RUGBY 7'S NEEDS ANALYSIS AND PROGRAMMING OF TRAINING

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ABSTRACT

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Introduction. After the International Olympic Committee's decision in 2009 to include rugby 7's in the summer Olympics, the popularity of rugby 7's has increased world-wide. Rugby 7's is a variation of rugby union and is played with similar rules and the same sized pitch as rugby union. The main differences between rugby 7's and rugby union is that in rugby 7's there are only 7 players on the field and 5 substitutes per team, whereas in rugby union there are 15 players on the field and 7 or 8 substitutes per team. Rugby 7's is usually played in tournament mode, where each team plays 5-6 games over 2-3 days. Rugby 7's matches last 14 minutes, including two 7-minute halves, separated by a 2-minute half time.
Game demands. Because of the shorter game time and having less players on field while still using the same field size as rugby union, rugby 7's is played with greater intensity than rugby union. Typically, rugby 7's players cover around 1200-1500 m during the match, with an average relative distance of around 100-120m/min. Rugby 7's players cover on average 200 m with high intensity running during the match.
Physiological demands. They need well developed strength, endurance and sprinting capacities to optimally perform at an international level. International level athletes have been shown to have an average VO_{2max} of 53.8±3.4 ml/kg/min and 51±4 ml/kg/min for male and female players, respectively. International level male players have been shown to have relative strength levels of 1.5 times their body weight in bench press and 2 times their body weight in squat, while international level female players have been shown to have a relative strength of around 1-1.2 times their body weight. International level male players have been shown to reach maximum speeds of 9.2 m/s, while the maximum speed for international female players is around 8.2 m/s.
Conclusion. Because of the high intensity of game play, and the tournament style used, the physical preparation of rugby 7's players is important. Off-season training should aim to improve the athlete's strength and endurance strength and endurance of the athletes, whereas during in-season training, the emphasis should be on maintaining strength, improving power and speed. Nutrition, sleep, and recovery from tournaments are important during in-season training, and an individualised plan for these aspects should be developed for each player to optimize performance.
Key words: rugby, sevens, 7's, physical, preparation, needs analysis

CONTENT

1 INTRODUCTION

Ever since making its debut in the 2016 Summer Olympics, the popularity of rugby 7's has been increasing (Goodale et al. 2016). Rugby 7's is a variation of 15-a-side rugby union, played on the same size field and with seven players a side. The players are divided into three forwards and four backs. Another major difference is that the rugby 7's game includes two 7-minute halves separated by a 2-minute break. The final match of the tournament usually includes two 10-minute halves. Rugby 7's is often played in a tournament style, which includes 2-3 games per team per day over 2-3 days (Suarez-Arrones et al. 2012a), whereas rugby union and rugby league typically involve only one game per week. Because playing time is much shorter than in other styles of rugby (league and union), game intensity, running velocity and work-to-rest ratios are much higher in rugby 7's.

Current research has shown that rugby 7's players cover on average 96-120 m/min, whereas rugby union players cover an average of 70m/min (Higham et al. 2016, Couderc et al. 2016) and 90-100m/min for rugby league (Cummins et al. 2016). Rugby 7's players also perform a higher proportion of high intensity running than rugby union players, 17.1% and 7.7-11.9%, respectively. Rugby 7's requires a higher work-to-rest ratio than other rugby codes. During a rugby 7's match, the work-to-rest ratio is 1.7:1 to 1.8:1 (Suarez-Arrones et al. 2014), whereas in rugby league the ratio is 1.3:1 (Suarez-Arrones et al. 2014) and in rugby union it is 1:4 to 1:5.7 (Lacome et al. 2014, Cunniffe et al. 2009). Furthermore, a higher proportion of high speed running, overall intensity, and a reduced work-to-rest ratio, requires rugby 7's players to have well developed aerobic and anaerobic capacities.

Rugby 7's places different demands on athletes than rugby union and rugby league, and physical preparation for rugby 7's needs reflect these differences. Furthermore, because rugby 7's is played in tournament style, this places a greater emphasis on optimizing recovery methods and nutrition during the tournament. (Schuster et al. 2018.) By optimizing recovery and nutrition during a tournament, the coach can ensure that athletes are ready to perform after a short break, and it also minimizes fatigue in later stages of the tournament. The aim of the work was to investigate the physical and technical needs of rugby 7's and to prescribe a physical preparation program for a female rugby 7's player.

2 RUGBY 7S MATCH DEMANDS

2.1 Technique

Rugby has strict rules on several different aspects of the game, including the tackle, ruck, scrum and maul. Rucks, mauls and scrums are unique to rugby, and the rules for tackling are different compared to many other contact sports. For example, shoulder charging and shoulder-to-shoulder contact are not allowed in rugby. (World Rugby 2018.) No previous research was found on effective techniques in tackling, scrummaging and mauls for rugby 7's. Rugby 7's have the same basic rules as 15-a-side rugby union with only minor differences, therefore technique for the special skills are the same in both rugby codes.

In rugby 7's, the tackle is considered to happen when the ball carrier is held by one or more opponent and the ball carrier is bought safely to the ground. A tackle is considered to have occurred when the ball carrier's knee, or both knees, are in contact with ground, or when the ball carrier is sitting on the ground. After the ball carrier is brought to the ground, the tackler must immediately release the tackled player and get up or move away from the tackled player. The tackled player must try to make the ball available immediately. Furthermore, the ball carrier is not allowed to prevent their opponent from gaining possession of the ball. The ball carrier is allowed to pass the ball or place it onto ground, but not get up with the ball after the tackle. (World Rugby 2018.)

Previous research has shown the importance of correct tackling technique, because around 72% of all injuries during the match occur during tackling and other contact events. Research has also shown that by improving tackling technique, the number of injuries can be reduced. (Hendricks et al. 2018, Tierney et al. 2018a.) The most efficient tackles are front-on, where the tackler tackles ball carrier in front of their body, and side-on, were the tackler tackles the ball carrier diagonally from the side (Tierney et al. 2018b). Several technical aspects have been identified for a successful tackle. These aspects include 1) shortening the steps to prepare for evasive manoeuvres, 2) use of the shoulders to make contact and being explosive through the contact, and 3) leg drive on the contact. Body positioning, especially maintaining a straight back, affects the success of the tackle. Proper body positioning during the pre-contact phase allows the player to explode and use leg drive during the contact to perform an efficient tackle. (Tierney et al. 2018b.)

One rugby specific technical skill is a ruck. The ability to engage and win rucks has been shown to be associated with the overall success of the team. (Hendricks et al. 2018.) The ruck is considered to occur when 'a tackled player is brought to the ground, and one or more players from each team, who remain on their feet and in physical contact, compete for the ball on the ground through a variety of pushing and grappling movements' (Barkell, O'Connor & Cotton 2018). Better ability to retain and win rucks has been shown to be positively correlated with points scored and higher tournament ranking. In rugby 7's, the attacking team retains the possession of the ball 69% of the time for males and 73% for females during the rucks. Therefore, many recent studies have investigated the actions and techniques that lead to successful ruck performance. (Barkell, O'Connor & Cotton 2018.)

The most common ruck formation includes one attacker and one defender. Having a small number of players on the field encourages the attacking team to minimize the number of players engaged in the ruck. When possession of the ball is successfully retained by the attacking team with only one player contesting the ruck, this results in the attacking having more players available to attack quickly. Having only one player in the ruck, however, leads to a higher number of turnovers. Therefore, players need effective techniques to protect the ball. The most important factor that influences the result of ruck is the first player that arrives after the tackle. If the first player is from the attacking team, they will be more likely to maintain possession of the ball. Ball placement is another important aspect of a successful ruck. The further from the defending players the ball carrier can place the ball, the higher the chance of retaining ball possession. (Barkell, O'Connor & Cotton 2018.)

Previous research has identified three steps for body positioning for successful rucking. First, and most important factor, is shoulder height. When attacking player had their shoulders lower than defending player joining the ruck, attacking player was more likely to retain possession of the ball. On the other hand, if defensive player was able to enter ruck with their shoulders lower than attacking player, defensive player was more likely to produce turnover. These findings suggest, that when entering the ruck, players should aim to enter the ruck as low as possible. Second aspect identified for successful ruck was player’s weight distribution. When attacking player placed their hands on tackled player, they were more likely to protect the ball than when they tried to stay on their feet without placing hands on the tackled player. This technique resulted on higher shoulder height, which was shown to be critical for ruck success. Final aspect was the position of the first player joining the ruck in relation to the ball. When attacking player rucks past the ball, they will increase the distance that defensive player needs to push in order to win the ruck. This tactic was more successful than forming the ruck on top of the ball. (Barkell, O’Connor & Cotton 2018.) In summary, when forming the ruck player should aim to have their shoulders as low as possible, place their hands on tackled player, and ruck past the ball to successfully protect the ball, whereas defending player should aim to make contact under the shoulder of attacking player, to increase the chance to win the ruck.

Scrum is used to restart the game, and to contest the possession of the ball, after a small infringement that occurs in the field of play (Preatoni et al. 2013, Green et al. 2017). Scrum is formed after small infringement occurs in field of play and non-infringed team do not gain advantage. Small infringements include knock on, forward pass, and accidental offside. Three players from each team is needed to form a scrum. Players from same team bind together to form a single row. Outside players, called props, need to bind into to middle player, called hooker. Hooker must bind into both props, either over or under the arm of the prop. As soon as two teams bind together scrum half must feed ball into the middle of the tunnel (the space between the two teams). After ball is fed into the tunnel both teams can contest the possession of the ball. Front row player is not allowed to intentionally kick the ball out of the scrum towards the goal line of the opponent. Neither team is not allowed to intentionally lift or collapse the scrum. All the other players not involved with the scrum must stay 5 meters away from the scrum, until ball is out of the scrum. (World Rugby 2018.)

Barkell et al. (2016) showed that the winning men’s team were awarded significantly more scrums than the losing teams in the 2014 IRB World Series quarter and semi-final matches. The winning teams were also more effective, and showed more consistency, in winning the scrums. In comparison, there were no differences between the winning and losing teams in winning the scrum in women's matches. (Barkell, O'connor & Cotton 2016.) Other studies showed that the number of scrums, and the ball possessions retained from the scrum, increased the likelihood of winning an even match (Higham et al. 2014b). These findings show the importance of having an effective scrum technique, to be able retain or win the ball possession after the scrum.

There were no studies found investigating technique requirements of an efficient scrum in rugby 7's. The front row in rugby union and rugby 7's are similar, therefore the same technique that works for rugby union is considered to be optimal for rugby 7's scrummaging performance. Previous studies have shown that the most important factors influencing scrummaging performance are shoulder height compared to hip height, and hip angle compared to horizontal (Preatoni et al. 2016). This is considered to be important, because the forces produced during scrummaging are horizontal forces (Trewartha et al. 2015). When the shoulders are lower than the hips, this will cause downward movement of the trunk and might lead to a collapsed scrum, whereas if the shoulders are higher than the hips, this will cause upward movement of the trunk. In both cases, the horizontal forces produced are limited (Preatoni et al. 2016). More recent studies have shown that a lower pelvic height and a wider stance produce greater forces in rugby union forwards. When rugby players pelvic height increased and stance width narrowed, the amount of force they could produce decreased. (Green et al. 2017.) These findings suggest that the optimal technique for scrummaging in rugby 7's would be shoulders at hip height, pelvis as low as possible, and feet as wide as possible.

A maul begins when the player carrying the ball is held by one or more opponents, and when one or more of the ball carriers team mates' binds to the ball carrier. All players included in the maul must stay on their feet. After the maul is formed, the offside line is formed at the hind most foot of the last player in the maul. The maul ends when the player carrying the ball, or the ball, leaves the maul. No player is allowed to collapse the maul on purpose. (World Rugby 2018.) Previous research has shown that if a team has a high number of mauls per minute of play, the likelihood of winning the match decreases, however, if the team is able to retain the ball from a high percentage of mauls, they had a greater likelihood of winning the match. (Higham et al. 2014b.) These findings suggest the importance of effective mauling technique and skills. Unfortunately, no studies were found investigating effective mauling techniques in either rugby 7's or rugby union.

Sprinting speed is considered to be important for rugby 7's players, and time-motion analyses of rugby 7's matches have shown that players can reach sprinting speeds of 9.13±0.32m/s and 8.23±0.34m/s, for men and women respectively, during the match (Clarke, Anson & Pyne 2017). Previous studies have shown that sprinting speed and acceleration are associated with successful line breaks. The same research also showed that success in defensive performance measures also has a large association with sprinting speed. (Ross et al. 2015.) These findings support the importance of sprinting speed in rugby 7's athletes. No research was found investigating acceleration and sprinting technique with rugby 7's athletes, therefore, studies using team sport athletes were used.

Proper technique is considered important for athletes to acquire high sprinting speed. The sprinting and acceleration demands for team sports (rugby 7's) differ from traditional track and field. One major difference in sprinting technique in team sport athletes, when compared to track and field athletes, is running posture. Track and field athletes are encouraged to run with an upright posture and to stand tall, whereas if team sport athletes, especially contact sport athletes, are encouraged to run with an upright posture they become vulnerable to injury from tackles. Team sport athletes also need to maintain a lower centre of gravity than track and field athletes. A lower centre of gravity improves players balance and agility. Players can only change their speed, or direction, when at least one of their feet is on the ground. This means that team sport athletes need to have faster foot speed than track and field athletes. (Sayers 2000.) When teaching sprinting technique to rugby 7's athletes, it is important to consider running posture and foot speed.

In track and field, athletes have 100m to achieve maximum speed, and top athletes usually require 65-75 meters to reach their maximum speed. In rugby 7's, athletes need to acquire top speed during a much shorter distance, which places emphasis on acceleration abilities. (Sayers 2000, Lockie et al. 2011.) Previous research has shown that two important factors affecting acceleration ability in team sport athletes, are short contact time and stride frequency (Murphy, Lockie & Coutts 2003). This finding is supported by a more recent study by Lockie et al. (2011), who found that faster team sport athletes had significantly shorter contact time during acceleration than slower athletes. In their study, Lockie et al. (2011) also found that faster athletes had a faster time to peak force, whereas there were no differences in maximum force produced during acceleration between faster and slower athletes. These findings suggests that rugby 7's athletes need the ability to produce forces quickly and have a high step frequency to achieve greater acceleration ability.

2.2 Physiological demands

Several studies have investigated the physical demands of rugby 7's matches. Most of the studies have measured game demands using GPS technology to measure speed, distance and time spent in different speed zones. Studies have shown that on average, international level rugby 7's players cover 113-120 m/min during match play (Hogarth, Burkett & McKean 2016). Furthermore, although average intensity is under 120m/min, research has shown that peak distance covered in one minute can be as high as 192±26m/min (Murray & Varley 2015). In their study, Granatelli et al. (2014) showed that rugby 7 backs achieve a greater game intensity than forwards during the match, which places different physiological demands on backs and forwards during the match (figure 1). Based on these findings, coaches should ensure that training involves intensities higher than average match intensities, to ensure that athletes become accustomed to these intensities and to protect against injuries (Malone et al. 2017a).

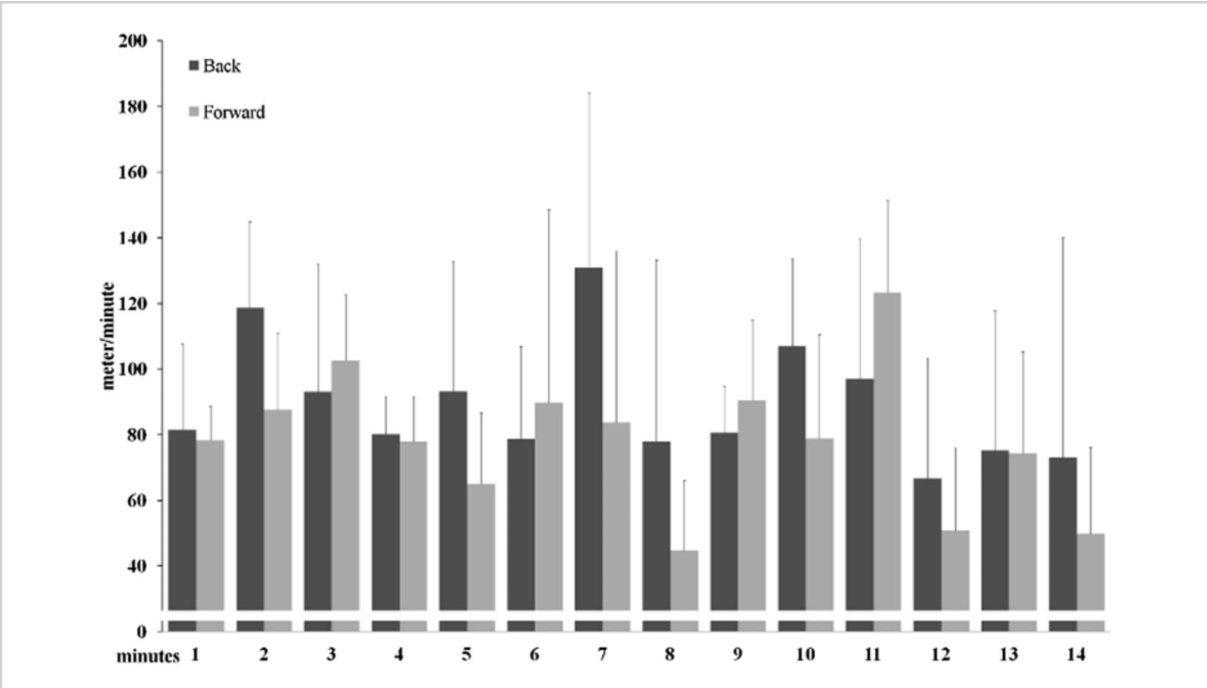

Figure 1. Distance covered by backs and forwards each minute during an international rugby 7's game (Granatelli et al. 2014).

Intensity during the match has been shown to vary greatly, depending on the position of the player (back or forward), if the player plays the whole game or if they entered the game as substitute, the level of the opponent, and if the team is winning or losing (Murray & Varley 2015). When comparing males and females, studies have shown that there is no difference in the total distance covered during an international match, 1580.8±146.3m (Suarez-Arrones et al. 2012b) and 1556.2±189.3m (Suarez-Arrones et al. 2012a) respectively, whereas other studies have shown difference between elite male and elite female rugby 7's players (Clarke, Anson & Pyne 2017). In their study, Clarke et al. (2017) reported that elite male players covered a relative total distance of 103±9m/min, whereas elite female players' relative total distance was 85.8m/min.

Studies have shown that backs cover more distance on average during the match than forwards. Relative total distance covered by backs has shown to be 103-107m/min, and forwards 96-98m/min on average. (Suarez-Arrones et al. 2014, Higham et al. 2016.) In their study, Ross et al. (2015) found no difference in total distance covered during the match between forwards and backs, 1452±243m and 1420±332m respectively. Rugby 7’s players seems to cover greater distance during the first half than second half (Higham et al. 2012, Portillo et al. 2014). When compared to first and second half of the match international level male players covered on average 103±15m/min during first half, and 86±19m/min during the second half (Murray & Varley 2015). Other studies have shown similar findings with female players (Portillo et al. 2014, Goodale et al. 2017). In their study Portillo et al. (2014), reported that female players cover total distance of 883.4±122.0m during the first half, and 725.2±157.1m during the second half. Goodale et al. (2016) showed that female players cover 776±118m and 640±180m total distance during first and second half, respectively. One study found no differences in relative total distance covered between first and second half (Suarez-Arrones et al. 2016). This difference is explained by fatigue that accumulates during the game (Goodale et al. 2017).

Murray and Varley (2015) showed in their study, that when a team is playing against an opponent that has a higher ranking, the team covers a greater total distance, has a higher peak relative distance, and a higher distance covered in high speed running than when playing against a lower-ranked team. They argued that this is due to the fact that higher-ranked opponents can dictate the tempo of the play by having a greater amount of ball possession, which causes the lower-ranked team to run more while defending. (Murray & Varley 2015.)

Several studies have investigated high-intensity running demands, including acceleration and deceleration demands, of rugby 7’s using GPS technology. Typically, these studies classify velocities into 5 different velocity zones: 0-0.2m/s low speed, 0.2-3.5m/s moderate speed, 3.5-5.0m/s high speed, 5.0-6.5m/s very high speed, and ≥6.5m/s top speed. A speed of over 5m/s is usually considered sprinting. (Goodale et al. 2017.) One way to divide acceleration into four acceleration zones is; zone 1: >1.5m/s^2; zone 2: >2.0 m/s^2; zone 3: >2.5 m/s^2; and zone 4: >2.75 m/s^2 (Portillo et al. 2014). Another commonly used method, is to divide accelerations into moderate (2-4 m/s^2) or high (>4 m/s^2) acceleration and to moderate (-4 to -2 m/s^2) or high (<-4 m/s^2) deceleration (Higham et al. 2012). The final method used to measure high-intensity movement demands during rugby 7’s match play is to use a percentage of maximum heart rate. When using this method, heart rate is commonly divided into 6 zones. Zone 1 is <60% maximum heart rate, zone 2 is 61-70% maximum heart rate, zone 3 is 71-80% maximum heart rate, zone 4 is 81-90% maximum heart rate, zone 5 is 91-95% maximum heart rate, and zone 6 is >95% maximum heart rate. (Suarez-Arrones et al. 2014.)

Research has found three main differences in high-intensity match demands in rugby 7's. There is a difference between non-elite and elite players when comparing the high-intensity demands of match play, in both genders (Clarke, Anson & Pyne 2017, Higham et al. 2012, Portillo et al. 2014, Vescovi & Goodale 2015). Another finding is that backs consistently have a greater amount of high-intensity efforts during the match than forwards (Goodale et al. 2017, Higham et al. 2016, Suarez-Arrones et al. 2014). Finally, there is a difference between the first and second half of the game (Portillo et al. 2014, Suarez-Arrones et al. 2012b, Suarez-Arrones et al. 2016).

When comparing the high-intensity demands of elite and non-elite rugby 7's players, research has found that elite level athletes cover a greater distance and perform a higher amount of sprinting activities during the match. In their study, Portillo et al. (2014) showed that international level female rugby 7's players performed on average 2.9±1.8 and 3.6±2.0 sprints (>20 km/h) during the first and second half respectively. In the same study, national level players only performed 0.6±0.9 and 1.0±1.0 sprints during the first and second half, respectively (Portillo et al. 2014). This finding is supported by the findings of Vescovi and Goodale (2015). Vescovi and Goodale (2015) found that international and developmental level female rugby 7's players covered a similar amount of low-intensity distance during a match, but international level players had a significantly greater total and relative distance covered as high-intensity running (224±55m and 14±3m/min, respectively) than developmental athletes (131±44m and 10±4m/min, respectively). International athletes also covered a greater relative sprinting distance than developmental athletes (8±4m/min and 4±3m/min, respectively) (Vescovi & Goodale 2015). Portillo et al. (2014) also showed that international level female rugby 7's athletes perform a significantly greater number of maximum accelerations than national level athletes (1.7±1.2 and 0.2±0.5, respectively). Similar findings have also been published in studies investigating the differences between different playing levels of male rugby 7's players. Clarke et al. (2017) found that elite male players cover a greater total distance over 5m/s (201±79m) than national and junior level players (189±41 and 182±53, respectively). Female international level players have also been shown to perform longer at a higher relative heart rate than national level athletes. International level athletes spend 33.8±10.9% and 25.0±14.8% of their time in heart rate zones 5 and zone 6, respectively, whereas national level athletes spend 22.9±11.9% and 10.7±9.4% of their time in heart rate zone 5 and 6, respectively. (Portillo et al. 2014.)

Studies comparing backs and forwards have shown that backs perform a greater number of high-intensity actions during the match than forwards. In their study, Higham et al. (2016) showed that backs cover significantly greater relative distances in velocity zones 3, 4, and 5 (23.3±7.4, 10.2±6.2 and 9.8±6.6m/min, respectively), than forwards (20.9±6.3, 8.9±4.8 and 6.4±5.1m/min, respectively). Suarez-Arrones et al. (2014) produced similar findings, where they showed that backs cover a greater relative sprinting distance during the match than forwards (12.0±6.3 and 9.5±3.2, respectively). Only one study investigating positional differences in female rugby 7's was found. Goodale et al. (2017) did not find any significant differences between backs and forwards in distance covered in different velocity zones.

Several studies have shown that rugby 7's players will fatigue during the match. Studies have also shown that performance during the second half decreases when compared to the first half. In particular, high-intensity efforts and the number of accelerations and decelerations, significantly decreases during the second half when compared to the first. (Portillo et al. 2014, Suarez-Arrones et al. 2014, Suarez-Arrones et al. 2012b, Suarez-Arrones et al. 2016.) Suarez-Arrones et al. (2012b) found that there were no differences between the average number of sprints performed during the first and second half, although average sprint distance decreased from 19.9±7.8m during the first half to 16.0±7.5m during the second half. In another study, Suarez-Arrones et al. (2016) showed that relative distance covered was not different between the first and second half (112.1±10.4m/min and 112.1±9.3m/min, respectively) in male rugby 7's players. Although there was no difference in the relative distance, there was a significant decrease in high speed running between the halves (21.9±9.9m/min in the first half and 16.3±5.9m/min in the second half). There was also a decrease in the number of high accelerations and decelerations from the first half (0.5±0.6 and 2.1±1.3, respectively), to the second half (0.2±0.4 and 1.3±1.1, respectively). (Suarez-Arrones et al. 2016.) Portillo et al (2014) showed that there is similar trend in female rugby 7's. They showed that there was significant decrease in all high-intensity activities during the second half when compared to the first half, in both national and international female rugby 7's matches (Portillo et al. 2014).

These findings show that rugby 7's matches are played with high-intensity and players fatigue during the match. Fatigue can be seen in all playing levels, and within both genders. Coaches should recognize this, and program training with the aim to minimize fatigue during the match. Another way to minimize the effect of fatigue during the matches is to use substitute players.

2.3 Injuries in rugby 7's

Rugby 7's has been shown to be faster and include a higher amount of high-intensity physical contacts compared to rugby union. When comparing to rugby union, rugby 7's players are involved in more frequent maximum sprints, open field tackles and rapid changes of direction including accelerations and decelerations. Greater physical demands and high speed physical contacts causes athletes to be vulnerable to injuries. (Mirsafaei Rizi et al. 2017.) While, injuries in rugby union are researched thoroughly, only a few studies were found that investigated injuries in rugby 7's players.

Recent reports from World Rugby found that backs have a higher rate of injury during the match. From 2008/09 until 2014/15 male rugby 7's backs had 121 injuries for every 1000 player-match-hours, whereas forwards had 91.5 injuries per 1000 player-match-hours. (Fuller & Taylor 2015a.) A similar trend is seen also in female rugby 7's, where backs have a higher rate of injury during matches. Backs have been reported to have an injury rate of 103.7 per 1000 player-match-hours, whereas forwards are reported to have 76.3 injuries per 1000 player-match-hours. (Fuller & Taylor 2015b.) These findings are supported by other researchers who found that injury rates for rugby 7's players are position specific. They showed that the injury rate for backs ranged from 101.5 to 129.1 injuries per 1000 player-match-hours and for forwards ranged from 81.9 to 119.8 injuries per 1000 player-match-hours. (Cruz-Ferreira et al. 2016.) Research has shown that the majority of injuries during match play occurs through direct contact with another player or with the ground. In their systematic review, Cruz-Ferreira et al. (2016) found that during the first half, forwards sustained an average of 40.5 and backs 37.7 injuries per 1000 player-match-hours, while during the second half forwards sustained an average of 59.5 and backs 62.3 injuries per 1000 player-match-hours.

In men’s rugby 7’s, 78.5% of the injuries are contact injuries (Fuller & Taylor 2015a), whereas in women’s rugby 7’s contact injuries are even more common, with up to 92.4% of match injuries being contact injuries (Fuller & Taylor 2015b). The same reports have shown that the tackle is the most injury prone game situation during the match. It is reported that being tackled causes 33.6% and 41.5% of injuries in men’s and women’s rugby 7’s, respectively. Furthermore, tackling causes 21.3% and 31.9% of injuries in men’s and women’s game, respectively. (Fuller & Taylor 2015a, Fuller & Taylor 2015b.)

The most common body part where injuries occur in international rugby 7’s, is the lower limb (61.1%% and 51.1% for men and women, respectively). Knee, ankle, and posterior thigh are the most common lower body injuries in men’s rugby 7’s, (17.8%, 14.3%, and 10.3%, respectively). In women’s rugby 7’s, the most common lower limb injury is the knee, followed by the ankle and posterior thigh (24.4%, 11.1%, and 5.2%, respectively). When comparing playing positions in men’s rugby 7’s, forwards have a higher rate of head and neck injuries than backs (19.7% and 13.6%, respectively). On the other hand, backs have more lower limb injuries, especially to the posterior thigh and knee, than forwards. Research has shown that 64.2% of injuries in backs occurs in the lower limbs, whereas forwards only experience 55.5% of injuries in the lower limbs. A similar trend can be seen in women’s rugby 7’s, where forwards have more head and neck (25.0%), and upper body injuries (27.1%) than backs (19.5% and 17.2%, respectively). Similar to men’s rugby 7’s, a greater percentage of injuries occur in the lower body in backs than in forwards (56.3% and 41.7%, respectively). When considering the type of injuries, the most common in both genders is joint or ligament injury. In men’s rugby 7’s, backs have a greater amount of muscle strains than forwards (22.0% and 9.1%, respectively). There were no major differences in women’s rugby 7’s between playing positions when considering injury types. (Fuller & Taylor 2015a, Fuller & Taylor 2015b.)

These differences in injury occurrence between playing positions, can be partly explained by different match demands of forwards and backs. Research has shown that backs cover a greater distance, and with higher speed, during the match than forwards. This difference places greater forces on the body during the contact. Backs will also have a greater maximum running speed, perform a greater number of accelerations, decelerations and changes of direction than forwards. Increased running speed increases the risk of posterior thigh injuries, whereas the most common mechanisms of knee injuries are acceleration, deceleration and change of direction (Cruz-Ferreira et al. 2016). All these factors increase the lower limb injury risk of backs when compared to forwards. The greater rate of head and neck, and upper limb injuries in forwards can partly be explained by the increased contact in forwards. Previous research has also shown that forwards are involved more in actions where ball possession is contested and perform more tackles than backs. This will increase the risk for head and neck, and upper body injuries. (Duthie, Pyne & Hooper 2003.)

Rugby 7's has a high incident of injuries ranging from 76.3 to 121 injuries per 1000 player-match-hours depending on gender and position. Most of the injuries occur during contact with another player or with the ground. Furthermore, a higher percentage of injuries occur either while being tackled or when tackling. In both male and female rugby 7's, backs are more likely to injure their lower body, whereas forwards are more likely to injure their head, neck, or upper body. These differences are a result of the backs need to cover greater distances and with higher running speed, and forwards more common involvement in tackles and contestation of the ball. When considering injury prevention strategies for rugby 7's, these factors should be considered, and the training program should be individualised for athletes based on gender and position.

3 RUGBY 7'S NEEDS ANALYSIS

3.1 Anthropometry

Table 1 summarises the anthropometrics of male rugby 7's players throughout different playing levels. At the international level, rugby 7's forwards tend to be bigger than backs, although both forwards and backs have a similar body composition. This difference comes from the different playing demands of forwards and backs. Forwards are usually involved in scrums and line outs, where possession of the ball is contested. In these situations, heavier and taller players will gain an advantage over shorter and lighter players. Backs are usually considered skills players and need greater speed and agility skills for which a smaller body size is considered more advantageous. (Higham et al. 2014a, Duthie, Pyne & Hooper 2003.) National level rugby 7's players tend to be smaller and have less lean body mass than international level players (table 1).

Table 1. Anthropometrics of male rugby 7 players. Results are presented in mean±SD.

Study	Playing level	Age	Height (m)	Weight (kg)	Body composition
Rienzi et al. (1999)	Int		Back 1.76±0.05 Forw 1.85±0.05	Back 78.6±7.1 Forw 93.5±7.8	Back 11.4±2.5% Forw 12.1±2.2% (body fat %)
Higham et al. (2014a)	Int	Back 21.5±2.0 Forw 22.4±2.3		Back 87.4±7.3 Forw 95.0±5.1	
Higham et al. (2013)	Int	21.9±2.0	1.83±0.06	89.7±7.6	51.7±4.3 (LMI kg/mm)
Higham et al. (2016)	Int	Back 21.0±2.2 Forw 21.6±2.4	Back 1.81±0.06 Forw 1.85±0.05	Back 86.2±5.6 Forw 95.8±6.7	
Clarke et al. (2017)	Int and Nat		Int 1.84±0.07 Nat 1.81±0.05	Int 92.0±6.9 Nat 88.5±10.2	Int 53.8±4.1 Nat 51.2±6.2 (LMI mm/kg)

Forw=forward; Int=international; nat=national; LMI=lean mass index.

The anthropometrics of female rugby 7's players are summarised in table 2. In women's rugby 7's, there is the same trend as in men's rugby 7's. In women's rugby 7's, forwards tend to be bigger than backs. National level players tend to be older and have less lean body mass than international level players. While national level players were shorter and lighter than international level players in men's rugby 7's, there were no differences in the height and body mass of different playing levels in women's rugby 7's.

Table 2. Anthropometrics of female rugby 7 players. Results are presented in mean±SD.

Study	Playing level	Age	Height (m)	Weight (kg)	Body composition
Goodale et al. (2016)	Nat	22.8±4.0	1.68±0.06	69.4±5.2	0.85±0.15 (mass skinfold ratio kg/mm)
Clarke et al. (2013)	Int	25±5	1.68±0.06	69±7	85±15mm (sum of 7 skinfold)
Agar-Newman et al. (2017)	Int	22.8±4.0	Back 1.66±0.06 Forw 1.71±0.04	Back 66.4±3.5 Forw 72.9±4.8	Back 0.84±0.18 Forw 0.78±0.08 (mm/kg)
Portillo et al. (2014)	Int and nat	Int 26.3±4.1 Nat 32.1±6.4	Int 1.67±0.077 Nat 1.67±0.03	Int 65.4±5.0 Nat 66.5±5.4	Int 19.3±4.1 Nat 21.5±5.1 (body fat %)

Forw=forward; Int=international; nat=national.

3.2 Aerobic requirements

Rugby 7's is played in a tournament style of play and has a high proportion of high intensity activities, and a small work-to-rest ratio (1.7:1 to 1.8:1), therefore rugby 7's requires high aerobic capacity from players (Suarez-Arrones et al. 2014). Only one study was found that directly measured the VO_{2max} of rugby 7's players, both in male and female players. In their study, Clarke et al. (2015) found that female rugby 7's players have a mean VO_{2max} of 51±4 ml/kg/min, whereas Higham et al. (2013) found that national level male rugby 7's players had a VO_{2max} of 53.8±3.4 ml/kg/min. Other studies have used several different field measurements to measure the aerobic capacity of rugby 7's players.

The most common test used in research is the YoYo intermittent recovery test 1 (IRT1) and 2 (IRT2) (Elloumi et al. 2012, Higham et al. 2013, Vescovi & Goodale 2015). In their study, Vescovi and Goodale (2015) found that there was a significant difference between international and developmental female rugby 7's players in total distance covered in YoYo IRT1 (1486±88m and 1252±135m, respectively). Male rugby 7's players have been shown to cover a total distance of 2256±268m (Higham et al. 2013) and 1925±332m (Elloumi et al. 2012), in YoYo IRT1 and IRT2, respectively. Another commonly used aerobic test is the 1600m test (Agar-Newman, Goodale & Klimstra 2017, Goodale et al. 2016). Goodale et al. (2016) investigated the difference between high-playing-minute and low-playing-minute athletes in female rugby 7's. Players who played higher minutes per game had an average speed of 4.3 m/s, whereas low-playing-minute athletes had an average speed of 4.1 m/s in the 1600m test (Goodale et al. 2016). These results are supported by findings of Agar-Newman et al. (2017), who found that backs had an average speed of 4.12 m/s and forwards 4.26 m/s. Higham et al. (2013) showed that national level male rugby 7's players had a $_{v}VO_{2max}$ of 4.2 m/s during the incremental running test.

To reach international level, players are required to have a high aerobic capacity. In men's rugby 7's, this means they must be able to cover at least 2200m in YoYo IRT1, whereas female players should aim to cover at least 1400m. Athletes should also have a maximal aerobic speed of around 4.3 m/s in both genders.

3.3 Strength requirements

Rugby 7's is classified as a collision sport, and previous studies have shown that muscular strength and power are important in collision sports. Due to the high contact nature of rugby 7's, as seen in the rucks, mauls and scrums, high levels of strength and power are important for players. (Ross, Gill & Cronin 2014.) Although strength and power are considered important factors in rugby 7's performance, there have been limited studies investigating the strength and power levels of rugby 7's players.

Two studies were found that investigated the relative strength of female rugby 7's players. In their study, Goodale et al. (2016) showed that international level female rugby 7's players have a relative power clean of 1.0±0.1 kg/kg, a relative front squat of 1.2±0.2 kg/kg, a relative bench press of 1.0±0.1 kg/kg and a relative natural-grip pull-up of 1.2±0.1 kg/kg. Agar-Newman et al. (2017) found similar strength levels in their study. They showed that forwards and backs perform similarly in relative strength tests, but backs have a greater relative front squat than forwards (1.25±0.17kg/kg and 1.15±0.11kg/kg, respectively) (Agar-Newman, Goodale & Klimstra 2017, Goodale et al. 2016). These findings suggest that to compete in international level female rugby 7's, players are required to achieve relative strength levels of 1.0kg/kg or higher in power clean, front squat, bench press, and neutral-grip pull-up.

Only two studies were found that investigated strength levels of international male rugby 7's players. Bouaziz et al. (2016) showed that Tunisian national team players had a mean 1RM squat of 170.4±3.8 kg, and a mean bench press of 118.0±2.6 kg, after a six week training period, during the preparation phase for the Rugby 7's World cup. In another study, Ross et al. (2015) showed that international and provincial rugby 7's players had a mean bench press and weighted reverse grip chin up of 122±14 kg and 136±12 kg, respectively.

Power is important for tackling, jumping and sprinting in rugby 7's. In rugby league and union, power has been showed to be a better indication of playing level than strength. (Ross, Gill & Cronin 2014.) Only one study was found that compared vertical jump results between different playing levels in male rugby 7's players (Clarke, Anson & Pyne 2017). Clark et al. (2017) reported that elite level players had a greater vertical jump, 65.8±9.3cm, than senior and junior level players (60.3±6.1cm and 62.2±9.7cm, respectively). In other studies, male rugby 7's players were reported to have a 43-66.3cm countermovement jump (Higham et al. 2013, Marrier et al. 2016, Loturco et al. 2017). Previous studies have investigated horizontal power production capacity in rugby 7's players. These studies have shown that international level male rugby 7's players have a horizontal jump of 264±13.3cm (Ross et al. 2015) and five jump test of 12.7±0.24m (Bouaziz et al. 2016).

Few studies have reported on power qualities in female rugby 7's players. Agar-Newman et al. (2017) reported that international level female rugby 7's backs had a standing long jump of 229±11cm, and a standing triple jump of 705±32cm. In their study, rugby 7 forwards had a standing long jump of 228±9cm, and a standing triple jump of 691±28cm (Agar-Newman, Goodale & Klimstra 2017). In their study, Goodale et al. (2016) reported standing long jump values of 227.3±9.0cm and 230.4±11.0cm for female players with high-playing-minutes and low-playing-minutes, respectively. They also reported that high-playing-minute players had a standing triple jump of 691.9±24.9cm, whereas low-playing-minute players standing triple jump was 704.8±35.3cm. The findings from the Goodale et al. (2016) study is in contrast with previous studies showing that higher level rugby union and league players have greater power than lower level athletes (Ross, Gill & Cronin 2014). In contrast to the Goodale et al. (2016) study, Clarke et al. (2017) found a difference between higher and lower level female rugby 7's players. In their study, junior level players had a 43.3±5.0cm vertical jump, whereas senior level and elite female rugby 7's players jumped 47.7±5.5cm and 49.6±3.8cm, respectively. This might be due to the fact that previous studies have investigated male rugby players, and Goodale et al. (2016) investigated female players.

Findings from the previous studies show that rugby 7's players require a high level of strength and power to compete at the highest level. Female rugby 7's players should aim to reach strength levels of at least 1.0kg/kg relative strength in front squat, power clean, bench press and pull up.

3.4 Speed requirements

Sprinting speed has been shown to be an important factor in successful rugby 7's teams. Having greater sprinting speed has been shown to result in more line breaks, attacking meters gained and tries scored. (Ross et al. 2015.) Previous research has shown that international male rugby 7's athletes can reach a top speed of 9.2±0.4 m/s (Higham et al. 2013). Furthermore, national level players have been shown to reach speeds of 9.03±0.17m/s, and junior players 8.88±0.48m/s (Clarke, Anson & Pyne 2017) during a 40m sprint test. International female rugby 7's players have been shown to reach a speed of 8.21±0.26m/s and

8.02±0.25m/s during the 40m sprint test, for backs and forwards respectively (Agar-Newman, Goodale & Klimstra 2017). National level players have been shown to reach 7.77±0.26m/s and junior players 7.39±0.41m/s during the 40m sprint (Clarke, Anson & Pyne 2017).

Several time-motion analyses have analysed the match demands of both international and national rugby 7's, investigating both male and female matches. These studies have shown that during an international match, the maximum speed that male rugby players will reach ranges from 8.4m/s (Ross et al. 2015) to 8.70m/s (Clarke, Anson & Pyne 2017), whereas the maximum speed for national level players ranges from 8.1m/s (Higham et al. 2012) to 8.68m/s (Clarke, Anson & Pyne 2017). In their study, Clarke et al. (2017) showed that the maximum speed junior level players reach during the match was 8.51±0.76m/s. Backs have been shown to reach a greater maximum speed than forwards (8.40±0.72 and 7.90±0.83, respectively) (Ross et al. 2015).

Similar to men's rugby 7's, several studies have investigated the maximum speed reached by female rugby players during a match. Studies have shown that during an international match, the maximum speed that female rugby 7's players reaches ranges from 6.44 to 8.05m/s (Clarke, Anson & Pyne 2017, Suarez-Arrones et al. 2012a). Only one study was found that investigated the game speeds of national level players. In their study, Clarke et al. (2017) found that the maximum speed that national level female rugby 7's players reach was 7.40±0.52m/s. Furthermore, two studies were found that investigated the match speeds of junior level female players. The maximum match speeds of junior female players ranged from 6.83 to 7.08m/s (Clarke, Anson & Pyne 2017, Vescovi & Goodale 2015). No studies investigating the differences between backs and forwards were found.

Elite level rugby 7's players have been shown to reach faster speeds during field tests and matches than national and junior level players, in both male and female rugby 7's (Higham et al. 2013). Research has shown that national level players can barely reach the same speed during a field test than what international level athletes can reach during a match (Clarke, Anson & Pyne 2017). These findings show the importance of speed in international level athletes and highlights the importance of speed development for rugby 7's athletes.

4 RUGBY 7’S AND COANCHING OF RUGBY 7’S IN FINLAND

4.1 Rugby 7’s in Finland

Rugby Union has long roots in Finland and the first rugby matches were played in Finland in 1968 (rugby.fi). The same year, the Finnish Rugby Federation was formed, and in the year 2001 the it was affiliated with World Rugby. Although rugby union has been played in Finland for 50 years, rugby 7’s is a fairly new version of rugby in Finland. The Finnish women’s national team played their first official matches in the European Women’s 7’s Championship in 2013 in Division B, and in 2016 the women’s national team played in the European top 12 competition (the highest level in Europe). They also secured a place in the European Olympic qualification tournament in 2016. The national team’s long term goal is to qualify for the Olympics. (Rugby.fi.)

While the Finnish women’s national team has been playing officially for 5 years and gained success in Europe, the men’s national team was only formed in 2016, and played its first official games in Europe in summer 2017. During 2017, the men’s national team played in the men’s rugby 7’s conference 2, in which they placed third. In 2018, the men’s national team will play in conference 1.

In Finland, the rugby 7’s domestic competition is mainly played during winter and spring, because 15-a-side rugby is played during the summer. During 2018, 9 men’s team and 8 women’s teams participated in tournaments. Both men and women played in total four tournaments during winter and spring in Finland. Although there is a separate competition for rugby 7’s in Finland, most of the players also play rugby union, due to the small number of registered rugby players in Finland. The Finnish Rugby Federation does not currently have any youth competition or youth national teams, but clubs and the federation are trying to recruit more young players to participate in both rugby 7’s and union.

4.2 Rugby 7's coaching system in Finland

The Finnish Rugby Federation follows the World Rugby's syllabus (figure 2). The Finnish federation organises level 1 (introductory level) coaching courses several times a year and organizes level 2 courses if needed. Furthermore, the Finnish Rugby Federation organises level 1 Strength and Conditioning courses several times a year and level 2 if there is enough participants for the course.

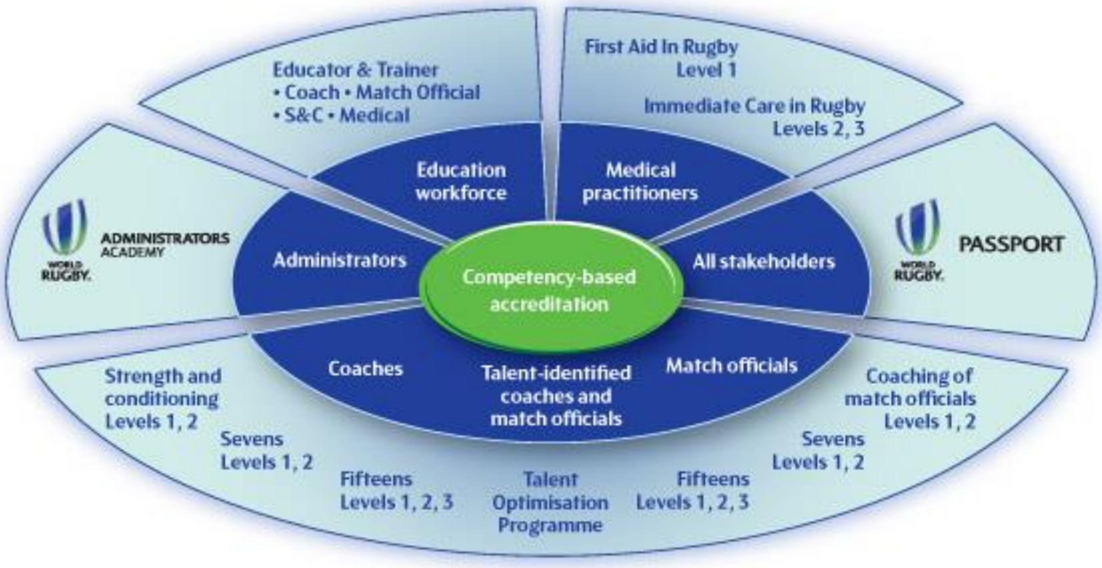

Figure 2. World Rugby's syllabus for coaching, officiating and others involved in rugby. (World Rugby, http://coaching.worldrugby.org/index.php?page=160)

5 PROGRAMMING AND PERIODIZATION OF TRAINING

The training program and nutrition guidelines developed for this report are based on a fictional women's national team player, playing for the Finnish national team. The athlete is 23 years old, 169cm tall and 66kg (body fat 20%) and she plays as a back in her club team and the national team. She has five years of experience in rugby. She also works full time, so this needed to be consider when planning the training.

The Finnish women's national team plays in the second highest level in Europe. Their competitive season (2018) is during the summer and consists of two tournaments played at the end of June (23th and 24th) and early July (7th and 8th). Tournaments are held two weeks apart and played overseas. These tournaments are played with a normal rugby 7's schedule ie. the team will play 5-6 games over two days, depending on the results.

During pre-season, the athlete also takes part in the Finnish championship rugby 7's competition, which includes four tournaments played from November to April. All Finnish championship tournaments include four games, all played during the same day. Off-season is considered to be from September until November. During the competitive season, the player is also taking part in the Women's Finnish Championship in rugby union.

5.1 Testing and monitoring of training

Testing is important for rugby 7's players to achieve high performance and to monitor player development. Due to the limited resources available for Finnish rugby 7's, athlete testing needs to be low budget and easily to undertake. Research has used several low budget methods when investigating physical qualities of athletes. Tests include an anthropometric test, aerobic and anaerobic tests and strength tests. When testing a rugby 7's athlete, it is important to know the athlete's height, weight and body composition. There are several ways to measure body composition, but for this athlete a 7-skinfolds test was selected. Skinfolds were measured because it is important to have a high body mass, while also maintaining a low fat mass, to enhance performance and prepare the athlete for physical contact.

As for the aerobic test, YoYo IRT1 was selected due to its wide use in the scientific literature investigating the aerobic demands of rugby 7's players, and also because of the calculations developed to estimate VO_{2max} and maximum aerobic speed from the results. It has also been shown to have a relationship with the total distance covered and average game speed measured with GPS (Clarke et al. 2013). In their study, Clarke et al. (2013) showed that athletes with a higher score in the YoYo test covered greater total distances and their average speed during the match was higher than athletes with a lower YoYo test score.

Because linear speed and agility have been shown to be important factors effecting rugby 7's results, 40m sprint and T-test were included in the testing battery. From the 40m sprint, 10m and 30m splits were also recorded. The first 10m was used to measure the athlete's acceleration ability, the 10 to 30m split was used to measure the athletes flying 20m ability, and the split from 30m to 40m was used to calculate the athlete's maximum running speed. The strength tests that were selected include the power clean, 3RM front squat, 3RM bench press and weighted neutral grip pull-up 1RM. The tests were performed in the same order as mentioned above. All results were converted to be relative to the athlete's body mass.

The athletes training was monitored using session RPE (sRPE). The scale that was used to estimate sRPE was from 1-10, where 1 equals rest and 10 maximal exertion. The duration of all training sessions sRPE was collected at the end of the session and the duration of the session was then multiplied by sRPE to estimate the training load of each session. Total weekly load was calculated by adding the training load of each session during the week. The acute training load (current training week) was compared to the chronic training load (past four weeks) to ensure that the training load did not increase or decrease too much. (Gabbett 2016.) Current research has shown that if acute to chronic training load ratio increases or decreases too much, this will increase the injury risk to the athlete (Gabbett 2016, Malone et al. 2016).

Strength training was monitored by calculating total load lifted during the session. The athlete wrote down all the sets, reps and weights used during each session for each exercise. Sets, reps and the load of each exercise was then multiplied to calculate the total load for each exercise. To calculate total load lifted during the session, the loads of each exercise were added together. Progression can be monitored by the total load lifted during the session. If total load increases from the previous session, the athlete has improved their performance. If there was no improvement in load lifted for one exercise, the exercise could be changed.

The final monitoring that was used was a weekly questionnaire. The questionnaire included five questions related to the wellbeing of the athlete, where they were asked to rate their 1) sleep quality, 2) fatigue 3) energy level, 4) stress level and 5) muscle soreness on a seven-point scale. On the seven-point scale, 1 equalled highly disagreed and 7 equalled strongly agreed. A simple wellbeing questionnaire has been shown to have a positive relationship with measurement of external load. Research has shown that when overall wellness of the athlete decreases, the athlete's physical performance during training also decreases. Decreased wellbeing also increases sRPE score when compared to higher wellbeing. (Gallo et al. 2016, Malone et al. 2017b.) Because of these factors, monitoring of wellbeing was added to the athletes training plan.

5.2 Pre-Season season

The aim of the pre-season training was to improve the athlete's strength, endurance and speed. A typical training week included two rugby training session, three strength training sessions and three additional conditioning sessions. Rugby training sessions were held Tuesday and Thursday nights, whereas strength training sessions were held Tuesday, Thursday, and Saturday mornings. Additional conditioning was done Monday, Wednesday and Friday afternoons. A sample of a typical training week can be seen in table 3.

During the pre-season, polarized training was used. This periodization method allows designated high-intensity days to be performed at the required intensity with minimal cumulative fatigue. Lower intensity days were used to recover from high-intensity days, but at the same time to improve conditioning. Monday was a low-intensity day, to allow the athlete to ease back into training after a rest day. Strength training was included the same day as rugby training, because both trainings are either moderate or high intensity training. (Seiler & Kjerland 2006.)

Table 3. Sample of typical training week of the athlete during pre-season.

	Mon	Tue	Wed	Thu	Fri	Sat	Sun
AM	Off	Strength Lower	Off	Strength Upper	Off	Strength Full body	Off
PM	Cond	Rugby training	Cond	Rugby Training	Cond	Off	Off
Int	Low	High	Low	High	Low	High	

Mon=Monday, Tue=Tuesday etc.; Cond=conditioning; Int=intensity of training day.

Strength training was divided into lower body dominant, upper body dominant, and full body training split during the pre-season because there was only a limited amount of time for training. This training split also allowed the greatest total volume of training for both upper and lower body, without accumulating too much fatigue. Research has shown, that having two to three strength training sessions a week is enough to improve strength and increase muscle mass (Schoenfeld et al. 2015). A sample strength training week can been seen in table 4.

Table 4. Example of the weekly strength training exercise selection during pre-season. Modified from (Schuster et al. 2018).

Session 1, Lower body emphasis		Session 2, upper-body emphasis		Session 3, full body	
A1 Front Squat	4x4	A1 Bench Press	4x4	A1 Trapbar Deadlift	4x4
		A2 Pull Ups	4x4		
B1 SL Deadlift	3x10es	B1 Hip Thrust	4x8	B1 Split Squat	3x8es
B2 Military Press	3x10	B2 Psoas March	4x6es	B2 Batwing Row	3x8
C1 45º Back Extension	3x12	C1 Seated Row	3x12	C1 Lateral Lunge	3x8es
C2 Bent Over Row	3x12	C2 DB Shoulder press	3x12	C2 DB Bench Press	3x8

A1, First exercise of the first superset; A2, second exercise of the first superset; SL=single leg; es=each side; DB=dumbbell.

5.3 Competitive season

Competitive season for rugby 7's was considered to start one month prior to the first national team tournament, until the end of the second tournament (table 5). Because strength is an important quality in rugby 7's, the athlete continued doing two strength training sessions per week. During resistance training at the start of the competitive season, emphasis was placed on improving strength qualities, whereas when tournaments were approaching (4 weeks before the first tournament), emphasis was more on power and maintaining strength. Between the tournaments, three resistance training sessions were conducted (2 week after the first tournament and 1 week before the second tournament) to maintain strength and power. Emphasis during these sessions was placed on power. (Schuster et al. 2018.)

Table 5. Calendar for the competitive season.

	May			June			July
Monday (week)	21^{st} (7)	28^{th} (6)	4^{th} (5)	11^{th} (4)	18^{th} (3)	25^{th} (2)	2^{nd} (1)
Main event of the week	Start of the competitive season; Tournament France (21^{st} & 22^{nd})	Strength power emphasis		End of additional conditioning (end of the week)	Tournament Ukraine (23^{rd} & 24^{th})	Recovery; Strength and Power maintenance	Tournament Hungary (7^{th} & 8^{th})

Additional conditioning was still included in training, but the volume was decreased and the intensity increased. Emphasis was placed on sprint training. Additional conditioning was terminated one week prior to the first national team tournament in June. The monitoring schedule was maintained during the competition schedule. Session RPE was collected from each session, and the total load of each week decreased progressively as tournaments approached. Additional wellbeing questionnaires were included the day after each tournament and 4 days after each tournament. These were added to monitor recovery and wellbeing of the athlete. If wellbeing was still down four days post tournament, the training plan was altered to include more recovery into the athlete's training plan.

Table 6. Training plan for the weeks prior and between the tournaments.

Day	Week of first tournament	Week after first tournament	Week of second tournament
Mon	Resistance (strength & power)	Recovery; Travel to Finland	Rugby training
Tue	Rugby training	Active recovery on bike	Rugby training
Wed	Travel to Ukraine	Resistance training (strength & power) Rugby training	Travel to Hungary
Thu	Resistance (explosive power) Rugby tactics	Rugby tactics and technique	Resistance (explosive power) Rugby tactics
Fri	Rugby tactics	Rugby training	Rugby tactics
Sat	Tournament Ukraine (day 1)	Resistance training (strength & power)	Tournament Hungary (day 1)
Sun	Tournament Ukraine (day 2)	Off	Tournament Hungary (day 2)

Mon=Monday, Tue=Tuesday etc.

6 NUTRITION AND RECOVERY

6.1 During Training Season

The aim for pre-season nutrition was to maintain body weight and increase lean body mass. Research has shown, that if an athlete needs to improve their body composition, off-season and pre-season are the optimal time to achieve this (Burke, Loucks & Broad 2006). To achieve these goals. the athlete needed to consume fewer calories than she burns during the day. Negative energy balance cannot be too high because low energy availability can lead to serious consequences for the hormonal health status of the athlete (Burke, Loucks & Broad 2006). Research has shown that if energy availability is low and energy expenditure is high (high level athletes), this could lead to female athlete triad. In female athlete triad, low energy availability leads to compromised bone health and problems with the menstrual cycle. (Manore, Kam & Loucks 2007.) Therefore, it is important to maintain adequate energy availability to avoid the negative health effects of low energy availability.

Research has shown that to maintain body weight, an athlete should consume around 45 kcal/kg FFM/day (Manore, Kam & Loucks 2007). For the athlete in this report, this would equate to a total energy intake of 2300 kcal/day (66kg*0.8*45kcal/kg=2376kcal). Protein is important to increase muscle mass and repair tissues after training. Research recommends that athletes consume 1.2-1.7g/kg/day of protein. The athlete should also consume an adequate amount of carbohydrates during the day. Carbohydrates are important for high-intensity exercise and recovery (Burke, Loucks & Broad 2006). Low muscle glycogen levels decrease exercise intensity, and negatively affect training and recovery. Therefore, the athlete should consume 5-8g/kg/day of carbohydrates. The athlete should also consume high quality fats daily, and the recommended daily dietary fat intake is a minimum of 20-25% from total energy intake (Broad & Cox 2008). Table 7 summarises the athlete’s daily macronutrient requirements.

Table 7. Recommendations for daily macronutrient intake in grams.

	Carbohydrates	Protein	Fats
High-intensity training day	528g	79-112g	52-66g
Low intensity training/rest day	330g	79-112g	52-66g

During rest days and low intensity training days, a decreased energy intake is recommended. This can be done with carbohydrate cycling, which means eating less carbohydrates on days that activity is decreased and more on days with higher activity requirements. Carbohydrate cycling, and its associated decreased energy intake on days with lower activity levels, is recommended as the energy requirements for these days are lower than on days with high-intensity training or two sessions per day. This helps to maintain energy intake in line with daily requirements and prevent unwanted weight gain. (Burke 2001, Burke, Loucks & Broad 2006.)

Nutrition can also be used to improve recovery after training. Athlete can start recovery straight after training session by consuming a mixture of carbohydrates and protein. Research has shown that consuming 1-1.5g/kg of carbohydrates and 20 to 25g of protein after training enhances recovery and rebuilding of muscles after training. (Schuster et al. 2018.) Proper recovery after training is especially important if there is a second training session soon after, for example the same day or the next morning (Kersick et al. 2017). It is important that these recovery drinks are considered in the total energy intake, to avoid weight gain due increased energy intake. Another important recovery tool is sleep. The athlete should aim to sleep 9-10 hours every night (Bonnar et al. 2018). To improve sleep quality, the athlete should avoid blue light (light from electrical devices) for at least one hour before sleeping. Blue light has been shown to decrease melatonin secretion and decrease sleep quality (Caddick et al. 2018). Melatonin is a natural hormone that the body secretes to regulate sleep and circadian rhythm. Decreased serum melatonin decreases sleep quality and therefore negatively affects performance and recovery. (Zhao et al. 2012.) The athlete is recommended to sleep in a room that is dark and a pleasant temperature. They should also avoid exposure to artificial light 1-2 hours before bedtime. (Bonnar et al. 2018.)

6.2 During competitive season

When planning recovery and nutrition during the competitive season, emphasis was placed on the nutrition and recovery requirements of tournaments. Before the tournaments, and in the week between the tournaments, the nutrition plan was the same as during the pre-season. When planning nutrition and recovery for rugby 7's competitive season, the tournament style of play makes planning more difficult than with other team sports where only one match is played in a day. There was no published literature found on the energy demands of a single rugby 7's match. Previous research has shown that a rugby union player's energy expenditure is 3.3-4.1 MJ in 40 minutes of match play. Research also shows that rugby 7's players cover a greater relative distance, and with higher velocity, during a match than rugby union players. (Dziedzic & Higham 2014.) The high relative intensity of rugby 7's and with three games played during a single day, means energy requirements will be high. To optimally prepare athletes for competition nutritionally, more research is needed to investigate energy requirements during a rugby 7's match.

Another important factor to consider is hydration of the athlete. Dehydration has been shown to decrease performance in several different laboratory and field tests. A loss of 1% of body mass has been shown to decrease exercise performance, and low to moderate dehydration (2% of body mass) can have an affect on sprint performance. (Maughan & Shirreffs 2010.) Because dehydration causes a decrease in performance, it is important to calculate the athlete's sweat rate to optimally rehydrate the athlete post-game. Body weight will acutely change during exercise due to sweating. This knowledge can be used to estimate total sweat loss. (Sawka et al. 2007.) To calculate total sweat loss, the athlete needs to know their body weight before and after exercise and their fluid intake during the exercise (Cheuvront, Haymes & Sawka 2002). Total sweat loss can be calculated using the following formula:

Total sweat loss = pre body weight – post body weight + fluid intake (Cheuvront, Haymes & Sawka 2002).

Using this calculation, the athlete can estimate how much fluid they need to consume after the match to rehydrate themselves.

Because rugby 7's is played in a tournament mode, with 5-6 games played in two days, a proactive approach for nutrition and hydration before the first match of the tournament is necessary. To refuel athletes, and to ensure adequate overall energy intake, a well-developed individual plan after each match needs to be developed. (Dziedzic & Higham 2014.) Previous research has shown, that in team sports the amount of sprints performed during the match are highly influenced by muscle glycogen concentration pre exercise (Balsom et al. 1999). Low carbohydrate intake for 3-4 days will decrease muscle glycogen concentration and negatively affect performance. To optimize muscle glycogen concentration, rugby 7's athletes should consume 5-8g/kg of carbohydrates daily during the final days leading up to the tournament. (Dziedzic & Higham 2014, Schuster et al. 2018.) Pre-tournament, athletes also need to consume an adequate amount of protein, to prevent muscle loss (MacKenzie et al. 2015). Previous research has shown, that an athlete should ingest 1.2-2.0 g/kg/day of high quality protein. This amount is adequate to prevent muscle loss, and they do not gain extra benefit from consuming higher amounts of protein than recommended. (Broad & Cox 2008, MacKenzie et al. 2015.)

Before the first match of the tournament, the athlete should consume a high carbohydrate breakfast or meal 3-4 hours before the first match, if the schedule allows. The athlete should at least consume a high carbohydrate snack 1-2 hours before the match. (Dziedzic & Higham 2014.) The athlete should also maintain adequate hydration during the morning before the first match, especially in hot and humid conditions. If the athlete enters the competition dehydrated, sweating will increase dehydration and further decrease performance. (Maughan & Shirreffs 2010.) The recommendation for athletes is to slowly consume 5-7 mL/kg at least four hours before the first match (Sawka et al. 2007).

Due to the short time of play and short half-time (2 minutes) there is no time for in game nutrition. The athlete should try to drink during the match if there is an opportunity and use the short half-time to rehydrate herself. (Dziedzic & Higham 2014.) She should start to rehydrate and refuel herself straight after the match, to prepare herself for upcoming matches. Because of the high-intensity of rugby 7's matches, acceleration and decelerations, and high-speed collisions, athletes need to refuel muscle glycogen stores and start the repairing of the muscle tissue. It is recommended that the athlete consumes carbohydrates (1-1.5g/kg) and protein (20 to 25g) within 30 minutes of the game. (Schuster et al. 2018.) The athlete should also try to replenish 150% of sweat lost during the match, and these liquids should include electrolytes to compensate for electrolytes lost through sweating (Dziedzic & Higham 2014). If there is a long break between the games, the athlete can consume a carbohydrate rich meal no longer than 1 hour before the next match to continue refuelling herself (Schuster et al. 2018). It is important to eat a carbohydrate rich meal within the recovery window after the last match of day 1, to optimally prepare the athlete for the second day of the tournament.

Table 8. Recommendations for carbohydrate, protein and liquid consumption during competition season for female rugby 7's player.

Nutrient	Days before match	Before first match	Between matches
Carbohydrate	330-528 g	66-99g	66-99g
Protein	80-112g	20-25g	20-25g
Liquid	2-3 litres	330-462ml	1 650ml

Nutrition is one important recovery tool during the tournament, but other recovery modalities can also be utilized between the matches. If the team has access to cold-water baths, the athlete can use cold-water immersion to enhance recovery between games. A minimum of 10 minutes in 12 to 15 ºC water with whole-body immersion, has been shown to enhance recovery. The improved recovery is due decreased hyperthermia, decreased muscle inflammation and damage, and decreased muscle soreness. If there is no access to cold-water immersion baths, the athlete should at least use different soft-tissue care methods. This can be done using foam rollers or with massage. Figure 3 shows recommendations for recovery strategies between games during the tournament. (Schuster et al. 2018.)

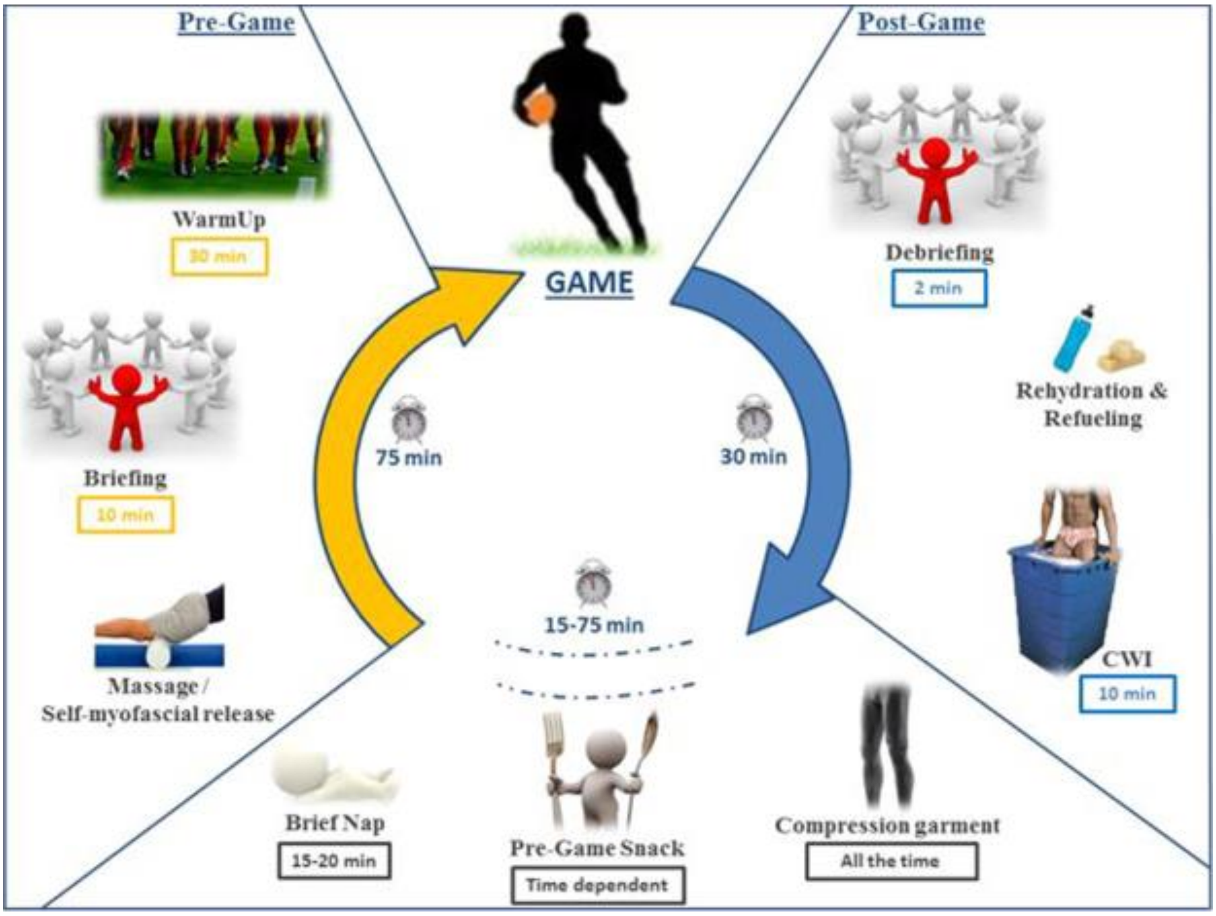

Figure 3. Example of recovery strategies to use between the games during rugby 7's tournament (Schuster et al. 2018).

6.3 Supplements in rugby 7's

For decades, athletes' have tried to find new ways of improving their performance. Several companies have taken advantage of this and developed different supplements that claim to enhance athletic performance. Not all supplements are created equal, and some supplements do not enhance performance, despite advertising claims. Research has shown that some supplements contain illegal substances, through cross-contamination during manufacturing, even though there is no mention of them on the label. These supplements might cause athletes to test positive in a doping test, even though they have not knowingly taken any illegal substances. Athletes should be aware of this, especially if they are under doping control. Athletes should be sure that all of the supplements they use contain no traces of any illegal substances. (Outram & Stewart 2015.) They should only buy supplements with the informed-sport logo on them. Informed-sport is a global quality assurance program and is only given to supplements that do not have any traces of illegal substances after being fully testing.

Research on effective supplements to use in rugby 7's is limited. Research has shown that some supplements can enhance strength and power, high intensity running performance, and cognitive function in other sports. One supplement that has been shown to increase work capacity during a training session and thus improve strength, is creatine. During the match, rugby 7's athletes perform several high-intensity efforts with a short rest period between bouts. Creatine supplementation has been shown to increase the rate of creatine synthesis during recovery from a high-intensity exercise, and thus improving recovery between the bouts. Research has also shown, that ingesting creatine alongside a carbohydrate rich diet can enhance recovery after a training session by enhancing glycogen uptake to the muscles. Through these two mechanisms, creatine supplementation could be used to enhance performance during a rugby 7's tournament. Although creatine has been shown to improve performance and recovery between bouts of high-intensity exercise, rugby 7's athletes should avoid rapid-loading protocols of creatine. Rapid-loading protocols have been shown to increase an athlete's body weight, by increasing the amount of water the body retains. Increased body weight will compromise the athlete's power to weight ratio, and thus compromise performance. A suggested loading protocol for a rugby 7's athlete, is to consume 3g/day of creatine over 28 days. Improved muscle glycogen uptake after a match or training is achieved by co-ingesting 75-100g of carbohydrates with creatine. (Dziedzic & Higham 2014.)

Caffeine supplementation has also been shown to influence perception of fatigue, enhance muscle fibre recruitment and improve nervous system drive. These improvements can be achieved by ingesting 1-6mg/kg of caffeine. Ingesting 6mg/kg of caffeine prior to rugby union specific tests has been shown to improve sprinting and passing accuracy. Although caffeine has been shown to improve performance, athletes should be careful with caffeine ingestion during tournaments. Caffeine can disrupt sleep and thus effect recovery during the tournament. If an athlete wants to use caffeine as a supplement to improve performance, they should start with low doses of 1-3mg/kg and monitor how caffeine affects their sleep and recovery. Athletes should also try to avoid daily doses of greater than 6mg/kg/day. (Dziedzic & Higham 2014.)

The third supplement that could be used to enhance performance is beta-alanine. Beta-alanine has been shown to increase carnosine content in muscles, which is known to enhance intracellular buffering. To meet the high energy requirements of training and tournaments, athletes could use protein powders with carbohydrates, sport bars etc. To improve recovery and hydration, athletes could use specifically formulated sports drinks, that include electrolytes, to replace electrolytes which are lost through sweating. (Dziedzic & Higham2014.)

7 FUTURE OF RUGBY 7'S AND CONCLUSION

The International Olympic Committee has decided to include rugby 7's as a part of the next three summer Olympic games in 2020, 2024 and 2028. This decision will result in national federations around the world investing more money into their rugby 7's programs, in order to be in contention for the Olympic gold. In turn, this will most likely increase the game demands and physiological requirements of both male and female players, as players are able to dedicate more time to training and competing than before. Some federations have already created more national competitions, in order to increase participation and popularity of rugby 7's in their country.

The popularity of rugby 7's at the youth level has also increased. Rugby 7's has been part of the Youth Olympics since 2014, where U-18 national teams compete against each other. Rugby Europe also hosts an U-18 rugby 7's European championship every year. Including rugby 7's in the Olympics will increase the number of young rugby players participating in rugby 7's. This allows future rugby players to take part in specific training for rugby 7's earlier, which will likely result in an increase of both the skill and physical demands of rugby 7's in the future, because athletes have participated longer in rugby 7's specific training.

Including rugby 7's in the Olympic schedule for next three Summer Olympics will also attract more players to play rugby 7's from other football codes. Players from rugby union and league, and from other sports that are not in the Olympics, may switch to rugby 7's to fulfil their dream to participate in the Olympics. While participation in rugby 7's increases, at the same time the popularity of rugby 7's will most likely increase. This will increase the money gained from sponsorships and ticket income and will allow more and more athletes to become professional in the sport. This in turn allows athletes to practise and play rugby 7's year around. As the game demands of rugby 7's change, athletes will need specific preparation to meet these demands. Rugby 7's athletes will require specialised physical, tactical and skills training. Countries that can meet these demands will be the ones in contention for future Olympic gold medals.

In Finland, the popularity of rugby 7's has also increased after the 2016 Olympic qualifiers and games. The Finnish women's national team played well in the Olympic qualifiers, which raised the profile of the game in Finland. While Rugby 7's is still a small game in Finland, this has created an opportunity to grow and develop the sport from the junior level all the way up to national teams. The Finnish Rugby Federation has a lot of work to do so that Finland can become competitive at the international level. The Federation should work on getting more funding to hire full-time staff members, particularly a development officer, whose job description would be to develop rugby 7's from junior to senior levels. Promotion of the sport needs to begin in the local communities, at the grassroots level.

Another aspect of Finnish rugby 7's that could be improved is to attract more young players to participate in the sport. In countries where rugby is popular, young athletes can participate in the sport from a young age. This allows them to develop the necessary skills early on, whereas in Finland most rugby 7's athletes are introduced to the sport at an older age. This will limit the game skills and might negatively influence the national team's success in the future. The general attitude in Finland about rugby 7's is that it is a violent and brutal game. Some parents might be hesitant to allow their kids to play rugby 7's because they are afraid of injuries. This could be avoided by introducing a non-contact version of rugby 7's, touch football, in schools and for young players, which could help to improve participation at the youth level. Some of these players may continue on to participate in full contact rugby 7's in the future. The Rugby Federation and teams should also try to recruit "retired" athletes from other sports to take part in rugby, especially from sports like ice-hockey, wrestling and other contact or crippling sports. These athletes are already accustomed to body contact and could make good rugby 7's players, while also raising the profile of the sport within Finland.

One hurdle that Finland will face as the sport becomes more professional in other countries who have more resources to dedicate to their national teams is, how does Finland compete against these teams when competing for a place at Olympics or at other international events. The physical demands of rugby 7's will increase, which means more specific training is required in order for Finnish teams to be competitive at the international level. In countries where rugby 7's is more popular than in Finland, athletes can compete either as professionals or semi-professionals. These athletes can concentrate fully on training for rugby 7's, whereas in Finland rugby 7’s is an amateur sport and athletes have to work full time outside of rugby 7’s. This gives the advantage to other countries when they are competing against Finland. This is why the Rugby Federation needs to dedicate funds and resources on continuing to raise the profile and popularity of the game in Finland, as this will bring more money and sponsorship opportunities to the sport, allowing players to play full-time.

Rugby 7’s is a high intensity contact sport, which requires athletes to have high levels of aerobic fitness, strength and speed. The tournament-style of playing places special demands on the physical preparation of the athletes, and on recovery during the tournament. To be able to play multiple games within a two-day period requires coaching staff to plan recovery well for the tournament to optimize the team performance and minimize risk of injuries. In the future, the physical and skill demands of rugby 7’s at the international level will increase, due to the increased professionalism of the game and the greater amount of rugby 7’s specific physical and skill training. This can be achieved, because national federations will invest more money in their rugby 7 programs, as a result of its inclusion in the next three Olympics.

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