exhibition of Inventions of Geneva. 2015
- The exhibition, hosted under the patronage of the Swiss Government and the World Intellectual Property Organization (WIPO)

Journal publication

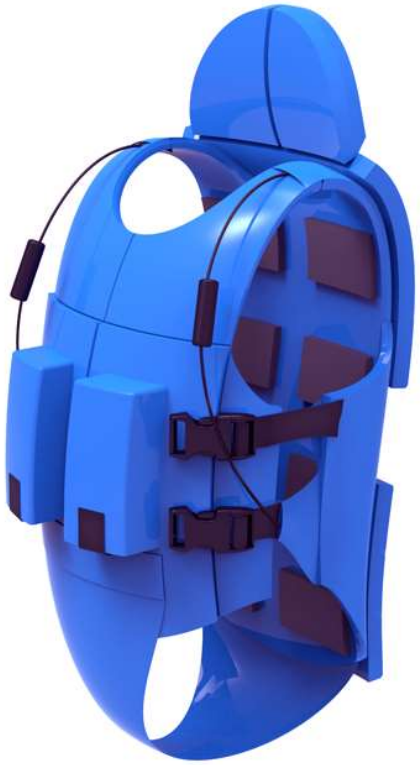
- Han, F., **Shin, K.** & Chow, D. (2016) User centred design approach for hydrotherapy wetsuit. *International Journal of Fashion Design, Technology and Education, 9(1),* pp. 16-22. DOI: https://doi.org/10.1080/17543266.2015.1103785

Commercial Fair

- Hong Kong International Medical Devices and Supplies Fair
- Hong Kong Convention and Exhibition Centre, 3-5 May 2016
- Hong Kong Convention and Exhibition Centre, 18-20 May 2015

Research Output / Body of Work

- **1 inventions (patent pending)**
  - Adaptive hydrotherapy wetsuit
- **1 clinical trial case study**



Research Output / Body of Work

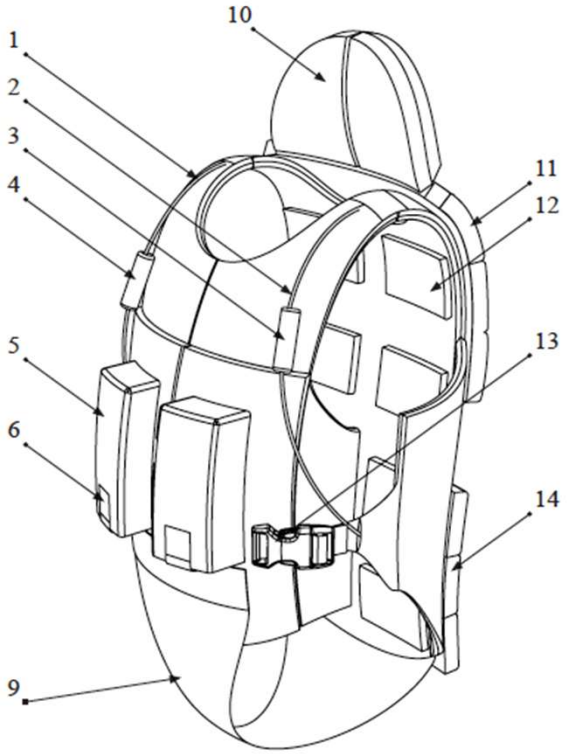
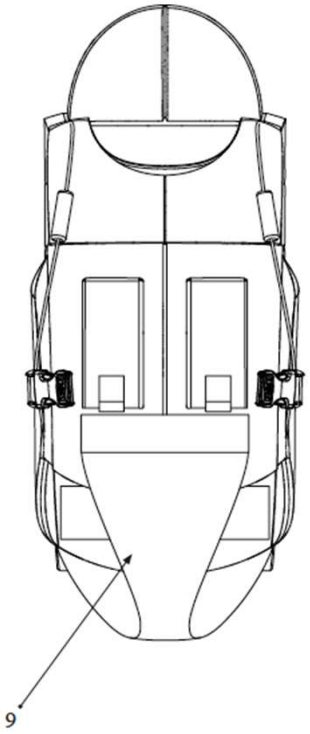


Figure 1



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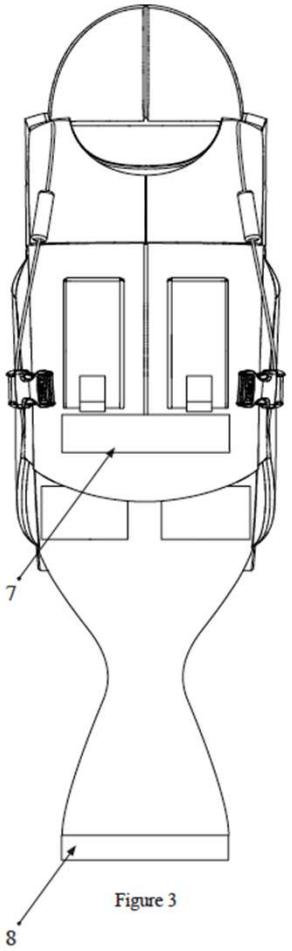

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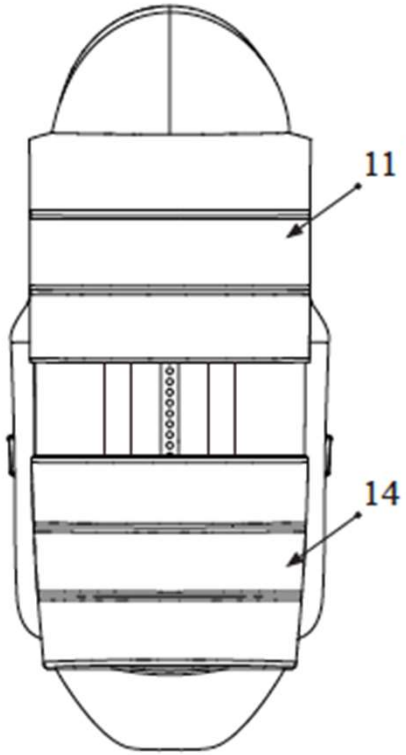
Research Output / Body of Work



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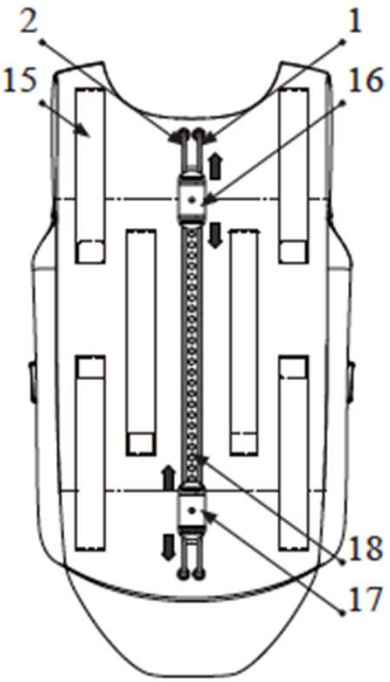

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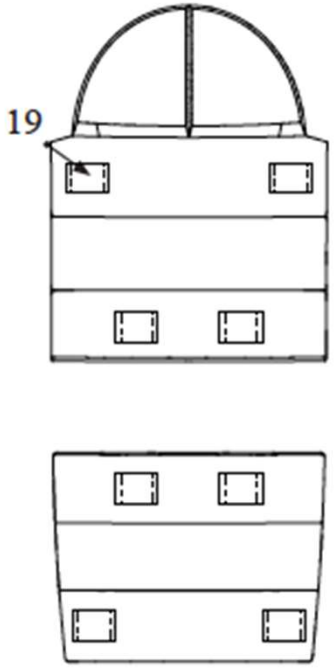

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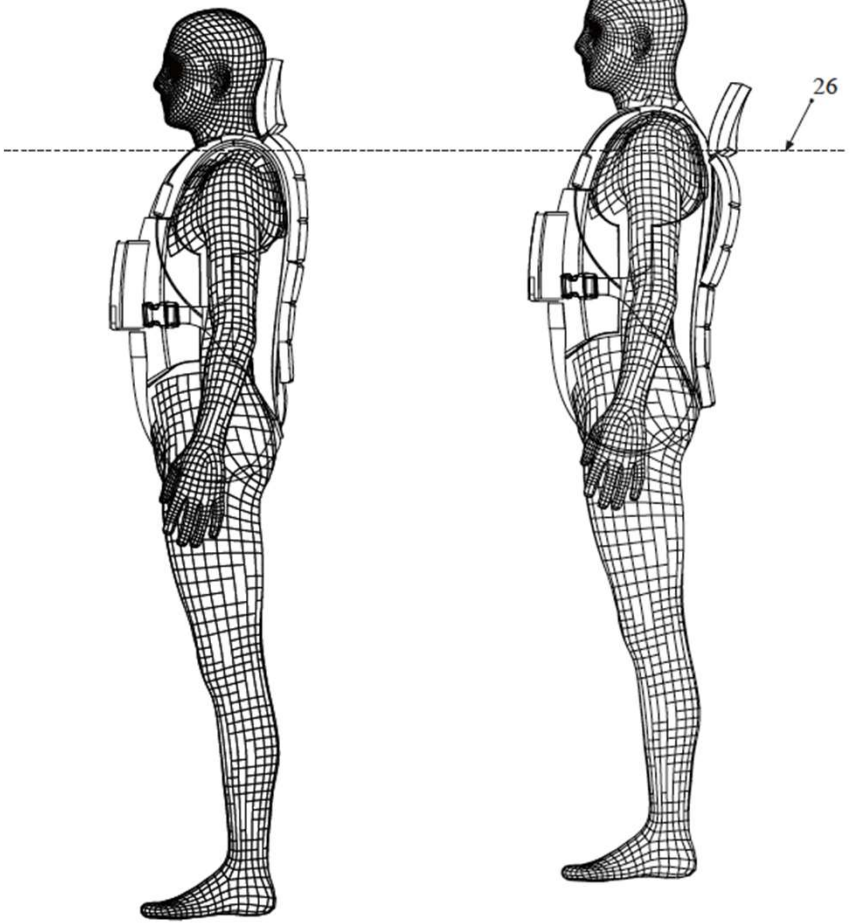
Research Output / Body of Work



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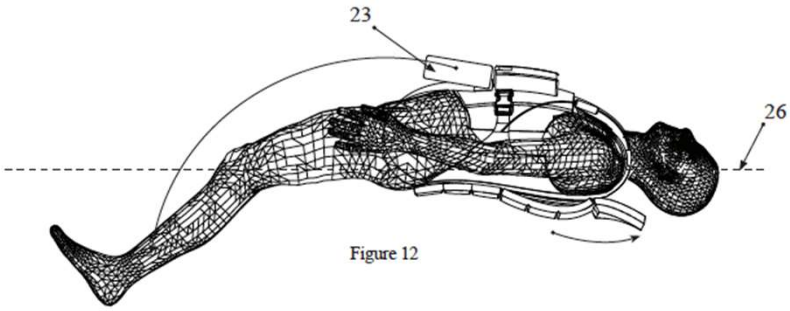

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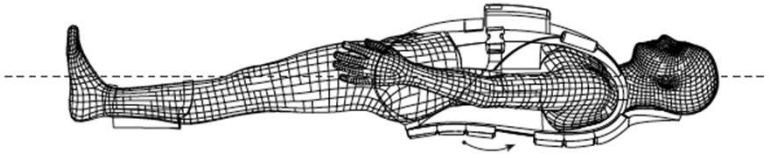

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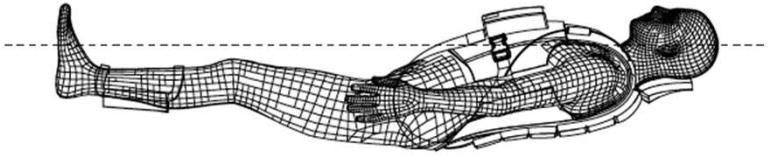

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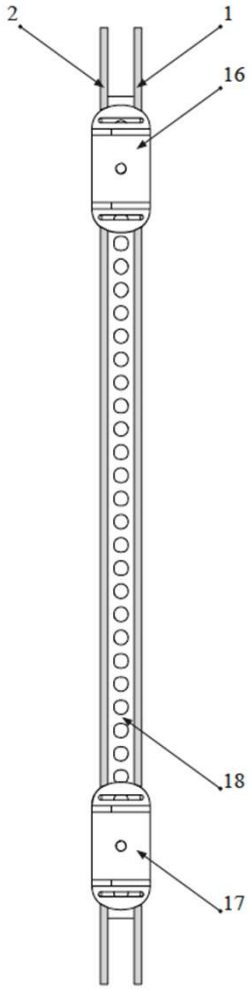
Research Output / Body of Work



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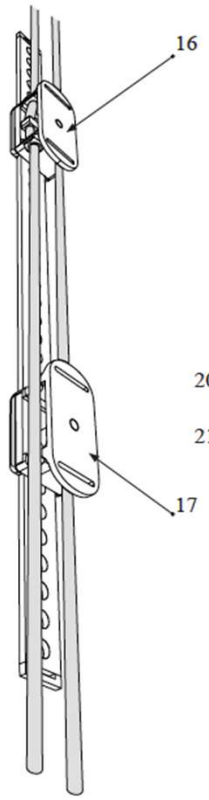

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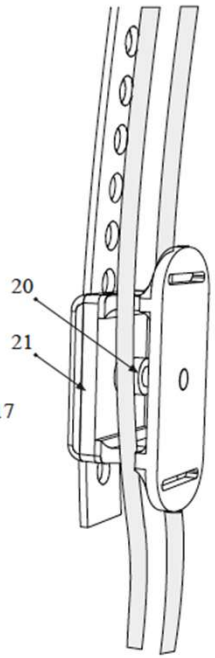

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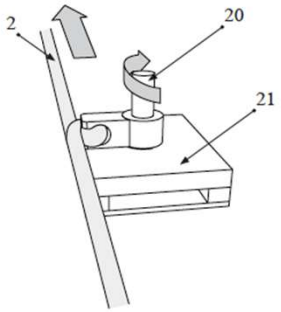

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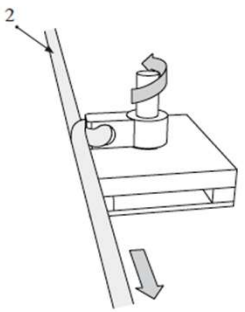

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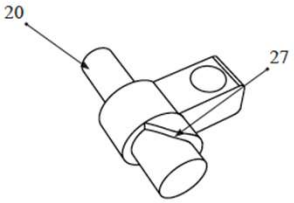

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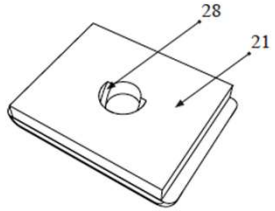

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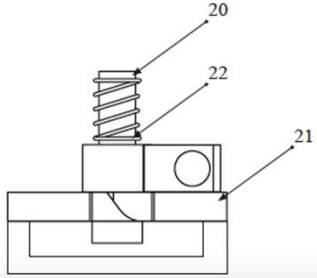
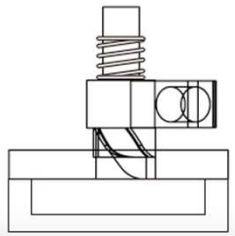
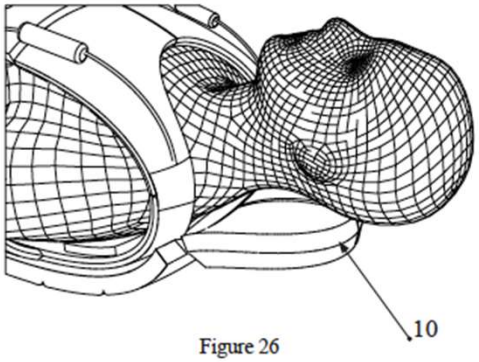




Research Output / Body of Work



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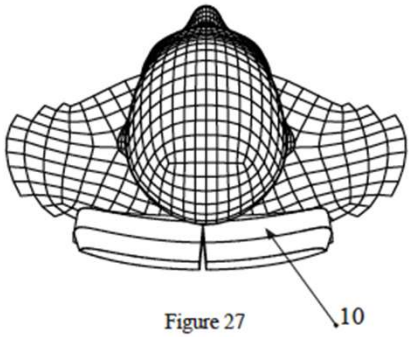

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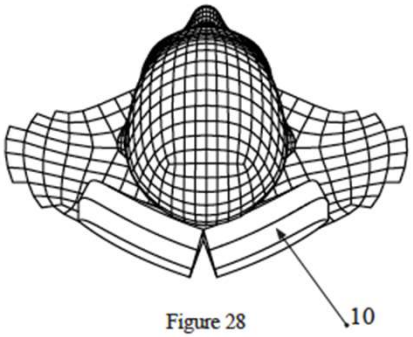


Figure 28

Research Output / Body of Work

Brief Description of the Drawings

Fig. 1 is the three-quarter front view of the overall wetsuit design.
Fig. 2, 3 are the front views of the wetsuit.
Fig. 4 is the rear view of the wetsuit with the movable foams.
Fig. 5 is the rear view of the wetsuit without the movable foams.
Fig. 6 is the inner view of the wetsuit with loops.
Fig. 7-9 are the rear views of the wetsuit (Movable foams are in different position)
Fig. 10-11 are the side views of the wearer in the upright position in the water.
Fig. 12-14 are the side views of the wearer in the suit in the supine position.
Fig. 15- 16 are the perspective views of the detachable foam wrapped in the wearer's ankle.
Fig. 17-19 are the perspective views of the detailed slide/locking system parts.
Fig. 20-21 are the perspective views of the locking system in motion - pulled up and pulled down.
Fig. 22 is the perspective views of the pin.
Fig. 23 is the perspective views of the slide/lock base.
Fig. 24-25 are the perspective views of the pin in motion – locked and unlocked.
Fig. 26-28 are the views of the wearer's head being cradled by the headrest in the supine position.

1. Wire connected to the moveable foams (Right)
2. Wire connected to the moveable foams (Left)
3. Handle to control the moveable foams (Left)
4. Handle to control the moveable foams (Right)
5. Pocket for the detachable foam
6. Strap with Velcro for pocket opening
7. Velcro hook (male)
8. Velcro loop (female)
9. Crotch panel
10. Headrest
11. Movable foam (top)
12. Extended foam for water circulation
13. Opening Buckle (Both side)
14. Movable foam part (Bottom)
15. Strap for interlocking with the movable foam loop
16. Slide/lock system (Top)
17. Slide/lock system (Bottom)
18. Slide bar/rail
19. Loop for interlocking with the strap
20. Pin of the slide/lock system
21. Base of the slide/lock system
22. Spring
23. Detachable foam for lower limb
24. Strap pad
25. Buckle
26. Water level
27. Bevel surface on the pin
28. Bevel surface on the slide/lock base

Research Key Works Referenced

[1] Silva, H. R., Afonso, P. C., Morim, P. M., Oliveira, P. M. & Correia, J. H. (2005). Wireless hydrotherapy smart-suit network for posture monitoring. 2007 IEEE International Symposium on Industrial Electronics, 2713-2717.

- A wireless smart-suit network for monitoring body kinetics, heart and respiratory rate during hidrocinesiotherapy sessions is presented. Sensing modules composed by 3-axis accelerometers, 3-axis magnetometers and interface electronics are used to monitor the body kinetics.

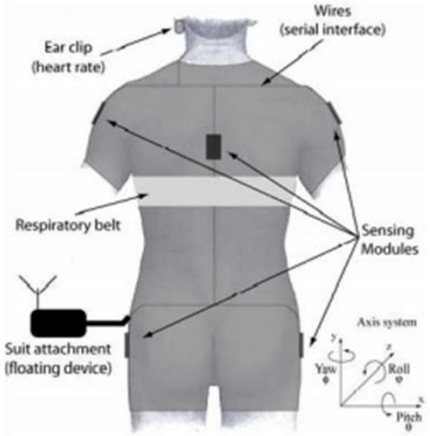


Figure 2. Location of the sensing modules in suit.

[2] Lamont, L. S., Panagiotis, P., Armitano, C. & Clapham, E. (2014). Development of a wet suit for children with down's syndrome. International Journal of Aquatic Research and Education, 8(1), 98-103.

- Individuals with Down syndrome have body types that make it difficult to fit for a standard wet suit. In general, their body composition includes an increase in central body adiposity and an endomorphic somatotypic body type in which the trunk is large while the limbs are shorter. Because of these physical characteristics, the participation by individuals with Down syndrome in aquatics exercise programs in which wet suits are needed can be very limiting. We observed that it was challenging to get these aquatic exercise participants into and out of the wet suits that had a standard wet suit design.

Figure 2 — Specialized wet suit compared with one of typical design.

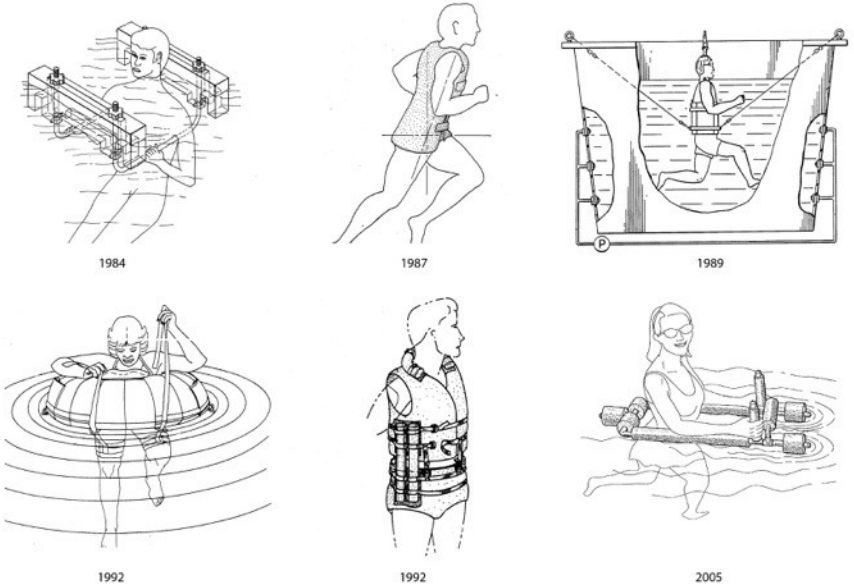
Research Gap

There is a clear research gap in the area of hydrotherapy wetsuit design that is user-centric, versatile, safe and comfortable for the wearers yet provides easy hydrotherapy administration experience for physiotherapists.

Research Methods and Materials

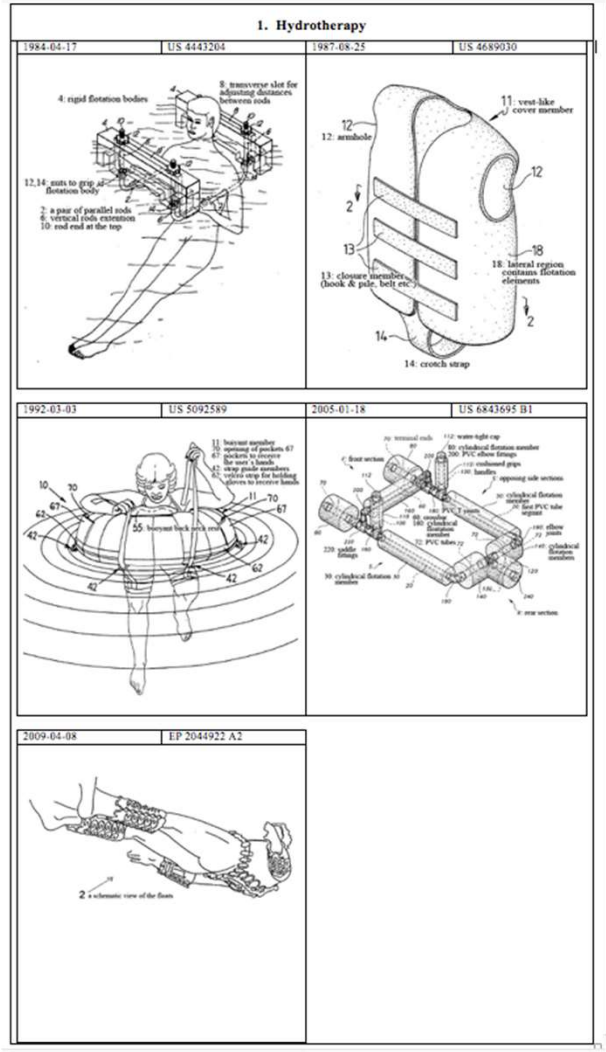
Problem of Current Devices

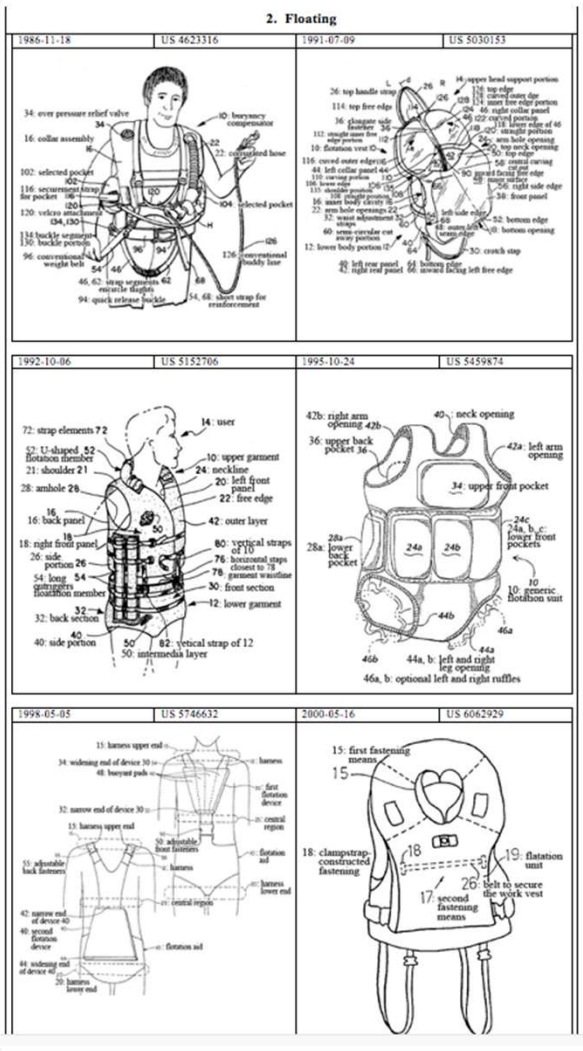
- Not **versatile** enough
- Do not **fit closely** to the patient's body
- Tendency to ride up over the shoulders
- Pose **potential safety risks**
- Less **cost-effective** and less efficient in delivering hydrotherapy programmes
- **Requires two helpers** for adult patients with moderate impairment level

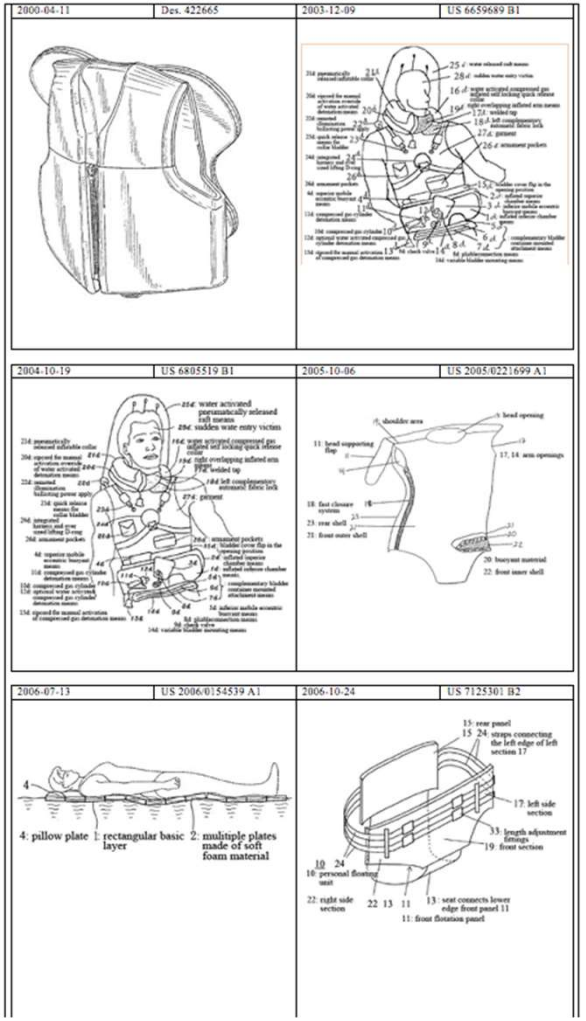


Research Methods and Materials

Review of 53 Patents from 1984 to 2012







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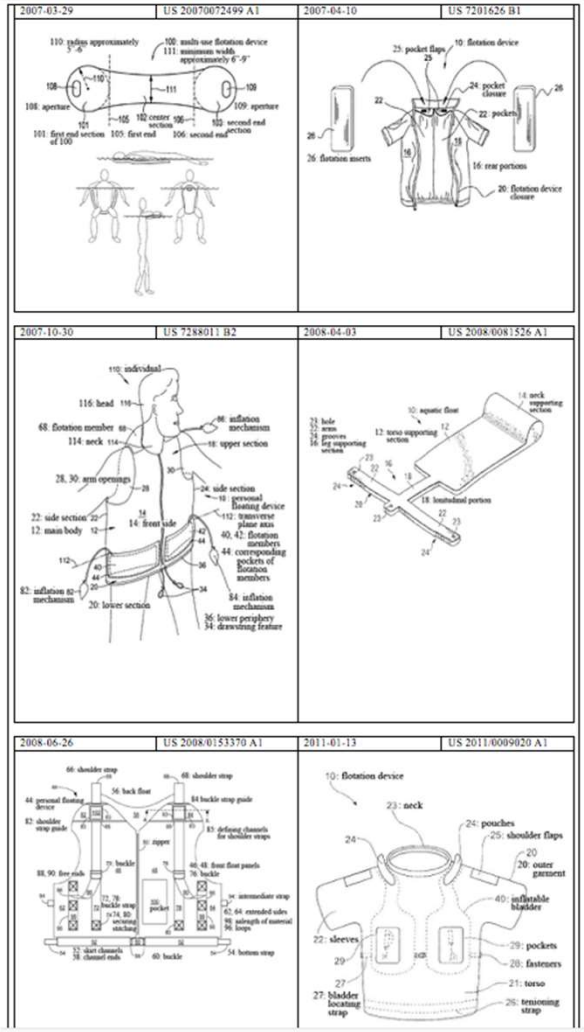

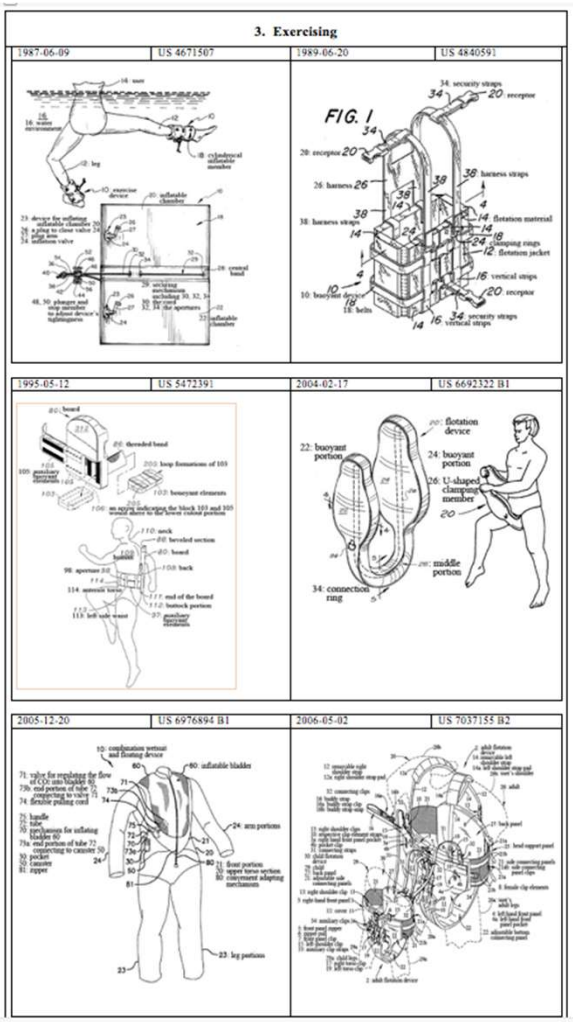

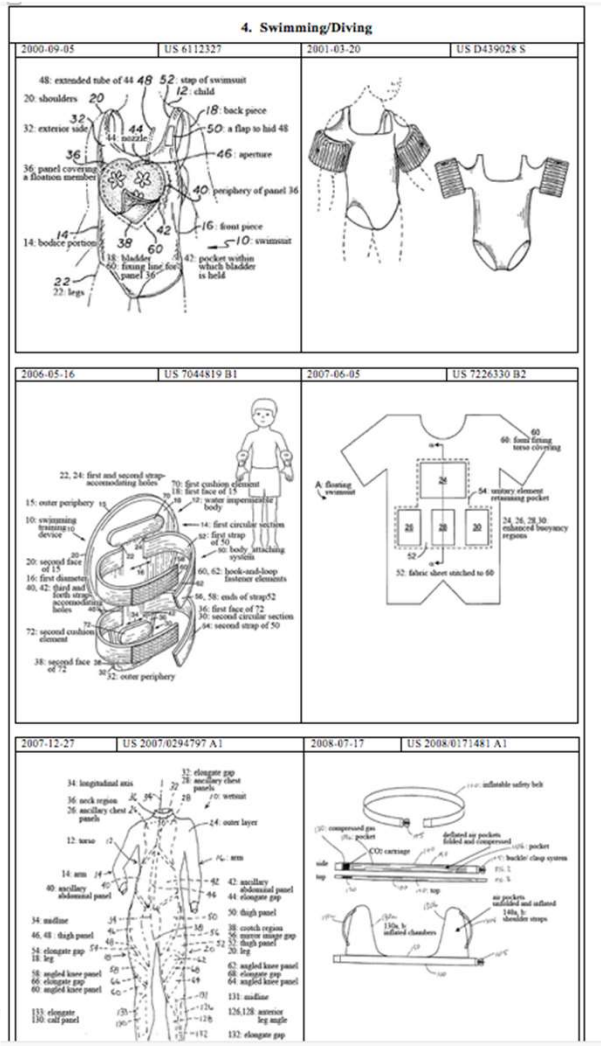

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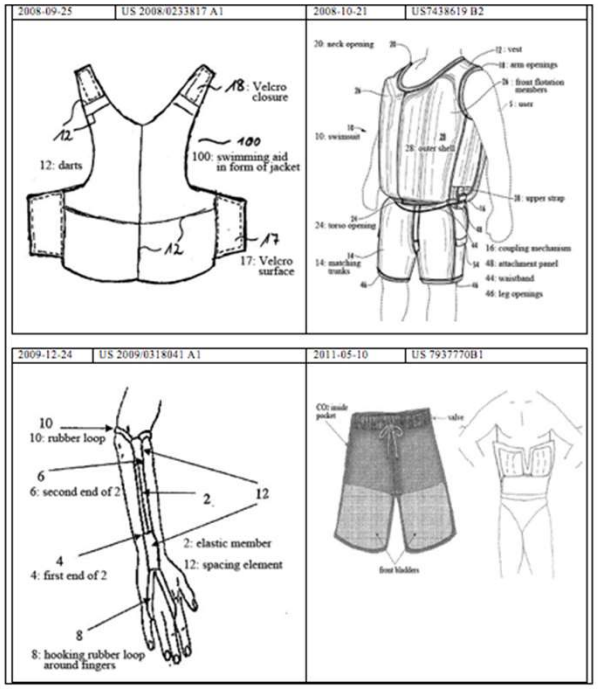

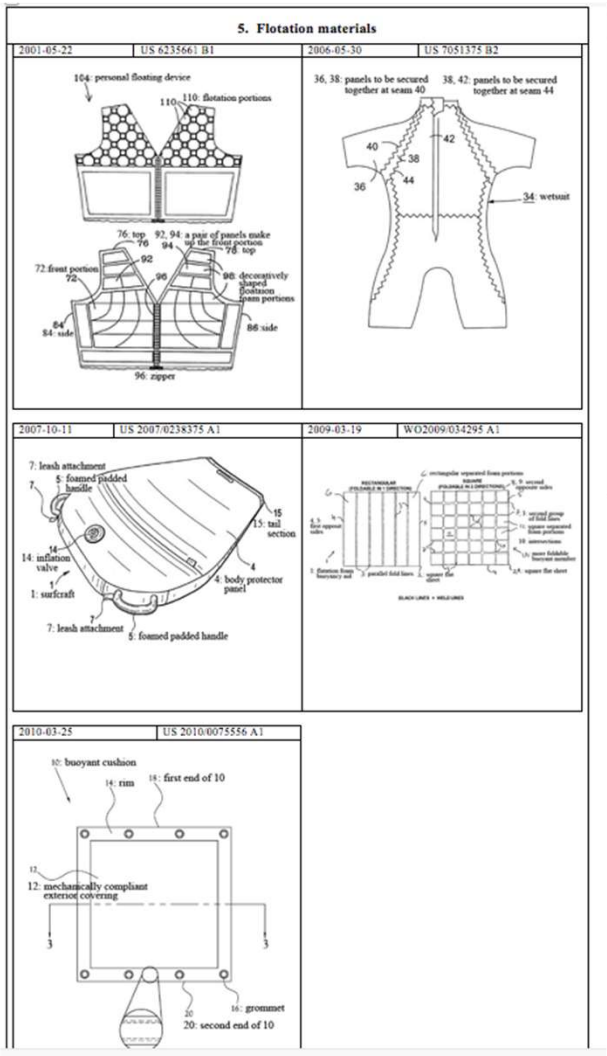

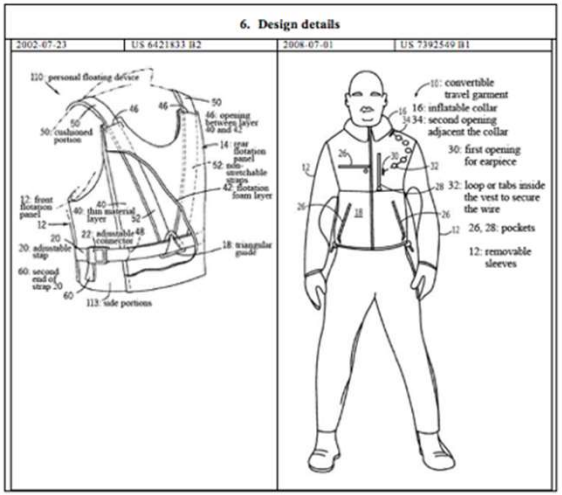

Research Methods and Materials

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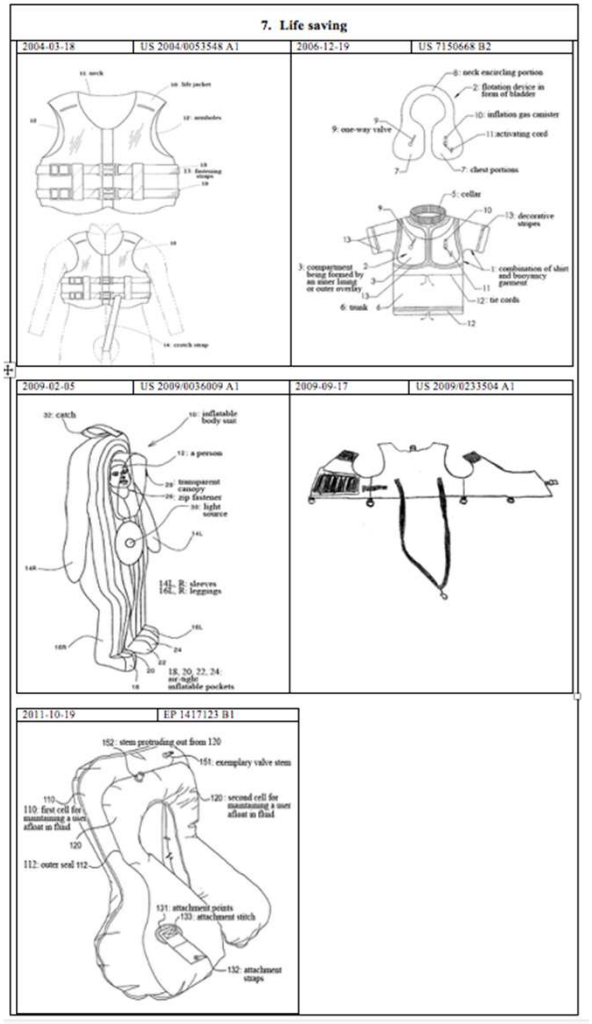
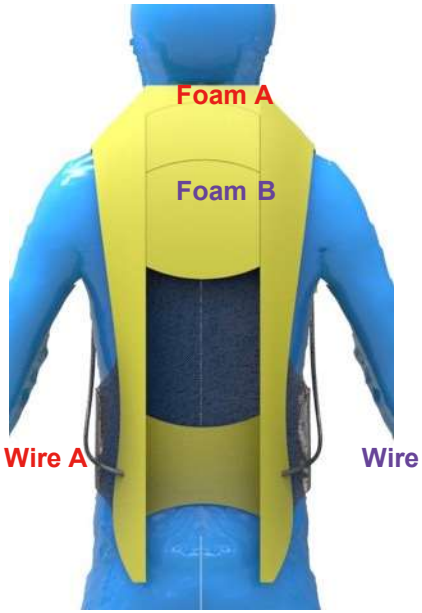
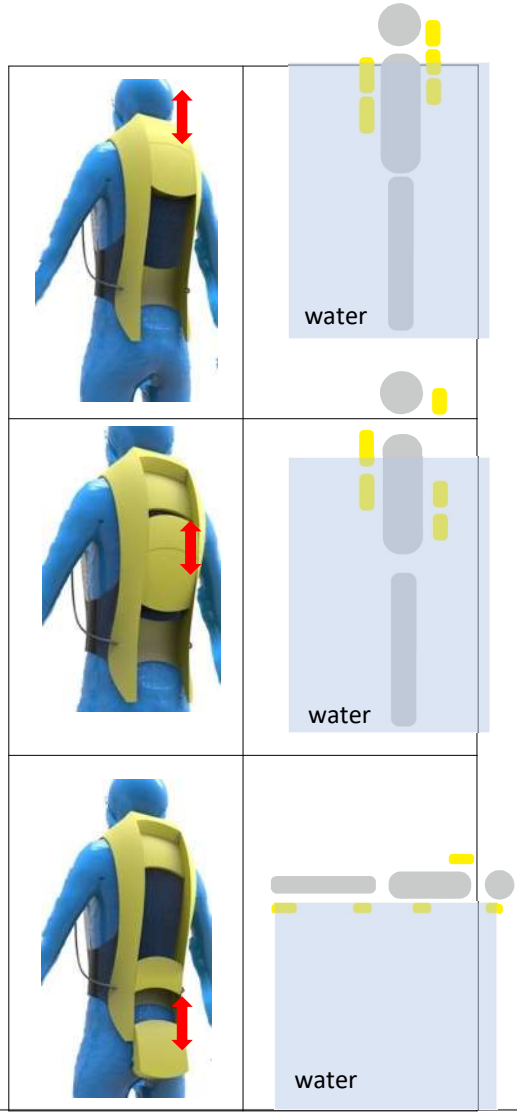


Research Methods and Materials

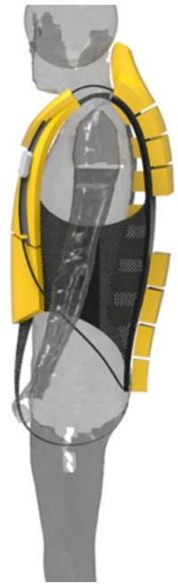
Process of Product Development: First Phase Concept



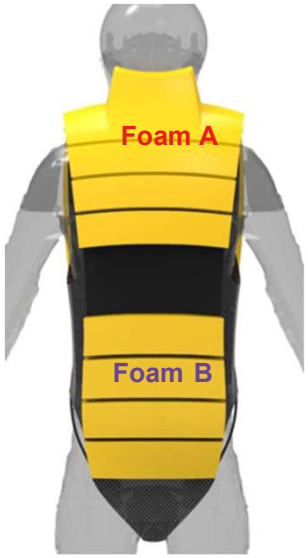


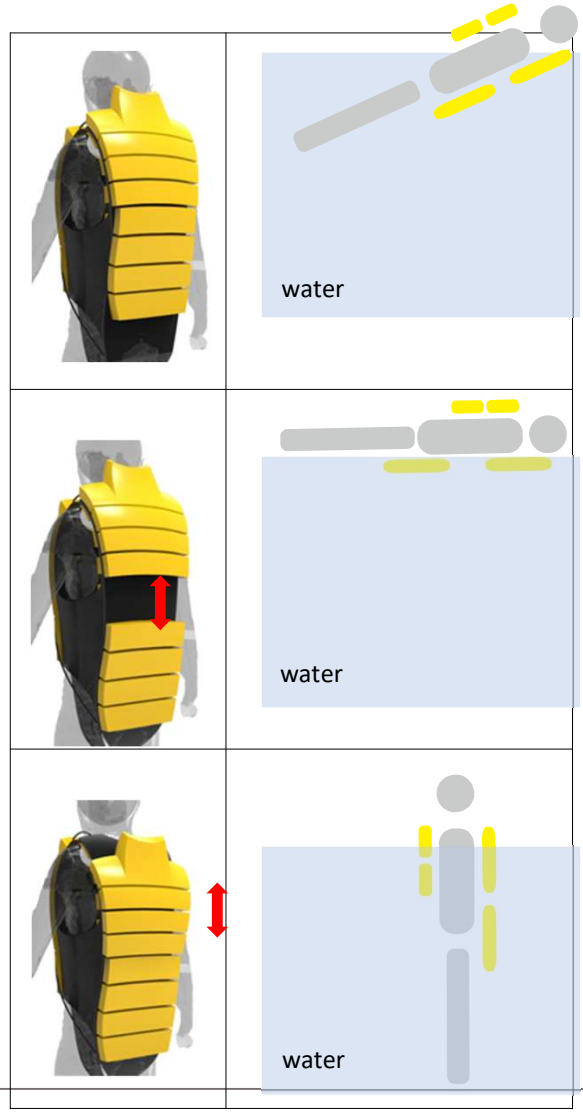
Research Methods and Materials

Process of Product Development: Second Phase



Adjustment handle location



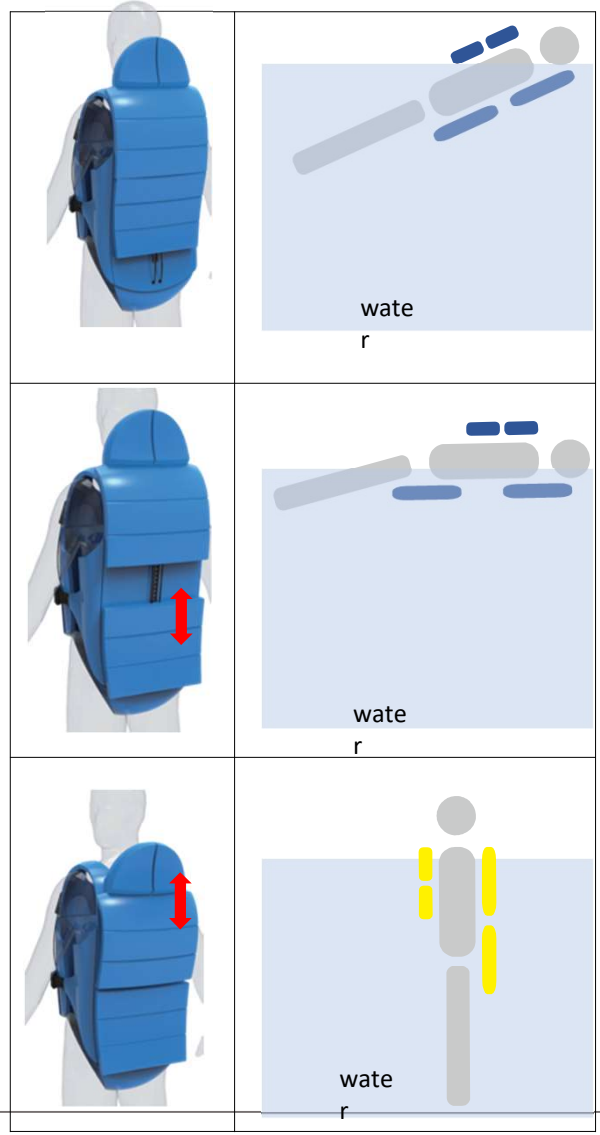


Research methods and materials

Process of Product Development: Second Phase

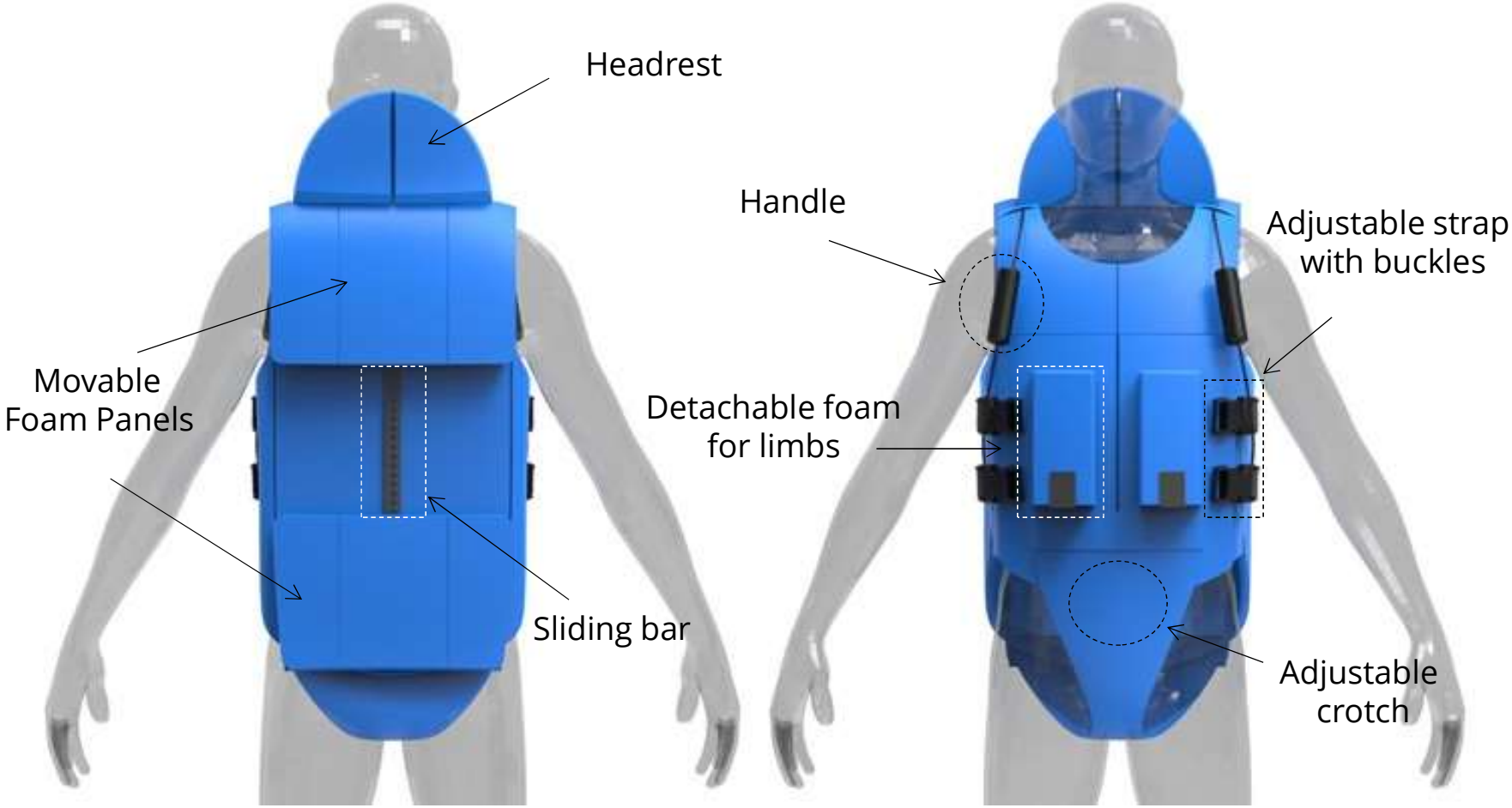
Research Methods and Materials

Process of Product Development: Final Design



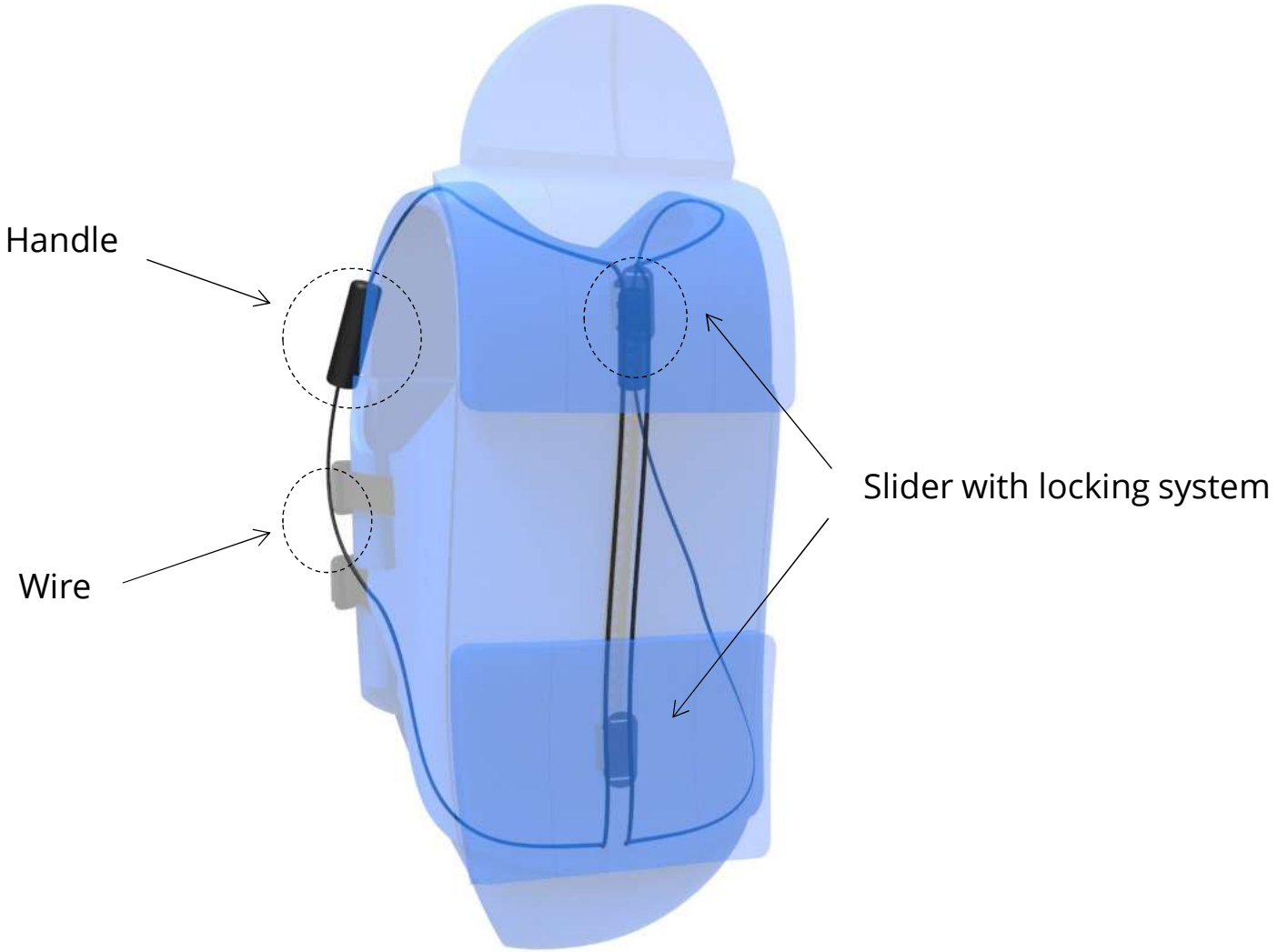
Research Methods and Materials

Final Design Features



Research Methods and Materials

Final Design Features: Sliding and Locking System

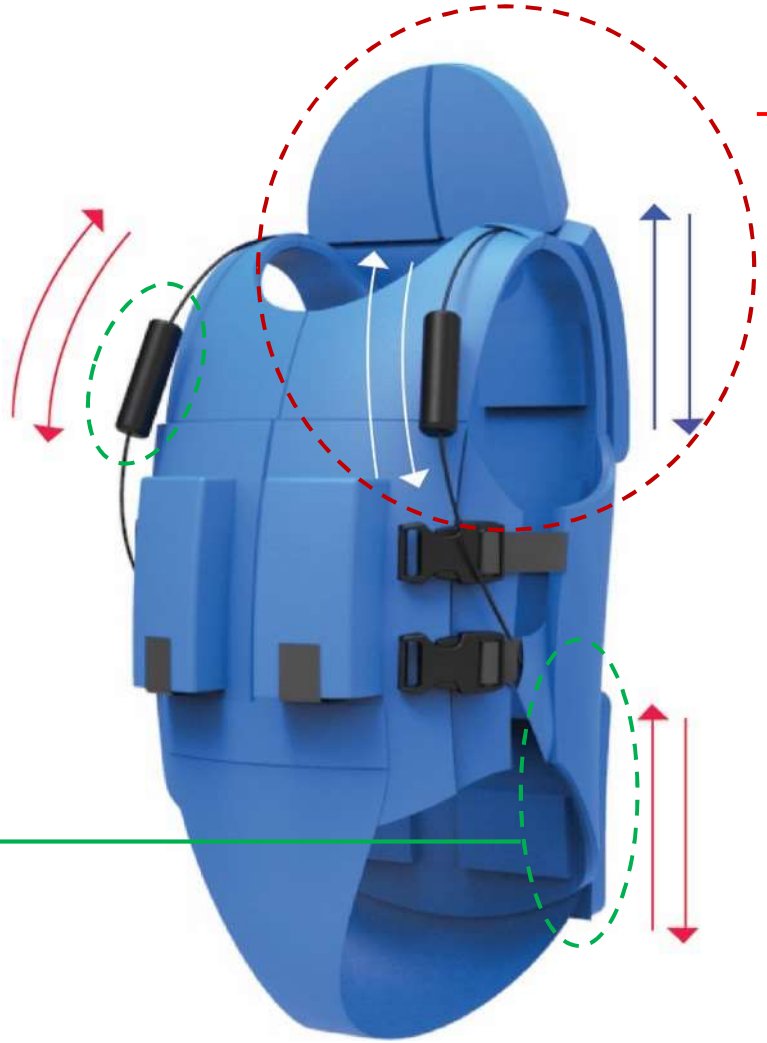


Research Methods and Materials

Final Design Features: Movable Foam Pads and Handles

Left handle is connected to the upper foam

Right handle is connected to the upper foam



- The movable foam panels on the back of the wetsuit are connected to two handles located at the front via two wires
- When the patient pulls one of the wires from the front, the corresponding movable foam panel on the back moves up or down

Research Methods and Materials

Final Design Prototype

Research Methods and Materials

Process of Product Development: Prototype and User Test

1, A wear trial in collaboration with SAHK:

•Age: 85 year old
•Gender: Female
•Nationality: Hong Kong Chinese
•Medical history:
–Severe grade osteoporosis (DEXA T-score < -3 at hip)
–Received bilateral knee arthroplasty (Total knee replacement on both sides)
•Experience in swimming: Incapable of swimming or floating independently in water before
•Hydrotherapy period: One month

About SAHK
•Founded in 1963
•Provides welfare and rehabilitation services including physical, occupational and speech therapy
•62 service units
•Over 1,500 staff including over 150 paramedical professionals (including PT, OT & ST)
•Serving 8,000 Hong Kong resident families annually
•4 core services: Children & family support, special education, adult service, community support service

2. Hydrotherapists' testing by The Hong Kong Society for Rehabilitation
About HKSR:
A government recognized charitable organization established in 1959
The only hydrotherapist training organisation in Hong Kong

3. A wear trial in collaboration with Les bains de Cressy (Hydrotherapy team of University of Geneva)
Hydrotherapy with a child with myopathy

Research Methods and Materials

Process of Product Development: Prototype and User Test

Research Conclusion Per Research Question

Q1. How to incorporate user-centred design approach into a hydrotherapy wetsuit design?

This user-centered adaptive hydrotherapy wetsuit is for people with limited mobility, in particular paraplegic patients and the elderly. As water can minimize the impact on patients' joints and muscles during conditioning exercises, hydrotherapy is recommended for users with limited mobility.

This project's key features include 1) Slide/lock system for self-operation and 2) Adjustable foam mechanism to change position from upright position to supine position during hydrotherapy.
These features enable the wearers to change between an upright position and a supine position in water during hydrotherapy by self-operating the adjustable foam panels.

Q2. How to enhance the comfort of the hydrotherapy experience?

The adoptive wetsuit provides the wearers with maximum comfort through ergonomic design as well as skin-friendly fabrics and accessories.

Q3. How to improve the hydrotherapy efficacy whilst enhance the cost-efficiency?

Hydrotherapy usually requires the involvement of at least two physiotherapists. However, with the user-operative design, the number of required physiotherapists can be reduced to one. This will contribute to improvement in the hydrotherapy efficacy and cost-efficiency.

Dissemination and Distribution of outcomes

1 patent, 1 international award, 1 journal publication, 2 medical fairs

Patent

- **Adaptive Hydrotherapy Wetsuit** (CN105983169A) Pending
  Filed on 10 March, 2015 to Chinese patent office

International award

- **Silver medal:** 43rd International Exhibition of Inventions of Geneva. 2015
- The exhibition, hosted under the patronage of the Swiss Government and the World Intellectual Property Organization (WIPO)

Journal publication

- Han, F., **Shin, K.** & Chow, D. (2015) User centred design approach for hydrotherapy wetsuit. *International Journal of Fashion Design, Technology and Education, 9(1),* pp. 16-22.

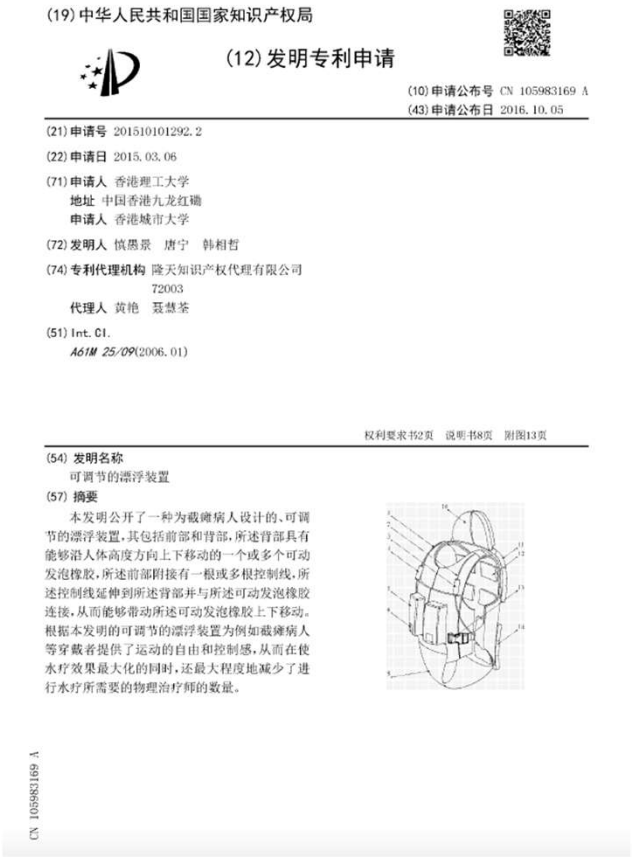
Commercial Fair

- Hong Kong International Medical Devices and Supplies Fair
- Hong Kong Convention and Exhibition Centre, 3-5 May 2016
- Hong Kong Convention and Exhibition Centre, 18-20 May 2015

Dissemination

1 patent, 1 award, 1 journal publications, 3 medical fair

Year	Patents (Pending, submitted to Chinses Patent Office on 10 March 2015)
2015	Adaptive Hydrotherapy (Application no.: 201510101292.2)



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(54)发明名称
可调节的漂浮装置

(57)摘要

本发明公开了一种为截瘫病人设计的、可调节的漂浮装置，其包括前部和背部，所述背部具有能够沿人体高度方向上下移动的一个或多个可动发泡橡胶，所述前部附接有一根或多根控制线，所述控制线延伸到所述背部并与所述可动发泡橡胶连接，从而能够带动所述可动发泡橡胶上下移动。根据本发明的可调节的漂浮装置为例如截瘫病人等穿戴者提供了运动的自由和控制感，从而在使水疗效果最大化的同时，还最大程度地减少了进行水疗所需要的物理治疗师的数量。

CN 105983169 A

Dissemination

1 patent, 1 award, 1 journal publications, 2 medical fair

Year	Award
2015	Silver medal, Adaptive Hydrotherapy Wetsuit 43rd International Exhibition of Inventions of Geneva. 15-19 April 2015 The exhibition, hosted under the patronage of the Swiss Government and the World Intellectual Property Organization (WIPO)

Dissemination

1 patent, 1 award, 1 journal publications, 2 medical fair

Year	Award
2015	Silver medal, Adaptive Hydrotherapy Wetsuit 43rd International Exhibition of Inventions of Geneva. 15-19 April 2015 The exhibition, hosted under the patronage of the Swiss Government and the World Intellectual Property Organization (WIPO)

Dissemination

1 patent, 1 award, 1 journal publications, 2 medical fair

Year	HK Chief Executive's Reception for Hong Kong Innovations Global Winners
2015	Silver medal, Adaptive Hydrotherapy Wetsuit, April 2015

Dissemination

1 patent, 1 award, 1 journal publications, 2 medical fair

Year	Journal publication
2015	Han, F., **Shin, K.** & Chow, D. (2016) User centred design approach for hydrotherapy wetsuit. *International Journal of Fashion Design, Technology and Education, 9(1),* pp. 16-22. DOI: https://doi.org/10.1080/17543266.2015.1103785

Dissemination

1 patent, 1 award, 1 journal publication, 2 medical fair

Year	International Medical Fair
2016	Hong Kong International Medical Devices and Supplies Fair Hong Kong Convention and Exhibition Centre, 3-5 May 2016 Hong Kong Convention and Exhibition Centre, 18-20 May 2015