Cross-training workouts: using high-intensity energy-system conditioning for injured athletes

By Dan Baker

Introduction

In professional field sports, and especially in collision sports such as rugby league and union, injuries are a somewhat common occurrence in competition and training.[8] The severity of injuries can vary considerably, but those that cause an athlete to miss competitive games are deemed most serious.[8] Other injuries may simply require a modification of training – for example, to reduce or eliminate inappropriate stress/overload for some short period (eg, one day to one week) or specified time (eg, during rehab from a certain injury such as an ACL repair).[8]

When injured athletes cannot train with their teams, they can – in the author's opinion – sometimes become emotionally distressed ... because their sense of self is often caught up with the perception of being a competitive or hard-training athlete. When long-term injured athletes are not competing and not training hard, then they may not see themselves as athletes any more – or they may feel confused about their identity or worth to the team or others. This can lead to problems in their personal lives. Therefore, having injured athletes perform very hard training is not only essential for the athletes' successful return to sport as early as possible, but also for their emotional state of mind.

With that in mind, it is essential that injured athletes continue, develop or maintain high levels of energy system conditioning (aerobic and anaerobic) when they are injured – and that is a position taken by myself, my fellow strength and conditioning coaches, the physiotherapists, assistant coaches and, – most importantly – the head coach at my club. For athletes who cannot run (eg, with lower limb soft tissue injuries, broken lower limbs) or who cannot take contact during skill/tactical training (eg, upper body soft tissue injuries or broken limbs), this high level of conditioning is attained by using cross-training modalities such as rowing, cycling, boxing, wrestling, paddling, swimming and sometimes circuit training.

Dan Baker, PhD, is a S&C coach for the Brisbane Broncos rugby league team, a position he has held for over 17 years. He completed his Phd at Edith Cowan University, Perth, Australia, under Dr Rob Newton. He has over 34 peer-reviewed international publications concerning strength and power testing and training and as many again published in the ASCA's own journal. He is president of the Australian Strength & Conditioning Association (ASCA), an ASCA Level 3 S&C coach and an ASCA master coach of elite athlete S&C. His responsibilities include the development of strength and power for Broncos players, but also the development of energy system conditioning for injured players and contributing to the same for all other players.

'F troop' session on Saturdays

Also, during the preparation period, some athletes who have returned to training with inappropriate skinfold/bodyfat levels or who fail our high-intensity running test must also perform an extra session each week on a Saturday morning at 7am; all other players have the weekend off. Clearly, the timing of this session suggests this is a punishment session for failing to maintain professional levels of body composition and/or an appropriate level of high-intensity aerobic fitness during the off-season, as well as being an extra session to quickly bring those players to the levels of fatness or fitness that we deem appropriate. The name of this training group is 'F troop' (F for fitness or fatness). This workout is always a cross-training session to reduce the impact overload on the lower limbs, as these players have already spent four days of the week performing running for conditioning, skill and tactical training.

Therefore, cross-training workouts are performed by all injured athletes and athletes with modifications to running or collision/impact training year-round and during the preparation period. Additionally they are used by the less fit and less lean athletes as an extra session. We want injured players to return to play as quickly as possible in their normal competition, and play as many minutes as possible or even the full game. We do not progress injured top-line NRL players back through the second division to ease them back into competition – consequently they must be ready for top-line NRL intensity and impact when they return to competition.

General preparation phase

Table 1 depicts some of the general guidelines I use for '**general preparation phase**' high-intensity aerobic running conditioning, before progressing to more

Mode of training	Interval length & intensity (%MAS)	Recovery length, mode & intensity	Work:recovery	Considerations
Running	15-30 s @ 100-110%	15-30 s Active recovery @ 50-70%	1:1	Typically 15:15 x 10-20 reps = 5-10 mins x 2-4 sets
Running	10-30 s @ 120-130%	10-30 s Passive recovery	1:1	Typically 15:15 x 16-20 reps = 8-10 mins x 1-3 sets
Running	30 s @ 100%	15 s Passive recovery	2:1	Typically 30:15 x 6-12 reps =5-10 mins x 1-3 sets
Running	40 s @ 92.5 -100%	20 s Active recovery @ 50-70%	2:1	Typically 40:20 @ 92.5:65% x 5-10 reps = 5-10 mins x1-3 sets
Running	60-180 s @ 92.5-100%	60-180 s @ 40-60% MAS	1:1	Typically 4-6 min x 1-6 sets

Table 1. General guidelines for running training aimed at improving high-intensity energy-system conditioning (predominantly aerobic system) during the preparation period

sport-specific additions to the running drills (ie, impact/tackling, wrestling, getting off the ground, changing direction/shuttling).

The concepts and rationale for this type of training have been previously explained;[1] they are based on research regarding the effectiveness of training at the 'maximal aerobic speed' (MAS) or above.[2-7, 9] As cross-training is seen as a general fitness concept, the cross-training workouts will reflect these basic running conditioning guidelines. The sport-specific fitness components will be addressed when the athletes can run, change direction and take impact (ie, on full return to training), so we don't fret about being excessively 'sport-specific' with most cross-training work-outs.

Determination of 100% MAS

The determination of the high-intensity MAS is necessary for most of these work-outs. The options for running tests have been previously described.[1] As there is no universally-agreed field test across all training modalities,[7] I simply default to a five-minute all-out effort test in rowing, cycling, arm-grinding and paddling etc. This is because other researchers have shown that – on average – across different modes of exercise, the 100% MAS can be held for four to six minutes in well-trained athletes.[4, 7]

However, athletes often present with injuries during a session – or on short notice[8] – and training sets must then be calculated on the spot, despite not knowing an athlete's MAS on a number of cross-training modalities. It is therefore necessary to have default scores to use, which are based upon data from the hundreds of athletes I have trained over nearly two decades.

For example, if the rowing 100% MAS is not directly known, I default to 5 m/s for the 100% MAS for the 'average NRL player' (this assumes a 94-100 kg athlete can row 1500m in five minutes). For players lighter (<94 kg), heavier (100-105 kg) or the heaviest players (>106 kg) and for players with very high running MAS scores, the defaults are 4.9 m/s, 5.1 m/s and 5.2 m/s, respectively.

For acyclical modes of exercise where MAS cannot be calculated, such as grappling and punching/boxing, if necessary heart rate (HR) can be used to determine if the athlete is working to the level of difficulty that we expect. But we make most use of the rower, bike and grinder as the exact measures of distance and time inherent in the use of these ergometer pieces, which allows for an accountability of performance.

Description and rationale for various workouts

'F troop'

Table 2 depicts a simple programme that I use in the '**general preparation phase**' with F troop and injured athletes. This is performed at 7am on Saturday mornings by those athletes who have failed to meet our expectations of presenting as professional athletes (by failing to maintain a prescribed appropriate level of fitness/fatness or by failing to maintain an injury-free body during the off-season).

This 'F troop' workout is a classic manifestation of the 100%:70% MAS interval protocol, except that the intervals are 30 s long, rather than the typical 15 s used when we do the same type of workout when running.[1] I have found that when performing rowing and cycling ergometer conditioning, it is sometimes more effective to use these longer 30 s intervals when in earlier stages of the Preparation Period. This ergometry workout is used, as we want to de-load the lower body structures from weight-bearing (running), as we have already performed running conditioning and skills/tactics throughout the week. The continuous nature of the five-minute sets (albeit as 30 s hard, 30 s easier), with only a one-minute rest between, greatly affects the basic aerobic qualities, which is the appropriate stimulus for this stage of the training year. The athletes can start on any of the prescribed stations, but rotate through the session in the order as listed.

By prescribing cycling (lower body peripheral), grinding/punching (upper body peripheral) and rowing (whole body), we aim to stress not only the central heart/lung cardiovascular adaptations but also the peripheral adaptations within the musculature. The time spent exercising at > 100% MAS equals 15-minutes, although the HR actually stays elevated above 85% maximum for a much longer period.

'Harden up'

Table 3 depicts the 'Harden up' workout that is performed in the '**specific preparation phase**' and can

Mode of training	Set length	Work intervals	Recovery	Work:recovery	# of hard reps	Rest
Rowing	5 mins	30 s @ 100% MAS	30 s @ 60-70% MAS	1:1 Active recovery	5	1 min
Grinder	5 mins	30 s @ 100% MAS	30 s @ 60-70% MAS	1:1 Active recovery	5	1 min
Cycling	5 mins	30 s @ 100% MAS	30 s @ 60-70% MAS	1:1 Active recovery	5	1 min
Rowing	5 mins	30 s @ 100% MAS	30 s @ 60-70% MAS	1:1 Active recovery	5	1 min
Heavy bag punching or focus mitts	5 mins	30 s hard punching	30 s tempo punching	1:1 Active recovery	5	1 min
Cycling	5 mins	30 s @ 100% MAS	30 s @ 60-70% MAS	1:1 Active recovery	5	1 min

Table 2. Standard 'F Troop' Saturday morning workout = 36 mins

clearly be seen as a progression from the F Troop workout (17:40 mins spent > 100% MAS). By this stage of the training year, there are no athletes performing this training session for fatness reasons, but only for fitness or injury reasons, so intensity of efforts becomes an even greater concern. The sets are only 3:40 minutes, with a 1:20 minute recovery, but the working intensity of around 110% MAS for 20 s, even with a passive recovery of 20 s, is much harder to complete.

Clearly by exercising above the 100% MAS, the anaerobic system must be called into play to provide additional energy to attain the pacing demands of 110%. This workout also contains an element of contact conditioning with boxing sparring or grappling when the athletes are already in a deeply fatigued state – I deem the ability to absorb contact with an elevated breathing rate and heart rate at a pace above the 100% MAS as a critical aspect of 'hardening up' the body for the realities of a game of rugby league.

'Total annihilation'

This workout, depicted in Table 4, is one of my 'competitive period' (in-season) variations, all with a familiar theme. Typically, this will be used with athletes who have a long-term injury or who may have a transient injury that merely precludes them from the entirety of the field session (running conditioning plus skill/tactical) for a brief period. Whereas the previous two workouts were typified by a 1:1 work:rest or work:active recovery ratio, this workout entails varying

Mode of training	Set length	Work intervals	Rest or recovery	Work:rest	# of reps	Rest
Cycling	3:40 mins	20 s @ 105-110% MAS x 6	20 s Rest x 5	1:1 Passive rest	6	1:20 mins
Rowing	3:40 mins	20 s @ 105-110% MAS x 6	20 s Rest x 5	1:1 Passive rest	6	1:20 mins
Rowing	3:40 mins	20 s @ 105-110% MAS x 6	20 s Rest x 5	1:1 Passive rest	6	1:20 mins
Cycling	3:40 mins	20 s @ 105-110% MAS x 6	20 s Rest x 5	1:1 Passive rest	6	1:20 mins
Rowing	3:40 mins	20 s @ 105-110% MAS x 6	20 s Rest x 5	1:1 Passive rest	6	1:20 mins
Rowing	3:40 mins	20 s @ 105-110% MAS x 6	20 s Rest x 5	1:1 Passive rest	6	1:20 mins
Heavy bag punching	3:40 mins	20 s hard punching x 6	20 s Rest x 5	1:1 Passive rest	6	1:20 mins
Boxing sparring	3:40 mins	Full contact sparring, but only ~ 50% force to head	No rest during the set	NA	6	1:20 mins

Table 3. Saturday morning 'harden up' workout = 40 min

Mode of training	Set length	Work intervals	Rest or recovery	Work:rest	# of reps	Rest
Rowing	6 mins	20 s @ 105-110% MAS	20 s rest	1:1 Passive rest	9	2 mins
Heavy bag punching	4 mins	15 s hard punching	15 s rest	1:1 Passive rest	4	2 mins
Rowing	6 mins	30 s @ 100% MAS	15 s rest	2:1 Passive rest	8	2 mins
Heavy bag punching	4 mins	15 s hard punching	15 s rest	1:1 Passive rest	4	2 mins
Rowing	6 mins	45 s @ 93-100% MAS	15 s rest	3:1 Passive rest	6	2 mins
Heavy bag punching	4 mins	15 s hard punching	15 s rest	1:1 Passive rest	4	2 mins

Table 4. Total annihilation workout = 40-mins

work:rest ratios and varying work lengths.

The punching sections are maintained at 1:1 for 15 s intervals of work:rest (the rest is actually holding the heavy bag for the partner); however, the rowing sets of six minutes are much more difficult. The first rowing set is at 20:20, the second at 30:15 and the third at 45:15; the ratio of work:rest increases from 1:1 to 2:1 to 3:1. Although the prescribed intensity for the final 45:15 set is 93-100%, I want the athlete to be at 100% (or as close to it as possible); however, we have to accept that sometimes cumulative fatigue prevents them from attaining their 'non-fatigued state 100% MAS'. Nevertheless, 93% MAS is the lowest I will accept without prescribing penalty reps. The motto is: 'Do the intensity or do extras'. Accordingly, this workout with >17:30 mins > 100% MAS is deemed 'total annihilation'.

'Complete towel up'

This workout (Table 5) is another variation used in the competitive in-season period. It uses a little more variety, in that grappling and cycling are also utilised, but other than that it is essentially the same in method and difficulty as the previous one.

There are a number of other variations of these two in-season favourites, but the one constant we maintain are the three six-minute rowing sets with the increasing work:rest ratios to induce a high level of energy system fatigue and stress.

What we do manipulate, however, is whether the other sets include grappling, boxing, battling ropes, cycling, grinding, sport specific drills (tackling, shuttling etc) and so on, which itself is based upon the individuals injury status and how close they are to returning to play.

'Three-way energy system'

As the name suggests, this work-out stresses all three energy systems in a methodical order and can be performed rowing or cycling (Table 6), on next page. It is generally performed by long-term injured players, (eg, ACL rehab), and only on an irregular basis during the competitive period, and each of the three portions is performed immediately after the other, with no rest. The first ten-minute set stresses the anaerobic ATP-PC system with five x 10 s intervals with a complete active recovery (110 s) before morphing into the anaerobic lactic system workout. The lactic workout can be 20 s with 100 s active recovery (1:5) or even 30 s with 90 s active recovery (1:3). This is an extremely difficult portion of the workout.

Following this, the aerobic portion is similar to many workouts listed above, with 30 s at 100% MAS alternated with 30 s of 70% MAS.

Mode of training	Set length	Work intervals	Rest or recovery	Work:rest	# of reps	Rest
Rowing	6 mins	20 s @ 105-110% MAS	20 s rest	1:1 Passive rest	9	2 mins
Grappling – Side control or escape	4 mins	20 s, top must pin, bottom must escape	10 s rest to alternate top & bottom	2:1 Passive rest	8	2 mins
Rowing	6 mins	30 s @ 100% MAS	15 s rest	2:1 Passive rest	8	2 mins
Heavy bag punching	4 mins	15 s hard punching	15 s rest	1:1 Passive rest	4	2 mins
Rowing	6 mins	45 s @ 93-100% MAS	15 s rest	3:1 Passive rest	8	2 mins
Cycling	4 mins	30 s @ 100% MAS	30 s @ 70% MAS	1:1 Active recovery	4	2 mins

Table 5. 'Complete towel up' workout = 40 mins

Mode of exercise	Energy system	Portion length	Work intervals	Recovery	Work: recovery	# of reps
Rowing or cycling	ATP-PC	10 mins	10 s @ >95%	110 s @ 40-60% MAS	1:11	5
Rowing or cycling	Lactic	10 mins	20 s @ >90%	100 s @ 40-60% MAS	1:5	5
Rowing or cycling	Aerobic	10 mins	30 s @ 100% MAS	30 s @ 70% MAS	1:1	10

Table 6. 'Three-way energy system' continuous workout

Rowing max aerobic power

This simple workout (Table 7), at foot of page, is typically used where it is deemed prudent that an athlete does not perform running conditioning due to some minor niggling injury, but that he or she may perform skills training. Thus, this workout(s) stresses their energy system conditioning 'off their feet' to reduce impact load in a session. In this way, it may be performed at any stage of the training year, as it is a set that is used in conjunction with other training. The two versions are essentially the same – one variant is to row for a prescribed time of 20 s (1:1) for 16 repetitions (11-minutes) and add up the total metres attained. The other variant is to prescribe a set distance of 110 m (which takes most players between 18-21 s) and add the total time taken to row the 16 intervals with a set 20 s rest between each interval.

Circuits

Generally I am not a big fan of circuits, as I believe that for very strong athletes, they induce high levels of fatigue that can wear them down with prolonged exposure. But athletes with long-term injuries need some variety in their total training stimulus if they are performing multiple training sessions each week. So, provided they are still performing their prescribed strength/power programme, and performing one to two of the conditioning workouts already listed each week, then about once every two or so weeks, an upper body circuit can be used. Typically, this will consist of 6-9 exercises with an order of upper body pushing, upper body pulling, torso/abdominal exercise throughout the circuit.

There are a few different methods to increase the difficulty of circuits, but I prefer to use an exactly prescribed order of exercises, resistance and reps (eg, 20), and monitor how long it takes for the athlete to finish the circuit. After a prescribed rest period they will repeat the circuit and possibly do one more repeat after that.

Add up the total time it took to complete the two or three circuits as a gauge of performance. When the athlete repeats the circuit workout in two weeks' time, they have to improve their total time. My advice is to use a given combination of exercises, resistances and reps only three times and then alter it, as circuits are neurally boring.

The 'shock-adaptation-maximisation' process inherent in the concept of block periodisation may take only three workouts with circuit training. By this, I mean the first time a circuit is performed it is a 'shock', the second time you are already 'adapting' to it and improving and the third time you should be 'maximising' your performance at that particular workout.

Less improvement in performance will occur from the third to fifth workout as compared with from the first to third. So I prefer to change the workout after three sessions and keep the improvements/motivation happening.

Conclusion

A brief rationale and depiction of the cross-training performed by injured athletes has been presented. High-intensity energy system conditioning is prescribed not only to maintain or further develop the athletes' energy system conditioning but also to help injured athletes with their state of mind and to reduce psychological stress.

References

1. Baker, D. Recent trends in high-intensity aerobic training for field sports. *Professional Strength & Conditioning* 22 (Summer): 3-8. 2011.
2. Baquet, G, Berthoin S, Gerbeaux M and Van Praagh E. High-intensity aerobic training during a 10-week one-hour physical education cycle: Effects on physical fitness of adolescents aged 11 to 16. *Int. J. Sports Med* 22:295–300. 2001.
3. Berthoin S, Manteca F, Gerbeaux M and Lensel-Corbeil G. Effect of a 12-week training program on maximal aerobic speed (MAS) and running time to exhaustion at 100 percent of MAS for students aged 14 to 17 years. *J. Sports Med. Phys. Fitness* 35:251–256. 1995.
4. Billat, V and Koralsztein. JP. Significance of the velocity at O2max and time to exhaustion at this velocity. *Sports Med* 22:90–108. 1996.
5. Buchheit, M. The 30-15 Intermittent Fitness Test: Accuracy for individualizing interval training of young intermittent sport players. *J. Strength Cond. Res* 22(2):365-374. 2008.
6. Dupont, G., K. Akakpo, and S. Berthoin. The effect of in-season, high-intensity interval training in soccer players. *J. Strength Cond. Res* 18(3):584–589. 2004.
7. Faina, M, Billatt, V., Squadrone, R., De Angelis., Koralsztein and A. Dal Monte. Anaerobic contribution to the time to exhaustion at the minimal exercise intensity at which maximal oxygen uptake occurs in elite cyclists, kayakists and swimmers. *Eur. J. Appl. Physiol* 76-13-20. 1996.
8. Gabbett, T. Incidence of injury in semi-professionalism rugby league players. *Br J Sports Med* 37:36-44. 2003.
9. Tabata I, Nishimura K, Kouzaki, M, Hirai Y, Ogita, F, Miyachi M and Yamamoto K. Effects of moderate-intensity endurance and high intensity intermittent training on anaerobic capacity and VO2 max. *Med. Sci. Sports Exerc* 28:1327–1330. 1996.

Mode of exercise	Set length	Work intervals	Recovery	Work:recovery	# of reps	Rest
Rowing version #1	11 mins	20 s @ 105% MAS	20 s	1:1 passive rest	16	4 mins
Rowing version #2	11-12 mins	110 metres – add the time for all 16 reps for total	20 s	~1:1 passive rest	16	4 mins

Table 7. Maximum aerobic power & capacity rowing workout (versions 1 & 2)