



PROTECTIVE EQUIPMENT IN RUGBY – LITERATURE REVIEW

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Providing coaches, referees, players, and administrators with the knowledge, skills, and leadership abilities to ensure that safety and best practice principles are incorporated into all aspects of contact rugby.

INTRODUCTION

The sport of rugby union has changed considerably over the last few years, becoming a faster and more physical game. Due to the popularity of the game, the number of players actively participating has increased over a broad spectrum of skill and fitness levels. Players start playing rugby on a more formalised basis at a much younger age, women and girls are now also involved in playing the game and the level of competitiveness at schools has increased dramatically. At a semi-professional and professional level, monetary and other incentives has made the game more competitive. These changes in the game have resulted in a greater risk of injury.

To this end, several commercial companies have become involved in the design and production of protective equipment and clothing specific to the sport of rugby, with the overall goal of reducing the risk of injury. Protective equipment now encompasses a broad spectrum of items that are widely available, though not necessarily affordable to all. A study by Marshall et al. ^[27] (327 male and female rugby players) showed that less than 15% of the players used protective devices (i.e. support sleeves, headgear, head tape and grease), other than mouth guards and taping of joints.

Similarly, a study by Comstock et al. ^[10] also found that fewer than 15 % of players wear various types of protective equipment, excluding mouth guards. Players reported wearing shoulder pads to prevent injury and neoprene sleeves to protect current or recent injuries. Even though more scientific studies are being done on the effectiveness of protective equipment, both to ensure the protection of players and to substantiate manufacturers' claims, much controversy remains.

To manage and control the protective wear industry and thus protect the players, the International Rugby Board (IRB) has issued certain directives and specifications pertaining to the wearing of protective equipment by players. These are contained in Schedule 1 (regulation 12), dated 2007, entitled "Specifications relating to players' dress" and Appendix 2 – Law 4.3, entitled "Safety aspects of rugby boot sole design. General Design Guidance" of the IRB rules and regulations ^[20].

This is a comprehensive document available on the internet (www.irb.com) which discusses items such as shin guards, fingerless mitts, shoulder pads, headgear, chest pads for women, studs and banned items of clothing.

The document also covers the following aspects:

- Terminology.
- General Requirements:
 - ergonomics
 - construction e.g. materials
 - sizing
 - design.
- Performance Requirements:
 - impact attenuation
 - retention system strength
 - effectiveness (headgear only).
- Testing methods are described.
- Requirements for product marking.
- Instructional literature.

The aim of this section is to examine the scientific literature on protective equipment for rugby players with a view to providing evidence-based practical guidelines for players, coaches and officials.

EQUIPMENT

MOUTH GUARDS

Mouth guards were reportedly first used as early as the 1920s by professional boxers [7, 21, 25]. Mouth guard usage was mandated in 1962 for US high school football teams after extensive lobbying by the American Dental Association (ADA). The ADA currently recommends mouth guards to be used in 29 different sporting codes [25]. At the beginning of the 1997 rugby season, the wearing of mouth guards was made compulsory for all players at the under-19 level and below in New Zealand. This rule was then extended to include all grades of domestic rugby at the beginning of the 1998 season [41].

Several scientific studies have been done on mouth guards pertaining to various aspects of their physical properties and abilities to prevent injury.

Type of materials and construction

Mouth guards are generally classified into 3 types according to the type of material used, manufacturing, and fitting methods [3, 6]. Type I are generally very cheap, constructed of rubber or latex, and do not need to be fitted. Type II are also not extremely expensive and occur in “shell-liner” (older models) or “thermoplastic” models. Thermoplastic being the normal “boil-and-bite”-type mouth guards. Type III are

custom-made mouth guards, made with superior materials (ethylene vinyl acetate) and fitted by dentists, and thus more expensive [6]. Mouth guards are evaluated according to their shock-absorbing qualities, hardness, stiffness (protective capability), tensile strength, tear strength (durability) and water absorption [18, 40]. The type of materials used to construct mouth guards include i) polyvinylchloride; ii) polyvinylacetate-polyethylene or ethylene vinyl acetate (EVA) copolymer; iii) latex rubber; iv) acrylic resin; and v) polyurethane. Mouth guards constructed with EVA and polyurethane have been shown to have superior qualities, compared to those constructed using latex [18, 25, 40].

Different types of mouth guards

There is still controversy as to whether custom-made mouth guards are superior to the normal “boil-and-bite” versions.

A study conducted by Finch et al. [13] on a group of 301 Australian rules football players during the 2001 season, monitored the injury rates of players wearing either a customised or regular mouth guard. Results indicated that players generally wore mouth guards more often when playing a game compared to when they trained. The overall injury rate was 2.7 injuries per 1000 exposure hours, with a higher injury rate during matches. The custom made mouth guards seemed to have had a significantly higher protection rate compared to the regular mouth guards during matches and training combined, with an incidence ratio of 0.56 (95% CI: 0.32 – 0.97).

Another study examining the efficacy of mouth guards monitored a large group (87 Division I teams) of college football players over one season to determine whether custom made mouth guards were superior to boil-and-bite mouth guards in preventing concussion [47]. Out of a total of 506,297 incidents, 369 concussions were identified. In contrast to the previous study [13] there was no difference between the two different types of mouth guards in protecting against concussion.

A multicentre, cluster-randomised, controlled study done by Barbic et al. [4] specifically examined the effectiveness of the WIPSS Brain-Pad mouth guard compared to other mouth guards in preventing concussion in a total of 646 university football and rugby players during the 2003 season. Data collected included symptoms of concussion and dental injuries. The study concluded that there was no evidence to suggest that the WIPSS mouth guard was more effective in preventing concussion compared to other mouth guards in this group of players studied.

Injury vs. mouth guard usage

The incidences of dental injury claims in relation to the wearing of mouth guards was examined using data from studies that were conducted in 1993, 2002 and 2003 [41]. Data from rugby dental injury claims were available for the period 1995 – 2003. These data should be interpreted in the context that the

wearing of mouth guards was only made compulsory in certain groups of players in 1997 and 1998 in New Zealand as previously mentioned.

Players' self-reported use of mouth guards increased from 67 % in 1993 to 93 % in 2003. At the same time rugby related dental claims decreased by 43 %. Assuming that the number of players and matches remained constant throughout this period, the savings in monetary terms alone amounted to approximately 1.87 million NZD. The study concluded that wearing a mouth guard is a simple and effective way of preventing injury in rugby players and should be recommended for all players during both training and match situations ^[41].

Several studies have concluded that wearing any type of mouth guard is effective in terms of a reduction in the incidence of minor injuries, fractured teeth and head acceleration, compared to wearing nothing at all ^[3, 4, 6, 7, 13, 17, 25, 40, 41]. A meta-analysis of the studies found that the risk of sustaining an orofacial injury was approximately 1.6 – 1.9 times higher when the player did not wear a mouth guard ^[25]. However, none of the studies could positively conclude that mouth guards would be effective in preventing concussion.

Structural and material changes in mouth guards

A study by Rossi et al. ^[43] examined the structural changes to mouth guards in a group of 15 high school football players over one playing season. The custom-made mouth guards were examined three times through the course of the season (before, midway, end) to identify any changes to the material thickness and shape. The thickness of the mouth guards at the incisor / canine and molar teeth regions was tested, as well as the shape retention of the mouth guard by measuring the width of the mouth guard channel at the first molar. It was found that the material thickness at the incisor / canine region decreased by 16 % and at the molars by 23 % after a six week period. The shape of the mouth guards also changed. Park et al. ^[40] also found a decrease in thickness of between 25 and 50 % in type III custom-made mouth guards and an alarming 70 – 99 % decrease in type II (boil-and bite) mouth guards at the occlusal surfaces.

At this stage the evidence recommends frequent inspections of mouth guards to ensure that safety is not compromised, replacing children's mouth guards at least every six months and adults at least every two years ^[6]. Future studies need to develop more specific guidelines about how long mouth guards may be worn before having to be replaced.

Disease transmission

Only one study could be found on the possibility of disease transmission through mouth guards ^[15]. In this study the clinical history of two junior high school football players are discussed. One player had the

same bacterial strain on his leg cellulitis and his mouth guard. The other player had severe exercise-induced asthma, which suddenly became uncontrollable. These symptoms may have been exacerbated by the different species of mould found on his mouth guard.

Players' attitude

The attitude and knowledge of players towards mouth guard usage is an important aspect to consider when promoting the wearing thereof.

A study ^[9] was conducted to assess the knowledge of a group of professional rugby players regarding the benefits of wearing mouth guards and how important they felt this to be. At the same time, a group of parents of rugby playing children were questioned regarding their views on the use and importance of mouth guard use in children. Both the parents and the group of professional rugby players felt it was important that players wear mouth guards when playing rugby. However, despite the parents agreeing that mouth guards were important, very few of their children actually used mouth guards. The reasons cited for this paradox were mainly of a financial nature as mouth guards had to be replaced frequently due to the changes taking place as the children grew, and also the difficulty in actually getting children to a dentist to have mouth guards made.

Another study ^[6] indicated that even though 95 % of players questioned in the US rugby team believed it was beneficial to use mouth guards, only 50 % actually wore them. Of the players using mouth guards, nearly 91 % would not play without their mouth guards and 55 % felt that it should be made compulsory to use mouth guards. About a third of these players reported having suffered an orofacial injury that needed treatment, and none of them were wearing a mouth guard at the time of injury.

In conclusion, wearing a mouth guard, regardless of make or type, generally seems to be beneficial to all players of all ages and at all levels of the game. Mouth guards are relatively inexpensive and widely available in sports stores.

PROTECTIVE PADDING (e.g. shoulder pads, shin guards)

Rugby players are continually exposed to impact and collision situations, particularly during tackles and scrummaging, both during training and match situations ^[17]. A study on 105 first class rugby players showed that 45 % of the players have had some form of shoulder injury, the most common being a fall on the tip of the shoulder (57 %) ^[45]. The use of some form of protective padding to protect against these types of injury has become more common over the last few years. A study ^[28] was conducted to investigate the effect of protective wear on injury rates in US collegiate football players vs. New Zealand club rugby players. Protective padding and hard-shell helmets are compulsory in collegiate football but not in rugby. The study found that the injury rate for the footballers was about one-third that of the rugby

players (rate ratio [RR] = 0.35; 95 % CI: 0.31 – 0.40). Whilst the demands of the games are different, this study does lend support to the efficacy of padding.

Padding is generally constructed using various combinations of rubber, compressed foam and industrial foam rubber ^[17]. The type and degree of padding allowed are regulated and controlled by the International Rugby Board as contained in their regulations (Law 4.2) ^[20].

There is still much debate about the usefulness of padding in the prevention of injuries, particularly shoulder padding. The ability of shoulder pads to disperse and absorb force is the main reason why they are used by players. While the pads may reduce minor soft tissue bruising, there are no data to suggest that shoulder padding alone will be effective in preventing shoulder fractures or dislocations. The mechanism of these injuries involves direct impact forces and also rotational forces, something that the pads are not designed to resist ^[17].

Shin guards

Shin guards are mostly worn by soccer players and as such most of the data available pertains to soccer players. Shin guards may be constructed of a light, compliant material, which will not be a danger to other players. Different types of shin guards were examined by Bir et al. ^[5] in relation to their construction and performance capabilities. Impact force (peak loads) were measured in the laboratory and results indicated that shin guards reduced the peak load by between 41 – 77 %. The data suggests that shin guards have the potential to be effective in preventing impact injuries to the lower limb.

Other padding

The construction and design of specifically chest padding for female rugby players are prescribed in the IRB regulations pertaining to protective wear (Schedule1, regulation 12) ^[20].

In summary, padding may be generally effective for all level of players in reducing the incidence of minor injuries, but its effectiveness remains doubtful in more serious injuries such as dislocations and fractures.

HEADGEAR

The basis for wearing headgear can be summarized as: impact forces are attenuated, acceleration at the point of impact is reduced, forces are distributed over a larger area, and bone and soft tissue are protected against abrasions ^[46].

A recommendation arising from several studies on the relationship between headgear and injuries is that the use of headgear should be encouraged as a means of protection against lacerations and abrasions ^[46]. It should also be noted that headgear provides limited protection against impact injuries such as

concussion ^[46], although the symptoms of concussion of players wearing headgear may be less severe than the symptoms of players not wearing headgear ^[23].

A case-control study was conducted by Jones et al. ^[22] in the UK to ascertain whether using headgear was associated with a decreased risk of injury to the head and face. Headgear was used by 13 % of injured cases compared to the 21 % in the control group. They concluded that the wearing of headgear was associated with a substantial reduction in superficial head and face injuries. At the same time a review of the 41 games played during the 1999 Rugby World Cup compared the data to the case-control study ^[22]. Of the 547 players studied, 47 bleeding head injuries were observed. The use of headgear in the forwards was associated with a significant reduction in bleeding head injuries (odds ratio (OR) = 0.14, 95 % CI: 0.01 – 0.99, $p = 0.02$) but not in the backs. The forwards also tended to present with more facial injuries compared to the backs. In conclusion, the study found that the use of headgear may be effective in decreasing the incidence of certain types of injuries in all level of players, with the elite forwards gaining the most in the reduction of superficial head injuries.

Headgear construction

A two-year randomised controlled study examined different headgear used by under 13, 15, 18 and colt age groups in Australia ^[33]. The study consisted of a control, IRB-approved headgear model and a modified version of the IRB approved Canterbury Honeycomb model. The modified model was altered by increasing the foam density and thickness. Impact energy attenuation tests were performed in the laboratory, which indicated that the modified version was superior in its protection capabilities. The study, however, questioned whether the dimensional changes that were made to the modified version would be acceptable to players and indicated that the study would need to further examine if the improvements made to the modified version would in actual fact translate into reduced injury rates.

A study examined the impact energy attenuation of foam that could be used in the construction of headgear and evaluated the performance of these prototypes of modified headgear (Albion Headpro and Canterbury Body Armour honeycomb headgear) ^[34]. Various impact tests were performed on polyethylene foams using free-fall drop tests onto a flat, rigid anvil. Headform acceleration was measured. Results indicated that an increase in density and foam thickness of between 10 – 16 millimetres would improve the performance of the headgear. However, there was insufficient evidence to state conclusively whether these changes would reduce the rate and severity of concussions suffered by players. Further prospective studies need to be done to answer this question.

McIntosh and McCrory ^[31] tested eight different commercially available headgear products from six manufacturers to examine the level of impact energy attenuation and the products' abilities to reduce the incidence of concussion. They found that at an energy impact of around 20 J, the foam material was completely compressed, thus offering no protection against more severe impacts. They concluded that the current available headgear is not sufficiently capable of reducing the incidence of concussion.

Attitude

Apart from the safety aspect of protective wear, the attitude of players towards utilising this equipment should be taken into consideration.

A study by Finch et al. ^[13] aimed to assess the attitude of under-15 rugby players towards the wearing of headgear. The study took the form of a self report questionnaire at the end of the 1999 playing season. Results indicated that 76 % of the players always wore some sort of protective equipment, 94 % wore a mouth guard and 79 % headgear. Players indicated that they wore the equipment for safety reasons whilst 67 % said that wearing headgear made them more confident when playing. Players indicated that when they were wearing headgear, they were more confident generally and would tend to tackle harder, indicating that the wearing of protective equipment may influence and change a player's behaviour on the field. Problems associated with headgear usage related to players' heads feeling hotter, being uncomfortable to wear and communication problems because of their ears being blocked.

In conclusion, the wearing of headgear seems to be effective in preventing or reducing the severity of most orofacial injuries suffered by rugby players. However, their safety and efficiency in preventing concussion has not been proved conclusively.

COMPRESSION GARMENTS

Compression garments are tight fitting clothing worn on either the upper or lower limbs during and after exercise. Compression garments are used mostly to accelerate recovery after exercise, however some players do use them during training and matches with the goal of reducing the risk of injury.

Support sleeves were effective in reducing the risk of sprains and strains in a study of 304 rugby union players (RR = 0.58, 95 % CI: 0.26 – 1.27) ^[29]. A study by Doan et al. ^[11] evaluated the difference between custom-fitted compression shorts and normal loose-fitting gym shorts (control) on the performance of 20 track athletes. A secondary aim was to examine the mechanical properties of these two garments. The study found several significant differences between the two garments. The compression shorts reduced the hip angle flexion during sprinting, increased skin temperature more and faster during warm-up, muscle oscillation was decreased after landing during a vertical jump and the countermovement vertical

jump height was increased. As far as the mechanical properties of the compression garment were concerned, increased flexion and extension torque was observed at the end range of extension and flexion, which may help the hamstrings in controlling the end swing phase during sprinting. The compression shorts also significantly reduced the impact force by about 27 % compared to normal pants. The study concluded that all of these differences may translate into performance differences and a reduced rate of injury.

Similarly, a study by Bernhardt and Anderson ^[4] examined proprioception at the hip as well as the effect of the Coreshorts compression shorts on the performance of 13 subjects. Several hip measures were evaluated (active range of motion at hip, joint angle replication during hip flexion, abduction and hyperextension). Performance measures included leg power, agility, speed and aerobic endurance. The compression shorts decreased the active range of motion during hip flexion ($p < 0.05$), but had no effect on any of the other parameters tested. The subjects generally felt that the compression shorts were supportive if fitted correctly. The study concluded that moderate compression at and around the hip may assist in injury prevention.

Another study by Upton et al. ^[44] examined whether wearing thermal pants would decrease the risk of hamstring injury in 44 male rugby players over the course of the a season. All the players in the study had suffered previous hamstring injuries. The group who wore the thermal pants some of the time, had a lower injury rate (3 injuries / 1000 playing hours) compared to the 57 injuries / 1000 playing hours when not wearing the thermal warmers. The study concluded that although thermal warmers may have a role in the prevention of recurrence of hamstring injuries, other factors such as incomplete rehabilitation and poor pre-season conditioning may be bigger factors for injury.

In summary it seems that there may be some kind of beneficial effect on certain performance parameters through the wearing of compression garments. More studies are needed however to positively conclude whether these garments are performance enhancing or not, and to further clarify their role in injury prevention.

BRACING AND TAPING

Players are most often seen with taping on different joints and / or wearing some kind of brace when playing matches. A study by Marshall et al. ^[27] examined the level of use of protective equipment in a group of 327 players. Data were collected weekly over the course of a season. The study showed that the areas generally taped were the ankle, knee and hand.

Ankle

The use of prophylactic ankle taping is widely used as an injury prevention strategy by football players. A study conducted by Mickel et al. ^[36] of 83 football players over a playing season, found that there was no difference in the incidence of ankle sprains between two groups using either taping or braces. They also compared the cost related to either taping an athlete's ankle or using a commercially available brace and found that using a brace was substantially cheaper than using conventional prophylactic taping methods and also saved a tremendous amount of time.

A review by Hume and Gerrard ^[19] on the effects of external ankle support such as bracing and taping indicated that the effectiveness of these methods related to the material's properties, application methods, the player's ankle stability and history of previous injury. The study also found that for an external device to be effective in supporting a ligament, it should exceed the strength of that particular ligament. As such, taping can only provide very limited support and its effect may be more of a psychological nature. Bracing may be more effective in providing adequate injury reduction but further research is needed.

A study ^[42] was done on ten different ankle braces to determine their effect on performance specifically (rigid – 1; semi-rigid – 5; soft – 4). Thirty-four subjects who suffered from self-reported chronic ankle stability were tested, using both an objective performance measurement (agility course) and a subjective rating (comfort and stability) instrument. The objective performance measurements were not different between the braces tested, except for the rigid brace, which had slightly decreased values for all of the tests. The subjective opinions varied widely between the braces, but these differences were not substantiated by the objective performance evaluation. Individual preferences may thus dictate the type of brace used by athletes.

Knee

Knee injuries are a fairly common occurrence in rugby due to the number and intensity of biomechanical stresses experienced by players. Strapping and bracing are commonly used to protect a current or recent injury but there are still divided opinions on the effectiveness of either of these techniques ^[10].

According to Gerrard ^[16] there is no evidence to support the case for prophylactic taping of the knee as the stabilisation afforded by the taping only lasts for a short period of time. The rapid deterioration is due to the loss of the custom fit of the external support due to the vigorous activity and movement experienced. Sweating may also render taping useless within a few minutes.

Studies have determined that off-the-shelf braces have the ability to provide 20 – 30 % more resistance to lateral blows to the knee when in full extension, whilst custom fitted braces protected the knee even more, even when there was some knee flexion present ^[38]. However, there are some indications that braces may also affect performance in a variety of ways, such as slowing straight-ahead sprint speed, increasing early fatigue, increasing muscular relaxation pressures, energy expenditure, blood lactate levels, maximal torque output, oxygen consumption and heart rate ^[1]. The negative effects seem to vary between different braces, depending on their weight, design and leg / thigh strap pressure. The effects also depended on the individual player, with more experienced and stronger players showing fewer effects. The studies concluded that even though wearing a brace may protect the medial collateral ligament and possibly the anterior cruciate ligament from injury, performance may be adversely affected ^[1, 38].

In conclusion, bracing may be a more cost and time effective method of supporting ligaments and joints. Bracing and taping seems to be used more as a method of protecting current or recent injuries and less as a means of injury prevention. Even though bracing seems to be the more effective injury prevention method, it may also adversely affect performance.

CONCLUSION

The wide variety of protective equipment have the potential to make rugby union a safer game. The general consensus of all the studies seems to be that players should certainly be encouraged to use the available protective equipment, mostly due to its apparent ability to reduce the risk of minor injuries, if properly fitted, worn and cared for. However, cognisance should be taken of the fact that none of the studies could conclusively prove that the equipment was effective in reducing more serious injuries such as concussions, dislocations and fractures.

Another important fact to note is that players' attitudes may change when they are wearing equipment, thereby changing the way they play and approach the game. This may place them at greater risk of sustaining injuries, as especially younger players may deem themselves to be invincible when wearing some protective equipment. Education of all rugby players should include this important aspect.

AUTHORS' BIOGRAPHY

Dr Miriam Sinclair holds a Ph.D in Exercise Science from the University of Cape Town, and has performed extensive research on provincial rugby players as part of her Ph.D. She is also an international Powerlifter and the Project Manager of selected Clinical Trials at the University of Cape Town.

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