

# Evaluation of design recommendations for the development of wheelchair rugby sports-wear

Sara Braganca<sup>1</sup>, Ignacio Castellucci<sup>2</sup>, Simeon Gill<sup>3</sup>, Miguel Carvalho<sup>4</sup>, Pedro Arezes<sup>4</sup>

<sup>1</sup> Southampton Solent University, Southampton, United Kingdom

<sup>2</sup> Universidad de Valparaíso, Valparaíso, Chile

<sup>3</sup> University of Manchester, Manchester United Kingdom

<sup>4</sup> University of Minho, Guimaraes, Portugal

sara.braganca@solent.ac.uk, hector.castellucci@uv.cl, simeon.gill@manchester.ac.uk, mig-car@det.uminho.pt, parezes@dps.uminho.pt

**Abstract.** Currently, wheelchair rugby athletes face the challenges of playing the sport without specifically designed sports-wear kit. A few designs and recommendations have already been proposed by researchers but none have made it to market yet. The purpose of this study was to evaluate a set of design recommendations for the development of wheelchair rugby sports-wear. This was done so that the products to be created are developed in collaboration with their potential users, responding to their particular needs and requirements. The evaluation was done through an online survey, where the athletes were presented with a visual representation of the design recommendations. The results indicate that the people questioned agree with the majority of the proposed designs and would be happy to have these improvements made to their current sports-wear. The most criticised recommendations were for the gloves, as they are the most important part of the kit, so it is important that they are adequate and allow for a good performance.

**Keywords:** Sports-wear · Wheelchair rugby · Design recommendations · Inclusive design · Gloves

## 1 Introduction

Wheelchair rugby is a team sport for male and female athletes with a disability, however able-bodied people can also participate. This is one of the fastest growing wheelchair sports that has been especially developed for individuals with tetraplegia. Athletes' performance is as important in wheelchair rugby as in any other sport, and it can be influenced by both individual and team components [1–3].

Sports-wear is one of the several factors that can affect not only the athletes' performance, but also their safety and comfort. In the sports-wear field, users search for comfort, quality, durability, and style, but comfort and fit are presumably the two most important features in this type of clothing [4]. Kratz et al. (1997) compared the difference between wheelchair users wearing adapted clothes and non-adapted clothes for some sports. They concluded that less effort had to be made and more comfort was

felt when wearing the adapted clothes. In the study of Bragança et al. [6], it became clear that there is a lot of scope for innovation in wheelchair rugby sport-wear. The authors identified the athletes' needs by means of a questionnaire and a focus group, which then led to the development of some design recommendations for gloves, tops and bottoms, specifically though for wheelchair rugby.

The basic information designers use to create products should be derived from the real end-users, to assure that their real needs are being met and the problems are being solved. This is a more challenging way of creating novel solutions but it optimizes commercial success [7]. Many designers see design for disability as part of engineering and human factors [8]. The human factors and ergonomics hierarchical approach to design gives preference to environmental design to fit the human; selecting or training people to fit the environment is only an option when there is no other alternative [9]. According to Curteza et al. [10], to meet the special requirements of wheelchair users, fabrics with special properties, capacities and functions should be preferred (e.g. antibacterial, water proof, wear resistant, non-flammable).

Due to the limited choice or even unavailability of specialized garments, wheelchair users tend to adapt clothing designed for able-bodied people. In wheelchair rugby this happens very frequently, especially with the gloves. Gloves are an important part of the equipment for wheelchair rugby players, as they directly influence the wheelchair-user interface – more than protecting the hands, the gloves are used to have a better grip while maneuvering the chair and handling the ball [11, 12]. As no pair of gloves, specific for wheelchair rugby has been introduced in the market yet, athletes must use other types of gloves include adaptation to make the gloves more suitable for their needs, such as adding materials like glue, tape or extra rubber for obtaining sufficient grip on the hand rims and ball [6, 12].

The purpose of this paper was to evaluate and validate a set of 18 design recommendation for wheelchair rugby sports-wear that had been previously developed by the authors. The goal was not only to obtain the feedback from wheelchair rugby players but also to take their opinions and reformulate the initial design recommendations so that on a later stage the products can be developed according to the users' requirements.

## **2 Methodology**

42 non-professional wheelchair rugby athletes, from 16 different teams/clubs in the United Kingdom, participated in this study. Table 1 shows some characteristics of the sample, such as the distribution of age, gender and team where the sport is played.

This study used a short online survey as a means of gathering data. This survey was used to evaluate a set of design recommendations that the authors had developed for the design of wheelchair rugby sports-wear. A total of 18 design recommendations; divided into recommendations for gloves, tops, and bottoms; was initially proposed for evaluation. The full list of design recommendations can be seen on Table 2.

**Table 1.** Characterization of the sample.

Variable	Categories	N	%
Frequency in each age group	Under 18	1	2
	18–30	8	19
	31–40	12	29
	41–50	13	31
	51–60	6	14
	60+	1	5
Gender	Male	37	88
	Female	5	12
Team	Bristol Bears   Bristol	3	7
	Caledonian Crushers   Glasgow	7	17
	Dorset Destroyers   Poole	2	5
	Glasgow Panthers   Glasgow	1	2
	Gloucester Wheelchair Rugby   Gloucester	2	5
	Gravesend Dynamite   Gravesend	1	2
	Hull FC Wheelchair Rugby   Hull	1	2
	Leicester Tigers   Leicester	2	5
	London Wheelchair Rugby   London	6	14
	Ospreys   Cardiff	1	2
	Solent Sharks   Southampton	2	5
	Stoke Mandeville Maulers   Aylesbury	7	17
	West Coast Burn   Southport	1	2
	West Country Hawks   Plymouth	3	7
	Woodbridge Wheeled Warriors   Woodbridge	1	2
Yorkshire Lions   Featherstone	2	5	

**Table 2.** Design recommendations.

Garment	Design recommendation
Gloves	DRglo 1   Velcro wrap cuff
	DRglo 2   Elastic fingertips
	DRglo 3   Central opening
	DRglo 4   Palm coated with sticky material
	DRglo 5   Sweat-absorbent, breathable, malleable, resistant gloves
Tops	DRtop 1   Tight but not form-fitting tops
	DRtop 2   V-necked tops
	DRtop 3   Detachable sleeves by sections
	DRtop 4   Reinforced back of sleeves
	DRtop 5   More adequate textile structure and combination of materials
	DRtop 6   Longer back
Trousers	DRbot 1   Tight but not form-fitting bottoms
	DRbot 2   Elasticated waistband
	DRbot 3   Consider anthropometric measurements
	DRbot 4   Higher rise on back and lower rise on front
	DRbot 4   Higher rise on back and lower rise on front
	DRbot 5   Detachable legs by sections
	DRtop 6   Mix of synthetic and natural fibers
DRbot 7   Softer material in the back and minimal, flat seams	

The respondents were presented not only with the textual description of the design recommendation but also with a sketch of how the design recommendations would look if implemented on a pair of gloves, on a shirt and on a pair of trousers, respectively (Figure 1).

Please take a look at the design recommendation presented in bold in the Figure below. You can also find information about the problems/needs that this design recommendation is expected to solve.



**Fig. 1.** Example of visual representation of the design recommendations on the questionnaire.

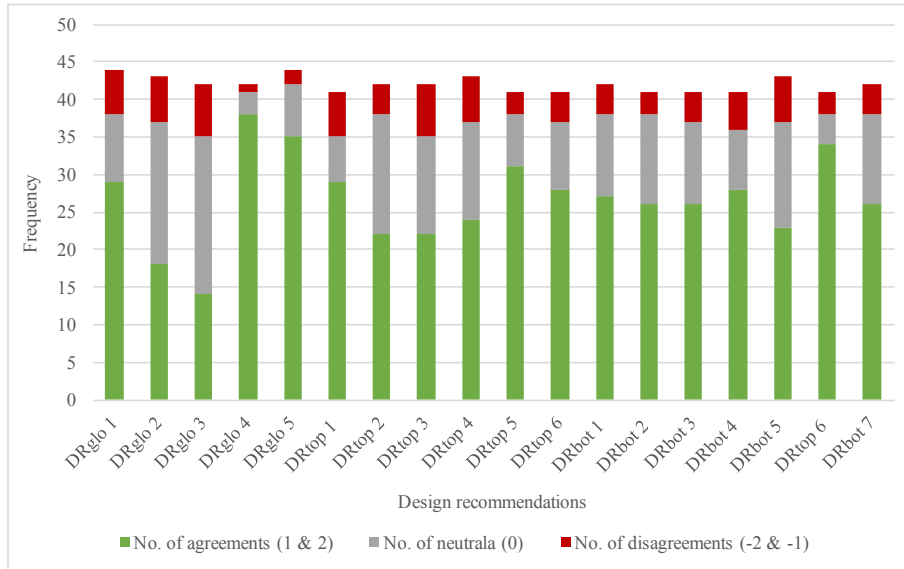
To evaluate the designs, for each design recommendation three questions were asked:

- Please rate your level of agreement with this design recommendation: (i) Strongly agree; (ii) Agree; (iii) Neutral; (iv) Disagree; (v) Strongly disagree;
- What would you change or do differently to solve the problem/need identified in the Figure above?;
- Do you think that implementing this design recommendation would improve: (i) Performance; (ii) Comfort; (iii) Safety; (iv) Nothing.

The results of the questionnaire were analyzed in terms of distribution of frequencies and other descriptive statistics.

### 3 Results and discussion

In general, the feedback obtained on the several design recommendations was very positive. The athletes seemed to be enthusiastic and excited with the possibility of having such improvements to their current sports-wear kit. Some of them were even surprised by some of the proposed interventions, as they had not yet thought about some of the ideas presented. The level of agreement with the design recommendations was mostly classified as “Agree” or “Strongly Agree”. Figure 2 shows the distribution of the levels of agreement with each design recommendations.



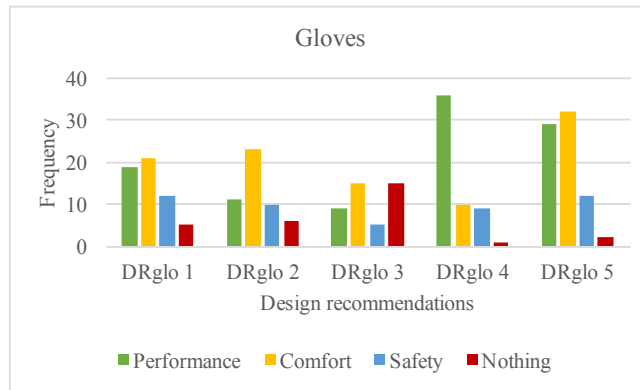
**Fig. 2.** Distribution of the responses regarding the agreements or disagreement with each design recommendation.

Of the 42 responses obtained, the highest number of disagreements for a single design recommendation was only 7 (for DRtop3), which means that the majority of the participating athletes agree with the proposed solutions. Accordingly, a relatively high number of strong agreements were registered for two design recommendations: DRglo5 and DRbot6 with 40% and 44% of people rating their opinion on the design recommendations as strongly agree, respectively.

The following sub-sections provide more detail on the athletes' opinions about each particular part of the sports-wear kit, namely, gloves, tops, and bottoms.

### 3.1 Gloves

The most recommended alterations to the initially proposed design recommendations occurred for the gloves. Nonetheless, the athletes agreed that implementing these design recommendations for the gloves would improve mostly performance and comfort (Figure 3). In general, the athletes agreed with most design recommendations but some of them had a few ideas that would improve the designs even further.



**Fig. 3.** Distribution of the responses regarding what aspects could be improved for each design recommendation.

For the first design recommendation (DRglo 1 | Velcro wrap cuff), the athletes suggested that the Velcro wrap should be longer so that it wraps around further into the forearm, making it more secure and tight. It was also mentioned that the fastening should be placed on top rather than the underside to make it more comfortable. Additionally, the importance of a long strap was also heightened as it would help to improve the athletes' independence levels as they would be able to put it on with their teeth. Hence, the improved design recommendation would be DRglo 1 | Long Velcro wrap cuff with extension to forearm.

The athletes did not seem to agree as much with the second design recommendation (DRglo 2 | Elastic fingertips) and mentioned that they would prefer to have a more resistant material on the fingertips instead of them being elasticated. To solve the issue of fitting every athlete's hands, they propose that a wider range of sizes (rather than the usual small, medium, and large) should be made available. It was stated that it is important that the fingers are well protected during the game, so the gloves should provide an extra reinforcement in this area. Consequently, the newly proposed design recommendation would be DRglo 2 | Extra resistant material on fingertips and greater availability of sizes.

The third design recommendation (DRglo 3 | Central opening) was another of the ones with which the athletes did not agree as much. They recognized that it would improve the ease of putting on and taking off, but as there are some players that push the wheelchair with the back of their hands it could be a safety risk. The athletes were concerned that this opening would represent more stitching and that would leave areas of the hand more vulnerable. Some suggested that a soft discrete zip could be included in one of the sides to make it easier to put on and take off. Thus, the new design recommendation would be DRglo 3 | Soft side zip.

The fourth design recommendation (DRglo 4 | Palm coated with sticky material) was the most successful one, with 92,5% of agreement. As happened for other design recommendations, some athletes pointed out that some of them push the wheelchair with the back of their hands and hence, this coating of sticky material would also be useful if applied to the back of the hand. To cater for everyone's need it was suggested that two models were created, one with the palm coated with sticky material and

the other where the back of the hand is coated. Another suggestion was to extend the surface covered by the sticky material. The athletes mentioned that the thumb is a very important area to be coated, as it is one of the main pushing areas. Additionally, some concerns were also raised on what regards the resistance to dust and the durability of the stickiness. To solve that problem some suggested that the sticky material would not be part of the glove, but instead a detachable part that could be replaced whenever necessary. So, the enhanced design recommendation would be DRglo 4 | Thumb and palm/back of the hand coated with replaceable sticky material.

The final design recommendation for the gloves (DRglo 5 | Sweat-absorbent, breathable, malleable, resistant gloves) was also well accepted and not many alterations were suggested. The only aspect pinpointed by the athletes were the fact that there are different levels of players, with different requirements. The gloves should always be sweat-absorbent, breathable, malleable and resistant but perhaps with different demand stages. As such, the fifth design recommendation remained unchanged.

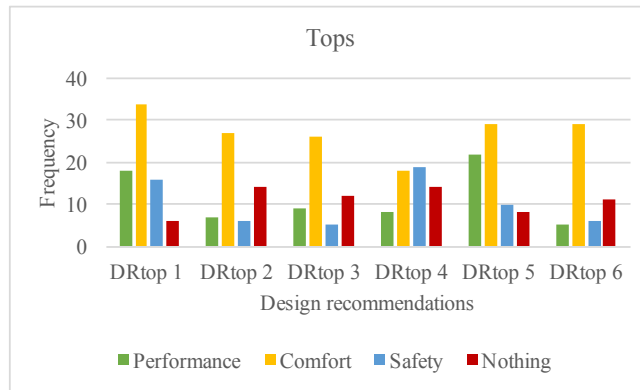
Table 3 lists the updated design recommendations for the gloves.

**Table 3.** List of reformulated and original design recommendations for the gloves.

Reformulated design recommendations	Original design recommendations
DRglo 1   Long Velcro wrap cuff with extension to forearm	DRglo 1   Velcro wrap cuff
DRglo 2   Extra resistant material on fingertips and more availability of sizes	DRglo 2   Elastic fingertips
DRglo 3   Soft side zip	DRglo 3   Central opening
DRglo 4   Thumb and palm/back of the hand coated with replaceable sticky material	DRglo 4   Palm coated with sticky material
-	DRglo 5   Sweat-absorbent, breathable, malleable, resistant gloves

### 3.2 Tops

Regarding the tops, the majority of the design recommendations were very well accepted by the athletes and consequently, only two of them were changed (DRtop 2 and DRtop 4). According to the athletes, the implementation of these design recommendations would improve mostly comfort, but also safety and performance (Figure 4).



**Fig. 4.** Distribution of the responses regarding what aspects could be improved for each design recommendation.

The athletes agreed that the tops should be tight but not form-fitting and suggested materials such as Lycra (DRtop 1 | Tight but not form-fitting tops). They also agreed that having sleeves that can be detachable in different sections would be very useful but warned that they should be durable, breathable, and resistant so that the sections do not divide while playing the game (DRtop 3 | Detachable sleeves by sections). Positive feedback was also given to the materials proposed, even though attention was drawn to the selection of fabrics with good sweat absorption capabilities (DRtop 5 | More adequate textile structure and combination of materials). Finally, agreement was also found for designs with longer backs (DRtop 6 | Longer back).

Concerning the neckline of the tops (DRtop 2 | V-necked tops), the athletes seemed to prefer round-necked tops due to the aesthetics. Nonetheless, they agree that some athletes struggle to put on the tops and suggest that small discreet zips could be added to the shoulder seams to facilitate the putting on and taking off processes. Hence, the improved design recommendation would be DRtop 2 | Round-necked tops with shoulder openings.

The athletes indicated that the sleeves of the tops (DRtop 4 | Reinforced back of sleeves) should not be solely reinforced on the back, but all over as players sometimes push with different parts of their arms, and sleeves can twist during the game. As such, they recommended reinforcing the whole sleeve, making sure that the material used is breathable and durable. Thus, the new design recommendation would be DRtop 4 | Reinforced whole sleeves.

Table 4 lists the updated design recommendations for the tops.

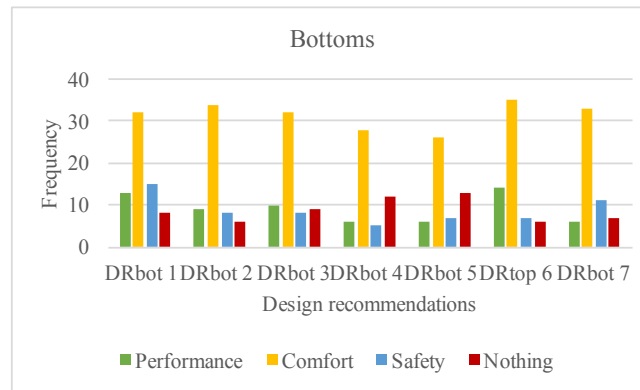


**Table 4.** List of reformulated and original design recommendations for the tops.

Reformulated design recommendations	Original design recommendations
-	DRtop 1   Tight but not form-fitting tops
DRtop 2   Round-necked tops with shoulder openings	DRtop 2   V-necked tops
-	DRtop 3   Detachable sleeves by sections
DRtop 4   Reinforced whole sleeves	DRtop 4   Reinforced back of sleeves
-	DRtop 5   More adequate textile structure and combination of materials
-	DRtop 6   Longer back

### 3.3 Bottoms

The design recommendations initially proposed for the bottoms were also very well accepted and, in this case, no alterations were made to any of them. The athletes seem to believe that implementing these design recommendations would improve mostly comfort (Figure 5).



**Fig. 5.** Distribution of the responses regarding what aspects could be improved for each design recommendation.

The athletes agreed that the design of the bottoms should be tight but not form-fitting (DRbot 1 | Tight but not form-fitting bottoms) and that there should be no pockets for safety reasons. They affirmed that having an elastic around the waist with a pull cord to tighten or loosen the bottoms as required would suit most players (DRbot 2 | Elasticated waistband). Different sizing systems were also viewed as a very important factor to improve the fit (DRbot 3 | Consider anthropometric measurements) as well as a design that is higher on the back than on the front (DRbot 4 | Higher rise on back and lower rise on front). The idea of having a pair of trousers in which the legs can be detachable in different sections was also well received, especially to fit amputees (DRbot 5 | Detachable legs by sections). Finally, the ideas for the materials (DRtop 6 | Mix of synthetic and natural fibers) and seams (DRbot 7 |

Softer material in the back and minimal, flat seams) were also supported by the majority of the athletes.

## 4 Conclusion

The results of this study showed that wheelchair rugby players are, in fact, interested in having sports-wear kit specific for this sport. Their feedback on the proposed design recommendations allowed for the reformulation of some designs.

The evaluation of the design recommendations was every useful to ensure that the products to be developed are in line with the athletes needs and wants from a sports-wear kit.

Once again it was clear that the most important part of the sports-wear kit are the gloves, whereas tops and bottoms despite being especially important for comfort, are sometimes overlooked even by the athletes. The gloves are the sports-wear item that impact the most on the athletes' performance and hence, should be the priority in terms of new product development.

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