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Headgear for Weakening Impact from Concussion in Rugby Games: Design and Development

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Abstract*: Rugby headgear is one of the important protective tool for protecting rugby players from head injury. However, there are still some professional or amateur rugby players who are not concerned about the use of headgear as a protective device. Rugby headgear has been created to protect the heads of rugby players in particular to avoid minor injuries such as wounds because rugby is a sport that requires strong physical movements and abusive techniques. At the same time, the ability of rugby headgear to protect against the occurrence of brain injury is questionable. Therefore, the objective of this project is to propose a conceptual design of rugby headgear by taking into account factors to prevent or reduce the potential of brain injury. The methodology used was a survey of professional and amateur rugby players to determine the need for the design of the headgear, conceptual map for the idea of development, House of Quality (HoQ) in assessing the needs of rugby players, Morphological Chart in determining the concept, Pugh's Selection Method in finding the most appropriate design. Headgear that is round and cover most of the heads has been selected as a conceptual design with sorbothane as core material. Valco strap was used as fastener and sponge in the head for the comfort to the player's head

Keywords* : *Headgear, Head Injury, Impact Resistant, Rugby Games.

I. INTRODUCTION

From hooker to fullback, each player's position in rugby games has a high probability of injury. During the games, players are not allowed to wear hard body protection equipment. Nevertheless, there are still a few equipment that was allowed by the International Rugby Board (IRB) [1] such as mouthguard, headguard, shoulder pad, etc. Headgear is important to protect a rugby player against injuries involving head. It was seldom used by the rugby players and not obligated in the rule of rugby games Player has the right not to wear rugby headgear [2]. Canadian Rugby Union suggested and advised all rugby players to not wearing the headgear because the lack of evidence in avoiding injury. In an investigation, IRB has affirmed headgear display and an altered rendition of the IRB endorsed Canterbury Honeycomb. The newly developed headgear was thicker at the front part. Effect vitality weakening tests were performed in the research facility, proving that the new model is superior to previous model in head protection capacity. The research addressed whether the dimensional changes that were made to the adjusted adaptation would be satisfactory to players and demonstrated in reality that it is capable of decreasing injury rates [3]. IRB has controlled the industry of protective wear by emphasizing the issue relating to the rugby protective equipment specifications according to rule and regulation in manufacturing the player's dress and the safety aspect of rugby boot sole design that made in compliance with general design guidance of the IRB rules and regulations. Formerly, researcher discovered that rugby players reluctant to wear the headgear although they aware about the importance of protective equipment like rugby headgear [4]. It was due to the discomfort anddisturbance caused by wearing the safety attire like rugby headgear that lack of air ventilation. In addition, sweating lead to irritation while playing the rugby games. Players also claimed that headgear made them feel too hot during the games and too tight while wearing close fitting headgear [5]. Disturbance to hearing senses is another limitation faced by players who wear headgear, makes them unable to hear the instruction from the captain or teammates [6]. There were studies that investigated the effect of the protective equipment in preventing injury such as headgear used in rugby union and the result shows that it is only capable to provide limited protection and decrease on the risk of injuries. There is continuous debate between rugby players, rugby coaches and rugby union about the performance of the headgear in rugby whether it has ability to prevent head concussion or vice versa.

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The debate also involves the disagreement about the headgear design whether it can minimize the shallow of head injury or either it's designed has capability to reduce the number and severity of neurological damages. Headgear is ordinary for players in New Zealand, Wales and rugby league.

This research involved with designing a new rugby headgear with appropriate material aimed to reduce the impact experienced by head during concussion. It was found earlier that eight various type of commercially headgear product can lessen the energy transferred where average magnitude supplied by the impact ranged around 902 J to 7608 J [7]. Foam material becomes completely compressed and it did not contribute to the protection of head against the severity of impacts. This concluded the incapability of current rugby headgear in decreasing or minimizing the occurrence of head concussion. Headgear is unable to absorb the large amount of impact during collision. However, it remains as question to how far the capability of the rugby headgear able to respond to collision with low impact since the damage resulting from concussion is less for players who wear headgear [8]. In addition, the laboratory tests proved that the impact performance by the rugby headgear can upgraded by increasing thickness and density of the headgear foam [9].

II. METHODOLOGY

The first stage of this research project was customer survey using simple random sampling method. S.C. Watson stated that the available sources specify the selection of the respondents [10]. A questionnaire consists of 20 questions was distributed to a group of 70 respondents for evaluation. All the information was gathered from rugby players and rugby coaches as they are the individual who involved and observed closely the effect of wearing a rugby headgear. The survey questionnaire was constructed based on the most important criteria for instance the core material, acceptable weight of the product, impact severity, etc. Concept map represents the information visually in translating the complex ideas into easier form to understand the whole ideas in visual diagrams. It helps to identify the missing elements or information needed to ensure that the information presented can be achieved. Arrows and lines connected boxes, circles, and other shapes to show the relevance between concepts and knowledge. Concept map method will point out the most important elements and essentials that must be involved in the process of designing rugby headgear. Headgear will be developed into several important element parts. Then, ideas is created using morphological chart by matching the functions and components. All functions and components can be used more than once. The components are split in specific sub-components which specifying the elements that belong to a category or parameter [11]. All functions were listed in columns while components were listed in rows. Parameters are free and abstract. It consists of elements unrelated to material properties. Morphological chart classify the purpose of the product into a set of sub functions and parameters which will be merged later to produce a new concept [12]. This idea should be the ultimate solution of carefully selected component combinations that together form overall solution. In generating ideas as much as possible, conceptual design was used. Any ideas urged in the beginning of the design works, where quantities exceed quality. Given alternative designs, these can be studied in depth and more critically. The objective of filtering and analysis in conceptualization is to identify innovative, feasible, useful, and practical ideas. Creating the best conceptual design in engineering is not similar to finding one or two good concept ideas from the creative idea-making session.

III. RESULTS AND DISCUSSIONS

A. Survey Analysis

The survey questionnaire was prepared for 70 rugby players as the respondents, including both male and female. There were two rugby coaches involved in this survey. The survey questionnaire was distributed to a few education institutions in Melaka, Perak, and Selangor. Varieties of respondents from different level involved in this survey including Malaysian's Women National Rugby Team, Selangor's Women Under -17 Rugby Team, Polytechnic Ipoh Rugby Team, Polytechnic Behrang Rugby Team and Polytechnic Shah Alam Rugby Team. The survey was held during the training time. The survey questionnaire consists of three parts which are personal detail in first part, design of headgear in second part B and recommendation in the last part. The objective of the first pat was to collect the data related to personal information including gender, age and occupation of the respondents. 77 % or 54 respondents from total 70 respondents of this survey questionnaires were answered by male. The rest 23% of the respondents are female. In the given time frame, most of the rugby players found on pitch are male. It shows that male are the most participated gender in rugby games in Malaysia. In terms of age, most of the rugby players involved in the survey are the person who aged is less than 20 years old with 59%. More than half of them are teenager. 33% of the respondent age was between 20-25 years old. Then, the respondents with their age years old 26-29 and above 30 years old were only 3% and 5%. Most of the respondents were teenagers showing that they are the most active group that involved in rugby games. From 70 respondents, 76% agree that headgear will be useful in avoiding injury during the games. They think that headgear gives them safety feeling and can protect their head from any injury in the games. The rest disagree with the commitment of wearing headgear during the rugby games because they believe it gives no difference. The most common body part that collides with head in rugby games was knee with 40%. It means 28 out of 70 respondents agreed that knee is the most common part that caused collision with head. The percentage is believed coming from the scrum activity that engaged players from both sides. The other 42 of 70 respondents believe that most collision happened with other parts of the body: 11% for upper limb, 13% for elbow, 23% for ground, 12% for head and 1% for shoulder. In terms of material, almost half of total respondents or 43% have picked sorbothane as the chosen main material in development of the headgear.

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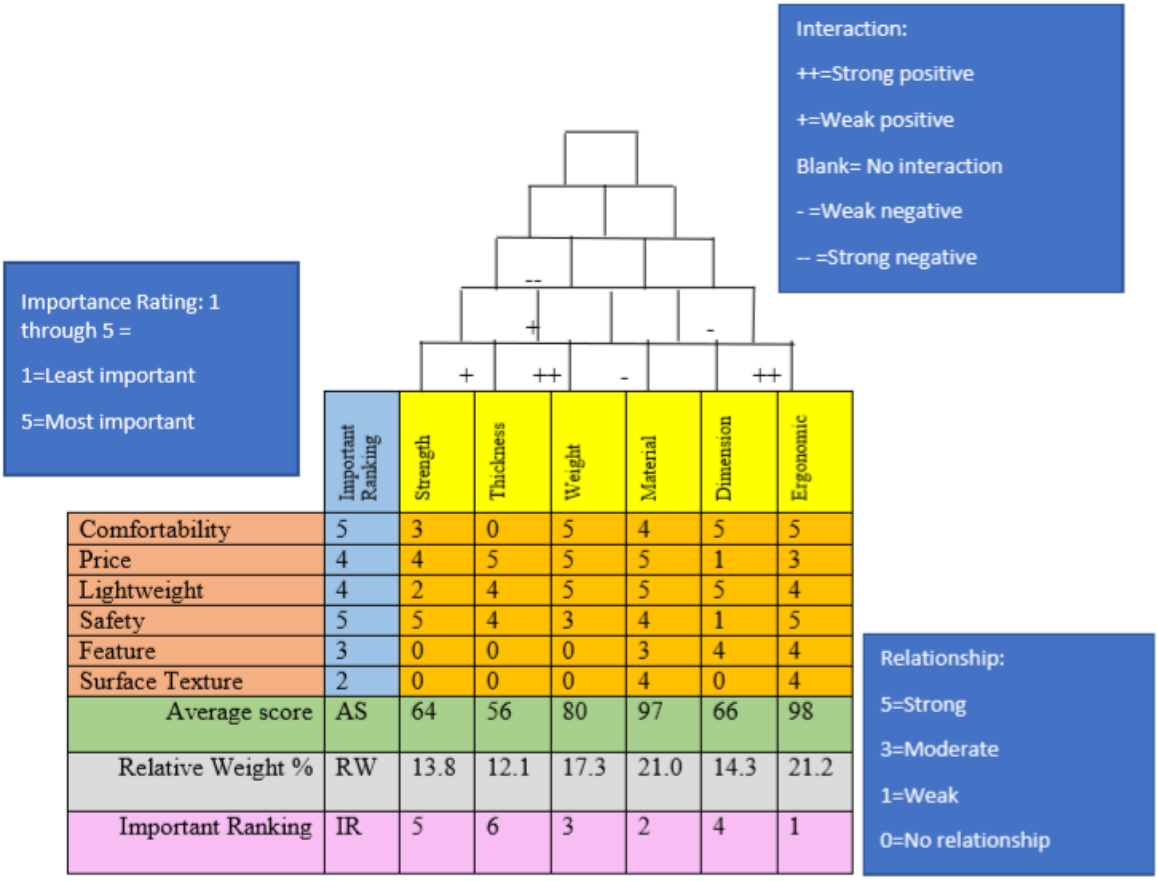
They believed that sorbothane has high resistance property to reduce impact.. 19% of respondents choose to use ethylene-vinyl acetate and 38% respondents choose to use polyethylene. For pattern, the type of air flow pattern was the most selected pattern by the respondent with 53%.

Players want a good airflow to reduce wet on their head during the games. The rest 47% respondents choose for other types of pattern including honeycomb, ventilated, headband etc.



	Important Ranking	Strength	Thickness	Weight	Material	Dimension	Ergonomic
Comfortability	5	3	0	5	4	5	5
Price	4	4	5	5	5	1	3
Lightweight	4	2	4	5	5	5	4
Safety	5	5	4	3	4	1	5
Feature	3	0	0	0	3	4	4
Surface Texture	2	0	0	0	4	0	4
Average score	AS	64	56	80	97	66	98
Relative Weight %	RW	13.8	12.1	17.3	21.0	14.3	21.2
Important Ranking	IR	5	6	3	2	4	1

Fig. 1. House of quality.

B. Pugh Selection Method

Using house of quality (HOQ) as shown by Figure 1, ergonomic characteristic shows the best ranked characteristics with average score of 21.2% and the thickness is the lowest in rank with 12.1%. Second and third best characteristics to be considered are material with 21% and weight with 17.3%. Thickness has the lowest mark with relative weight of 12.1%. In common with the investigation by IRB, the increase of weight or density able to improve the impact resistant of a headgear. However, the finding for thickness is in contrast with the previous study. Five possible parameters used in this study to generate possible solutions are material, shape, fastening, cover area and inner surface. Four best possible combinations was created which are: 1) [Sorbothane, Oval Shape, Valco Strap, Fully Cover, Sponge] 2) [Sorbothane, Circle Shape, Valco Strap, Fully Cover, Sponge, 3) [EVA, Square Shape, Helmet Strap, Fully Cover, Sponge] 4) [Polyethylene, Circle Shape, Shoelace, Top & Back Cover, Cotton]. All these 4 alternatives were compared with the datum using pugh concept selection matrix as in Table 2.

Table- 1: Morphological chart

No.	Parameter	Possible Solutions		
1	Main Material	Sorbothane	Polyethylene	Ethylene Vinyl Acetate
2	Shape	Square	Oval	Circle
3	Fastening	Helmet strap	Shoelace	Valco strap
4	Cover Area	Fully	Top	Top & back
5	Inner Surface	Sponge	Cotton	Cloth

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Referring to table 2, alternative 2 can be considered as superior to other alternatives. Over datum and other alternatives, alternative 2 was chosen to be developed further since it possessed the best rank based on mass, durability, cost of material, attenuation of energy, and cost of manufacturing. Alternative 1 seconded with 3 positive ratings and 1 neutral rating. The specifications and characteristics of alternative 2 is sketched by taking into account the needs of all customers.

Table- 2: Pugh decision matrix

	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
Weight	1	1	0.8	0.9	0.8
Durability	+	+	D	+	-
Material Cost	+	+	A	+	+
Stored Energy	+	+	T	-	-
Manufacturing Cost	-	+	U	-	-
Size	S	S	M	+	+
∑+	3	4		3	2
∑S	1	1		0	0
∑-	1	0		2	1

Fig. 2. Headgear isometric view.

afford to hire the third party to maintain their grease trap.

IV. CONCLUSIONS

The effect of a rugby headgear in reducing the impact to player's head during collision is still a question mark. Most researchers disagree on the fact. However, they believed that wearing headgear can prevent scar on the scalp skin. A new rugby headgear concept was designed in effort to reduce as much impact to the head as possible for any concussion event. Three characteristics has been considered which are ergonomics, material and weight of the headgear. Alternative 2 has been selected for further development since it was the most sustainable solution with 4 positives and 1 neutral compared to datum. The new developed headgear must be tested with ergonomic assessment tolls such as RULA or REBA [13] and needs to be tested experimentally to validate the efficiency of the headgear towards impact reduction [14]. Headgear structure can also be analyzed using finite element analysis. The impact strength of a headgear is represented by its ability to show minimum displacement and minimum von Mises stress value [15].

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