The Repair of Sleep Restriction Induced Neurocognitive Deficits After Recovery Sleep

Megan Manley

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Abstract

Background:

Chronic sleep restriction is common globally and has well documented negative effects on psychobehavioral and metabolic function. This review assesses research on the amount of sleep recovery needed to repair subjective sleepiness and lapses in psychomotor vigilance.

Methods:

An exhaustive search of MEDLINE-Ovid, CINAHL, and Web of Science databases was performed in July 2016 using the keywords “sleep restriction” and “sleep recovery”. The referenced works of qualifying articles were assessed for previously unidentified sources. Inclusion criteria were published full text papers with a combination of sleep restriction and a recovery period, that assessed psychomotor vigilance and subjective sleepiness. The included articles were graded for quality following GRADE workgroup guidelines.

Results:

Four studies met inclusion criteria with GRADE scores ranging from very low to high for the 2 outcomes of psychomotor vigilance and subjective sleepiness. Two nights of 8-10 hours time-in-bed (TIB) is sufficient to return measures of subjective sleepiness to baseline. No study had follow up long enough to demonstrate a return to baseline level of psychomotor vigilance testing (PVT) function. PVT lapses decreased within 3 days of recovery sleep but persisted at an increased level from baseline.

Conclusion:

Functional deficits persist beyond a subjective experience of sleepiness. The common sleep cycle of 5-7 days of restriction followed by 2-7 days of “catch-up” may be sufficient to repair subjective sleepiness and not other derangements of sleep restriction.

Keywords: Sleep restriction, sleep recovery, psychomotor vigilance testing, subjective sleepiness, Stanford Sleepiness Scale, Karolinska Sleepiness Scale, PVT, SSS, KSS.

Degree Type
Capstone Project

Degree Name
Master of Science in Physician Assistant Studies

Keywords
sleep restriction, sleep recovery, sleepiness, attention, sleep deprivation

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The Repair of Sleep Restriction Induced Neurocognitive Deficits After Recovery Sleep

Megan Manley

A Clinical Graduate Project Submitted to the Faculty of the
School of Physician Assistant Studies
Pacific University
Hillsboro, OR
For the Masters of Science Degree, 12 August, 2017
Faculty Advisor: Mark Pedemonte, MD
Clinical Graduate Project Coordinator: Annjanette Sommers, PA-C, MS
Biography
Megan Manley is originally from Colorado. University drew her to Oregon, where she received her BA in Theatre Arts. After many years working in a variety of clinical settings in the US, Mexico, and Guatemala she returned to the academic world in pursuit of a career that would allow her more time to work directly with patients.
Abstract

Background:
Chronic sleep restriction is common globally and has well documented negative effects on psychobehavioral and metabolic function. This review assesses research on the amount of sleep recovery needed to repair subjective sleepiness and lapses in psychomotor vigilance.

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An exhaustive search of MEDLINE-Ovid, CINAHL, and Web of Science databases was performed in July 2016 using the keywords “sleep restriction” and “sleep recovery”. The referenced works of qualifying articles were assessed for previously unidentified sources. Inclusion criteria were published full text papers with a combination of sleep restriction and a recovery period, that assessed psychomotor vigilance and subjective sleepiness. The included articles were graded for quality following GRADE workgroup guidelines.

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Conclusion:
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Keywords: Sleep restriction, sleep recovery, psychomotor vigilance testing, subjective sleepiness, Stanford Sleepiness Scale, Karolinska Sleepiness Scale, PVT, SSS, KSS.
Acknowledgements

To the faculty, staff, and visiting lecturers of the Pacific University PA Program: Your enthusiasm and passion for sharing your medical and personal expertise is inspiring on a daily basis. Thank you for supporting the individualized learning and growth of every student.

To my family of relation and family of choice: Your steady support, humor, and kindness has made it possible for me to focus on becoming the best human I can be. I am grateful for you every day.
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List of Abbreviations

KSS – Karolinska Sleepiness Scale
PVT – Psychomotor Vigilance Test
SSS – Stanford Sleepiness Scale
TIB – Time in Bed
The Repair of Sleep Restriction Induced Neurocognitive Deficits After Recovery Sleep

BACKGROUND

Chronically restricted sleep is very common in the US and globally. A 2009 CDC survey\(^1\) found 35\% of the population reporting an average sleep time of less than 7 hours a night. A 2016 study\(^2\) pooling responses from more than 20 countries found approximately 30\% of people routinely sleep less than 7 hours a night. Shortened sleep can lead to a wide range of performance and health deficits, including altered cortisol, interleukin, insulin like growth factor, and LDL levels.\(^3\)–\(^5\) Shiftworkers (those working schedules involving very late nights or early mornings, rotating shifts, or being prevented from sleeping during the night) have been studied as a group with frequent sleep disturbance and have been identified as being at higher risk for a wide range of disorders including a higher likelihood of developing metabolic syndrome than the population as a whole, with greater risks at longer lengths of time spent doing shiftwork.\(^6\)

As the metabolic and cognitive derangements of sleep loss are becoming better understood, professional organizations are changing their guidelines to better protect the health of both their employees and the people they serve. In 2011 the ACGME (Accreditation Counsel for Graduate Medical Education) adjusted guidelines for medical resident scheduling in an attempt to provide sufficient recovery time between shifts. Setting the recommendation at a minimum of 10 hours between working hours to allow sufficient time for 8 hours of sleep.\(^7\) The same year the Federal Aviation Administration changed their guidelines to not just recommend, but require, commercial pilots have 10 hours off between shifts with a minimum of 8 hours uninterrupted time available for sleep.\(^8\)

The harms of sleep restriction are becoming common knowledge, but there is not yet a full understanding of what degree of repair is possible for different cognitive and metabolic changes and what is required to recover fully from a period of total or partial sleep loss. Therefore a review of the current research will attempt to answer the question: How much recovery sleep is needed to repair the neurocognitive deficits of sleep restriction?
METHODS

An exhaustive search of MEDLINE-Ovid, CINAHL, and Web of Science databases was performed in July 2016 using the keywords “sleep restriction” and “sleep recovery”. The referenced works of qualifying works were assessed for previously unidentified sources. Inclusion criteria were published full text studies with a combination of sleep restriction and a recovery period, that assessed psychomotor vigilance and subjective sleepiness. The included papers were graded for quality following GRADE workgroup guidelines.9 (See Tables 1 and 2.)

RESULTS

Initial database searches produced 46 results once duplicates were removed. Two studies fit all inclusion criteria. A further search of referenced works resulted in 2 additional studies. In total 4 studies10-13 were included for analysis. (See Tables 1, 2, 3)

Axelsson et al.

Published in 2008 Sleepiness and Performance in Response to Repeated Sleep Restriction and Subsequent Recovery During Semi-Laboratory Conditions10 put 9 young healthy males through a multi-week sleep protocol. Two weeks prior to the first laboratory day participants spent approximately 8 hours time in bed (TIB) each night, from 23:00±30 to 07:00±30, then 4 nights of strict 23:00-07:00 TIB. Laboratory protocol was 2 days of baseline sleep (23:00-07:00), 5 days of restricted sleep (03:00-07:00) and 3 days of recovery sleep (23:00-07:00). A further 3 days were spent at home following the same instructions as the preparatory phase (23:00±30 to 07:00±30 with no less than 8 hours spent in bed).10

Participants took a simple serial reaction time test 3 times each day in laboratory. The test design is very similar to other psychomotor vigilance testing, lasting 6 minutes and with a lapse counted for any reaction >500ms. Subjective sleepiness was assessed using a slightly
modified Karolinska Sleepiness Scale immediately following reaction time testing.\textsuperscript{10}

During the 10 days spent in laboratory participants could play games, read, watch videos, use the internet, and could do light work or study. They were required to spend time outdoors at least twice a day for a minimum of 20 minutes each time. Participants had separate bedrooms available to them for both sleep and daytime activities.\textsuperscript{10}

Both subjective sleepiness and number of lapses increased with sleep restriction but only subjective sleepiness returned to baseline after 2 in-laboratory recovery days. Number of lapses remained elevated even at the final day of testing after continuing recovery at home for a total of 7 days of 8 hours TIB recovery.\textsuperscript{10} (See Table 3.)

Limitations of this study are its very small and homogenous subject group and lack of control group. There was also a very high degree of variation between participants, suggesting that individual differences may lead to great variation in response to conditions of restricted sleep and recovery.\textsuperscript{10}

\textit{Banks et al}

Published in 2010 \textit{Neurobehavioral Dynamics Following Chronic Sleep Restriction: Dose-Response Effects of One Night for Recovery}\textsuperscript{11} is a randomized control trial involving 159 healthy adults in laboratory for 12 days. Small groups of 4-5 participants were in laboratory at a time and were randomized as a whole group to either a sleep restricted condition or the control. Sleep restriction groups had two baseline nights of 22:00-08:00 (10 hours TIB). Sleep restriction was 04:00-08:00 for the next 5 nights. Subjects were informed of their randomized sleep recovery dose on night 4 of sleep restriction. The 6 possible recovery allocations were 0 hours TIB, 06:00-08:00 (2 hours) TIB, 04:00-08:00 (4 hours) TIB, 02:00-08:00 (6 hours) TIB, 00:00-08:00 (8 hours) TIB, or 22:00-08:00 (10 hours) TIB. Control groups were allocated 22:00-08:00 (10 hours) TIB for all laboratory nights.\textsuperscript{11}

Participants completed a 10-minute Psychomotor Vigilance Test (PVT), a 3-minute Digit Symbol Substitution Task, a Profile of Mood States, and a Karolinska Sleepiness Scale assessment starting at 08:00 each day and every 2 waking hours thereafter. The results are used as averages for the day and not broken down into time of day analysis.\textsuperscript{11}
During non-testing times subjects could play games, read, watch TV/movies, and interact with laboratory staff. Each day there was one scheduled opportunity to shower and 3 meals were provided.\textsuperscript{11}

As expected, sleep restriction produced an increase of subjective sleepiness and number of lapses in all groups. Amount of continued deterioration or repair of functional and subjective deficits were dose dependent after 1 night of recovery sleep. Significantly, even the highest recovery sleep dose of 10 hours TIB was insufficient to return either measure to control or baseline levels.\textsuperscript{11} (See Table 3.)

Limitations of this study are the relatively homogenous group of participants (age 22-45).\textsuperscript{11}

\textit{Belenky et al} \\
Published in 2002 Patterns of Performance Degradation and Restoration During Sleep Restriction and Subsequent Recovery: a Sleep Dose-Response Study\textsuperscript{12} is a randomized trial over 13 days of sleep protocol and testing. The first 3 days were at a baseline level of TIB from 23:00-07:00 (8 hours). Participants were randomized into 4 possible sleep conditions for the following 7 days, 22:00-07:00 (9 hours) TIB, 24:00-07:00 (7 hours) TIB, 02:00-07:00 (5 hours) TIB, or 04:00-07:00 (3 hours) TIB. Following 7 days of sleep restriction/augmentation there was 3 days of recovery with 23:00-07:00 (8 hours) TIB.\textsuperscript{12}

Participants completed a battery of tests including a 10-minute Psychomotor Vigilance Test and Stanford Sleepiness Scale (SSS) 4 times each day. The results are used as averages for the day and not broken down into time of day analysis.\textsuperscript{12}

Participants were assigned to two-person hospital-style bedrooms. Three meals were served each day with snacks and drinks available at any non-testing time.\textsuperscript{12}

PVT lapses increased over each day of sleep restriction in the 3-hour TIB group. There was a significant improvement after the first day of recovery sleep but 3 days of recovery sleep was insufficient to return performance to baseline. PVT lapses in the 5-hour TIB group increased across the sleep restriction phase, though not as significantly as the 3 hour group. Lapses failed to recover after 3 days, staying near the same level as the seventh day of restriction. PVT lapses in the 7-hour TIB group exhibited a very slight increase across sleep restriction and remained at the same level through 3
recovery days. The study authors did not see the slight increase as significant and counted the 7-hour group as experiencing no change in performance over the course of the study. PVT lapses in the 9-hour TIB group demonstrated no change through the entire study period.\(^\text{12}\) (See Table 3.)

SSS ratings for the 3-hour group increased significantly over the sleep restriction phase and returned to baseline after only a single day of recovery sleep and to below baseline after 3 days of recovery. SSS ratings for the 5-hour group increased very slightly over the sleep restriction phase and returned to baseline after 3 days of recovery. Both the 7-hour and 9-hour groups demonstrated no change or a very slight decrease in subjective sleepiness over the entire study period.\(^\text{12}\) (See Table 3.)

**Pejovic et al**

Published in 2013 *Effects of Recovery Sleep After One Work Week of Mild Sleep Restriction on Interleukin-6 and Cortisol Secretion and Daytime Sleepiness and Performance*\(^\text{13}\) is an experiment over 13 days with a mix of home and laboratory time. The first 4 days established baseline with 8 hours TIB (22:30-06:30). The next 6 nights restricted sleep to 22:30-04:30 (6 hours) TIB. The final 3 nights of recovery sleep was 22:30-08:30 (10 hours) TIB.\(^\text{13}\)

Participants were in laboratory for 24 hours on the last baseline day, the day following the last sleep restriction day, and the day following 2 recovery nights. On laboratory days subjects performed a 10-minute Psychomotor Vigilance Test every 2 hours and completed The Stanford Sleepiness Scale hourly during waking periods.\(^\text{13}\)

During non-testing times on laboratory days participants were able to play games, watch television, walk around, or use the computer. On non-laboratory days participants were instructed to maintain their usual daily routines, including exercise and diet, to not nap and to avoid caffeine.\(^\text{13}\)

Subjective sleepiness increased after sleep restriction and improved to below baseline after the recovery period. PVT lapses increased significantly after sleep restriction and though improved did not return to baseline after two nights of 10 hours TIB recovery.\(^\text{13}\) (See Table 3.)

Limitations of this study are the small, homogenous population.
DISCUSSION

These 4 studies\textsuperscript{10-13}, taken together, show a clear dose relationship for reparative effects of recovery sleep. They also show the doses required to repair different types of psychobehavioral changes are not all the same.

For the assessment of subjective sleepiness 2 different scales were used by the studies included for analysis. The Karolinska Sleepiness Scale is a 1-9 scale where 1=extremely alert, 5=neither alert nor sleepy, and 9=very sleepy, great effort to keep awake, fighting sleep. (See figure 1) The Stanford Sleepiness Scale is a 1-7 scale where 1=feeling active, vital, alert, or wide awake, 4=somewhat foggy, let down, and 7=no longer fighting sleep, sleep onset soon; having dreamlike thoughts. (See figure 2) Comparing the two scales is complicated both by their differing degree of gradation and that the endpoints of sleepiness on the two scales are not the same; a 9 on the KSS is more similar to a 6 on the SSS than a 7. Though the degree of change during the period of sleep restriction is not directly comparable the amount of recovery sleep required to return to baseline should not be affected by the difference of the scales.

The results of these studies\textsuperscript{10-13} suggest that an extended sleep period is helpful to repair subjective sleepiness after a period of restricted sleep. Three nights of 10 hours TIB improved subjective sleepiness to better than the baseline condition. Three nights of 8 hours TIB improved subjective sleepiness to baseline or better. Notably, many groups returned to baseline after day 2 of recovery sleep. The highest single night sleep dose was 10 hours, which was insufficient to completely return the participants to baseline though the scores did improve significantly. Banks et al projected the dose response curve to predict at what point it would intersect with the control group and estimated that a single sleep dose of 10.62 hours TIB would result in a return to baseline sleepiness.

In contrast to sleepiness no study included for analysis was able to achieve a return to baseline performance of psychomotor vigilance testing after sleep restriction. Axelsson et al\textsuperscript{10}, Belenky et al\textsuperscript{12}, and Pejovic et al\textsuperscript{13} show that there is a plateau to recovery of function that
persists for at least 3 days. Axelsson et al\textsuperscript{10} suggests that this reduced function persists for longer than 7 days of recovery. (See Table 4.)

The main limitations of these studies\textsuperscript{10-13} are overall small and homogenous sample groups. The largest and most diverse study (Banks et al\textsuperscript{11}) had only 159 participants between the ages of 22 and 45. The way group allocation was performed is unclear in both studies\textsuperscript{11, 12} with multiple groups. A further complication is what to consider a “control”. Both Banks et al\textsuperscript{11} and Balenky et al\textsuperscript{12} had test groups at either 10 or 9 hours TIB which could be considered either a control or an augmentation of baseline sleep. Also, the authors didn’t address the participant’s pre-study sleep patterns. Initial functional measures could have been affected by pre-study sleep even with days of preparatory baseline sleep included in the study design. Future studies with longer recovery periods that are able to follow functional return to baseline would further the understanding of recovery after sleep restriction. Other studies following a sleep pattern more similar to that found in many working people with 5-7 days of sleep restriction and 2-7 days of recovery sleep in a repeating pattern would be useful to learn if repeated cycles of restriction and recovery are ameliorative, repetitive, or additive in their effects on subjective and objective measures of function. While forming a better understanding of how sleep recovery works for populations research should also look more closely at the wide variation of individual responses and learn if it is possible to predict what helps a person to be less effected by sleep restriction and to recover faster.

**CONCLUSION**

These studies demonstrate that 2 nights of 8 or more hours of sleep is sufficient to return subjective sleepiness to baseline levels after up to a week of even severely restricted sleep. The same level of recovery sleep is insufficient to fully repair psychomotor vigilance and lapses continue at an improved but below baseline level for at least 3-7 days. No study was able to demonstrate a return to baseline in functional testing during the course of follow up so it is unknown how long those deficits may persist.

This review did not address the amount of recovery sleep needed to repair the many metabolic derangements of sleep restriction. As there is a high degree in variance just between two psychobehavioral measures it is possible that there is equal variation in the repair of metabolic measures as well.
The relatively rapid return to baseline for subjective sleepiness while functional measures remain impaired implies that people may subject themselves to cyclic sleep restriction because they rapidly feel better while their functional levels remain altered, possibly resulting in long term deficits of neurologic health or function.
References


### Table 1: Quality Assessment of Reviewed Articles

**Outcome: Psychomotor Vigilance Lapses**

<table>
<thead>
<tr>
<th>Study</th>
<th>Design</th>
<th>Downgrade Criteria</th>
<th>Upgrade Criteria</th>
<th>GRADE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Limitations</td>
<td>Inconsistency</td>
<td>Indirectness</td>
</tr>
<tr>
<td>Axelsson et al</td>
<td>Cohort Study</td>
<td>Not Serious</td>
<td>Not Serious</td>
<td>Not Serious</td>
</tr>
<tr>
<td>Banks et al</td>
<td>RCT</td>
<td>Serious&lt;sup&gt;b&lt;/sup&gt;</td>
<td>Not Serious</td>
<td>Not Serious</td>
</tr>
<tr>
<td>Belenky et al</td>
<td>RCT</td>
<td>Serious&lt;sup&gt;b&lt;/sup&gt;</td>
<td>Not Serious</td>
<td>Not Serious</td>
</tr>
<tr>
<td>Pejovic et al</td>
<td>Cohort Study</td>
<td>Not Serious</td>
<td>Not Serious</td>
<td>Not Serious</td>
</tr>
</tbody>
</table>

- <sup>a</sup> Small, homogenous subject group.
- <sup>b</sup> Group assignment protocol unclear.
Table 2: Quality Assessment of Reviewed Articles

**Outcome: Subjective Sleepiness**

<table>
<thead>
<tr>
<th>Study</th>
<th>Design</th>
<th>Downgrade Criteria</th>
<th>Upgrade Criteria</th>
<th>GRAD E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Axelson et al</td>
<td>Cohort Study</td>
<td>Serious&lt;sup&gt;a&lt;/sup&gt; Not serious Not serious Serious&lt;sup&gt;b&lt;/sup&gt; Not serious None Very low.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Banks et al</td>
<td>RCT</td>
<td>Serious&lt;sup&gt;a, c&lt;/sup&gt; Not serious Not serious Not serious Not serious Dose-Response Gradient Moderate.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Belenky et al</td>
<td>RCT</td>
<td>Serious&lt;sup&gt;a, c&lt;/sup&gt; Not serious Not serious Not serious Not serious Dose-Response Gradient Moderate.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pejovic et al</td>
<td>Cohort Study</td>
<td>Serious&lt;sup&gt;a&lt;/sup&gt; Not serious Not serious Serious&lt;sup&gt;b&lt;/sup&gt; Not serious None Very low.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a. Inherently subjective outcome
b. Small, homogenous subject group.
c. Group assignment protocol unclear
<table>
<thead>
<tr>
<th>Table 3: Summary of Findings</th>
<th>Lapses (PVT) Standard Lapse = reaction time &gt;500ms</th>
<th>Subjective Sleepiness</th>
<th>Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Axelsson et al</strong>&lt;br&gt;Mean scores only reported in graph form.</td>
<td>B=4.5&lt;br&gt;RES=10&lt;br&gt;REC=5.5</td>
<td>B=4.5&lt;br&gt;RES=7.75&lt;br&gt;REC=4.5</td>
<td>3 X 8hr not sufficient to repair performance deficits. Subjective sleepiness improves significantly after 2 nights recovery.</td>
</tr>
<tr>
<td><strong>Banks et al</strong>&lt;br&gt;Scores following 5 days of restriction are only reported in graph form for the entire subject group. ≈10.2&lt;br&gt;0h: B=2.2&lt;br&gt;REC=21.3&lt;br&gt;2h: B=1.8&lt;br&gt;REC=15.2&lt;br&gt;4h: B=2.8&lt;br&gt;REC=13.0&lt;br&gt;6h: B=1.6&lt;br&gt;REC=6.9&lt;br&gt;8h: B=3.4&lt;br&gt;REC=7.6&lt;br&gt;10h: B=3.1&lt;br&gt;REC=5.6</td>
<td>Scores following 5 days of restriction are only reported in graph form for the entire subject group. ≈5.5 KSS units&lt;br&gt;0h: B=4.42&lt;br&gt;REC=7.68&lt;br&gt;2h: B=3.5&lt;br&gt;REC=7.1&lt;br&gt;4h: B=3.1&lt;br&gt;REC=5.5&lt;br&gt;6h: B=3.0&lt;br&gt;REC=4.5&lt;br&gt;8h: B=3.3&lt;br&gt;REC=4.3&lt;br&gt;10h: B=3.0&lt;br&gt;REC=3.8</td>
<td>Single night recovery sleep doses studied were unable to return participants to baseline for performance or subjective sleepiness.</td>
<td></td>
</tr>
<tr>
<td><strong>Belenky et al</strong>&lt;br&gt;Mean scores only reported in graph form.</td>
<td>3h: B=2, RES=17, REC=7&lt;br&gt;5h: B=2.5, RES=6, REC=6&lt;br&gt;7h: B=2, RES=3, REC=3&lt;br&gt;9h: B=1, RES=1, REC=1</td>
<td>Baseline all groups between 1.5-2.&lt;br&gt;3h: RES=2.5, REC=1.75&lt;br&gt;5h: RES=2.2, REC=1.8&lt;br&gt;7h: RES=1.5, REC=1.4&lt;br&gt;9h: RES=1.6, REC=1.5</td>
<td>3 X 8hr recovery sleep not sufficient to return performance to baseline in groups that developed a deficit. Subjective sleepiness improves after 1 night recovery and is returned to baseline by night three in all groups.</td>
</tr>
<tr>
<td><strong>Pejovic et al</strong>&lt;br&gt;</td>
<td>B=2.9±0.4&lt;br&gt;RES=3.96±0.6&lt;br&gt;REC=4.3±0.6</td>
<td>Baseline – Restriction = -0.96±0.18&lt;br&gt;Baseline - Recovery=0.24±0.12</td>
<td>2 nights extended recovery sleep produced improvement of sleepiness and fatigue but did not improve performance.</td>
</tr>
</tbody>
</table>

**Abbreviations:**<br>B = Baseline, RES = Restriction, REC = Recovery<br>KSS = Karolinska Sleepiness Scale<br>SSS = Stanford Sleepiness Scale
Table 4: Baseline lapses – post recovery lapses

<table>
<thead>
<tr>
<th>Amount of Recovery Sleep</th>
<th>0 hr X1</th>
<th>2 hr X1</th>
<th>4 hr X1</th>
<th>6 hr X1</th>
<th>8 hr X1</th>
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<tbody>
<tr>
<td>3 hr X7</td>
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<td></td>
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<td>5 hr X7</td>
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<tr>
<td>7 hr X7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9 hr X7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### FIGURES

#### Figure 1: Karolinska Sleepiness Scale

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Extremely alert</td>
</tr>
<tr>
<td>2</td>
<td>Very alert</td>
</tr>
<tr>
<td>3</td>
<td>Alert</td>
</tr>
<tr>
<td>4</td>
<td>Rather alert</td>
</tr>
<tr>
<td>5</td>
<td>Neither alert nor sleepy</td>
</tr>
<tr>
<td>6</td>
<td>Some signs of sleepiness</td>
</tr>
<tr>
<td>7</td>
<td>Sleepy, but no difficulty remaining awake</td>
</tr>
<tr>
<td>8</td>
<td>Sleepy, some effort to keep awake</td>
</tr>
<tr>
<td>9</td>
<td>Very sleepy, great effort to keep awake, fighting sleep</td>
</tr>
</tbody>
</table>

#### Figure 2: Stanford Sleepiness Scale

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Feeling active, vital, alert, or wide awake</td>
</tr>
<tr>
<td>2</td>
<td>Functioning at high levels, but not at peak; able to concentrate</td>
</tr>
<tr>
<td>3</td>
<td>Awake, but relaxed; responsive but not fully alert</td>
</tr>
<tr>
<td>4</td>
<td>Somewhat foggy, let down</td>
</tr>
<tr>
<td>5</td>
<td>Foggy; losing interest in remaining awake; slowed down</td>
</tr>
<tr>
<td>6</td>
<td>Sleepy, woozy, fighting sleep; prefer to lie down</td>
</tr>
<tr>
<td>7</td>
<td>No longer fighting sleep, sleep onset soon; having dream-like thoughts</td>
</tr>
</tbody>
</table>