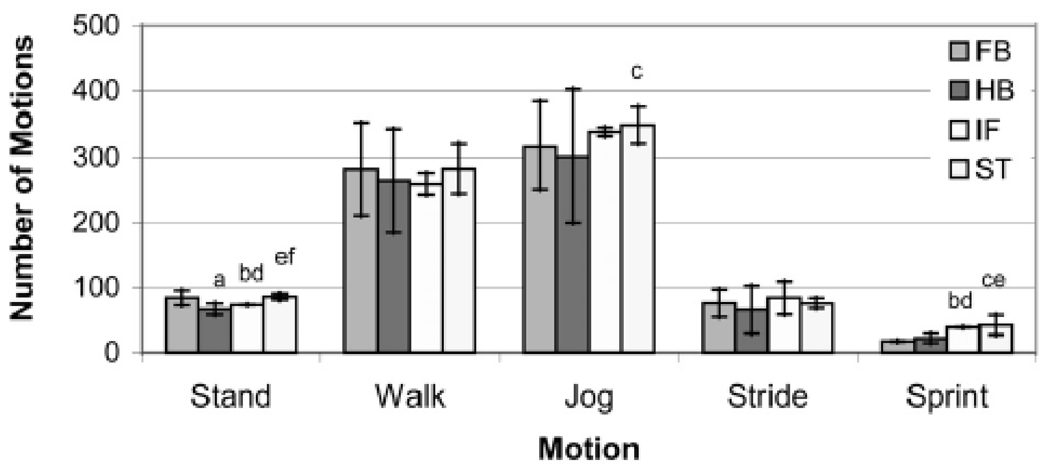
Module 2. Worst-case scenarios

In order to "look inside" the physical needs of performance in team sports, we must differentiate the average demands of competition from the most demanding passages of play (i.e. "the worst case scenario"). Researchers have used several approaches to study the most demanding passages of play, including the 'peak' 5 minute period of high-intensity running during match-play, longest ball-in-play periods, and repeated-sprint (and repeated high-intensity effort) activity. This course will focus predominantly on the very high-intensity activity that occurs during repeated-sprint and repeated high-intensity effort bouts. (Whitehead, Till, Weaving, Jones, 2018)

Spencer, Lawrence, Rechichi, Bishop, Dawson and Goodman (2004) studied the repeated sprint demands of international field hockey. They defined repeated sprinting as three or more sprints with an average recovery between sprints of ← 21 seconds.

On average, players performed a low frequency (1 to 2 per player) repeated sprint bouts in international competition. However, these repeated-sprint bouts tended to occur at critical moments of play; close to goal situations, or to shots on goal.

Figure 1: Motion frequency during the hockey game, by position

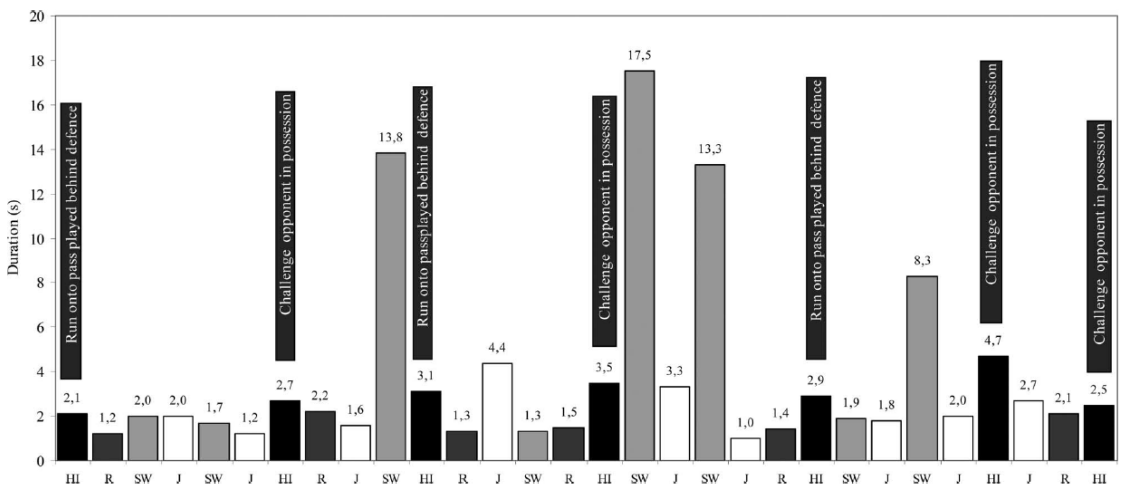


Source: Spencer et al. 2004, p.846. Bars from left to right: FB= full-back, HB=halfback, IF = inside-forward, ST= striker. Data are mean values ± standard deviation.

Looking “inside” your data

Let us give an example of a typical repeated-sprint sequence that occurs in football matches. A common situation during a game could be, a right defender doing some fast backwards running. As soon as his team recovers the ball, he changes direction and sprints to win possession of the ball, where he decelerates and changes direction (there might be some body checking with the opponent). Once in possession of the ball, he accelerates, passing the ball for a teammate to score a goal (or take a shot at a goal) (see Figure 2 for examples of how repeated-sprinting may occur within the context of a football (soccer) game.

Figure 2: Descriptive characteristics of the most intense repeated high-intensity activity bout performed by a centre-forward



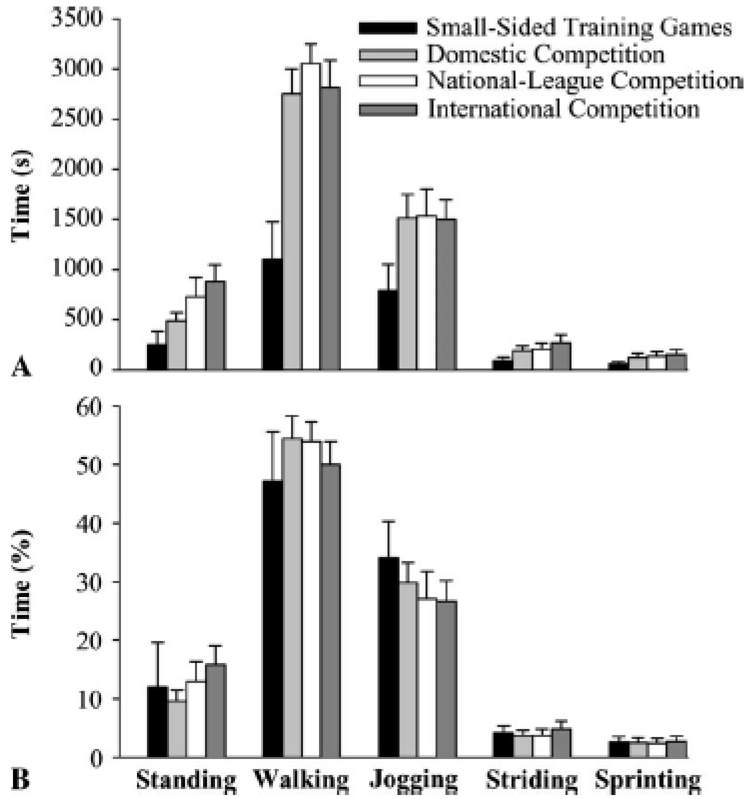
Source: Carling et al (2012). Movement classification: HI = high-intensity; R = running; J = jogging; and SW = standing/walking.

Quite often, the most important components of football matches occur during acute bouts (no longer than 20 seconds) of repeated maximal intensity actions. In the remainder of the game, the intensities of situations are lower. If players are physically prepared only for the average demands of competition, it is highly likely that they will be underprepared for the most important components of games - the most demanding passages of play (i.e. the worst-case scenarios). Therefore, an athletes’ ability to perform these repeated-sprints could be critical to the outcome of the game.

In the following paragraphs I provide details of how to study the physical demands of team sports. I have provided examples from several sports. Although not an exhaustive list, the strategies used can be translated to other sports.

Figure 3 shows the high-intensity actions (in this case sprinting) in relation to other lower-intensity actions (i.e. standing, walking, jogging, and striding). As expected, regardless of the level of competition, sprinting occurs less frequently than low-intensity activities.

Figure 3: Absolute (a) and relative (b) time spent in different activities in women's soccer



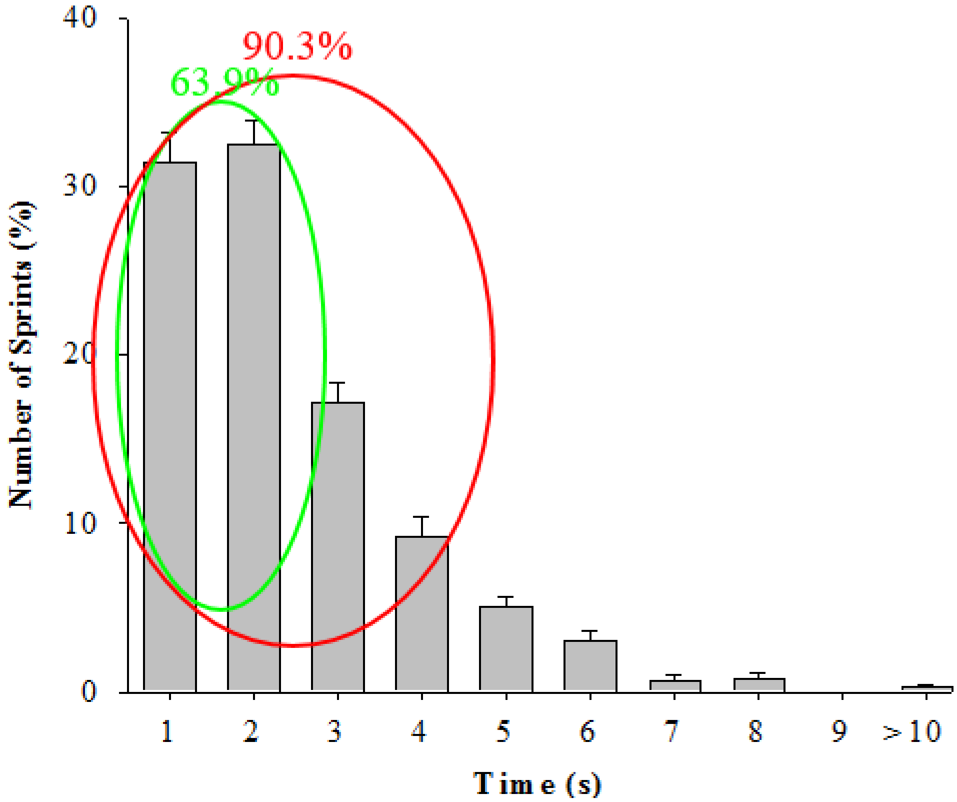
Source: Gabbett and Mulvey (2008) p. 545.

In 2008, before GPS was available, we spent considerable time with video cameras filming players, tracking individual players and then logging the amount of time in high-intensity actions (such as repeated-sprinting).

Sprinting activity in elite women's football competition

Figure 4 shows a breakdown on the sprinting demands of international women's competition. Sprints are divided by duration.

Figure 4: Frequency of sprints according to sprint duration



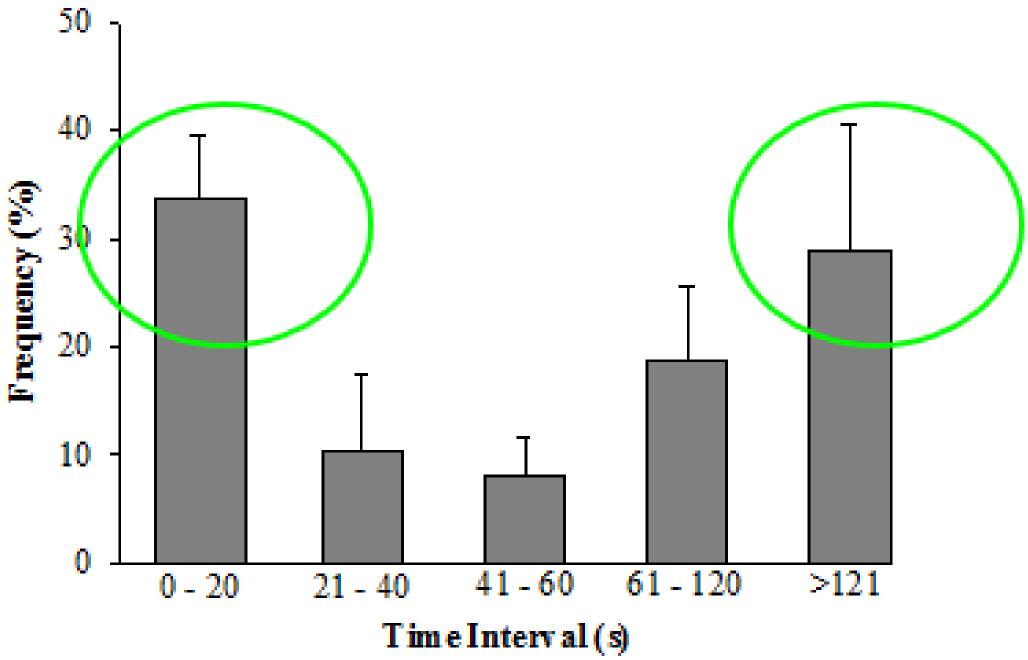
Source: adapted from Gabbett and Mulvey (2008) p. 545.

The first observation is that ~64%, of sprints that occurred in international women's football competition were 2 seconds in duration or less. Over 90% of sprints occurred over 4 seconds duration. Sprints that last 10 seconds are very few; it is very rare that our players will cover 100 meters in a single sprint.

The indication is rather than spending 99% of our time on something that occurs on 1% of occasions, to train specifically for your event, try to devote more time to the activities that occur more frequently in the game.

The next step after analyzing the duration of sprints was to determine what happens between high intensity efforts (Figure 5).

Figure 5: Distribution of recovery between sprints



Source: adapted from Gabbett and Mulvey (2008) p. 547.

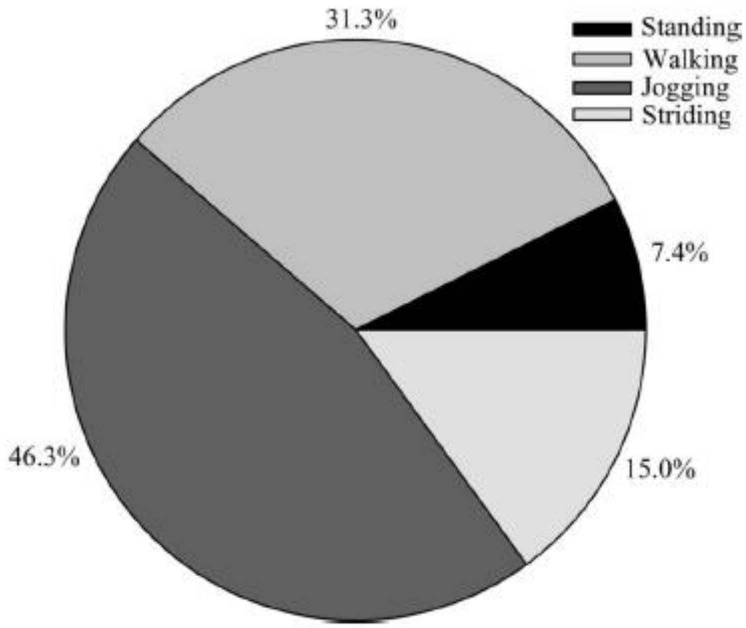
Figure 5 shows the breakdown in the distribution of recovery times between sprints. It shows that nearly 30% of sprints that occurred in international women's football competition occurred with long recovery times between sprints (greater than 2 minutes). However, there is also a large proportion, over 30%, of sprints that occurred with very short recovery times between them (less than 20 seconds recovery). There are important implications for how we interpret this data and then how we apply this to our training programs.

There are 2 main conclusions. First, we know that sprints are separated by large recovery times. These data suggest that *absolute speed* is important. In order to develop speed, some sprint training will be required to be performed with large recovery periods between efforts.

Secondly, because a large proportion of sprints during competition are separated by short recovery, we understand that *repeated-sprinting* is also important. Therefore, we also need to train our players using repeated-sprint activities, in order to develop repeated-sprint ability.

If we know the recovery durations between sprints, what happens in those recovery bouts? What is the intensity of the recovery? Are the recovery intensities between sprints high or low?

Figure 6: Recovery activities between repeated-sprint bouts



Source: Gabbett and Mulvey (2008) p. 547.

Figure 6 shows different activity motions during recovery between high-intensity efforts. Using this figure we can infer the intensity of the recovery. It is important to note in this figure, that only 7% of total recovery time was spent standing still. Most of recovery time involved locomotor activity, either walking, jogging or striding.

When training speed (and repeated-sprint ability), and in order to make our testing and training protocols as game-specific as possible, locomotor activity should be performed either at the beginning of the sprint effort and/or during recovery periods.

What do repeated-sprints "look" like?

Not all repeated-sprinting is the same for all positions; midfielders have different repeated-sprint demands than attackers and defenders.

Table 1: Physical demands, movement patterns, and repeated-sprint demands of international competition

	Attackers		Mid-fielders		Defenders	
Time in match-play activity (s) (%)						
Standing	906 ± 109	16.2	819 ± 198	14.4	922 ± 176	16.6
Walking	2958 ± 325	52.9	2791 ± 250	49.0	2744 ± 293	49.3
Jogging	1322 ± 115	23.6	1575 ± 232	27.7	1541 ± 171	27.7
Striding	213 ± 48	3.8	347 ± 74	6.1	237 ± 69	4.3
Sprinting	192 ± 14	3.4	162 ± 57	2.8	123 ± 47	2.2
Total	5592 ± 247	100.0	5694 ± 214	100.0	5568 ± 176	100.0
Match activity profile						
Change in activity	every 6.1 s		every 6.0 s		every 5.8 s	
Striding duration (s)	2.9 ± 1.7		4.2 ± 2.5		3.3 ± 2.1	
Maximal striding duration (s)	9.7 ± 2.5		12.5 ± 2.5		10.2 ± 2.2	
Sprinting duration (s)	2.5 ± 1.5		2.3 ± 1.6		2.4 ± 1.5	
Maximal sprinting duration (s)	7.0 ± 1.0		8.8 ± 3.0		7.2 ± 1.9	
Work bout duration (s)	2.7 ± 1.6		3.3 ± 2.3		2.9 ± 1.9	
Work to rest ratio	1:13		1:10		1:15	
Distance covered in match-play (m) (%)						
Walking	3432 ± 141	35.7	3104 ± 323	29.1	3104 ± 495	32.3
Jogging	3813 ± 425	39.7	4646 ± 618	43.5	4366 ± 370	45.4
Striding	1180 ± 336	12.3	1940 ± 502	18.2	1331 ± 392	13.8
Sprinting	1184 ± 146	12.3	981 ± 317	9.2	820 ± 327	8.5
Total	9609 ± 359	100.0	10672 ± 1338	100.0	9621 ± 1202	100.0
Repeated-sprint activity						
Bouts per player (*n*)	4.7 ± 4.0		6.0 ± 3.2		4.0 ± 1.9	
Sprints per bout (*n*)	3.4 ± 0.8		3.5 ± 1.0		3.2 ± 0.4	
Sprinting duration (s)	2.2 ± 0.7		2.1 ± 0.6		2.1 ± 0.7	
Maximal sprinting duration (s)	2.7 ± 1.2		3.0 ± 0.3		2.9 ± 0.8	
Recovery between sprints (s)	6.7 ± 3.8		6.6 ± 4.0		4.3 ± 3.7	

Source: Gabbett and Mulvey (2008) p. 546.

After all the analysis of the physical demands of the game, now we are getting a picture of the kind of demanding activities that we should prepare our players for.

So far we have defined repeated-sprinting similar to the international field hockey paper - 3 or more sprints with less than 21 seconds recovery between sprints.

In order to determine the positional demands of the game, we have broken these repeated-sprint bouts into a number of different components in terms of:

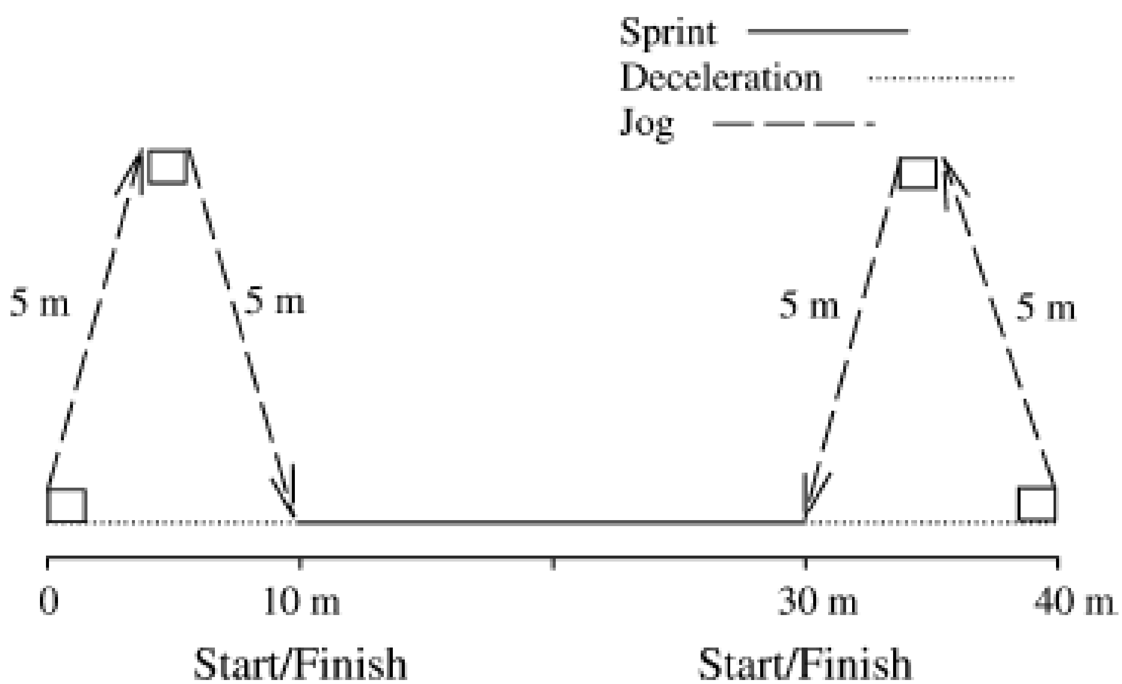
- Number of bouts that players perform during the game.
- Number of sprints in each bout.
- Duration of each sprint.
- Average sprinting duration.
- Maximal sprinting duration.
- Recovery between these sprints.

Table 1 shows that midfielders (wide midfielders particularly) tended to do more repeated sprinting bouts than other playing positions. In a 90-minute game, midfielders were required to perform, on average 6 repeated-sprint bouts (3 or more sprints with short recovery duration), and they tended to happen during critical moments of play.

Looking "inside" those bouts we found that the average number of sprints in a bout was ~4 sprints, and the maximum number of sprints in a bout was 6. The average duration of those sprints was 2 seconds, and the maximum duration of those sprints was 3 seconds (approximately 20 meter distance). The recovery duration between sprints was 6 seconds, which means that work-to-rest ratios were 1:3 and 1: 2. (as opposed to 1:12 across the entire match). The physical demands of the game are considerably higher during these repeated-sprint sequences.

With this information in our hands, we now know the number of bouts that players are required to perform in competition, along with the average and the maximum numbers of sprints within a bout. We also have information on the average and maximum duration of those sprints, and the recovery between sprints. We can use this information to design game-specific testing protocols and training programs. Figure 6 is an example of the way it was used for women's football.

Figure 7: Repeated-Sprint Test



Source: Gabbett, 2010, p. 1192.

In this repeated-sprint test, total repeated-sprint time can be measured. It also can be used to quantify progression in our players. Although this protocol can be used to "test" players, the way that I prefer to use it is to *train* our players - to regularly expose our players to these repeated high-intensity sprint demands.

Figure 7 demonstrates how we have used knowledge of the physical demands of competition to develop training and testing protocols. There is a start and a finish point at both ends of a 20-meter distance. At both ends of the 20-meter sprinting-line, is the deceleration zone. Then, there is an active recovery period, similar to what is required in the game. Remember that players need to actively recover, rather than recovering passively). That is why there is a 10-meter change of direction, active recovery, before they resume with another effort. This protocol is performed on a 15-second cycle where there are ~3 seconds to perform the 20-meters sprint and then players have 11-12 seconds to return to the start point before sprinting again. We do 6 efforts because we previously found that the maximum number of sprints in a repeated-sprint bout was 6 efforts. Thus, we intend to replicate exactly what players need to do in a game.

It is for the practitioner to decide whether they wish to *simulate* or *stimulate*. When we *simulate* the demands of competition, we are replicating what occurs in competition. But, by *stimulating,* we are attempting to provide a training stimulus to improve players. This may involve providing a stimulus above match demands so that the demands of competition are actually easier than training.

As an example, if players are required to perform a maximum number of 6 efforts in a repeated-sprint bout in competition, then maybe in training, we extend that up to 8 efforts. This way they have a greater preparation than what the demands of competition are requiring.

Other way of stimulating demands is to reduce the recovery periods slightly or to increase the distance that players are required to sprint. We should take into account that over a 20-meter distance, it is unlikely that an athlete will reach their maximum velocity. However, if we use a 25 or 30 meter distance, we may be able to make the training slightly more intense than competition.

What about sports that have efforts other than sprinting?

In collision sports we can use the same approach as described above. I will use rugby league as an example. Rugby league is slightly different from rugby union. The playing field has the same dimensions but there are more players on the rugby union field, and the demands are slightly different between the two sports.

Let's consider the *average* demands of competition in an 80-minute rugby league game. Players will cover, on average 8 kilometers. This equates to 100 meters per minute, with an average work-to-rest ratio of ~1:5. On average, for every 4 seconds of high-intensity activity, players will perform 20 seconds of low-intensity recovery.

Although the meters per minute is quite similar across all playing positions, each playing position has its own unique demands. For players in the middle of the field (i.e. the hit-up forwards), they tend to be more involved in high-intensity collisions. The effort distances are quite short, so when they sprint, it tends to be 5 to 10 meters, which is a very short distance. These high-intensity efforts typically end with very large collisions, involving 2 to 3 defenders at a time.

The further away from the middle of the ruck, the wider the spaces become. Therefore, outside backs (i.e. centres and wingers) have more space to move. Thus, the collision demands are not as great. Typically, they will be involved in one-on-one or two-on-one type tackles. Also, because they have more space to move, they tend to reach higher velocities, their effort distances tend to be longer, therefore their high-speed running demands tend to be greater.

This information should be taken into account when preparing player training programs. Due to the large collision demands that occur for a hit-up forward, their training requires exposing them to these collision demands. The way that outside backs need to be prepared is slightly different because the collision demands are lower and the high-intensity running demands are higher. Therefore, their training requirements are related to a greater high-speed running stimulus.

Let's look "inside" the average demands of a rugby league game to identify the most demanding passages of play.

You will recall that the average work: rest ratio of a rugby league game is 1:5 and that players cover on average, 100 meters per minute. However, in the spikes that occur within the most demanding passages of the game (the "worst case scenario") players will cover closer to 180-200 meters per minute. Players will covering a lot of distance in a short period of time, but the other thing that really stands out as a point of difference between contact and non-contact sports, is the high-intensity collision components. In these situations, the work-to-rest ratio is not 1:5. During the most demanding passages of the game, the work: rest ratio is 3:1 (i.e. three parts work, one part rest)!

In these situations, players are performing ~6 seconds of high-intensity work, followed by two seconds of recovery. This does not happen during long passages of play; the longest reported is a two-minute bout. Commonly these kind of bouts are 40 seconds long.

Players will make multiple tackles in a row, and these tackles can last between 4 and 8 seconds. They involve blunt force trauma, then they involve wrestling and grappling, and finally, players have to get to their feet with a short recovery before doing that activity again. Short sharp acceleration work and changes of direction can also occur during these bouts. The final point is that they can involve some longer high-speed efforts. Therefore, when preparing players for these repeated effort demands, it is important that sprinting, acceleration, change of direction and collision and wrestling components are trained.

There are differing demands between football (soccer), basketball, hockey, rugby, etc. Although the training differs, the concepts are the same for all sports. If athletes train for the average demands then it is highly likely they will be underprepared for the most demanding passages of play, the worst case scenarios.

Table 2 shows the sprinting demands of the National Rugby League competition in Australia.

Table 2: Sprint frequency, repeated-sprint activity, and repeated-effort activity in NRL competition

	Sprint Frequency (#)	Repeated Sprint Activity (#)	Repeated Effort Activity (#)
Hit Up Forwards	39 ± 5	2 ± 1	8 ± 1
Wide Running Forwards	37 ± 5	2 ± 1	10 ± 1
Adjustables	31 ± 4	1 ± 1	9 ± 1
Outside Backs	35 ± 4	1 ± 1	9 ± 1
Average	**35 ± 2**	**1 ± 1**	**9 ± 1**

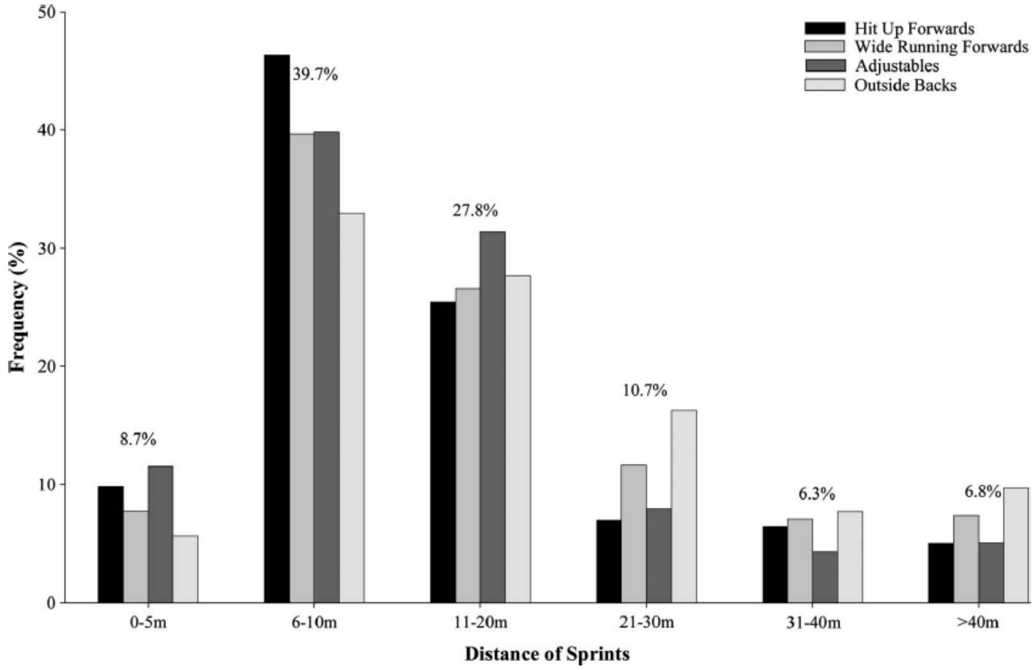
Data are means (and ranges). Repeated sprint activity; 3 or more sprints with 21s or less recovery between sprints.
Repeated effort activity; 3 or more sprints and/or tackles/collisions with 21s or less recovery between efforts.

Source: adapted from Gabbett (2012), p. 122.

These demands have been broken down into sprinting demands, repeated-sprinting demands and repeated high-intensity effort demands.

When we looked at the sprinting demands, we found that on average there wasn't a lot of difference across positions in terms of sprints. Players would cover around 35 sprints on average across the course of the game. The nature of those sprints differed, so our tight players, tended to do shorter effort sprints (anywhere up to 10 meters), whereas the outside backs tended to do much longer sprints (up to about 40 meters in distance).

Figure 8: Distance of sprints performed in National Rugby League competition

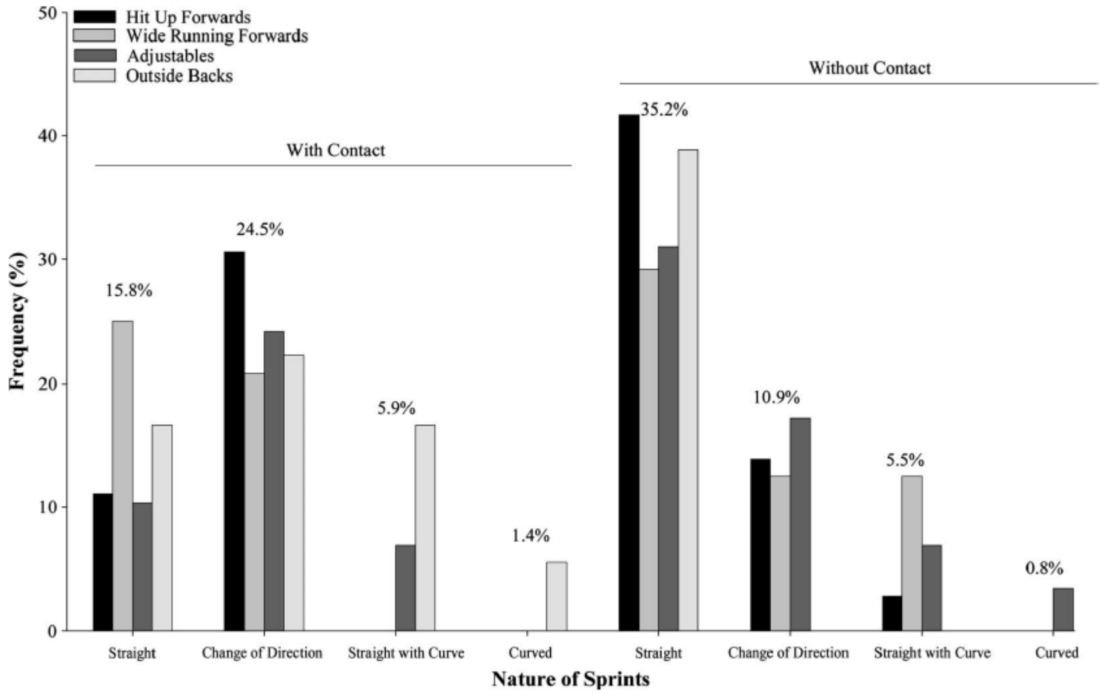


Source: Gabbett (2012), p. 122.

The repeated-sprint demands were also examined. Defined the same way as we've always done in the past: 3 or more sprints with short recovery (<21-second) between efforts. On average, players were required to perform *one* repeated sprint bout across the course of a game.

The final way we examined these high-intensity actions was by defining "repeated high-intensity effort" bouts. A repeated high-intensity effort bout includes high-intensity actions in addition to, and other than sprinting (e.g. accelerations and collision efforts). In this instance, we defined a repeated high-intensity effort bout as 3 or more sprints, accelerations, or collisions with less than 21 seconds recovery between efforts. On average, players performed up to 10 repeated high-intensity effort bouts across the course of the game.

Figure 9: Nature of sprinting demands in a collision sport



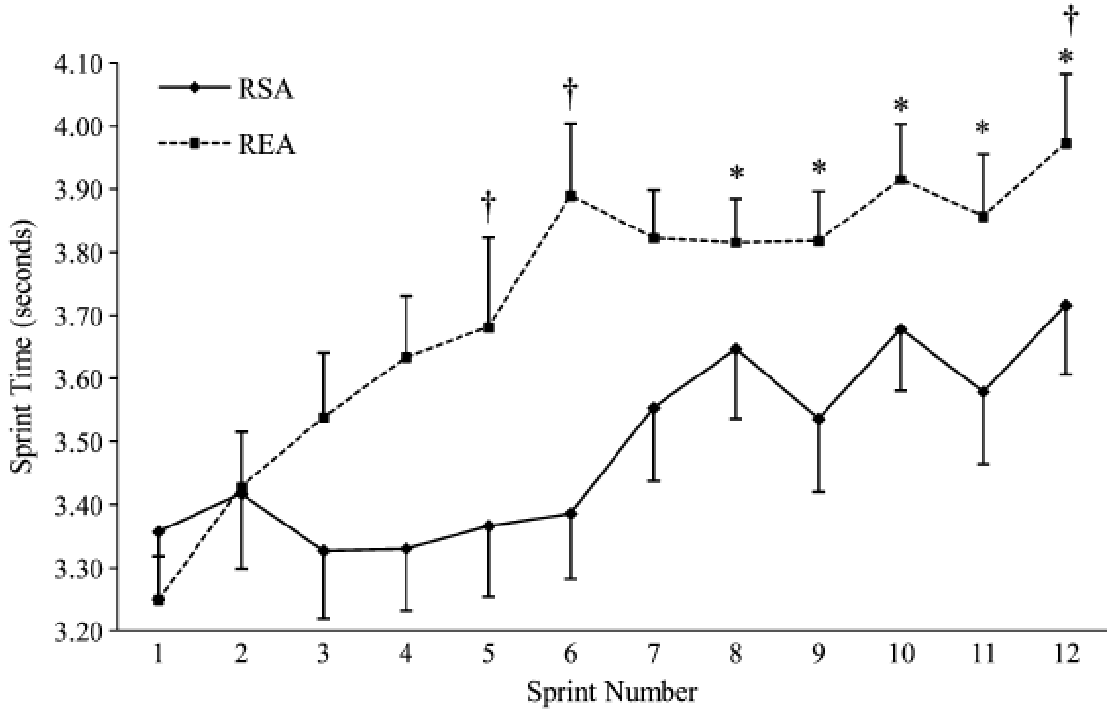
Source: Gabbett (2012), p. 123.

An important point when working with a collision sport is that the use of *repeated-sprinting alone* to prepare for those sports, will likely result in players being *underprepared for the repeated high-intensity effort bouts*, that involve sprinting and collisions.

So, why is repeated effort ability important for a sport like rugby league or some of these collision sports? Firstly, we know that in a sport like rugby league 70% of tries scored, occur in close proximity to a repeated high-intensity effort bout. The ability (or inability) to perform repeated high-intensity efforts could prove critical to the outcome of the game.

Secondly, repeated high-intensity effort bouts tend to be very fatiguing. Figure 10 shows the effect of repeated-sprinting and repeated sprinting combined with collisions on sprinting performance (Johnston and Gabbett, 2011). A protocol involving 12 repeated-sprints was used.

Figure 10: Sprint times for each sprint for both repeated-sprint and repeated-effort tests



Source: Johnston and Gabbett, 2011, p. 2791.

In this study, the protocol also added a collision component where players were required to wrestle each other for a short period following each sprint. Players were able to maintain repeated-sprint performance for the first 2 efforts but as soon as players were required to perform the third collision effort, they fatigued much quicker across the protocol. These findings demonstrate that the addition of collisions into a repeated-sprint protocol reduces an athlete's sprinting performance and also results in much greater heart rate and much greater ratings of perceived effort.

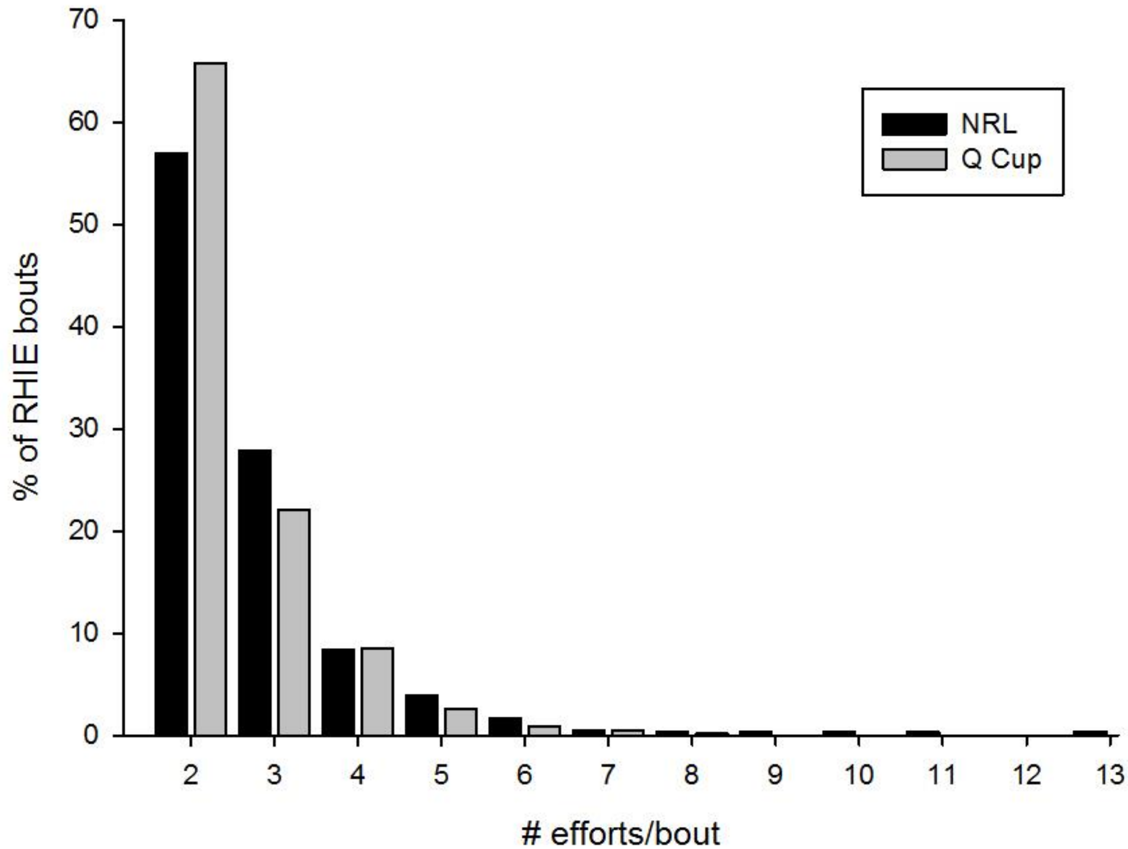
What about the "worst case – worst case scenario"?

Let's look "inside" the most demanding passages of play. We have discussed the "worst case scenario" but, how bad can those "worst case scenarios" actually be? What is the "worst case" for the "worst case scenario"?

Although we have previously defined a repeated high-intensity effort bout as having 3 or more sprint, acceleration or contact efforts, it is possible that this definition might underestimate the demands of the game. Although 3 efforts with limited recovery isphysically demanding, what happens if a player was required to perform two maximal efforts with very short recovery between those efforts? The reality is, that this type of repeated effort bout will also create some fatigue. Due to the "three or greater" efforts definition, in this situation the two-effort bout wouldn't be considered as a repeated high-intensity effort bout.

With this in mind, we investigated the repeated effort bouts that occurred in our collision sports that only involved two efforts in a bout. We also compared the repeated effort activity between our top-level players and our second level players.

Figure 11: Repeated High-Intensity Effort Bouts



Source: adapted from Black and Gabbett (2015), p. 713.

Firstly, when we included a two-effort bout, the ones that were previously excluded, we found another 60% of our repeated efforts came from those two-effort bouts. So, we were underestimating the true repeated effort demands of competition.

Secondly, you will notice that our second team players tended to perform more of the two-effort bouts but they tended to perform less of the three-effort bouts. We don't know whether it's the demands of the game that bring those differences, or if the type of players that are playing in the second team are playing there for a reason! Because they can do two-effort bouts but they can't go to the next level and do a three-effort bout. It is not really clear whether it's the player or whether it's the game. Whether it's the demands of the game or whether it's the demands that the player is prepared to expose on themselves. What we do know though is that there is definitely a difference between the top-level and second-team competition in terms of the nature of repeated high-intensity effort bouts. Repeated high-intensity effort activity distinguishes competition levels.

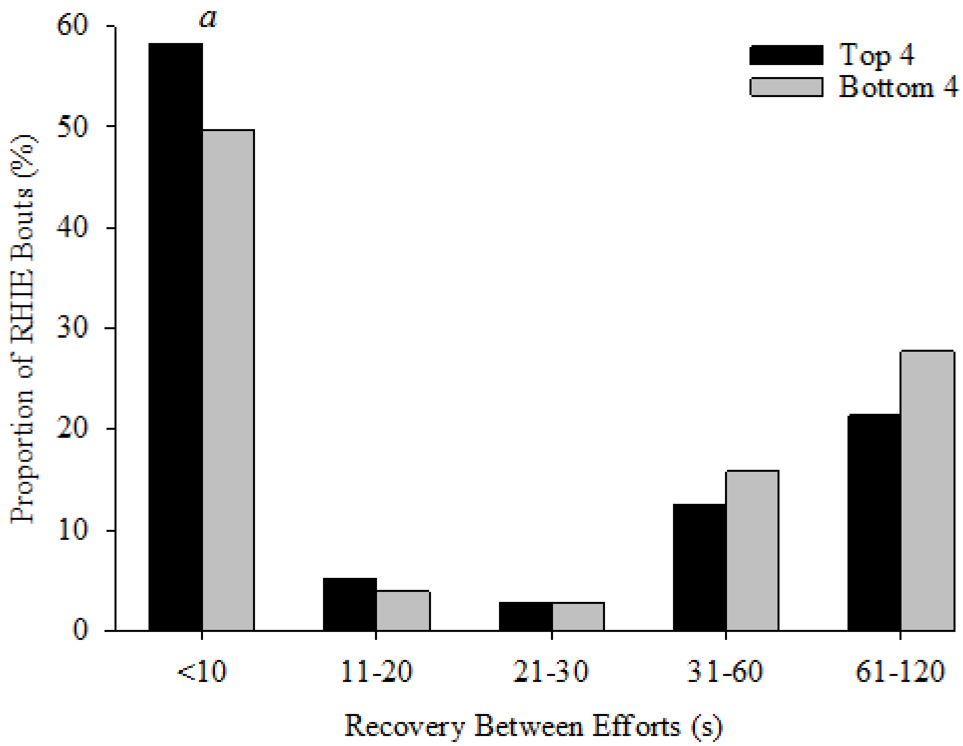
When we examined the most demanding repeated effort bout that players performed, the most number of efforts that we found in a single bout performed by any player across our lower level team, was eight. When we compared that to our first team players, the longest bout was 2 minutes and they had to do thirteen efforts in a bout. So the demands between the second team and the first team competition were quite different.

There are two important concepts we can glean from this study. Firstly, there is a difference in the repeated high-intensity effort demands between first team and second team. Secondly, it exposing players to these worst case scenarios in training helps them perform these activities when required in competition.

The other question is why use a recovery duration of 21 seconds or less? How many of repeated effort bouts fall just outside of the 21 seconds definition? And equally, how demanding can these repeated high-intensity effort bouts become? How short can those recovery periods be?

In order to determine how demanding repeated high-intensity effort bouts could be, we also investigated out how long recovery periods lasted.

Figure 12: Recovery between efforts



Source: adapted from Black and Gabbett (2015), p. 715.

Figure 12 shows that a large proportion (50 to 60%) of recovery periods between efforts in a repeated effort bout are very short (less than 10 seconds). However, in training we were using a 21-second recovery period. These findings suggest that athletes need to be exposed to repeated high-intensity effort bouts with very short (<10 seconds) between efforts).

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