

# Impact Of Sleep Restriction And Recovery On Motivation During Repeated Cognitive Performance Testing

Denise Lange<sup>1,2</sup>, Eva Hennecke<sup>1</sup>, Judith Fronczek<sup>3</sup>, Andreas Bauer<sup>3</sup>, Daniel Aeschbach<sup>1</sup>, David Elmenhorst<sup>3</sup>, Eva-Maria Elmenhorst<sup>1,2</sup>

1. German Aerospace Center, Institute of Aerospace Medicine, Cologne  
 2. RWTH Aachen University, Institute of Occupational Medicine, Aachen  
 3. Forschungszentrum Jülich, Institute of Neuroscience and Medicine, Jülich

## Introduction and Purpose

Both motivation and sleep deprivation affect cognitive performance. Especially during long-lasting studies with repeated cognitive performance tasks there is concern that subjects will lose motivation over time. Results may be confounded due to changes in motivation.

## Methods/Study design

36 healthy volunteers performed 55 cognitive performance tasks at three-hourly intervals in a 11-day inpatient study:

	Intervention group N=21; mean age 25.9 ± 3.6 years; 9 females	Control group N=15; mean age 27.5 ± 5.8 years; 5 females
Adaptation (+2)	8 h	8 h
Baseline 1	8 h	8 h
Baseline 2	8 h	8 h
Chronic Sleep deprivation 1	5 h	8 h
Chronic Sleep deprivation 2	5 h	8 h
Chronic Sleep deprivation 3	5 h	8 h
Chronic Sleep deprivation 4	5 h	8 h
Chronic Sleep deprivation 5	5 h	8 h
Recovery	8 h	8 h
Total sleep deprivation	2 h	2 h
Recovery	+8 h	+8 h

: Time in Bed  
 : KSS + How motivated are you now?  
 : Cognitive performance task

1= Very slightly or Not at All  
 2= A Little  
 3= Moderately  
 4= Quite a Bit  
 5= Extremely

Figure 1: Study protocol

After two baseline nights with 8 h time in bed (TIB) the intervention group underwent chronic sleep deprivation (CSD) for 5 nights (5 h TIB) with a following recovery night of 8 h TIB. The control group had the opportunity to sleep 8 hours every night. After that both groups were kept awake for 38 h, which was followed by a 10 h recovery night. Participants completed the Karolinska Sleepiness Scale (KSS) and a questionnaire about their motivation (from 1=very little/not motivated to 5=very motivated) at 6 p.m. on all days.

## Results

Sleepiness increased in the course of chronic sleep deprivation and resulted in a significant difference after total sleep deprivation (TSD) between control and intervention group (Figure 2, A). A significant difference between the two groups according to motivation is already found at the fifth chronic sleep deprivation day (control:  $3.0 \pm 1.3$ , experimental:  $2.2 \pm 0.6$ ) and remained after recovery sleep (control:  $3.1 \pm 1.0$ , experimental:  $2.3 \pm 0.6$ ) and total sleep deprivation (control:  $2.9 \pm 1.3$ , experimental:  $1.8 \pm 0.8$ ) (see Figure 2, B).

## Conclusions:

- Chronic sleep restriction for five days leads to an increase in sleepiness and a decrease in motivation
- One night of recovery is insufficient to reverse the motivation loss, contrasting with the beneficial effect on sleepiness
- Subjective motivation seems to decrease as a function of subjective sleepiness
- Without sleep loss, motivation remains high during long-lasting studies



**Cognitive performance task results base on study design and not on motivation loss**

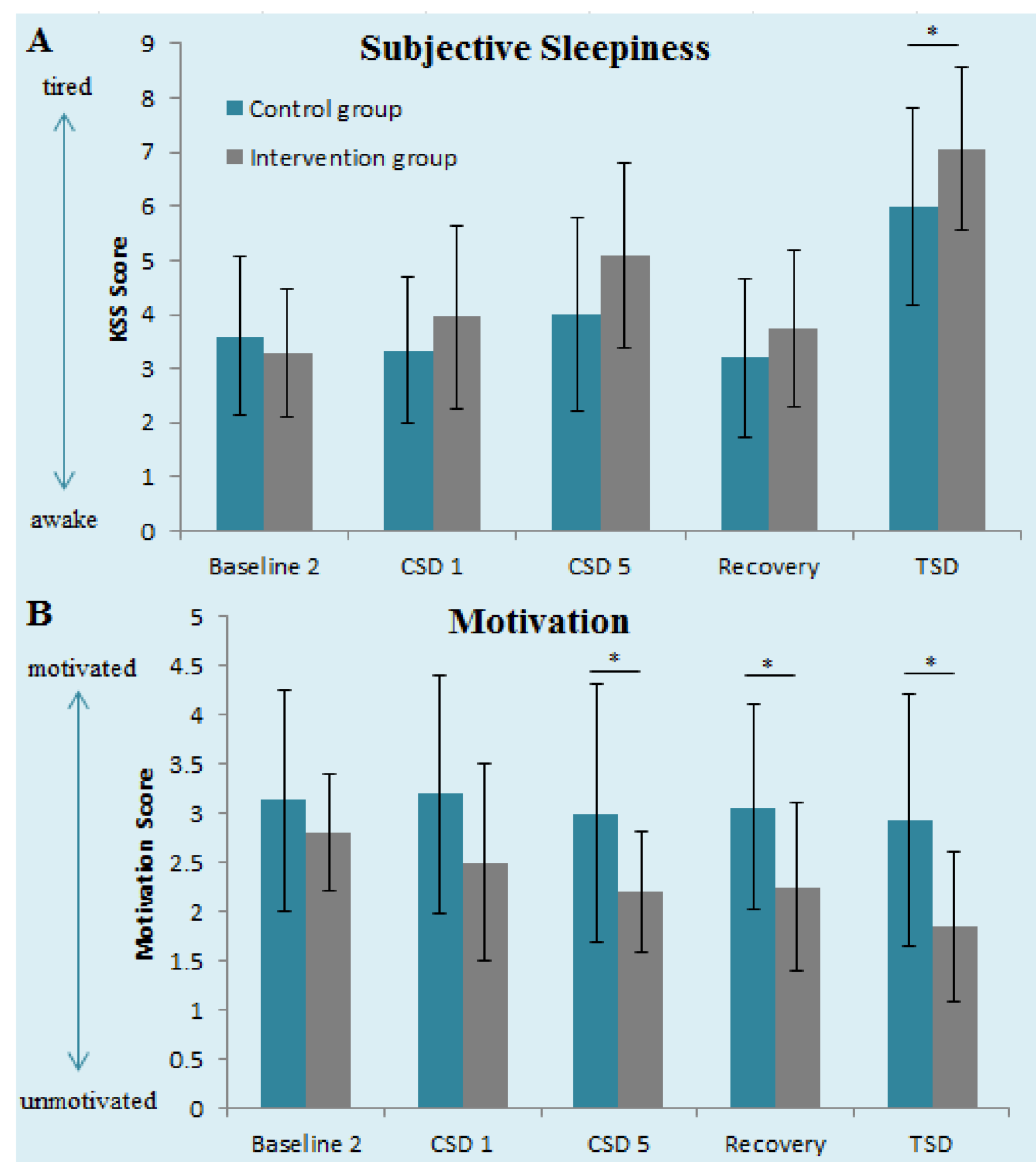


Figure 2: KSS (A) and Motivation (B) Score in control and intervention group.

A: KSS Score on total sleep deprivation for control group 6, for intervention 7.05 (p=0.0284)

B: Significant difference in motivation for chronic sleep deprivation 5 (p=0.0347), recovery (p=0.0205) and total sleep deprivation (p=0.0096).

Figure 3, A illustrates a significant increase in subjective sleepiness from baseline ( $3.3 \pm 1.2$  (SD)) to the first ( $4.0 \pm 1.7$ ) and last ( $5.1 \pm 1.7$ ) day of chronic sleep restriction for the experimental group. For total sleep deprivation, both groups show a highly significant increase in subjective sleepiness.

In comparison with baseline, motivation shows a significant decrease to the last day of chronic sleep restriction, to recovery and to total sleep deprivation for the experimental group.

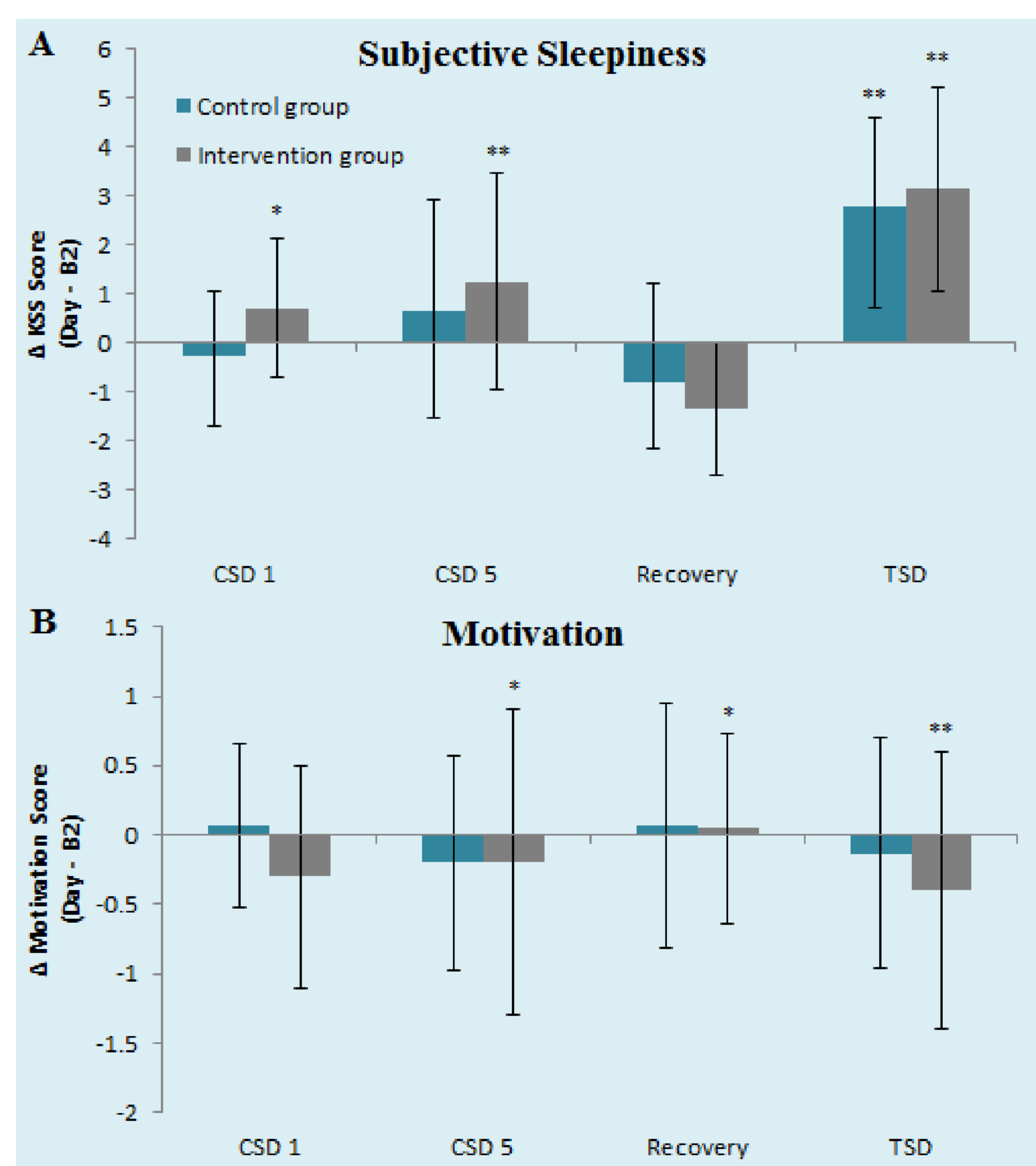


Figure 3: Δ KSS (A) and Motivation (B) Score between study-day and baseline.

A: Δ KSS Score is highly significant (control: p=0.0002, experimental: p=0.001) on total sleep deprivation.

B: Δ Motivation is significant on chronic sleep deprivation (p=0.0088), recovery (p=0.0164) and total sleep deprivation (0.0005).

Increase in sleepiness showed a significant Spearman correlation with loss of motivation ( $r = -0.47$ ,  $p < 0.001$ ).

