RECOVERY MODALITIES

Every athlete will experience a period of recovery following exercise. During this time the approach to individual recovery needs will primarily depend on when athletes are required to perform again. The demands of previous and upcoming bouts of exercise are also important considerations. There are a range of recovery modalities that can be utilised to support an athlete's recovery. The aim of this chapter is to provide an overview of the common recovery modalities used in sport.

The process of recovery is complex and multifaceted. Each recovery modality will have different protocols, mechanisms of action and potential benefits or outcomes. Understanding the demands of exercise (Pages 12 - 37) can help identify which recovery modality (or multiple modalities) are best suited to support the needs of the individual athlete. Indeed, there is no one-size-fits-all approach to recovery, given the different mechanisms involved in both fatigue, and recovery. Table 15 provides a checklist of factors to consider to help build a relevant and sustainable recovery strategy, specific to each athlete.

As a general guide, the different recovery modalities can be considered on a hierarchical basis (Figure 19). Given the strength of scientific evidence, it is recommended to first ensure nutrition and sleep practices are optimised, and training schedules are adjusted strategically, ensuring sufficient periods of rest, before the use of additional recovery modalities are considered. The following pages provide tools and guidance to support the development of appropriate and feasible recovery strategies.

Introducing a new recovery strategy, or adapting a previous strategy, may be a big change for an athlete. To help with this, methods to promote athlete behaviour change can be considered. Three key behaviour change principles have been shared elsewhere by Lindsay & Pitt (2022).

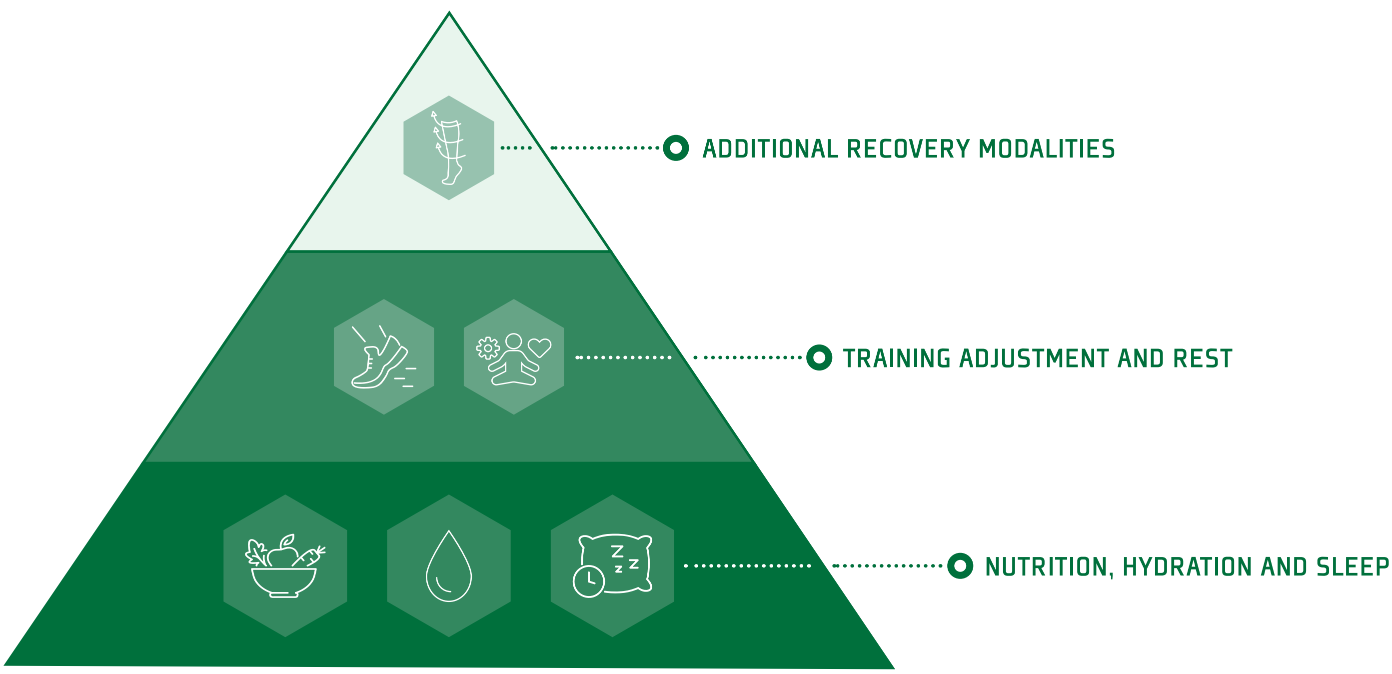


Figure 19

The Recovery Pyramid.

RECOVERY STRATEGY CONSIDERATION	YES/NO*	COMMENTS
WHY IS RECOVERY REQUIRED?		
Is there a clear rational as to why recovery is required?		
WHAT WILL BE THE AIM OF RECOVERY?		
Is there a clear rational as to if it is physiological and/or psychological recovery that is required?		
Is there a clear understanding of the relevant mechanisms of fatigue?		
HOW EFFICACIOUS IS THE RECOVERY MODALITY?		
Have nutrition, sleep, and training strategies been optimised to support recovery?		
Is there scientific evidence to support the use of the recovery modality for the specific aim?		
Is there scientific evidence to support the use of the recovery modality within the required recovery window? i.e. are benefits reported after 1h or 24h		
Is there scientific evidence to support the use of the recovery modality in the relevant population? i.e. evidence in elite athletes		
HOW FEASIBLE IS THE RECOVERY MODALITY TO USE?		
Are there facilities available to enable the use of the recovery modality? i.e. does the training centre have cryotherapy chambers / can these be accessed elsewhere?		
Does the practitioner have the knowledge/ experience to implement the recovery modality?		
Is there a clear protocol in place for the use of the modality?		
Is the modality simple for athletes to use?		
Is there sufficient time for athletes to engage with the modality?		
Can the modality be utilised effectively remotely? i.e. away from the training centre, at the stadium, or whilst travelling		
Has the protocol taken into account any evidence that may suggest the modality may be enhanced / impaired if combined with additional recovery modalities, if relevant?		
Is the modality sustainable from a human resource, time, and financial point of view?		

WHEN WILL RECOVERY OCCUR?		
Is there a clear rational as to when the recovery modality will be used?		
Has the protocol taken into account any potential negative impact of the recovery modality on subsequent performance, depending on timings?		
Will the system be used frequently enough to support recovery, without reducing compliance?		
Has the protocol taken into account any potential impact of the recovery modality on long-term adaptation, if this is a concern in the specific situation?		
HOW WILL RECOVERY BE MONITORED?		
Is there a clear rational as to how the efficacy of the recovery modality will be monitored? (See 'Monitoring to Support Recovery' section)		
Is there a clear rational as to how often the use of the recovery modalities will be monitored?		
HOW WILL FEEDBACK BE PROVIDED / RESULTS UTILISED?		
Is there a protocol in place to adapt the recovery modality if it is not working as required?		
Is there a plan to collect data to inform future recovery strategies?		

Table 15

Checklist for creating a relevant and sustainable recovery strategy. *Answering questions with a 'Yes' indicates that appropriate considerations in the development of a relevant and sustainable recovery strategy have been accounted for. If any questions are answered with a 'No', the specific question should be reviewed and the recovery strategy should be adapted appropriately, with the aim that the majority of answers, if not all, are answered with a 'Yes'.

NUTRITION

Alongside sleep, nutrition is at the foundation of the recovery process (Figure 19). Post-exercise, the body needs to restore the depleted energy substrates (carbohydrate and fats (intramuscular triglyceride)) (metabolic recovery), and repair any damage to the skeletal muscle (mechanical recovery) (Heaton, et al., 2017). Nutrition plays a key role in both recovery phases. Indeed, nutrition can help protein muscle regeneration, glycogen resynthesis, the reduction of fatigue, and support physical and immune health (Heaton, et al., 2017). All of which are factors contributing to recovery, and subsequent readiness. As such, optimal nutrition should be encouraged, and regularly reinforced with athletes (Meeusen, et al., 2013).

This section will provide tools and guidance to help support athletes' recovery through the utilisation of nutrition practices. Though this section is broken into individual macronutrients, micronutrients and hydration, utilising a combination of these practices will have a greater impact that utilising one in isolation. It is not the aim of this toolkit to provide an exhaustive list of all nutrients and supplements used to enhance recovery, instead it focuses on fundamental dietary strategies.

For more information on nutrition, including guidance on how to run a dietary analysis, and athlete consultations, as well as meal planning guidance, see the GSSI Sports Nutrition Toolkit. For information on recovery nutrition for specific sports, a list of GSSI resources are shared below:

- GSSI SSE Article #129: Recovery Nutrition for Football Players (Res, 2014)
- GSSI SSE Article #144: In-Season Recovery Nutrition for American Football (Baar & Heaton, 2015)
- GSSI SSE Article #166: Recovery Nutrition for the Basketball Athlete (Baar, 2016)
- GSSI Sports Nutrition For American Football Book
- GSSI Sports Nutrition for Basketball Book

ENERGY

Energy intake is an important consideration. Energy is expended during exercise, and must be replenished post-exercise to prevent fatigue. An increase in training load will likely increase energy expenditure, thus energy intake should be increased to match these demands. Meeting daily carbohydrate recommendations will ensure sufficient carbohydrate availability to the muscle and central nervous system and contribute to daily energy requirements.

Tools and guidance to help calculate an athlete's energy requirements can be found in the GSSI Sports Nutrition Toolkit.

THE THREE R'S OF RECOVERY		
Refuel CARBOHYDRATE	**Repair** PROTEIN	**Rehydrate** FLUID

REFUEL – CARBOHYDRATE

Carbohydrates are the body's main substrate used to provide energy during exercise at moderate to high intensities (Coyle, 2000). However, the human body can only store a limited quantity of carbohydrates, in the form of muscle or liver glycogen, at any one time. The rate at which these stores are depleted is dependent upon the duration and intensity of exercise. Glycogen depletion is a major cause of fatigue (Hearris, et al., 2018). For this reason, carbohydrate consumption is recommended post-exercise to promote recovery of glycogen stores. Meeting carbohydrate recommendations can also help reduce the risk of over-reaching and support immune function (Heaton, et al., 2017).

Figure 20 outlines carbohydrate recommendations for post-exercise refuelling. These recommendations differ depending on the time available for recovery. Specifically there is an increased focus on recovery for athletes with less than 8 hours between two consecutive bouts of exercise. For example those with multiple training sessions within the same day, or taking part in tournaments with back to back games. Tables 16 and 17 convert these recommendations into the total amount of carbohydrate required depending on body mass and exercise intensity. The two tables provide recommendations for carbohydrate consumption in the first four hours post-exercise (for those with <8 hours recovery time), and daily carbohydrate consumption respectively. Table 18 provides examples of 30g and 100g of carbohydrate to help guide the choice of recovery foods and beverages.

Time until next bout of exercise	RECOMMENDATIONS	TIPS AND ADVICE
< 8 hours	1.0 - 1.2 grams of carboydrate per kg body mass per hour for first 4 hours Then continue to work towards daily carboydrate recommendations	Moderate to high glycaemic carbohydrates are recommended Consuming a combination of glucose and fructose-based carbohydrates may better replenish liver glycogen stores
≥ 8 hours	Continue to work towards daily carbohydrate recommendations post-exercise	Timing and type of carbohydrate can be chosen based on individual preferences

Figure 20 ▲

Carbohydrate recommendations for post-exercise refuelling (Thomas, et al., 2016; Wallis & Podlogar, 2022).

Table 16

A guide to post-exercise carbohydrate consumption, for recovery periods of < 8 hours, based on body mass (BM), adapted from Thomas, et al. (2016). A conversion table between kilograms and pounds can be found in the Appendix (Table 25).

CARBOHYDRATE CONVERSION TABLES

Body Mass		Recommended Carbohydrate Intake (g) in the Post-Exercise Period Based on Body Mass	
kg	lb	1 g/kg BM	1.2 g/kg BM
60	132	60	72
65	143	65	78
70	154	70	84
75	165	75	90
80	176	80	96
85	187	85	102
90	198	90	108
95	209	95	114
100	221	100	120
105	232	105	126
110	243	110	132

		Light Intensity Exercise							
				Moderate Intensity Exercise					
					High Intensity Exercise				
Body Mass		Recommended Carbohydrate Intake (g) Per Day Based on Body Mass							
kg	lb	3 g/kg BM/d	4 g/kg BM/d	5 g/kg BM/d	6 g/kg BM/d	7 g/kg BM/d	8 g/kg BM/d	9 g/kg BM/d	10 g/kg BM/d
60	132	180	240	300	360	420	480	540	600
65	143	195	260	325	390	455	520	585	650
70	154	210	280	350	420	490	560	630	700
75	165	225	300	375	450	525	600	675	750
80	176	240	320	400	480	560	640	720	800
85	187	255	340	425	510	595	680	765	850
90	198	270	360	450	540	630	720	810	900
95	209	285	380	475	570	665	760	855	950
100	221	300	400	500	600	700	800	900	1000
105	232	315	420	525	630	735	840	945	1050
110	243	330	440	550	660	770	880	990	1100

Table 17

A guide to daily carbohydrate consumption based on body mass (BM) and activity levels, adapted from Thomas, et al. (2016).

CARBOHYDRATE QUANTITIES

Table 18 presents a selection of commonly consumed foods and beverages that will provide approximately 30 or 100g of carbohydrate. These examples, whilst not practically feasible in all cases, can be used as a guide for adapting quantities to meet an athlete's requirements. There is space within this column for the nutritionist to add foods that are more relevant to the athlete / club / country. A conversion table between grams and ounces can be found in the Appendix (Table 26).

Table 18

Common sources of carbohydrate providing ~30g and 100g respectively. Please note these values are estimates and food/beverage packaging can be reviewed to evaluate actual nutritional content.

~30g

1.5 SERVINGS OF GATORADE
Serving size: 12 fl oz / 540 ml
Carbohydrate: 33 g
Calories: 120 kcal

1 GLASS OF FRUIT JUICE
Serving size: 10 fl oz / 300 ml
Carbohydrate: 30 g
Calories: 140 kcal

1 STICK GATORADE POWDER
Serving size: 17 fl oz / 500 ml
Carbohydrate: 34 g
Calories: 130 kcal

1.5 BAG OF BAKED CHIPS
Serving size: 1.5 oz / 42g
Carbohydrate: 30 g
Calories: 180 kcal

~100g

LARGE PLATE PASTA
Serving size: 10.6 oz / 300 g
Carbohydrate: 100 g
Calories: 515 kcal

LARGE PLATE RICE
Serving size: 10.6 oz / 300 g
Carbohydrate: 95 g
Calories: 430 kcal

LARGE PLATE COUSCOUS
Serving size: 10.6 oz / 300 g
Carbohydrate: 100 g
Calories: 545 kcal

2 LARGE PLATES QUINOA
Serving size: 21.2 oz / 600 g
Carbohydrate: 105 g
Calories: 700 kcal

5 RICE CAKES
Serving size: 1.6 oz / 45 g
Carbohydrate: 32 g
Calories: 160 kcal

HANDFUL OF DRIED MANGO
Serving size: 1.4 oz / 40 g
Carbohydrate: 28 g
Calories: 155 kcal

2 SLICES WHOLEGRAIN BREAD
Serving size: 2.7 oz / 75 g
Carbohydrate: 28 g
Calories: 170 kcal

1.5 MEDIUM BANANAS
Serving size: 7.9 oz / 225 g
Carbohydrate: 30 g
Calories: 90 kcal

1 TORTILLA
Serving size: 1.8 oz / 50 g
Carbohydrate: 25 g
Calories: 150 kcal

1 HANDFUL RAISINS
Serving size: 1.6 oz / 45 g
Carbohydrate: 30 g
Calories: 135 kcal

1 MEDIUM BOWL OF OATMEAL & MILK
Serving size: 7.8 oz / 220 g
Carbohydrate: 27 g
Calories: 250 kcal

HALF A BAGEL
Serving size: 1.6 oz / 45 g
Carbohydrate: 25 g
Calories: 120 kcal

1.5 LARGE ORANGES
Serving size: 10.6 oz / 300 g
Carbohydrate: 30 g
Calories: 150 kcal

2 PANCAKES
Serving size: 2.1 oz / 60 g
Carbohydrate: 30 g
Calories: 150 kcal

2 PLATES OF NOODLES
Serving size: 17.7 oz / 500 g
Carbohydrate: 105 g
Calories: 550 kcal

2 BAKED POTATOES
Serving size: 17.7 oz / 500 g
Carbohydrate: 105 g
Calories: 500 kcal

7 SLICES WHOLEGRAIN BREAD
Serving size: 9.2 oz / 260 g
Carbohydrate: 100 g
Calories: 600 kcal

5 MEDIUM BANANAS
Serving size: 33.5 oz / 750 g
Carbohydrate: 100 g
Calories: 450 kcal

4 TORTILLAS
Serving size: 7.1 oz / 200 g
Carbohydrate: 100 g
Calories: 600 kcal

1 LARGE SWEET POTATO
Serving size: 12.4 oz / 350 g
Carbohydrate: 95 g
Calories: 430 kcal

4 MEDIUM BOWLS OF OATMEAL & MILK
Serving size: 31.1 oz / 880 g
Carbohydrate: 108 g
Calories: 990 kcal

2 BAGELS
Serving size: 6.4 oz / 180 g
Carbohydrate: 95 g
Calories: 500 kcal

5 LARGE ORANGES
Serving size: 35.3 oz / 1000 g
Carbohydrate: 97 g
Calories: 520 kcal

7 PANCAKES
Serving size: 7.4 oz / 210 g
Carbohydrate: 100 g
Calories: 525 kcal

REPAIR – PROTEIN

During exercise, the muscles may experience damage which can negatively impact muscle function and cause delayed onset muscle soreness. Consuming adequate quantities of protein can help repair damaged muscle proteins, providing the substrate for the synthesis of contractile and mitochondrial muscle proteins.

Throughout the day, athletes are recommended to consume approximately 0.25 – 0.3 grams of protein per kg body mass, every 3 – 5 hours (Thomas, et al., 2016). Table 19 highlights the recommended portion of protein per serve, depending on body mass, and Table 20 highlights daily protein recommendations, given recovery does not stop in the first few hours post-exercise.

Muscle protein synthesis will respond in a dose dependent manner to the quantity of protein ingested, and is upregulated for at least 24 hours post-exercise (Burd, et al., 2011). However, athletes typically struggle to ingest large quantities of protein immediately post-exercise, and it is common for appetite to be suppressed. Therefore, a practical approach is to ingest ~20g of high quality rapidly digested protein (whey) as part of a recovery drink (providing fluid and carbohydrate) after exercise (Figure 24), which is then complimented by additional protein intake through foods when appropriate as well as protein intake prior to sleep.

Table 21 provides examples of 20g of protein (approximately 0.25 – 0.3g protein for a 70 – 80kg individual). It is recommended that protein sources are complete, and rich in leucine (typically those of animal origin) (Heaton, et al., 2017). A dietitian/nutritionist can provide recommendations to ensure quality protein is consumed for those who have plant-based diets, where protein sources may not stimulate muscle protein synthesis to the same extent as animal-based proteins, unless particular combinations of proteins containing all of the essential amino acids are consumed together (van Loon, 2021). Page 49 provides a protein timeline that can be used with athletes to evaluate, and in turn help optimise, protein consumption throughout the day.

PROTEIN CONVERSION TABLES

Body Mass		Recommended Protein Intake (g) Per Serve, Depending on Body Mass	
kg	lb	0.25 g/kg BM	0.3 g/kg BM
60	132	15	18
65	143	16	20
70	154	18	21
75	165	19	23
80	176	20	24
85	187	21	26
90	198	23	27
95	209	24	29
100	221	25	30
105	232	26	32
110	243	28	33

Table 19 ▲

A guide to protein consumption per serve (meal occasion) based on body mass (BM). Recommendation adapted from Thomas, et al. (2016).

		Increasing Exercise Intensities →								
Body Mass		**Recommended Protein Intake (g) Per Day Based on Body Mass**								
kg	**lb**	**1.2 g/kg BM**	**1.3 g/kg BM**	**1.4 g/kg BM**	**1.5 g/kg BM**	**1.6 g/kg BM**	**1.7 g/kg BM**	**1.8 g/kg BM**	**1.9 g/kg BM**	**2.0 g/kg BM**
60	132	72	78	84	90	96	102	108	114	120
65	143	78	85	91	98	104	111	117	124	130
70	154	84	91	98	105	112	119	126	133	140
75	165	90	98	105	113	120	128	135	143	150
80	176	96	104	112	120	128	136	144	152	160
85	187	102	111	119	128	136	145	153	162	170
90	198	108	117	126	135	144	153	162	171	180
95	209	114	124	133	143	152	162	171	181	190
100	221	120	130	140	150	160	170	180	190	200
105	232	126	137	147	158	168	179	189	200	210
110	243	132	143	154	165	176	187	198	209	220

Table 20

A guide to daily protein consumption based on body mass (BM), and activity levels. Recommendations adapted from Thomas, et al. (2016).

PROTEIN QUANTITIES

Table 21 presents a selection of commonly consumed foods that will provide around, or greater than 20g of protein per serving. These examples can be used as a guide for the nutritionist, with the nutritionist adapting quantities to meet an athlete's requirements. There is space above the images for the nutritionist to add foods that are more relevant to the athlete / club / country. A conversion table between grams and ounces can be found in the Appendix (Table 26).

~20g

1 MEDIUM CHICKEN BREAST
Serving size: 4.2 oz / 120 g
Protein: 38 g
Calories: 175 kcal

1 SMALL SIRLOIN STEAK
Serving size: 3.9 oz / 110 g
Protein: 37 g
Calories: 250 kcal

SMALL PORTION LEAN GROUND BEEF
Serving size: 3.5 oz / 100 g
Protein: 22 g
Calories: 125 kcal

HALF A CAN OF TUNA
Serving size: 3.2 oz / 90 g
Protein: 21 g
Calories: 90 kcal

1 FILLET OF SALMON
Serving size: 3.5 oz / 100 g
Protein: 23 g
Calories: 205 kcal

1 MEDIUM FILLET OF COD
Serving size: 3.6 oz / 100 g
Protein: 24 g
Calories: 100 kcal

1 PLATE PRAWNS
Serving size: 4.2 oz / 120 g
Protein: 21 g
Calories: 90 kcal

3 MEDIUM EGGS
Serving size: 6.4 oz / 180 g
Protein: 21 g
Calories: 215 kcal

1 CONTAINER COTTAGE CHEESE
Serving size: 8.8 oz / 250 g
Protein: 23 g
Calories: 260 kcal

FAT-FREE YOGURT
Serving size: 7.1 oz / 200 g
Protein: 20 g
Calories: 110 kcal

1 LARGE GLASS MILK
Serving size: 20.1 fl oz / 568 ml
Protein: 19 g
Calories: 360 kcal

GLASS CHOCOLATE MILK
Serving size: 17.7 fl oz / 500 ml
Protein: 18 g
Calories: 360 kcal

SKIMMED MILK POWDER
Serving size: 2.1 oz / 60 g
Protein: 21 g
Calories: 210 kcal

1 SCOOP MM 100% WHEY
Serving size: 1.2 oz / 33 g
Protein: 25 g
Calories: 130 kcal

2 SCOOPS EVOLVE PROTEIN POWDER
Serving size: 1.6 oz / 48 g
Protein: 20 g
Calories: 160 kcal

GLASS SOY MILK
Serving size: 17.7 fl oz / 500 ml
Protein: 17 g
Calories: 190 kcal

SEITAN
Serving size: 3.5 oz / 100 g
Protein: 24 g
Calories: 120 kcal

SOY FLAKES
Serving size: 1.8 oz / 50 g
Protein: 27 g
Calories: 200 kcal

TEXTURED SOY
Serving size: 1.8 oz / 50 g
Protein: 24 g
Calories: 160 kcal

LARGE PLATE QUINOA
Serving size: 10.6 oz / 300 g
Protein: 21 g
Calories: 350 kcal

PEANUT POWDER
Serving size: 1.8 oz / 50 g
Protein: 25 g
Calories: 160 kcal

ALMOND PROTEIN POWDER
Serving size: 1.8 oz / 50 g
Protein: 22 g
Calories: 100 kcal

3 SERVINGS OF MIXED NUTS
Serving size: 3.2 oz / 90 g
Protein: 25 g
Calories: 550 kcal

TOFU
Serving size: 3.5 oz / 100 g
Protein: 24 g
Calories: 260 kcal

4 TABLESPOONS PEANUT BUTTER
Serving size: 2.1 oz / 60 g
Protein: 19 g
Calories: 450 kcal

MYCOPROTEIN
Serving size: 7.1 oz / 200 g
Protein: 22 g
Calories: 200 kcal

1 PLATE LENTILS
Serving size: 8.8 oz / 250 g
Protein: 19 g
Calories: 270 kcal

1 CAN CHICKPEAS
Serving size: 8.1 oz / 230 g
Protein: 17 g
Calories: 280 kcal

2.5 SERVINGS EDAMAME BEANS
Serving size: 7.1 oz / 200 g
Protein: 22 g
Calories: 280 kcal

1 CAN BLACK BEANS
Serving size: 14.1 oz / 400 g
Protein: 18 g
Calories: 260 kcal

Table 21

Common sources of protein providing approximately 20g. Please note these values are estimates and food/beverage packaging can be reviewed to evaluate actual nutritional content.

PROTEIN TIMELINE

NAME: ______________________ DATE: ______________

TYPE OF DAY (E.G. TRAINING DAY): ______________________

Three T's should be taken into account when evaluating protein intake: 'Total' amount, 'Timing' of intake, and 'Type' of protein consumed. To evaluate intake, the athlete can record a daily training or competition schedule on the 'Exercise Schedule' timeline and their daily protein consumption on the 'Current Protein Consumption' timeline. The nutritionist can then evaluate intake against the athlete's requirements, and present an optimized protein consumption plan on the 'Recommended Protein Intake' timeline. For information, to optimize protein synthesis for repair and adaptation, protein consumption is recommended at 15 – 20g every 3 – 5 hours (Thomas, et al., 2016).

CURRENT EXERCISE SCHEDULE

WAKE UP ———————————————— SLEEP

CURRENT PROTEIN INTAKE

WAKE UP ———————————————— SLEEP

RECOMMENDED PROTEIN INTAKE

WAKE UP ———————————————— SLEEP

REHYDRATE – FLUIDS

Athlete's bodies are approximately 60 – 70% water. Large volumes of body water can be lost as athletes sweat during exercise. Body water losses equivalent to, or more than, 2% of an athlete's pre-exercise body mass can have detrimental effects on both health and performance. This is known as hypohydration, commonly referred to as dehydration. Dehydration has been shown to affect both mental, and physical performance, whilst contributing to fatigue. Thus, it is important for athletes to rehydrate post-exercise. This helps replace fluid and electrolytes lost in sweat, and reduces the risk of starting the next bout of exercise in a dehydrated state, which can impair performance (Sawka, et al., 2015).

Post-exercise, athletes should aim to drink fluid equivalent to 120% - 150% of body mass lost during exercise (i.e. 1.2 – 1.5L of fluid per kg lost during exercise) (Shirreffs & Sawka, 2011). Figures 21 and 22 provides calculations that can be used to work out post-exercise fluid requirements in metric and imperial measures respectively. A change in body mass of 1kg is the equivalent of 1 litre of fluid loss (a change of 1lb is equivalent to 16 fl oz of fluid loss). Measurement conversion tables can be found in the Appendix (Pages 75 - 77).

Figure 21

Calculation for post-exercise fluid recommendations (metric)

FLUID:

Body mass loss = Pre-exercise body mass _________kg – Post-exercise body mass _________kg = [   ] kg

FLUID NEEDS:

___________ kg body mass lost * 1.2 = [   ] L TO ___________ kg body mass lost * 1.5 = [   ] L

FLUID:

Body mass loss = Pre-exercise body mass _________ lb – Post-exercise body mass _________ lb = [   ] lb

FLUID NEEDS:

___________ lb body mass lost * 20 = [   ] fl oz TO ___________ lb body mass lost * 24 = [   ] fl oz

Figure 22

Calculation for post-exercise fluid recommendations (imperial)

In addition, beverages containing sodium (~20 to 50mmol/L) enhance beverage palatability and stimulate thirst, whilst supporting rehydration due to sodium's impact on fluid retention and plasma volume restoration (Heaton, et al., 2017). As such, beverages containing 20 to 50 mmol sodium per litre, that are also chilled, flavoured and sweetened (factors contributing to beverage palatability and voluntary fluid intake) are recommended to support recovery from exercise (Heaton, et al., 2017). A detailed review of the fluid replacement process has been shared by Baker (2023).

For more information on hydration, including tools to support the monitoring of an athlete's hydration status, see the 'Hydration' section of the GSSI Sports Nutrition Toolkit.

ADDITIONAL NUTRIENTS

An overview of nutrients that may support physiological recovery are highlighted in Table 22 (Heaton, et al., 2017). In addition to these nutrients, it is important that athletes meet recommended daily intakes of all micronutrients. Though there may be a particular focus on the B vitamins, vitamin C, iron, magnesium, and zinc as deficiencies may lead to mental and physical fatigue (Tardy, et al., 2020). Iron is a common nutritional deficiency in athletes, especially in female athletes (McKay, et al., 2023). A guide on identification and treatment of iron deficiency can be found in the GSSI SSE Article #239 (Peeling, et al., 2023).

Anti-oxidants and nutrients that can reduce inflammation are listed in the table below. During exercise, oxidative stress and inflammation occur. However, too much oxidative stress and inflammation may impair recovery. As such, using nutrients strategically to reduce oxidative stress and inflammation may be beneficial. Conversely, high doses of antioxidants can blunt adaptations (Baar, 2014). Thus, chronic high, or poorly timed, antioxidant supplementation is not recommended.

Monitoring athletes' nutritional status, and/or intake can be helpful to understand if the diet needs to be modified, or supplements provided, to aid the recovery process. The GSSI Sports Nutrition Toolkit provides guidance on the use of dietary analysis methods. Pages 25 - 29 of this Toolkit provide guidance on the analysis of bloods; processes which can be adapted to monitor different nutritional biomarkers to assess athletes' nutritional status. Blood based, nutritional biomarkers can be compared to reference ranges found in the literature (e.g. Peeling, et al. (2023)).

Whilst a food first approach to recovery is preferential, it is acknowledged that supplementation may be useful in particular circumstances. Further details on supplement use, including decision trees to help identify appropriate supplements, can be found in the 'Dietary Supplements' section of the GSSI Sports Nutrition Toolkit. Blackhouse, 2023, provides advice to reduce the risk of inadvertent anti-doping rule violations from supplement use.

NUTRIENT	DOSAGE	BEST SOURCES	BENEFITS	STRENGTH OF EVIDENCE*
Creatine Monohydrate	20 g/day for 5 days followed by 3–5 g/day to increase and maintain elevated muscle creatine. OR 3–5 g/day for about 30 days to increase muscle creatine	Meat, poultry, fish	Support training adaptations and recovery via increased expression of growth factors, reduced inflammation, and enhanced glycogen resynthesis	Good
n-3 PUFA	~3 g/day of EPA/DHA	Cold water fatty fish (tuna, salmon), fish oils, krill oil	Reduce inflammation Support immune function Support muscle repair and remodelling when protein intake is insufficient	Fair
Vitamin D	RDA (adults) 600 IU/day. Vitamin D status (blood 25OHD) 20–50 ng/L	Sunlight, supplements, fortified foods, fatty fish, egg yolk	Support muscle repair and recovery	Fair
Antioxidants	Individual antioxidant supplementation is not recommended. Aim to consume a balanced diet containing a variety of fruits and vegetables	Whole fruits and vegetables and 100% fruit and vegetable juices. Montgomery cherry juice, or concentrate providing 600 mg polyphenols (Botwell, et al., 2019)	Reduce inflammation	Fair
Gelatine/collagen + vitamin C	≥15 g of collagen hydrolysate with ≥50 mg of vitamin C delivered 1 h before training	Gelatin, vitamin C-rich foods (e.g., oranges, raspberries, grapefruit), dietary supplements	Promote collagen synthesis	Fair
Curcumin	Dose dependent on bioavailability 0.4–5 g/day	Turmeric, dietary supplement	Reduce inflammation	Limited
Bromelain	900–1000 mg/day	Pineapple, dietary supplements	Reduce inflammation	Limited

Table 22

Micronutrients and supplements dosage, sources, and benefits. Adapted from Heaton et al. (2017). DHA = docosahexaenoic acid, EPA = eicosapentaenoic acid, n-3 PUFA = omega-3 polyunsaturated fatty acids, RDA = recommended dietary allowance, 25OHD = 25-hydroxyvitamin D.
***Strength of evidence conclusion statements are assigned a grade by the authors based on the systematic analysis and evaluation of the supporting research evidence. Grade I = good; grade II = fair; grade III = limited; grade IV = expert opinion only; and grade V = not assignable (because there is no evidence to support or refute the conclusion). See grade definitions at http://www.andevidencelibrary.com/**

Figure 23

Examples of recovery meals

RECOVERY FOODS AND BEVERAGES

This section provides examples of recovery meals and suggestions on how to build a recovery smoothie (Figures 23 and 24 respectively)

PASTA WITH SAUCE

Carbohydrate: Pasta

Protein: Meat in the sauce e.g., beef mince or chicken

RICE/NOODLE BASED STIR FRY

Carbohydrate: Rice/noodles

Protein: Meat, tofu or fish in the stir fry

JACKET POTATOES WITH FILLING

Carbohydrate: Potato

Protein: Filling e.g., tuna, beans, chicken

BAGEL WITH FILLING

Carbohydrate: Bread

Protein: Filling e.g., lean meat, egg, tuna

TACOS

Carbohydrate: Taco and rice (side)

Protein: Meat, fish, tofu, beans

OATMEAL

Carbohydrate: Oats and fruit

Protein: Milk and yogurt

VEGETABLE CHILLI WITH RICE

Carbohydrate: Rice

Protein: Mixed beans and pulses

RECOVERY SMOOTHIES

Mix and match the ingredients to create a smoothie which contains carbohydrate, protein and fluid to support post-exercise recovery.

PROTEIN

- Protein powder
- Milk powder
- Yoghurt

CARBOHYDRATE

- Fruits: Banana, apple, mango, pineapple, orange, strawberry, cherries, blueberries
- Honey
- Frozen fruit
- Dried fruits

FLUID BASE

- Water
- Fruit juices (adds carbohydrate)
- Milk (adds protein)
- Soy milk (adds protein)
- Almond milk
- Oat milk

Figure 24

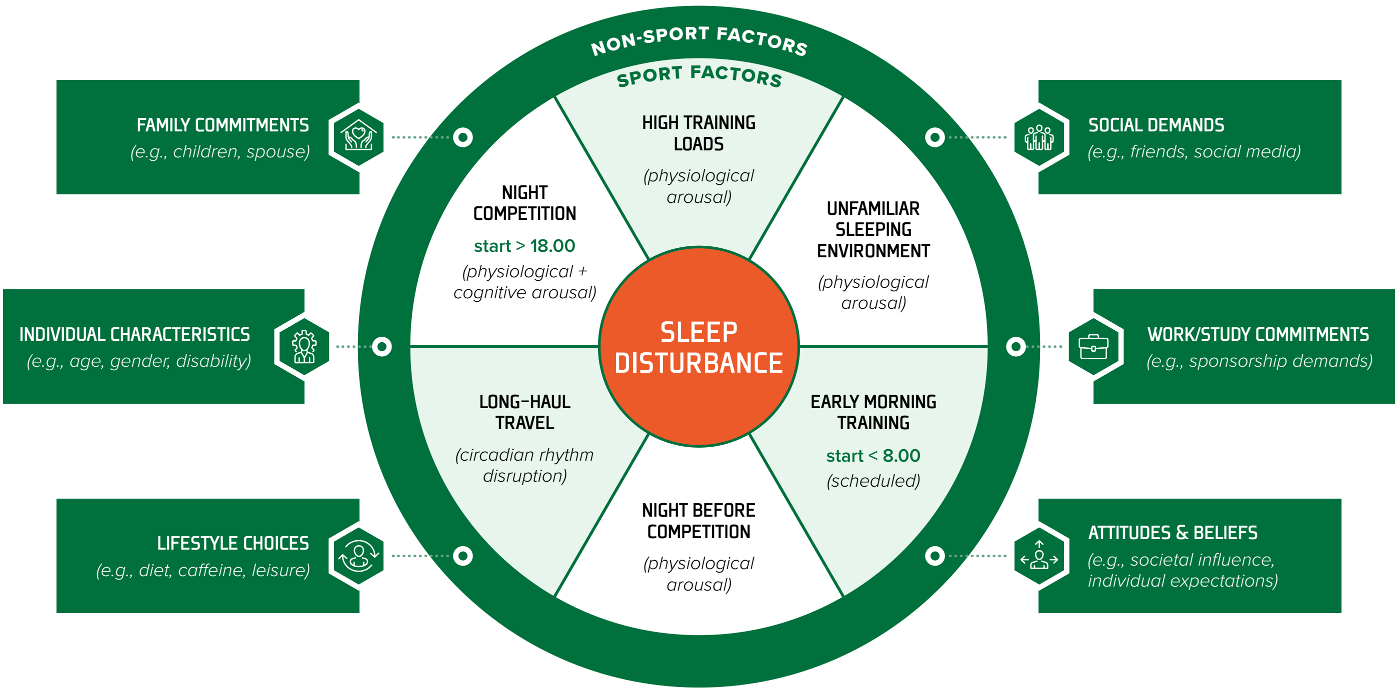
Example of how to build a recovery smoothie

Figure 25

Examples of contributory factors for sleep disturbance in athletes.
Adapted from Walsh, et al., (2020).

SLEEP

Sleep is an essential element of the recovery process, allowing athletes to recover from the mental and physical demands of sport (Halson, 2014; Kölling, et al., 2019; Lambing & Bender, 2023). Inadequate sleep can lead to mood disturbances and impaired performance, decision-making ability, learning and cognition and immune function (Halson, 2016). However, there are many challenges with sleep in athletes. Some of these are highlighted in Figure 25.



Athletes require 7 – 9 hours of sleep per night (Hirshkowitz, et al., 2015). However, a one-size-fits-all approach for sleep recommendations is not ideal; instead, an individualised approach is recommended given the impact of training load and competition stress on sleep (Walsh, et al., 2020).

To improve sleep quantity and quality in athletes, a number of practical actions can be considered. Figure 26 highlights the top five practical recommendations to improve sleep in athletes. Table 23 provides a checklist of actions that can help to guide conversations with athletes, and allows sleep strategies to be developed/reviewed.

Figure 26

Top five practical recommendations to improve sleep in athletes.
Adapted from Lambing & Bender (2023).

CONSIDERATION FOR A GOOD NIGHT'S SLEEP	YES/NO*	COMMENTS
Can training load be reduced? *(If relevant and feasible)*		
Can early morning training sessions be avoided? *(If relevant and feasible)*		
Has the athlete been provided with education on sleep? *(Including quantity, quality, timing, and sleep preparation; frequent check-ins are suggested to reinforce benefits of sleep)*		
Has feedback been provided to the athlete in regard to their own sleep? *(Feedback should be individual, and provided in a simple, easy to read/comprehensive format, focusing on practical recommendations on how to improve sleep, to help reduce anxiety and thus subsequent sleep disturbances)*		
Is the athlete's bedroom cool? *(Temperatures between 16°C and 20°C or 60°F to 68°F)*		
Is the athlete's bedroom dark?		
Are additional sources of light (e.g. lamps, lights on TV screens) covered?		
Is external light blocked from coming through the athlete's window when in bed? *(e.g., through the use of blackout curtains)*		
Does the athlete use an eye mask? *(Also helpful when travelling)*		
Is the athlete's bedroom quiet?		
Does the athlete use earplugs? *(Also helpful when travelling)*		
Does the athlete have a pre-sleep routine that promotes relaxation? *(e.g., reading a hard copy of a book, creating to-do lists to help with racing thoughts, and no use of electronic devices)*		

Does the athlete take a warm bath or shower before bed?		
Does the athlete engage in stretching and deep breathing before bed?		
Does the athlete go to bed at the same time each night? *(Where possible)*		
Does the athlete wake up at the same time each morning? *(Where possible)*		
Does the athlete avoid evening exposure to bright / blue light? *(e.g. watching television / using their phone / computer in bed)*		
If it is not possible to avoid evening light, is the athlete using blue-light blocking glasses or screen covers to limit exposure?		
Does the athlete avoid caffeine 4 – 5 hours prior to sleep? *(Times may vary between individuals)*		
Does the athlete consume limited fluid pre-bed, avoiding the need to use the bathroom in the night?		
If the athlete naps, are naps between 20 and 90 minutes, and away from the bedtime period, i.e. early afternoon / before 7pm? *(Note naps longer than 30 minutes may lead to sleep inertia which may result in athletes taking ~30 minutes to recover post-nap)*		
If the athlete has an important event coming up, or knows they will face periods of sleep deprivation, can they 'bank' sleep in advance?		
Has the athlete's diet be optimised to support sleep? *(If answering 'No' – See 'Nutrition for Sleep' section on page 56)*		
Does the athlete have a strategy to help cope with Jet lag when travelling? *(If answering 'No' – See 'Travel and Sleep' section on page 56)*		

Table 23

Checklist of actions to support the development / review of sleep strategies with athletes (Halson, 2013; Kölling, et al., 2019; Halson, 2019; Walsh, et al., 2020; Lambing & Bender, 2023; Bender & Lambing, 2023). *Answering questions with a 'Yes' indicates that appropriate considerations to support sleep have been accounted for. Not all answers need to be 'Yes', but any questions answered 'No' may provide opportunities to adapt sleep strategies to improve sleep.

NUTRITION FOR SLEEP

Good nutrition cannot replace a good night's sleep. However, nutritional interventions may be helpful to influence sleep (Halson, 2014). A list of practical recommendations to support sleep, through nutrition, can be found in Table 24. It is important to note that evidence to substantiate these recommendations are minimal, and inconclusive. For additional guidance on supporting an athlete with changes to their diet, see the GSSI Sports Nutrition Toolkit.

PRACTICAL RECOMMENDATIONS				
High GI foods such as white rice, pasta, bread, and potatoes may promote sleep; however, they should be consumed > 1 h before bedtime.	Diets high in carbohydrate may result in shorter sleep latencies (time taken to fall asleep).	Small doses of tryptophan (1 g) may improve both sleep latency and sleep quality. This is the equivalent of approximately 300 g of turkey or 200 g of pumpkin seeds.	Diets high in fat may negatively influence total sleep time.	Magnesium may also play a role in sleep, with supplementation benefiting symptoms of insomnia.
Alcohol can disturb both sleep quantity, and quality.	Caffeine can impact sleep by increasing sleep latency and reducing sleep efficiency and duration. Sources of caffeine include, but are not limited to, coffee, tea, caffeinated sodas and chocolate.	Diets high in protein may result in improved sleep quality.	The hormone melatonin, and foods that have a high melatonin concentration, may decrease sleep onset time. Tart cherry juice can impact melatonin secretion.	When total caloric intake is decreased, sleep quality may be disturbed.

TRAVEL AND SLEEP

Training and competing often require both short and long term travel. This can result in travel fatigue. If travels result in jet lag, there may also be disturbances to the body's 24-hour circadian rhythm which prepares the body for night time sleeping and waking up in the morning. Both travel fatigue and jet lag may impact subsequent performance and recovery (Kölling, et al., 2018; Walsh et al., 2020; Janse van Rensburg, et al., 2021). A review and consensus statement on monitoring travel fatigue and jet lag in athletes (Janse van Rensburg, et al., 2021) provides detailed information to help manage and prevent/reduce the effect of travel fatigue and jet lag.

TRAINING ADJUSTMENT AND REST

Training provides the body with a repeated stimulus, to which it can adapt over time to improve exercise capacity and performance (Hargreaves & Hawley, 2003). Allowing athletes to experience a level of stress, causing fatigue, overload, and/or overreaching, followed by a period of rest, is essential to drive adaptation, therefore enhance performance over time (Meeusen, et al., 2013; Thorpe, 2021). In addition, training allows athletes time to learn and master new moves, skills, and/or tactics in preparation for competition.

Exercise demands will depend on the goals of the individual training sessions, and the demands of competition within a period of time. That is, exercise demands may be high in pre-season to promote adaptations, and high during congested fixture periods, but might be lower during periods of tactical training sessions.

A build-up of intensified training, without adequate recovery may result in non-functional overreaching, and/or prolonged decrements in performance, and symptoms of maladaptation, as well as an increase in perceived mental and physical fatigue (Meeusen, et al., 2013; Kellmann, et al., 2018). In turn, this can also result in sleep disturbances, which is known to further impact both recovery and performance (Walsh, et al., 2020). As such, it is important for athletes to balance stress (from exercise and life demands, and the resultant fatigue)

Table 24 ▲

Potential practical recommendations to support sleep quality and quantity (Vella, et al., 2010; Halson., 2014; Lambing, et al., 2022).

with recovery to support adaptations and performance (Kellmann, et al., 2018). Training load can be adjusted to help balance stress and fatigue proactively, or reactively in response to athlete monitoring.

Adequate rest is one of the simplest methods to reduce stress and fatigue from training, and/or manage symptoms. It is suggested that athletes have at least one day of passive rest per week, especially during periods of intensified training. Rest days may also allow distractions from competition, and thus reduced psychological stress (Meeusen, et al., 2013).

In addition to rest, training load should be individualised (increased or decreased) to manage fatigue depending on the specific athlete's response to training (Budgett, 1998; Meeusen, et al., 2012). In team sport environments, training load (volume, intensity, or frequency), can be adjusted regularly (periodised) depending on the phase of the training cycle and demands of competition (Halson, 2014).

Return to play strategies for athletes who have had a period of time off as a result of inadequate recovery should be individualised on the basis of signs and symptoms, given there is no definitive indicator of recovery (Meeusen, et al., 2013).

PSYCHOLOGICAL RECOVERY

Mental fatigue is defined as a psychobiological state that arises during prolonged demanding cognitive activity and results in an acute feeling of tiredness and/or a decreased cognitive ability as well as mood changes. Mental fatigue can reduce physical capacity, assessed through reduced time to exhaustion and elevated rating of perceived exertion (RPE) and has been shown to fluctuate throughout a competitive season (Van Cutsem, et al., 2017; Russell, et al., 2021).

Rest and breaks from training can also provide additional opportunities for psychological recovery. This recovery may be proactive, and may help athletes increase their capacity to cope with the stresses of training and competition (Driller & Leabeater, 2023). These recovery strategies are typically determined by the individual athlete, to suit their individual needs, but should be encouraged by members of the sports performance team. Examples of such strategies are listed in Figure 27. Further research is required to understand best-practice management strategies (Russell, et al., 2023). The sports psychologist within the performance team can be consulted to help support psychological recovery.

Figure 27

Examples of strategies to support psychological recovery (Kenttä & Hassmén, 1998; Loch, et al., 2019; Driller & Leabeater, 2023; Russell, et al., 2023).

ADDITIONAL MODALITIES

Nutrition, sleep, training adjustment and rest, form the foundations and centre of the recovery pyramid (Figure 19). At the top of the pyramid, sits additional recovery modalities. These may be considered to help support athletes' recovery once best practices for nutrition, sleep, and training adjustment and rest have been implemented. These additional modalities include different forms of water immersion, compression, massage and more.

This section of the toolkit aims to provide an overview of the latest science, covering common recovery modalities, and acts as a guide, rather than specific recommendations. It is out of scope to provide a full review of all recovery modalities, though reviews can be found elsewhere (Halson, 2013; Driller & Leabeater, 2023). In some cases, combinations of recovery modalities may be better than the use of single recovery modalities, though it is not in the scope of this toolkit to review potential combinations.

Pages 59 - 65 provide infographics with overviews of potential protocols, mechanisms and benefits of common recovery modalities. Much is unknown about many of the recovery modalities, thus more research is required to confirm the details shared. In addition, more research is required to understand chronic use of these recovery modalities, and their potential effect on physiological adaptations (Driller & Leabeater, 2023). However, this is not discussed in this Toolkit.

When reviewing the following pages, it is important to consider that there are variations in physiological and psychological stressors that occur during exercise. These variations may occur for a number of different reasons, including the mode of exercise, and level of training. In addition, recovery modalities may impact individuals in different ways. For example, some recovery modalities may impact well-trained athletes to a different level, compared to individuals who have less training. As such, there is no one-size-fits-all approach to recovery.

Information gained from the athlete monitoring process can first be reviewed, in combination with knowledge of cause(s) of fatigue, to understand the specific recovery needs of athletes. For example, do athletes need to recover from muscle soreness, or something else? Once this has been established, the infographics on the following pages can be used as a starting point, to help identify suitable recovery modalities. From here, the literature can be reviewed specific to an athlete's sport, or mode of fatigue. This is because each recovery modality may have different protocols, suitable for different sports, depending on the mode of fatigue. As an example, Basketball specific recovery modalities can be found in the GSSI Basketball Nutrition book. The information on the following pages should be reviewed alongside considerations in Table 15, to help build a recovery strategy.

Wilcock, et al., 2006; Versey, et al., 2013; Stephens, et al., 2017; Tipton, et al., 2017; Dupuy, et al., 2018; Davis, et al., 2022; Moore, et al., 2022; Moore, et al., 2023

COLD WATER IMMERSION (CWI)

POTENTIAL PROTOCOL

Temp	Duration	Depth	Passive or Active	Timing
10°C to 15°C	5 to 15 mins	Unknown. Typically whole body minus head and neck. Minimum depth likely waist height.	Unknown. Typically passive.	Proximity to exercise unknown. Typically within 30 minutes post-exercise or the following day.

POTENTIAL MECHANISMS

Cold water immersion may impact recovery due to the effects of hydrostatic pressure and cold water, which may:

- Impact cardiac output, peripheral resistance and blood flow
- Lower skin, muscle and core temperature
- Reduce nerve conduction velocity
- Provide an analgesic effect

Which in turn, may help:

- Reduce inflammation
- Reduce formation of oedema
- Reduce secondary muscle damage
- Reduce muscle spasm
- Reduce feelings of pain

POTENTIAL BENEFITS

- Reduced perception of muscle soreness
- Increased perception of recovery
- Reduced perception of fatigue
- Recovery of power performance

PRACTICAL TIPS / ADVICE

If passive, could combine with recovery nutrition practices.

Could combine with active recovery, if practical.

Athletes / practitioners could create their own CWI where other means are not available. For example, adding 10 – 20lb (5 – 10kg) bags of ice to hotel baths / inflatable tubs.

Targeted cooling may be an alternative option (e.g. application of an ice pack or cooling devices).

Water immersion alone (independent of temperature) may support recovery due to the impact of hydrostatic pressure, and may be an alternative when CWI is not appropriate.

Athletes should be supervised at all times when immersed in water.

CONTRAST WATER THERAPY (CWT)

POTENTIAL PROTOCOL

Temp	Duration	Depth	Passive or Active	Timing
10°C to 15°C and ~36°C to 38°C Unknown if CWT should end with HWI or CWI.	Alternating 1 minute immersions / showers, for up to 15 minutes.	Unknown. Studies reporting benefits typically immerse whole body minus head and neck.	Unknown.	Proximity to exercise unknown.

POTENTIAL MECHANISMS

Contrast water therapy may result in:

- Vascular pumping / squeezing (vaso-pumping). This is alternating vasoconstriction and vasodilation, as a result of differing temperatures
- Increased blood flow

Which in turn, may help:

- Increase clearance of metabolic waste
- Reduce inflammation
- Reduce formation of oedema
- Reduce muscle spasm
- Reduce stiffness and pain
- Increase range of motion

POTENTIAL BENEFITS

- Reduced perception of muscle soreness
- Recovery of strength performance
- Recovery of power performance

PRACTICAL TIPS / ADVICE

If passive, could combine with recovery nutrition, e.g. shakes. Though this may be more challenging as a result of movement between hot and cold pools / showers.

CWT may be a time effective recovery modality for larger teams, with athletes split between hot and cold pools

Athletes should be supervised at all times when immersed in water.

Myrer, 1994; Wilcock, et al., 2006; Bieuzen, et al., 2013; Versey, et al., 2013; Juliff, et al., 2014; Dupuy, et al., 2018

Banfi, et al., 2010; Dupuy, et al., 2018; Lombardi, et al., 2017; Rose, et al., 2017; Bouzigon, et al., 2021

WHOLE-BODY CRYOTHERAPY

POTENTIAL PROTOCOL

Temp
-110°C to -140°C

Duration
60 seconds at -60°C followed by two to three minutes at -110°C to -140°C.

Timing
Immediately post-exercise and in the two to three days post-exercise.

POTENTIAL MECHANISMS

Whole-body cryotherapy may:

- Induce peripheral vasoconstriction
- Stimulate autonomic nervous parasympathetic system and increase noradrenaline
- Increase muscle oxygenation
- Provide an analgesic effect

Which in turn, may help:

- Reduce inflammation
- Reduce secondary muscle damage
- Reduce feelings of pain

POTENTIAL BENEFITS

Evidence on the efficacy of whole-body cryotherapy is inconsistent. Some of the evidence suggests potential benefits for:

- Reduced perception of muscle soreness
- Reduced perception of pain

PRACTICAL TIPS / ADVICE

Athletes should be dry, and wearing minimal/safety clothing (i.e. bathing suits, shoes/socks, masks, gloves and or hats) when inside a cryotherapy chamber.

Should only be used in the presence of a trained professional.

Athletes with differing body fat percentages may respond differently to the treatment.

Cryotherapy may help with sleep, however more research is required.

ACTIVE RECOVERY

POTENTIAL PROTOCOL

Type/Intensity
Low to moderate intensity, aerobic exercise. Should not result in substantial additional fatigue.

Target muscle
Likely beneficial to incorporate the same muscles that have been fatigued / damaged.

Duration
Unknown, however 6 – 10 minutes has shown benefits.

Timing
Proximity to exercise unknown. Typically within 1 hour post-exercise.

POTENTIAL MECHANISMS

Active recovery may:

- Increase blood flow to exercised area
- Increase oxygen delivery and oxidation to exercised area
- Decrease blood pooling in the limbs
- Help restore heart rate to normal activity

Which in turn, may help:

- Increase clearance of lactate from blood*
- Increase clearance of additional metabolic waste

**The practical relevance of blood lactate clearance in recovery is questionable*

POTENTIAL BENEFITS

Evidence on the efficacy of active recovery is inconsistent, with the majority of the evidence suggesting no effect on recovery of performance. However, active recovery may support:

- Reduced perception of muscle soreness
- Increased perception of recovery

PRACTICAL TIPS / ADVICE

Could combine with mobility sessions.

Active recovery may be used to support relaxation, and provide opportunities to socialise and reflect on training or competition.

Halson, 2014; Mika, et al., 2016; Dupuy, et al., 2018; van Hooren & Peake, 2018; Ortiz Jr, et al., 2019

Weerapong, et al., 2005; Halson, 2014; Poppendieck, et al., 2016; Dupuy, et al., 2018

MASSAGE

POTENTIAL PROTOCOL

Duration
Unknown. 5 – 12 minutes may be helpful for short-term recovery.

Massage Type
Unknown. Typically targets fatigued muscle.

Timing
Proximity to exercise is unknown. Massage immediately post exercise has shown benefits.

POTENTIAL MECHANISMS

Massage may:

- Decrease tissue adhesion
- Increase muscle compliance
- Increase blood flow
- Alter release of hormones
- Reduce muscle tension

Which in turn, may help:

- Decrease muscle-tendon stiffness
- Increase range of motion
- Reduce pain
- Increase relaxation
- Reduce inflammation
- Reduce swelling and muscle spasm

POTENTIAL BENEFITS

To date, evidence does not suggest massage supports recovery of performance. However, some benefits of massage may include:

- Reduced perception of muscle soreness
- Reduced perception of fatigue

PRACTICAL TIPS / ADVICE

May support relaxation, and could be used in combination with other methods to support psychological recovery e.g. listening to music, or mindfulness.

MYOFASCIAL RELEASE
(E.G. FOAM ROLLING, MASSAGE BALLS)

POTENTIAL PROTOCOL

Duration
90 - 120 seconds per muscle group. Less than 45 seconds appears to be inadequate.

Type of roller
Unknown.

Amount of force
Bodyweight, or up to 50% of maximum discomfort.

Timing
Proximity to exercise is unknown.

POTENTIAL MECHANISMS

Myofascial release involves direct and sweeping pressure on soft tissue, which may:

- Increase blood flow
- Reduce arterial stiffness
- Reduce muscle tension
- Effect pain-modulating mechanisms such as the diffuse noxious inhibitory control

Which in turn, may help:

- Increase clearance of metabolic waste
- Reduce formation of oedema
- Reduce inflammation
- Improve tissue repair
- Increase range of movement
- Support an analgesic effect

POTENTIAL BENEFITS

- Reduced perception of muscle soreness
- Reduced perception of pain
- Recovery of sprint performance
- Recovery of strength performance

PRACTICAL TIPS / ADVICE

Can be easily added into daily routine.

Not time intensive.

Massage devices can easily be transported when travelling.

Could be used in combination with other methods to support psychological recovery, e.g. listening to music.

Hughes & Ramer, 2019; Wiewelhove, et al., 2019; Hendricks, et al., 2020; Ferreira, et al., 2022

Watanuki & Murata, 1994; Kraemer, et al., 2001; Halson, 2014; Brown, et al., 2017; Dupuy, et al., 2018; Hill, et al., 2017; Davis, et al., 2022; Weakley, et al., 2022

COMPRESSION GARMENTS

POTENTIAL PROTOCOL

Garment pressure
Likely ≥14 - 15mmHg, with graded compression to the limbs from proximal to distal.

Target area
Entire limb which has been used in prior exercise.

Duration
As long as comfortable, but should not let garments compromise sleep.

Timing
Proximity to exercise is unknown. Likely as soon as possible post-exercise.

POTENTIAL MECHANISMS

Mechanical pressure from the use of compression garments may:

- Increase blood flow
- Enhance venous return
- Reduce intramuscular space available for swelling

Which in turn, may help:

- Reduce swelling / formation of oedema
- Reduce delivery time of oxygen and nutrients to working muscles
- Increase clearance of metabolic waste

POTENTIAL BENEFITS

The majority of evidence suggests that compression garments have no impact on recovery of performance. However, there may be benefits for:

- Reduced perception of muscle soreness
- Reduced perception of muscle pain
- Reduced perception of fatigue

PRACTICAL TIPS / ADVICE

May be a helpful passive recovery modality for use when travelling post-training/competition, especially on long-haul flights.

Could be used in combination with other methods to support psychological recovery e.g. listening to music, or mindfulness.

STRETCHING

POTENTIAL PROTOCOL

Type of movement
Dynamic and pain free, and should not elicit discomfort and pain.

Duration
≥ 60 seconds per muscle group.

Timing
Proximity to exercise is unknown.

POTENTIAL MECHANISMS

Stretching may:

- Increase 'stretch tolerance'
- Reduce tendon and muscle stiffness

Which in turn, may help:

- Improve range of movement

POTENTIAL BENEFITS

Whilst some individual studies have reported positive benefits of post-exercise stretching, to date, several reviews have concluded that there is not sufficient evidence to conclude benefits for performance or reduced perception of muscle soreness.

PRACTICAL TIPS / ADVICE

Suggest focusing on areas that are tight, but not painful.

Taking time to stretch also allows time for mindfulness and breathing exercising to facilitate mental recovery.

Easy to adopt and not dependent on equipment.

Sands, et al., 2013; Halson, 2014; Dupuy, et al., 2018; American College of Sports Medicine, 2018; van Hooren & Peake, 2018; Afonso, et al., 2021

SIGNIFICANTLY MORE RESEARCH IS REQUIRED

The recovery modalities discussed next require significantly more research. Literature on these modalities is limited, with few meta-analyses or systematic reviews completed (Driller & Leabeater, 2023). The information provided should be reviewed with caution, given the limited literature to date.

There is very little data in athletes to support the use of saunas on recovery, and the available data suggests their use could impair factors of recovery, thus it has not been discussed here, though there may be potential to support relaxation (Driller & Leabeater, 2023).

HOT WATER IMMERSION (HWI)

POTENTIAL PROTOCOL

Temp	Duration	Depth	Passive or Active	Timing
Approximately 36°C to 38°C	Unknown. Studies reporting benefits have ranged from 14 – 24 minutes.	Unknown. Typically whole body minus head and neck.	Unknown. Typically passive.	Proximity to exercise unknown, but avoid using if body temperature is elevated.

POTENTIAL MECHANISMS

Hot water immersion may result in:

- Vasodilation
- Increased blood flow
- Increased skin, muscle and core temperature
- Eased muscle tension

Which in turn, may help:

- Reduce delivery time of oxygen and nutrients to working muscles
- Increase clearance of metabolic waste

POTENTIAL BENEFITS

Few studies have investigated the use of HWI on recovery to date, with inconsistent results. Whilst significantly more evidence is required, some of the evidence suggests potential for the following benefits:

- Recovery of jump power performance*
- Recovery of isometric squat force

**In combination with underwater jet-massage*

PRACTICAL TIPS / ADVICE

If passive, could combine with recovery nutrition practices – Ensure provision of sufficient fluid, given the higher temperatures.

A warm bath can aid relaxation, and before bed can aid sleep.

Water immersion alone (independent of temperature) may support recovery due to the impact of hydrostatic pressure, and may be an alternative when CWI is not appropriate.

Athletes should be supervised at all times when immersed in water.

▲ Viitasalo, et al., 1995; Kuligowski, et al., 1998; Wilcock, et al., 2006; Valie, et al., 2008; Versey, et al., 2013; McGorm, et al., 2018; Davis, et al., 2022; Jackman, et al., 2023

Cranston & Driller, 2022; Heapy, et al., 2018; Blumkaitis, et al., 2022

INTERMITTENT PNEUMATIC COMPRESSION (IPC)

(E.G. COMPRESSION BOOTS)

POTENTIAL PROTOCOL

Pressure
Unknown. Of studies reporting benefits, typically 80 – 110 mmHg is used.

Duration
Unknown. Of studies reporting benefits, typically 20 – 30 minutes.

Timing
Proximity to exercise unknown.

POTENTIAL MECHANISMS

Intermittent pneumatic compression may:

- Reduce area available for swelling
- Increase venous and lymphatic return
- Increase blood flow

Which in turn, may help:

- Formation of oedema

POTENTIAL BENEFITS

Few studies have investigated the use of IPC on recovery to date, with inconsistent results. Whilst significantly more evidence is required, some of the evidence suggests potential for the following benefits:

- Reduced perception of muscle soreness
- Reduced muscle fatigue
- Recovery of jump performance

PRACTICAL TIPS / ADVICE

Could be used in combination with other methods to support psychological recovery e.g. listening to music, or mindfulness.

PERCUSSIVE THERAPY

(E.G. MASSAGE GUNS)

POTENTIAL PROTOCOL

There is limited research to discuss potential protocols for the use of percussive therapy.

POTENTIAL MECHANISMS

The delivery of pressure/vibration/massage from Percussive Therapy may:

- Promote blood flow
- Reduce myofascial restriction and tension
- Break up myofascial trigger points

Which in turn, may help:

- Increase range of motion
- Alleviate pain

POTENTIAL BENEFITS

Few studies have investigated the use of percussive therapy for recovery to date, with inconsistent results. Whilst significantly more evidence is required, some of the evidence suggests potential for the following benefits:

- Reduced muscle stiffness
- Recovery of maximal voluntary contractions

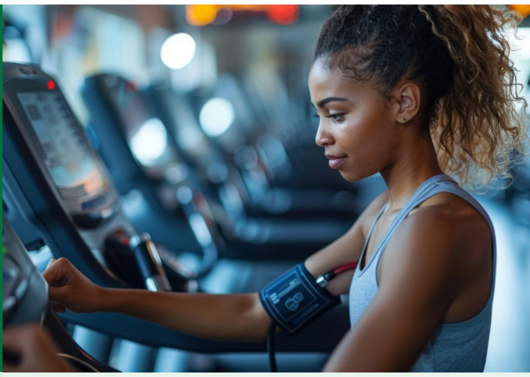
PRACTICAL TIPS / ADVICE

Athletes should seek advice from qualified professionals before incorporating into a recovery program.

García-Sillero, et al., 2021; Wang, et al., 2022; Ferreira, et al., 2023

Beaven, et al., 2012; Page, et al., 2017; Arriel, et al., 2018; Daab, et al., 2021; Ceylan, et al., 2023; Oliva-Lozano, et al., 2024

BLOOD FLOW RESTRICTION (BFR)



POTENTIAL PROTOCOL

There is limited research to discuss potential protocols for the use of blood flow restriction. Studies with potential benefits have used a variety of different protocols.

POTENTIAL MECHANISMS

BFR restricts arterial inflow and venous outflow (occlusion), before reperfusion which together may result in:

- Hypoxia in the muscle tissue
- Increased blood flow
- Elevated levels of adenosine and nitric oxide
- Vasodilation

Which in turn, may help:

- Reduce muscle damage
- Reduce muscle soreness

POTENTIAL BENEFITS

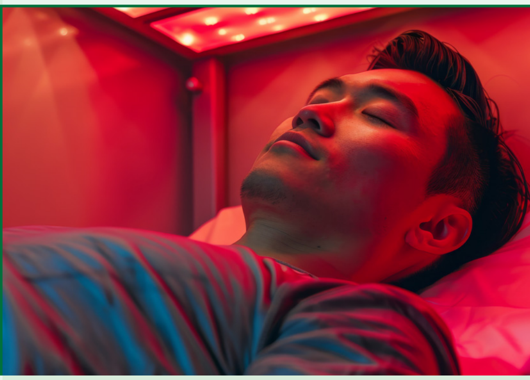
Few studies have investigated the use of BFR on recovery to date, with inconsistent results. Whilst significantly more evidence is required, some of the evidence suggests potential for the following benefits:

- Reduced perception of muscle soreness
- Recovery of jump performance
- Recovery of sprint performance
- Recovery of cycling performance (time to exhaustion)
- Recovery of maximal voluntary contractions

PRACTICAL TIPS / ADVICE

Athletes should seek advice from qualified professionals before incorporating into a recovery program.

FAR INFRARED (FIR) RADIATION



POTENTIAL PROTOCOL

There is limited research to discuss potential protocols for the use of far infrared radiation. Studies with potential benefits have used a variety of different devices and protocols.

POTENTIAL MECHANISMS

Far Infrared Radiation may:

- Be perceived by the body as radiant heat and absorbed by the body
- Have anti-inflammatory effects
- Help rejuvenate muscle-tendon unit issues
- Promote cerebral blood flow and enhance blood circulation

Which in turn, may help:

- Delay the appearance of muscle fatigue

However, these potential mechanisms are based off in vitro and animal studies

POTENTIAL BENEFITS

Few studies have investigated the use of FIR on recovery to date, with inconsistent results. Whilst significantly more evidence is required, some of the evidence suggests potential for the following benefits:

- Reduced perception of muscle soreness
- Recovery of jump performance
- Recovery of maximal voluntary contractions

PRACTICAL TIPS / ADVICE

No known interaction with Nutrition.

Mero, et al., 2015; Bontemps, et al., 2021; Hsieh, et al., 2022; Chen, et al., 2023)