



Short Sleep Duration is Associated with Weight Regain – an Analysis of Sleep during Weight Loss Maintenance with Exercise, Liraglutide or Both Combined

Adrian F Bogh^{1,*}, Simon B K Jensen^{1,*}, Christian R Juhl¹, Charlotte Janus¹, Rasmus M Sandsdal¹, Julie R Lundgren¹, Bente M Stallknecht¹, Jens J Holst^{1,2}, Sten Madsbad³, Signe S Torekov¹

¹Department of Biomedical Sciences, University of Copenhagen, Denmark, ²NovoNordisk Foundation Center for Basic Metabolic Research, University of Copenhagen, Denmark ³Department of Endocrinology, Hvidovre Hospital, Denmark, * contributed equally

Introduction

Sleep disturbances are prevalent in modern society. Short sleep duration is associated with increased risk of developing obesity as well as other adverse health outcomes such as all-cause mortality, cardiovascular diseases and metabolic syndrome. Sleep restriction may cause metabolic changes that affect glucose metabolism, appetite control, energy intake and expenditure. It has been previously hypothesized that an individual's sleep habits may be a contributing factor in weight regain after a weight loss. Given the continuous increase in the prevalence of obesity, investigation of potentially modifiable lifestyle variables in adults with obesity apart from energy intake and expenditure is warranted.

Aim

To investigate changes in sleep duration and quality during diet-induced weight loss and subsequent weight loss maintenance with placebo, GLP-1-receptor agonist liraglutide, exercise or the two combined.

Methods

This study is based on data from the randomized placebo-controlled S-LiTE study (figure 1). During an 8-week low-calorie diet, 195 adults with obesity (BMI 32-43 kg/m²) lost 12% body weight (figure 2). Participants were then randomly assigned to 1-year weight loss maintenance with either: 1) placebo, 2) exercise + placebo, 3) liraglutide 3.0 mg/day 4) or exercise + liraglutide. Sleep duration was objectively measured accelerometers before and after the low-calorie diet and after 13, 26 and 52 weeks of weight maintenance. Sleep quality was subjectively measured with the Pittsburgh Sleep Quality Index (PSQI). To test the association between sleep and weight gain, participants were stratified into subgroups according to their sleep duration (below/above 6 hrs/night) or sleep quality (below/above a PSQI score of 5) at randomization (after low-calorie diet).

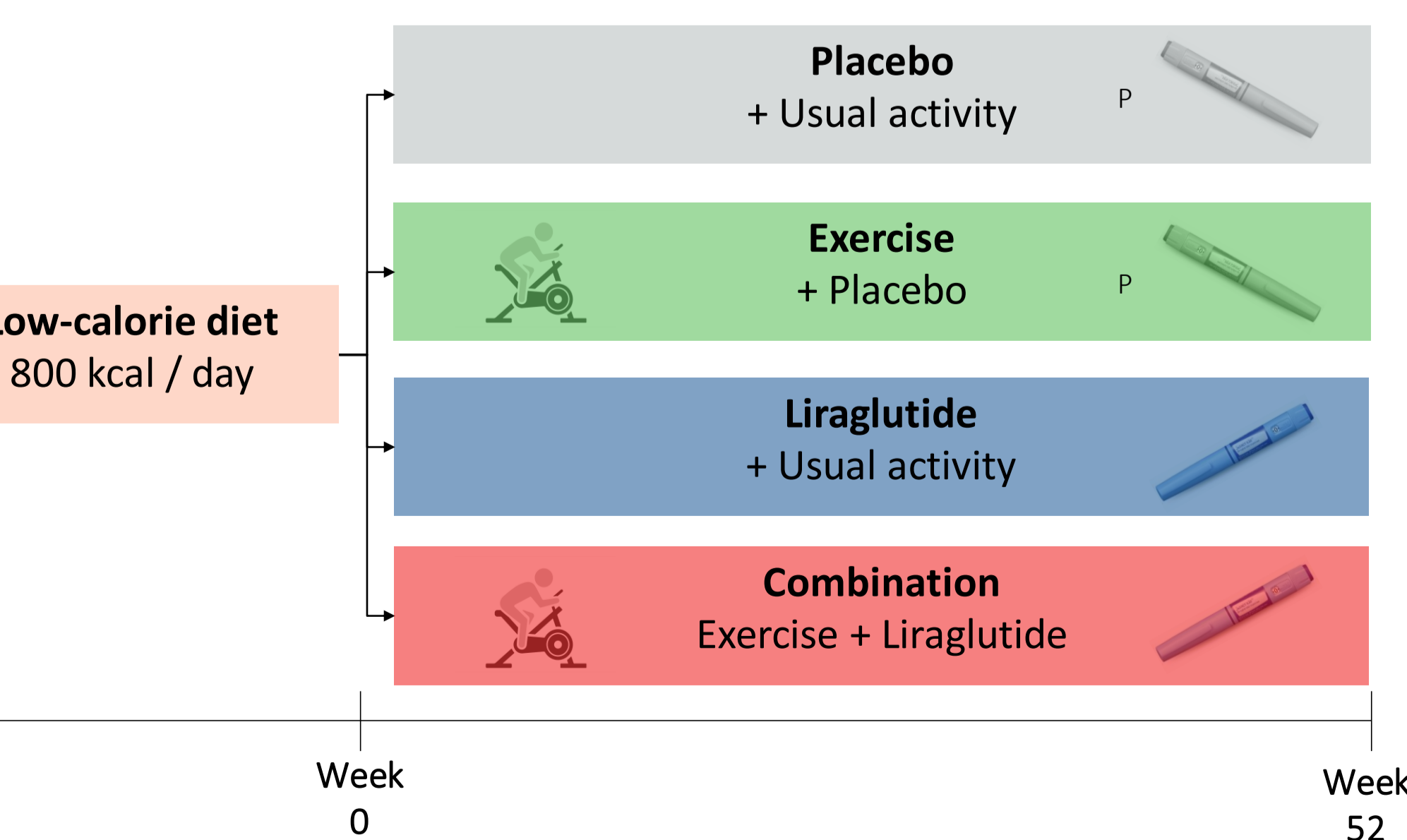


Figure 1. S-LiTE Study design.

Interventions

Exercise: Two exercise sessions per week supervised by the study personnel and two exercise sessions per week performed individually. Supervised exercise was 30 min spinning plus 15 min circuit training.

Liraglutide and placebo: Subcutaneous injections once daily with either placebo or Liraglutide 3.0 mg

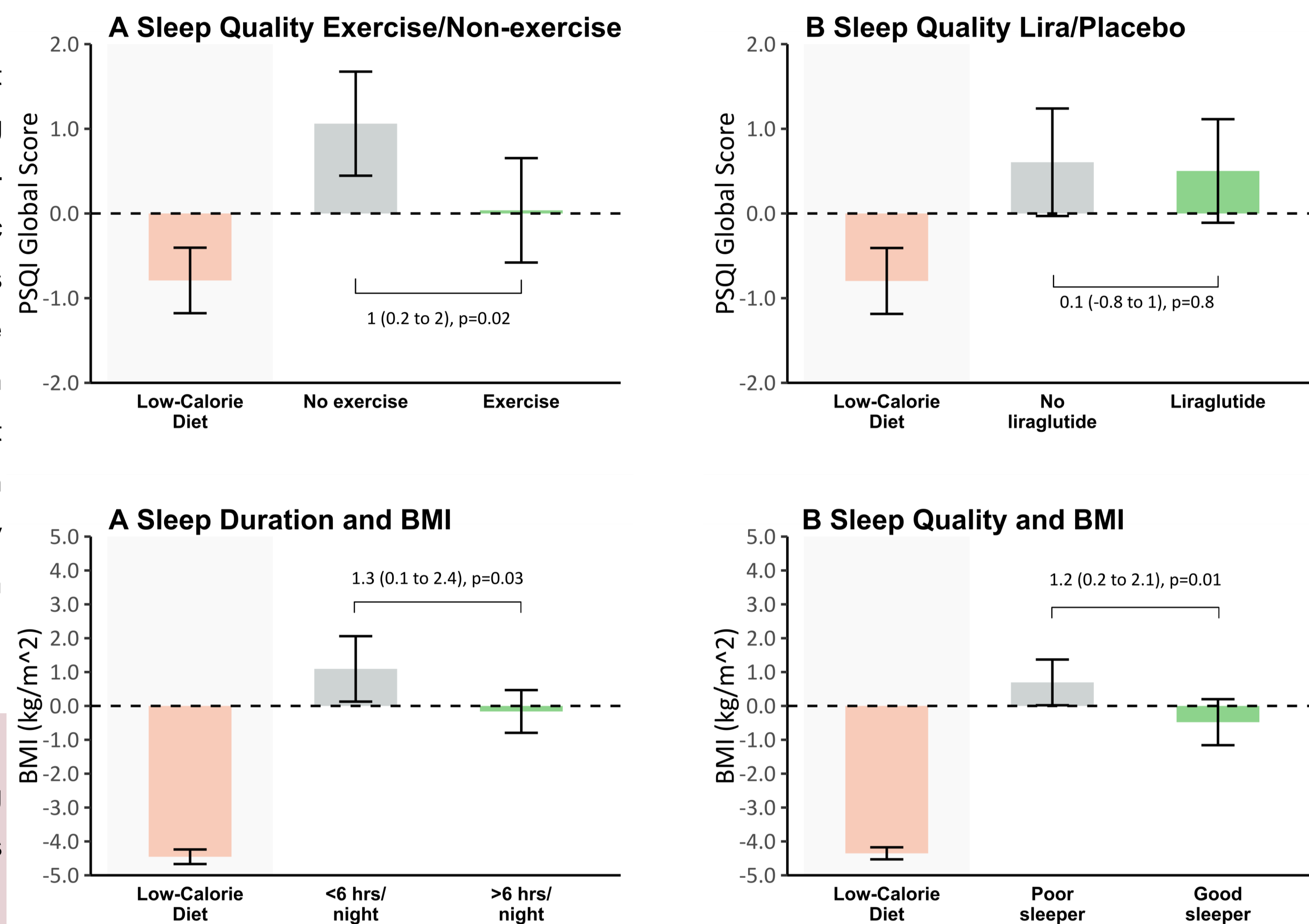


Figure 2: Changes in sleep quality as measured by PSQI global score in participants assigned to exercise compared to those that were not (A) and in participants assigned to liraglutide and placebo (B) during an 8-week low-calorie diet and during the weight loss maintenance phase as estimated mean differences. Between group differences are shown as estimated mean differences with 95% confidence intervals.

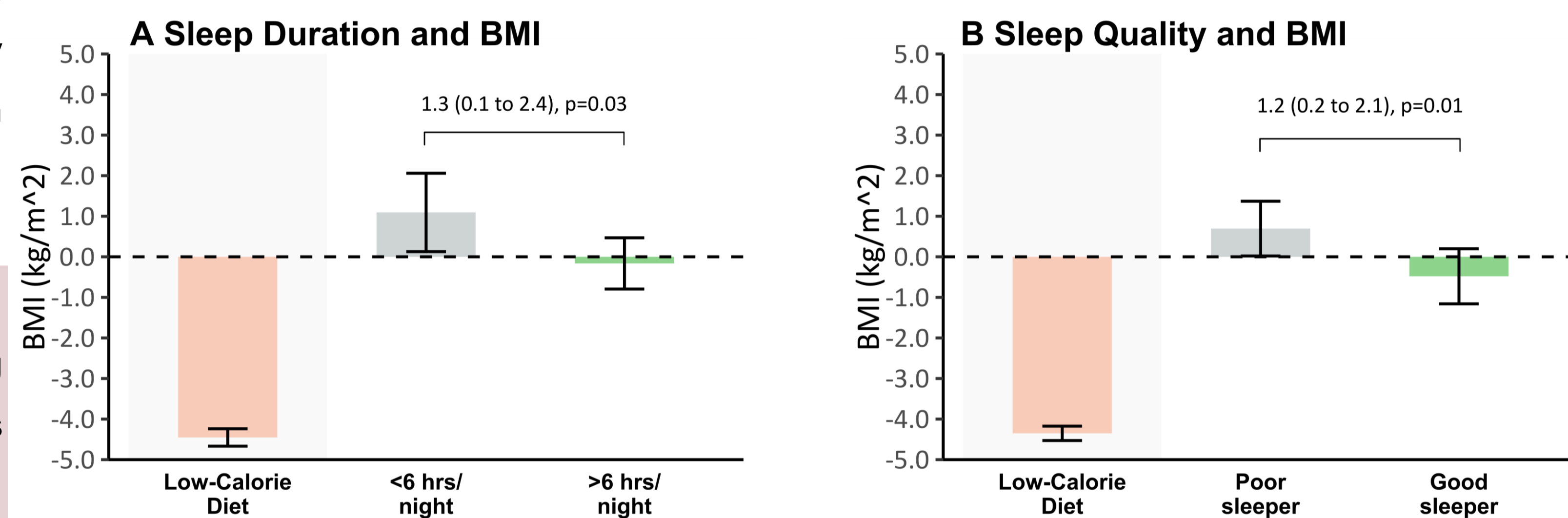


Figure 3: Changes in BMI during 8-week low-calorie diet and during weight loss maintenance phase for objective sleep duration groups (A) and sleep quality groups (B) as estimated mean differences. Between group differences are shown as estimated mean differences with 95% confidence intervals

Results

Low-calorie diet

After the 8-week low-calorie diet, sleep quality and sleep duration improved by 0.8 global PSQI score points and 17 minutes/night ($P < .0001$), respectively.

Weight loss maintenance with exercise

At week 52, the exercise groups maintained self-reported sleep quality increments attained from the low-calorie diet, whereas non-exercise groups relapsed indicating a between-group difference in PSQI global score of 1.0 ($P = .02$) (figure 2A). No difference was seen in sleep duration between the two groups (figure 4).

Weight loss maintenance with liraglutide

No significant changes in sleep parameters were observed between participants receiving liraglutide and placebo throughout the weight maintenance phase (figure 2B + 4).

Effects of sleep habits after weight loss on subsequent weight loss maintenance

At week 52, short sleepers (<6 hrs/night of sleep after low-calorie diet) increased their BMI by 1.1 kg/m², which was not observed among normal sleepers (>6 hrs/night) where BMI decreased by 0.16 kg/m² indicating a between-group difference of 1.3 kg/m² ($P = .03$) (figure 4A).

Poor sleepers (PSQI ≥ 5 after the low-calorie diet) increased their BMI by 0.7 kg/m² during the weight maintenance phase, whereas good sleepers (PSQI <5) showed no significant changes resulting in a between-group difference of 1.2 kg/m² ($P = .01$) (figure 3B).

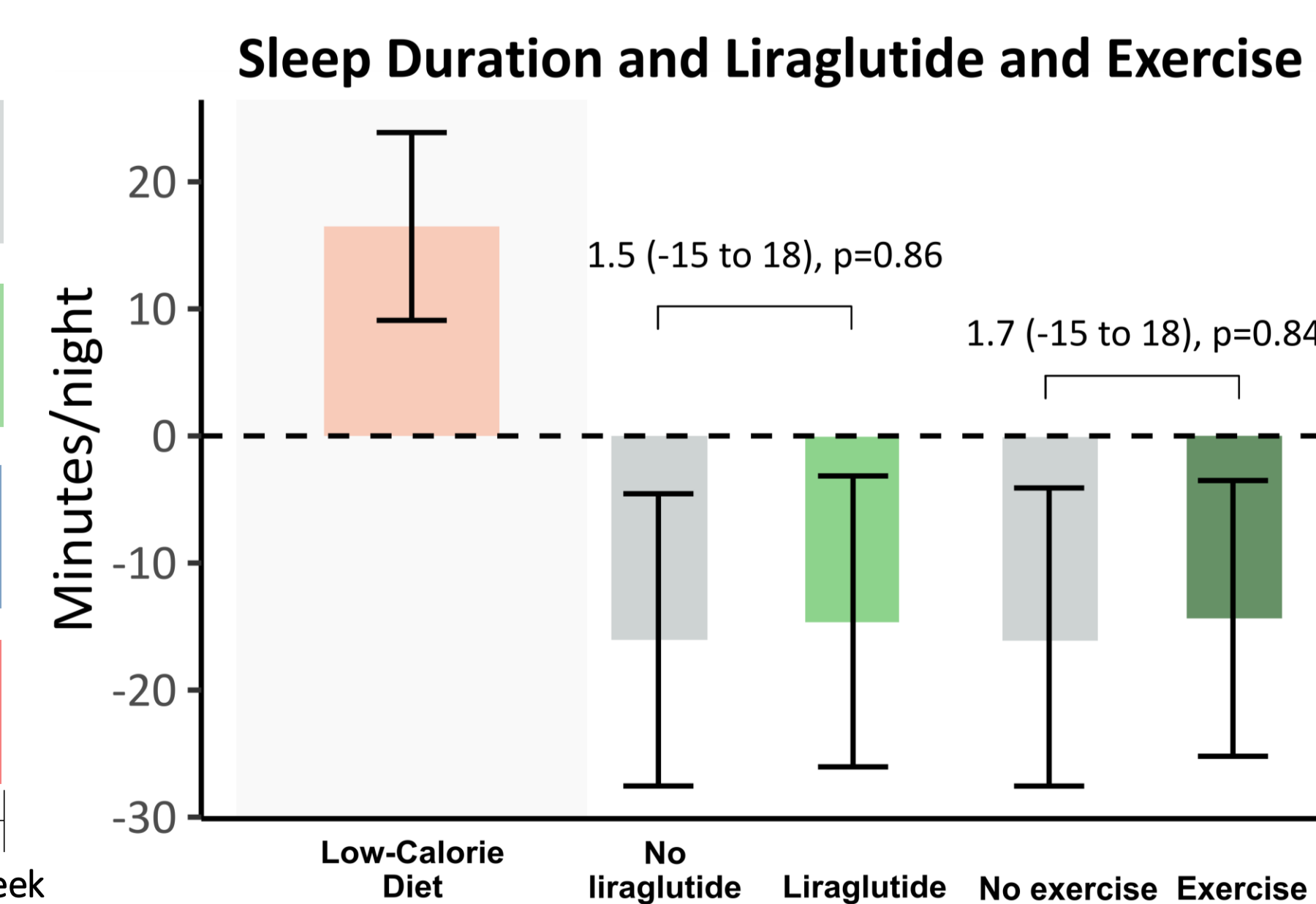


Figure 4: Changes in sleep duration during 8-week low-calorie diet and during weight loss maintenance phase in participants assigned to exercise/no exercise and liraglutide/no liraglutide as estimated mean differences. Between group differences are shown as estimated mean differences with 95% confidence intervals

Summary

As a weight maintenance strategy, exercise was able to maintain weight loss-induced improvements in sleep quality but not duration, whereas liraglutide treatment did not affect these sleep parameters. Adults with short sleep duration and poor sleep quality at the initiation of weight maintenance may be less successful in maintaining weight loss than those with sufficient sleep.