Case Report: A time-course observation of reductions in lean body mass following surgery in Elite Rugby Union

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Team Sport | **Atrophy** | **Injury nutrition** | **Fat-free mass** | **Immobilisation**

Headline

Rugby union is a collision-based team sport characterised by intermittent activity, including periods of low intensity movements, such as walking and jogging and frequent bouts of high intensity activities such as running and sprinting. Recent running performance data has shown that the mean distance covered during match-play is 6053 ± 710 m with a relative work rate of 70 ± 4 m min^{-1} for all players. Players have also been shown to complete 250 ± 177-m of high-speed running above 5.5 m s^{-1}. Sprint analysis shows players complete 2-5 sprint efforts during game play interspersed with 164 ± 30 high-intensity efforts (Sheehan et al., 2021). The game is physically demanding and includes collision and contact activities such as tackling, rucking, mauling, and scrummaging in addition to the running performance requirements highlighted (Gabb et al., 2015; Sheehan et al., 2021). The combination of these running and collision demands increase the risk of injury to players (Williams, et al., 2013).

In this case study, a player presented with an injury to the left shoulder which required a Latarjet surgical procedure. The principle of this procedure is to relocate the coracoid bone with the conjoined tendon (coracobrachialis and short head of the biceps) and fill the glenoid bone defect (Hurley, et al., 2019). Following a Latarjet procedure, return to play (RTP) rates among collision athletes are 88.2%, with 69.5% returning to the same level of play (Hurley, et al., 2019). The mean time to RTP following the procedure is 25.2 weeks (range 14 – 35 weeks) (Hurley, et al., 2019), with a 5.4% re-dislocation rate reported within cohorts who require the procedure (Baverel et al., 2018).

The hierarchical objectives of nutrition interventions during the early stages of injury are to support nutritional sufficiency. Furthermore, these nutritional interventions aim to ensure the player is not deficient in any aspect of their nutrition by evaluating global energy and macro- and micro-nutrient intakes; increasing nutritional intakes to limit muscular atrophy, enhance the general healing process and; offer specific nutrients for injuries to specific tissue types (Tipton, 2015). These practical processes are applied during the rehabilitation process during severe injury events due to the measurable levels of muscle loss that can occur during phases of muscle immobility. These have been shown to range from 1.4 ± 0.7% to 3.1 ± 0.7% depending on the duration of immobilisation during the injury (Wall, et al., 2014). A progressive loss of fat-free mass, reduction in functional strength, and an alteration in metabolic responses and fat depositions can occur during these immobilisation periods (Wall et al., 2014; Crossland et al., 2019) with this likely due to a combination of resistance of muscle to protein ingestion following immobilisation (Wall, et al., 2013) and the lack of muscle stimulation during the period of injury.

Aim

We present a case study that highlights the short- and long-term changes in body composition during the rehabilitation from a long-term injury in the presence of an acute nutritional intervention with the secondary aim of understanding the feasibility and value of adopting an injury specific nutritional intervention and DXA timeline for future long-term injuries.

Athlete

The player is an academy rugby union out-half. Within rugby union the out-half represents a position in rugby that usually stands behind the scrum-half during a ruck or scrum and receives the ball from the scrum-half during specific phases of play. The out-half represents one of two positions in the half-back line on a rugby field during competition. The out-half positions main purpose on the field is to act as a main director of actions for the other backs and is often in charge of starting attacks for the other backs. Typically, an out-half will cover 6698 ± 986 m of total distance; 256 ± 108-m of high-speed running, and 33 ± 11 high intensity efforts across match-play (Sheehan et al., 2021). At the time of this case-study his physical characteristics were as follows: age: 20.1 yrs old; body mass: 87.2 kg; height: 183.2 cm. Prior to the injury, the player was engaged in a weekly training schedule that included one skills session, a field-based rugby session, up to four resistance training sessions and one competitive game. During the Under-20 Rugby World Cup, the player sustained a contact injury that required surgery. The operated limb was locally immobilised for the following 14-day period, limiting whole body training activities. The injury timeline was estimated to be 20-weeks in duration, involving a gradual transition through different loading phases, each requiring tailored nutritional recommendations (Milsom et al., 2014; Anderson et al., 2019). The player provided written consent for publication of this case study and ethical approval was granted by TU Dublin research ethics committee (REIC-21-100).

Assessment of the Athlete

The player underwent dual-energy x-ray absorptiometry (DXA) scans two days prior to surgery (baseline; DXA0d), seven days post-surgery (DXA7d) and one-month post-surgery (DXA30d), to highlight changes in fat-free mass, and fat mass during the rehabilitation process. All scans took place at the same location and the same time of day (within 1 hour of waking), in a fasted state. The time periods of DXA assessment were decided upon to advance our understanding of what occurs in the acute post-surgery period (Nana et al., 2016). A limitation of the current case study is that for ethical reasons, due to the low-level radiation experienced during DXA scans the local University limits individuals' exposures to four scans per annum. In this case, the player had a scan in the previous April as part of the systematic seasonal body composition assessment protocols, therefore, a fourth time point, 60 days post-surgery was not possible. However, as part of the systematic anthropometric assessments in the club, players routinely have their body composition measured through skinfold measurements by an International Society for the Advancement of Kinanthropometry (ISAK) accredited level 1 anthropometrist (TEM <3 %). Sum of 7 sites skinfold thickness (ΣS7) was recorded throughout and provide a view of the player's response to the training and nutrition interventions during the return to train phase.

At the beginning of pre-season (July), the player was asked to fill in food diary for 7-days using a smartphone application (Teixeira, et al., 2017) to estimate his current dietary intake. There are limitations with this method, as it relies on self-reported data, which can lead to misreporting, recall biases or altering the individual's 'normal' dietary behaviour patterns (Archnudia Herrera & Chan, 2018) as well as inaccuracies with the application itself due to user-entered food data (Ravelli & Schoeller, 2020). These intake values were compared with a predictive equation for estimating energy requirements (Cunningham, 1980) available in dietary analysis software (Nutritics, 2019). Without access to laboratory methods for estimating energy homeostasis (Gropper & Smith, 2017) this method was chosen, alongside monitoring the player's body mass, as an appropriate means for estimating baseline energy intake along with current macro- and some micro-nutrient intakes. Surgery or trauma may require up to 20% more calories, depending on the site and nature of the procedure (Frankenfield, 2006). It was determined that to maintain weight, this player's baseline energy intake was $\sim$2800 kcal·day^{-1} [11.7 MJ], and thus the post-surgery target was $\sim$3300 kcal·day^{-1} [13.8 MJ].

Table 1. Food diary record for injured player in the 7 days following Latarjet surgical procedure.

Meal	Description	Energy (MJ) [kcal]	Carbohydrate (g)	Protein (g)	Fat (g)
Breakfast	Breakfast Muffins: 1 toasted English Muffin, 3 scrambled eggs, 2 bacon medallions, 30 g cheddar cheese. 220 g porridge made up with low-fat milk, 1 medium banana, 90g mixed berries. 1fish oil capsule (900 mg N-3; 540 mg EPA, 360 mg DHA)	4.8 [1144]	86	64	60
Post-rehab snack	1 scoop (30 g) whey protein isolate, 1 scoop (5 g) creatine monohydrate	0.5 [113]	1.6	24.5	0.99
Lunch	Beef Stir fry: 110g beef strips, 250 g cooked basmati rice, 300g mixed stir fry vegetables, fruit cordial	2.8 [661]	106 37.6	9.5	
Afternoon snack	300 g strained protein yoghurt (Glenisk), large handful of mixed dried fruits, 1 tbsp almond butter, and 1 banana	2.1 [500]	70	31.2	10.6
Dinner Large	($\sim$200g) baked salmon darne, 200g cooked potatoes, 200 g mixed vegetables	2.4 [583]	37.3	53	24.8
Night-time snack	350 g skyr yoghurt, 60 g blueberries, 15 g (1 tbsp) flaked almonds	1.3 [322]	17.2	42	9.1
Total Intake		13.9 [3322]	319	251	115

Overview of Nutritional Plan and Intervention

The primary goal of the acute nutrition intervention was to maximise healing (Tipton, 2015). Secondly, the multidisciplinary team and player agreed that a successful return to play would coincide with increases lean body mass and decreased fat mass compared to baseline values. Evidence suggests establishing carbohydrate intake followed by protein intake are the priorities for optimising body composition (Aragon et al., 2017). Once protein targets were established, the player's remaining energy was distributed between carbohydrates and fat. Carbohydrates (352 g·day^{-1}; 1408 kcal [5.8 MJ].day^{-1}) typically equated to 42% of daily kilocalories, (4 g.kg.day^{-1}) within the desired 3 - 5 g.kg.day^{-1} range for light-moderate training (Burke et al., 2011). Carbohydrates were further adjusted across the intervention based on the daily training demands of the athlete (Jeukendrup, 2017). Low-glycaemic index sources of carbohydrates, such as vegetables and fruits, were primarily recommended to provide a sustained energy source as well as to enhance satiety (Holt et al., 1995) and provide antioxidant rich sources of carbohydrates. Furthermore, fat is a necessary component of a healthy diet as it provides essential elements of cell membranes, facilitates the absorption of fat-soluble vitamins and provides energy (Thomas et al., 2016). After equating the kilocalories of protein and carbohydrate requirements, the remainder of the athlete's energy intake was made up from fat (1.4 g.kg.day^{-1}; 120 g.day^{-1};1080 kcal.day^{-1} [4.5 MJ]). A variety of saturated, mono- and poly-unsaturated fatty acids, through the inclusion of foods such as olive oil, avocados, salmon, flaxseed, and nuts, were recommended.

In the lead up to surgery, the player was instructed to maintain baseline energy intakes with a slight increase in protein to offset any potential skeletal muscle atrophy (Jones, et al., 2004; Wall, et al., 2014). The player was provided with a collagen and vitamin C supplement to offset the blunting of collagen synthesis following trauma from surgery (Shaw, 2016) and to aid in tendon remodelling (Vieira, et al., 2018). For the day of surgery, the aim was for the player to stay hydrated and consume enough amino acids while immobilised following the procedure to enhance the initial recovery period. Liquid options were recommended primarily to overcome the loss of appetite due to general anaesthetic and postoperative fatigue (Hall & Salmon, 2002). Additionally, the player was given an electrolyte supplement, to help achieve an euhydrated state, along with sachets of whey protein to provide regular doses of leucine-rich amino acids (English, et al., 2016). To offset muscle atrophy, leucine-rich amino acid availability was increased by setting protein intake to 2.5 g·kg^{-1} (equating to 220 g [880 kcal/3.6 MJ]) (Tipton, 2015). The total intake was split into three main meals (0.4 g·kg^{-1}·meal^{-1}; ∼34 g) and three mini-meals (0.3 g·kg^{-1}·meal^{-1}; ∼26 g) to maximise the anabolic response at each meal (Schoenfeld & Aragon, 2018). A food diary of the athlete 7-days post-surgery is shown in Table 1.

Results

During the first week post-surgery, a 1.1 kg (1.3%) loss of total body mass (Table 2) was observed, with a 1.3 kg (1.9%) loss of lean body mass (Figure 1). Total body absolute and relative fat mass was shown to increase in the 7-days following surgery (0.2 kg [1.5%] and 0.6% [3.7%], respectively). Arms and legs lean mass decreased 2.1% and 5.6%, in the 7 days following surgery (Table 2).

The loss of lean mass in the upper limbs in the 30 days post-surgery was 5.4%, with a similar decrease of 12.8% in lean mass in the injured limb (Table 3). The left and right leg increased lean mass 3.4% and 2.5%, from DXA7d to DXA30d. When trunk lean mass was considered, there was a 4.1% decrease observed across the observational period, with side-to-side differences apparent (Table 3). A subsequent 2.1% increase in total body mass was observed across the rest of the month.

Specific regional analysis highlighted the greatest increases in fat mass occurred around the trunk. When skinfolds were considered, there was an increase from 53.1 mm pre-surgery to 58.6 mm post-surgery to 71.3 mm one-month post-surgery (Figure 2). It was observed that during the return to training phase that the players body mass was maintained at 87.2 kg, while skinfolds continually declined to 51.3 mm (Figure 2).

Table 2. The changes in total body mass, total body lean mass (LBM) and total body fat mass (FM) from pre-operation (DXA0d), 7-days post-operation (DXA7d) and 30-days post-operation (DXA30d).

	DXA0d	DXA7d	Δ kg (%)	DXA30d	Δ kg (%)	Overall Δ kg (%)
Total Mass (Kg)	87.2	86.1	-1.1 (-1.3)	87.9	+1.8 (2.1)	+0.7 (0.9)
LBM (kg)	69.4	68.1*	-1.3 (1.9)*	67.3 †	-0.8 (1.2)	- 2.1 (3.0) †
LBM (%)	79.6	79.2	-0.4 (0.5)	76.5	-2.7 (3.4)	-3.1 (3.9)
FM (kg)	13.4	13.6	+0.2 (1.5)	16.2 ‡	+2.6 (19.1)	+2.8 (20.8) ‡
FM (%)	16.1	16.7	+0.6 (3.7)	16.1	+0.6 (3.5)	=0 (0.0)

* = 1.87% lean body mass decrease from baseline. †= 3% lean body mass decrease from baseline. ‡= 20.8% fat mass increase from baseline.

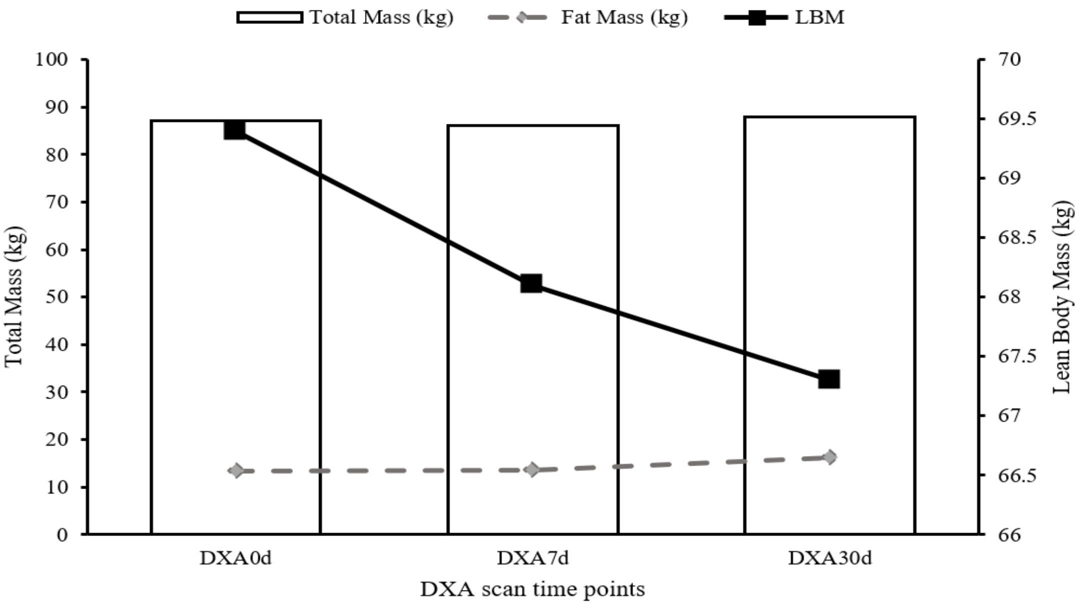

Fig. 1. The changes in total body mass, total body lean mass and total body fat mass from pre-operation (DXA0d), 7-days post-operation (DXA7d) and 30-days post-operation (DXA30d).

Table 3. The change in regional (top) and sub-regional (bottom) lean mass from pre-operation (DXA0d), 7-days post-operation (DXA7d) and 30-days post-operation (DXA30d).

Region	DXA0d	DXA7d	Δ kg (%)	DXA30d	Δ kg (%)	Overall Δ kg (%)
Arms (kg)	9.5	9.2	-0.24 (2.1)	8.8	-0.5 (5.4)	-0.8 (7.8)
Legs (kg)	25.2	23.8	-1.42 (5.6)	24.4	+0.6 (2.5)	-0.8 (3.2)
Trunk (kg)	31.4	32.0	+0.59 (1.9)	30.7	-1.3 (4.1)	-0.7 (2.2)
Sub-region	DXA0d	DXA7d	Δ kg (%)	DXA30d	Δ kg (%)	Overall Δ kg (%)
Left Arm	4.7	4.5	-0.2 (4.3)	4.1	-0.4 (8.8) *	-0.6 (12.8) *
Right Arm	4.8	4.7	-0.1 (2.0)	4.7	0.0 (0.0)	-0.1 (2.0)
Left Leg	12.5	11.8	-0.7 (5.6)	12.2	+0.4 (3.4)	-0.3 (2.4)
Right Leg	12.6	11.9	-0.7 (5.6)	12.2	+0.3 (2.5)	-0.4 (3.2)
Left Trunk	15.5	16.3	+0.8 (5.2)	15.3	-1.0 (6.1)	-0.2 (1.3)
Right Trunk	15.9	15.7	-0.2 (1.3)	15.4	-0.3 (1.9)	-0.5 (3.1)

Δ = change from previous scan. Overall Δ = change from baseline.

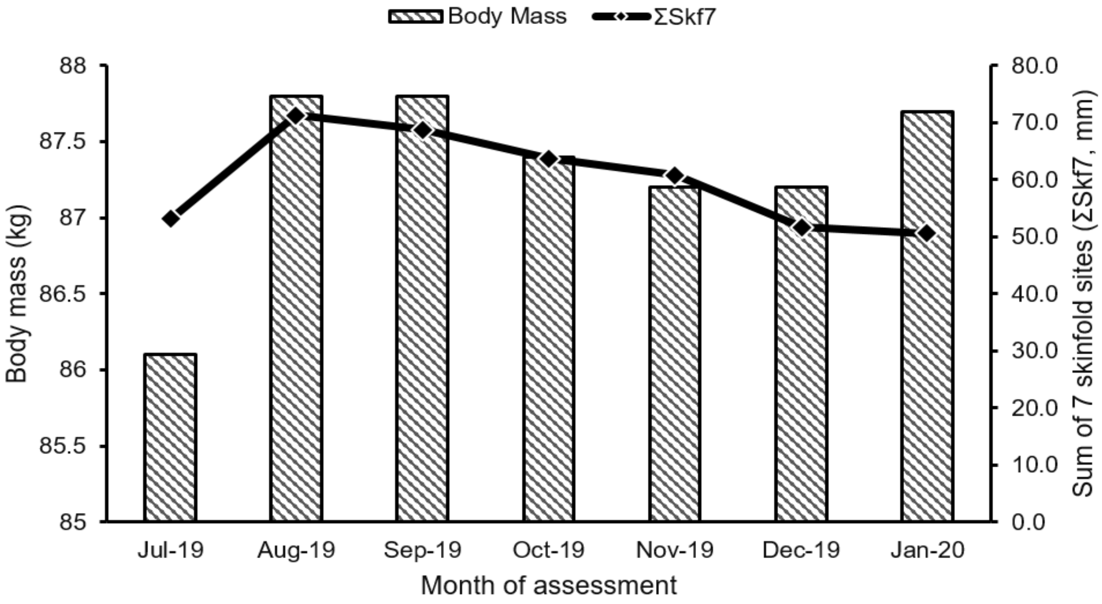

Fig. 2. The changes in the player's body mass (kg; bars) and sum of 7 sites skinfolds (mm; black line) from pre-injury (July), post-surgery (August) through the return to play protocol to return to competition (December).

Discussion

The purpose of the current case study was to highlight both the short- and long-term changes in body composition observed during rehabilitation from injury in a professional sporting context. Total body mass decreased by 1.1 kg, with a 1.3 kg (1.9%) loss of total lean body mass in the 7-days post-surgery. Total body mass increased by 1.8 kg (2.1%) from day 7 to day 30; however, there was a further 0.8 kg (1.2% [3.1% total]) reduction in total lean body mass observed. The changes in lean mass are greater than the ∼0.73 kg loss per week (averaged ∼8 weeks) reported within a Premier League soccer player case study of immobilisation (Milsom et al., 2014). Regional analysis indicated that a substantial proportion of lean mass losses in the first 7-days came from the left and right leg (both 0.7 kg [5.6%]), with a 0.2 kg (4.3%) reduction in the injured and immobilised limb. The present data are greater to those observed previously where leg lean mass was reduced by 1.4 ± 0.7% following 5 days of immobilisation in non-injured males (Wall et al., 2014). The injured structure demonstrated the greatest total reductions in lean body mass (-12.8%), with the greatest reductions (8.8%) occurring between day 7 and day 30. The reductions in lean mass is likely due to limited mobility and resistive loading opportunities as the player was unable to expose the tissue to a resistance stimulus (Jones et al., 2004), compounding the disuse-induced anabolic resistance to protein (Glover et al, 2008; Wall, Snijders et al, 2013). The non-injured limb displayed no further losses, while a restoration of lower-body, lean mass was observed in the 30-days. While this was not sufficient time to restore it to baseline values, the data would highlight changes in tissue loading parameters in the non-injured areas can have global effects on lean body mass maintenance, which could have implications for future injury in these areas.

Based on findings in previous case studies (Anderson et al., 2019; Milsom et al., 2014), we aimed to prescribe a relatively high caloric intake to overcome energy deficits, and increased protein intake to offset losses of lean body mass. Despite this, we observed losses of lean body mass, substantially in the injured limb, with increases in fat-mass. Tentative evidence suggests a combination of blood flow restriction with electrical muscle stimulation twice daily can preserve lean mass, but not strength in immobilized limbs (Slysz et al., 2021). A concerted effort from the multidisciplinary team is required to minimize the loss of lean body mass during the short- and long-term injury recovery process.

The aim of any nutrition intervention post-surgery is to maximise healing; with the secondary aim of any intervention being returning the injured player to full training and game availability. We aimed to do this while also aiming to increase lean body mass and decreased fat mass within the reported case-study. Indeed, the player returned to full training within 18 weeks following the surgical procedure, with isokinetic testing indicating the structure had healed. Upon returning to full training, body mass and skinfold measurements indicated there was an increase in fat-free mass and a reduction in fat-mass. Identifying appropriate caloric and specific nutrient requirements is still difficult during immobilization and the rehabilitation period following an injury. Practitioners should aim to maintain body mass in the initial post-surgery period. A more continuous ("injury specific") body composition assessment schedule could be prudent to more accurately tailor energy and macronutrient provision during a long-term injury. Further investigation into the role of specific nutrients to limit muscle protein breakdown and/or promote muscle protein synthesis in an immobilised and injured limb is warranted across multiple sporting contexts. The above suggestions may aid in the development of standards of working for nutritional practitioners when faced with short to long-term injuries within team sports.

Conclusion

The purpose of the current case study was to highlight both the short- and long-term changes in body composition observed during rehabilitation from injury in a professional sporting context. Within the case study we repot an MDTs collaborative effort to return a player from a significant injury that resulted in an elongated period of immobilisation. Within the return to performance pathway, the case study highlights the specific nutritional intervention employed by the MDT to maximise healing and return the injured player to full training and game availability. The specific intervention adhered to specific nutritional guidelines providing a balanced nutritional intake across the key macronutrients. Despite this, we observed losses of lean body mass, substantially in the injured limb, with increases in fat-mass. Based on our findings we suggest that a concerted effort from the MDT is required to minimise the loss of lean body mass during the short- and long-term injury recovery process, with an interwoven pathway of agreement across medical, strength and conditioning, and nutritional staff required to maximise results. However, it may be suggested that due to immobilization of the joint post-surgery that irrespective of interventions, reductions in lean body mass, with increases in fat-mass around the joint post-surgery may have to be accepted by the player and MDT, with these expected to be work-on's for the player post-surgery.

Key take home messages

- Despite prescribing a relatively high caloric intake to overcome energy deficits, and increased protein intake to offset losses of lean body mass, we observed losses of lean body mass, substantially in the injured limb, with increases in fat-mass also observed. MDTs may be more aggressive in their prescription of caloric intakes based on our observations; however these may need to be tapered given the logistical and consumption issues associated with higher caloric intakes in any sporting environment.
- Post any surgical intervention within any sporting domain, it is important that a concerted effort is made across all departments within an MDT to minimise the loss of lean body mass during the short- and long-term periods across the recovery process, with an interwoven pathway of agreement across coaching, medical, strength and conditioning, and nutritional stakeholders required to maximise return to function, minimise time-loss and maximally aid a players return to performance.

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