"If your athletes go to bed, fall asleep within 30 minutes, sleep through the night with brief awakenings, feel refreshed within 60 minutes of waking most days (5/7 days/week) then congratulations: your athletes are normal sleepers!"

– Dr Samuels, 2013

We know from decades of research that sleep is important for human performance1. So, why would we even think about screening athletes when it comes to sleep? Why not just apply basic principles of sleep and generalise from the research that's been done in other areas such as law enforcement2-3, the military4-7 or aviation8-9? As a result of this research and knowledge athletes, coaches, sport medicine physicians and trainers are interested in understanding the relationship of sleep to training, recovery and performance in athletes. The complicating factor is that athletes, and elite athletes in particular, are very different than the average individual or members of occupational groups such as law enforcement or the military, on whom prior research is based. Athletes have unique physical and mental demands, have to accommodate rigorous competition and training schedules and have to adapt to difficult travel regimes. So we have to be careful and specific about applying what we know about sleep to athletes. There is a clear need for developing valid, reliable tools to screen and monitor athlete sleep behaviours as the basis for understanding and developing effective interventions.

Most countries are developing high performance training programmes for National/Olympic team athletes and are committed to investing in every available tool to help them succeed. We know from the scientific study of sleep that it promotes physical and mental recovery10. However, the theoretical principles behind the relationship between sleep and recovery have only just started to be explored in athletic populations. Without a structured assessment of relevant sleep behaviours and the development of valid, reliable tools to acquire accurate data we will have nothing upon which to base useful research questions. Without these tools there will be no way to drive data collection, analyse the data and determine how sleep may affect training, recovery and performance. Finally, valid, reliable data collection methods are necessary to monitor the effectiveness of therapeutic interventions.

Over the past several years the University of Calgary Sport Medicine Sleep and Human Performance Research Initiative has developed the Athlete Sleep Screening Questionnaire (ASSQ) ©. This tool is designed to capture athlete sleep behaviours, identify athletes with abnormal sleep and primary sleep disorders and...
determine the frequency with which athletes have difficulty with sleep when travelling. The ASSQ® screening system stratifies athletes into those who require basic sleep education, assessment with the sport medicine physician and those who require a sleep medicine consultation and investigations. The goal of this article is to provide:

1. A clear understanding of the relationship between sleep and recovery.
2. An understanding of the ASSQ®, and how it can be used to benefit elite athletic teams.
3. A summary of ASSQ® results collected from teams and athletes to date.

THE RELATIONSHIP BETWEEN SLEEP AND RECOVERY

Sleep factors have been shown to have a direct effect on executive cognitive function, metabolic control of energy balance, appetite and weight and tissue repair. Cognition, metabolism and tissue repair are critical physiological processes that contribute to training capacity, recovery and performance. Recent research on athlete populations has provided objective evidence that confirms the importance of sleep in athlete development and performance.

The relationship between sleep and post-exercise recovery and regeneration can be viewed in a structured fashion:

1. Sleep length (total sleep requirement: hours/night, plus naps).
2. Sleep quality (sleep disorders, environmental disturbance or sleep fragmentation).
3. Sleep phase (circadian timing of sleep).

These three parameters of sleep are the key factors affecting the overall recuperative outcome of the sleep state. They affect an athlete’s ability to train, maximise the training response, perform and recover. Capitalising on the restorative power of sleep will help maximise energy, mood, decision-making skill and reflex response. In addition, attending to the importance of sleep will reduce the risk of overtraining/under-recovery, enhance resistance to illness and improve recovery from injury.

SLEEP LENGTH

For sleep to be recuperative it must be of adequate duration. This is a universal principle, but applies especially to athletes whose physical recovery may need to be greater than the average individual. Sleep requirements change over the course of an individual’s life; in particular the amount of sleep required. For example, 8 to 12 year olds need about 9.5 to 10 hours, 12 to 16 year olds need about 9 hours, and 16 to 22 year olds need about 9 to 10 hours per night. Naps can count towards total sleep time, should be restricted to 30 minutes and should be scheduled between 2 to 4 pm for the average sleeper. Strategic napping may be particularly beneficial for young athletes who, due to school commitments and training, may not be able to achieve the recommended amount of sleep per night.

SLEEP QUALITY

Maintaining a regular sleep/nap routine, establishing a comfortable sleeping environment and monitoring for sleep disorders can maximise sleep quality. A key indicator of sleep disorders is excessive sleepiness, despite adequate sleep length. This is due to ‘non-restorative’ sleep, which is poor quality due to interruptions from sleep disorders such as insomnia, sleep apnoea or restless legs syndrome. Sleep disorders are common and treatable, but often remain undiagnosed. It’s especially important to find out if young athletes suffer from sleep disorders because intervention at a young age could make a huge difference for their long-term athletic development and performance. Travel can also affect sleep quality, so jet lag management and sleep scheduling while traveling is critical.

### Table 1

<table>
<thead>
<tr>
<th>Sport</th>
<th>Total sleep time mean hours/night (SD)</th>
<th>Sleep difficulty score mean (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paralympics (n=13)</td>
<td>7.94 (1.26)</td>
<td>8.15 (2.44)</td>
</tr>
<tr>
<td>Bobsleigh skeleton (n=10)</td>
<td>7.70 (0.86)</td>
<td>9.30 (4.16)</td>
</tr>
<tr>
<td>Speed skating (n=34)</td>
<td>8.00 (1.09)</td>
<td>8.74 (3.29)</td>
</tr>
<tr>
<td>Swimming (n=11)</td>
<td>7.86 (1.18)</td>
<td>9.91 (4.11)</td>
</tr>
<tr>
<td>Volleyball (n=6)</td>
<td>8.62 (0.68)</td>
<td>8.83 (4.36)</td>
</tr>
<tr>
<td>Waterpolo (n=11)</td>
<td>7.82 (1.02)</td>
<td>8.64 (4.03)</td>
</tr>
<tr>
<td>Wrestling (n=6)</td>
<td>7.71 (1.27)</td>
<td>8.83 (3.82)</td>
</tr>
</tbody>
</table>

Table 1: Total sleep time and sleep difficulty score by athletic team.
per day results in a chronic sleep debt that adolescents need 9 to 10 hours of sleep to get up for school (7 to 8 am) and the fact that delaying bedtime affected. For example, adolescents have a circadian phase that is out of phase with a peak in the evening around 6 to 8 pm. After this point sleepiness increases, which affects daytime performance, alters mood, increases appetite and impairs post-exercise recovery.

From a clinical perspective, we want information on athletes’ sleep behaviours to solve existing problems and help them improve post-exercise recovery and regeneration. However, it’s equally important to gather data from athletes at the aggregate level to start drawing some inferences or ‘best practices’ that can apply to particular sports or athletes in general. The Athlete Sleep Screening Questionnaire© (ASSQ) has both strong clinical relevance, but also allows us to gather population-level data, learn about trends in athlete sleep behaviour and start providing the athletes, coaches and support staff with some answers about how they should manage athletes’ sleep.

### THE ATHLETE SLEEP SCREENING QUESTIONNAIRE

The ASSQ© has been about 6 years in the making. Our goal was to create a questionnaire that gathered information on athlete sleep behaviours to enable nationwide screening of a large population of athletes, provide efficient data gathering for research and validation and to implement targeted clinical intervention. The ASSQ© is derived from standard sleep screening questionnaires and made up of 23 items representing four domains that capture the essence of the key sleep parameters of interest. The sleep difficulty score is used to categorise respondents into four meaningful categories that are associated with specific interventions:

1. No clinical problem = education.
3. Moderate clinical problem = see the sport physician.
4. Severe clinical problem = sleep physician.

We wanted the tool we created to provide practical answers. We retain the theoretical concepts of sleep length, sleep quality and sleep phase; but translate results into simple ‘do this/don’t do that’ recommendations. In a nutshell, we are illuminating sleep problems, educating athletes that don’t suffer, finding the athletes that do and getting those athletes help.

The ASSQ© process is very straightforward. A team physician typically requests access to the questionnaire and is emailed a link to the online site. The athlete goes online and fills out the questionnaire, submits the results, and sends a letter back to the doctor giving them advice for their athlete. If an athlete presents with a moderate or severe clinical problem a Skype consultation is set up with the principal investigator, and a visit to a sleep doctor scheduled if necessary.

### RESULTS FROM THE ASSQ©

Between its launch in 2011 and the end of 2013, 307 elite athletes completed the ASSQ©. Of these, 132 were male and 168 female. Athletes have participated from BMX, curling, rugby, alpine skiing, biathlon, bobsleigh, cycling, paralympic athletes, skeleton, speed-skating, swimming, volleyball, water-polo and wrestling. Some athletes have also participated anonymously, where sport is not reported. Tables 1 and 2 show the number of participating athletes where the team is known (248/307), the average hours slept per night and the average sleep difficulty score for each team. Sleep difficulty scores greater than 4.5 are classed as severe clinical problems.

### Table 2

<table>
<thead>
<tr>
<th>Sport</th>
<th>Total sleep time mean hours/night (SD)</th>
<th>Sleep difficulty score mean (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMX (n=11)</td>
<td>8.11 (0.94)</td>
<td>8.83 (4.21)</td>
</tr>
<tr>
<td>Curling (n=27)</td>
<td>8.12 (1.07)</td>
<td>7.93 (3.06)</td>
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<tr>
<td>Rugby (n=50)</td>
<td>7.71 (1.16)</td>
<td>9.30 (2.86)</td>
</tr>
<tr>
<td>Alpine skiing (n=30)</td>
<td>7.80 (1.14)</td>
<td>8.83 (4.21)</td>
</tr>
<tr>
<td>Biathlon (n=6)</td>
<td>8.38 (0.86)</td>
<td>8.83 (2.23)</td>
</tr>
<tr>
<td>Bobsleigh (n=12)</td>
<td>7.85 (0.90)</td>
<td>8.50 (2.97)</td>
</tr>
<tr>
<td>Cycling (n=21)</td>
<td>8.20 (1.10)</td>
<td>8.33 (3.01)</td>
</tr>
</tbody>
</table>

Table 2: Total sleep time and sleep difficulty score by athletic team.
than 12 indicated clinically significant sleep disturbance and required follow-up consultation.

Within these teams, distinctive sleep profiles have started to emerge. For example, skeleton, swimming and rugby athletes tend to sleep less and experience greater sleep difficulty, whereas curling and cycling athletes tend to sleep more and experience less difficulty sleeping than other sports.

Approximately 13% of athletes screened with the ASSQ to date have had sleep difficulty scores requiring them to have follow-up Skype consultations. Females have tended to have slightly higher sleep difficulty scores than males, although not significantly so. Athletes’ increasing age and reduced sleep were significantly associated (P=0.01). Also, increasing age and increased sleep difficulty were significantly associated (P=0.03). Not surprisingly, a significant relationship was found between total sleep time and sleep difficulty score, with athletes who sleep less tending to have higher sleep difficulty scores (rho=-0.52).

Athletes who reported satisfaction with their sleep tended to have total sleep times averaging over 8 hours per night, whereas athletes reporting dissatisfaction with their sleep tended to have total sleep times averaging less than 7 hours per night. This finding is consistent with previous research demonstrating that extended hours of sleep are related to increased performance in intercollegiate athletes55. As dissatisfaction with sleep increased, so did average sleep difficulty score, suggesting that athletes are pretty good judges of their own sleep – if they are dissatisfied, chances are they are getting poor quality sleep.

**Team case study:**
The Canadian Women’s National Curling Program was very invested in sleep screening in preparation for the Olympic Trials and the 2014 Sochi Olympic Games. The national team coach initiated the screening and 22 athletes were screened from across the country. The data from the athletes who were screened were analysed at the team level to provide a sleep profile for the team as a whole:

- The median hours slept a night was 8 hours (with a range of 5.30 hours to 9.15 hours).
- Comment: while the median was reassuring, the range revealed that there was at least one athlete (possibly more) who was/were severely sleep deprived (<6 hours/night).
- On average the athletes took 2 to 3 naps per week (average nap length 31 to 60 minutes).
- Comment: it was encouraging that athletes napped, however routine napping for 20 to 30 minutes a day was recommended for all athletes.
- On average it took the athletes 15 minutes or less to fall asleep.
- Comment: this was a normal sleep onset latency.
- Very few of the athletes had trouble staying asleep, or used medication to help them fall or stay asleep.
- Comment: this was very encouraging. Inappropriate use of sedative medication is common amongst athletes and should be monitored and controlled.
- The average level of satisfaction with sleep was ‘somewhat satisfied’ or ‘neither satisfied nor dissatisfied’.
- Comment: this question is the most predictive question for high probability of a clinically significant sleep disturbance.
- The majority of the athletes did not snore or routinely gasp, cough or choke in their sleep.
- Comment: while the likelihood of sleep apnoea is low in this population, the impact of the disease is significant and if treated can have substantial implications for the athlete.
- The median sleep difficulty score for the athletes was 10.
- Comment: the early validation data suggests that a score greater than 12 indicates clinically significant sleep disturbance and requires follow-up consultation.
- 30% (n=7) of the athletes had a sleep difficulty score greater than 12, and required follow-up Skype consultation.
- The majority of the athletes experienced difficulty sleeping while travelling for their sport, however, the majority did not experience performance disturbance while travelling.
- Comment: this indicated that there was value in developing a jet lag and travel fatigue programme to assist athletes with this disturbance.

**CONCLUSION**
Sleep is the foundation of recovery and critical to the management of athletic training regimens. Sleep is often ignored and compromised by athletes as a result of their busy schedules, other demands such as work and school and most importantly by the intrusion of technology (cell phones, computers and tablets) into their life. This technology inhibits normal sleep physiology and fosters a heightened state of arousal, which acts as a barrier to the onset and maintenance of the sleep state. Understanding the actual sleep behaviours of athletes, how sleep parameters affect training and performance, and the impact of specific interventions on sleep and

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performance is important. This information will provide athletes, coaches and support staff with the tools necessary to manage sleep and improve athletes’ tolerance of strenuous training regimens. A better understanding of sleep behaviour and the effect of interventions will provide important solutions for the management of the negative impact of travel on athlete health and performance. The ASSQ® and global sleep screening of large populations of elite athletes will provide the information necessary to develop research methods, design informative studies and provide effective interventions. This article provides insight into how this can be achieved along with examples and early results of the work accomplished by the Canadian Own the Podium programme in preparation for the Sochi Winter Olympics.

References