

Project Randomized Experiment

Effect of sleep reminder apps on University student's sleep quality and quantity

ECON-664

Submitted to : Matthieu Chemin

Submitted by :

Prachi Singhai

Department of Economics

McGill University

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ABSTRACT

In this study we aim to analyze the sleeping patterns and habits of the university students. As part of the study, participants in the treatment group will use a mobile application that monitors their sleeping habits, reminds them of sleep and nap times, and offers guidance on effective sleeping habits. The main goal of the research is to assess that whether participants who were asked to use the sleep application, experienced any improvement in their sleep quality and quantity when compared to the control group. The study will also attempt to measure whether improvements in a participant's sleep cycle affected other areas of life such as overall level of happiness, there ability to focus and level of stress.

INTRODUCTION

Around 62% of the adults worldwide do not get sufficient sleep. Losing one two hours of sleep can have significant impact on motor and cognitive functions of the brains. In this paper we would like to focus on the sleeping problem of particular group of population ie. university students. University students are among the most at risk of poor sleep quality (Al-Kandari, et al., 2017). Sleep deprivation can also result in lower GPA's, increased risk of academic failure, compromised learning, impaired mood, and increased risk of motor vehicle accidents. (S.D. Hersner, R.D. Chervin, 2014). Other studies have shown that inadequate sleep is associated with students because they are the most active cohort of population and they have varied activities lined for the day. Many students forgo sleep in favor of completing heavy workloads, honoring social engagements and household responsibilities. Other disruptors of sleep include consumption of alcohol and/or caffeine, eating unhealthy food among other things.(C. Brown, C. Buboltz Jr, & Soper, 2002).

It is evident from the studies mentioned above that there is a need to improve the sleeping habits of the university students. Therefore, in our study we seek to introduce an intervention with the aim to improve the sleeping and daily habits of these students. The intervention is in the form of mobile application and we wish to analyze its effect on sleep hygiene as well as on the sleep quality of students of the ECON-664 course. In order to carry out our experiment we will randomly assign students of the class into two groups, a control group and a treatment group. The treatment group will be subjected to an intervention whereas the control group will not receive the instructions for intervention.

The intervention to which the treatment group will be subjected will consist of downloading a sleep application named, Sleep Theory - Sleep Tracker. The app is free and available on all Android and iOS devices. At the very beginning of our study, the students in the treatment group will be invited to browse the app to discover tips and tricks promoting good sleep habits (which can be fully read in under 10 minutes). We will also ask the treatment group members to enter their daily sleep data into the app. The sleep time, the wake up time, and the duration of naps taken during the day. These are the examples of information that the students in the treatment group will have to provide. Data entry will take no more than 5 minutes per day and the study will not be compromised if a student forgets to enter their data a few days during the experiment. Throughout the study, the students will receive daily reminders that their bedtime or naptime is approaching. Also, the app has features such as setting specific number of hours after which the student wants to wake up. It also includes different white noise music that can be used as an aid to fall asleep faster.

To analyze the changes in the sleeping patterns and daily habits influenced by the use of the mobile application, three rounds of surveys are conducted where the students are asked to fill the questionnaire. As part of our questionnaire, we will ask various questions related to sleep hygiene, the quality of sleep of the students under study, their eating, drinking and smoking habits, their stress and health levels. Through this study, we want to observe whether the students who used the sleep application experienced a significant improvement in their sleep habits and therefore in their sleep quality compared to the

control group. We are aware of the fact that our sample is small most of our results are likely to be insignificant. However, it will be an interesting smallscale study that will help to know the effect of sleep applications on sleep quality, as such type of intervention is free, less time-consuming, easy to use and has consequential effects on the quality of students' life.

Depending on the outcome of our study, we will explore the use of these sleep reminders as a first stage instrumental variable. If we do indeed find they do give an impact we will then measure second stage variables such as stress, well-being, health and happiness.

EXPERIMENTAL DESIGN

During the first week of our survey we collected the data regarding the sleeping pattern and the daily habits of eating, working and leisure. The data was collected from the 18 individuals who consented to participate in the survey. After the data was collected from all the individuals in the round 1, half of the individuals were put in a group that received the treatment and the other half were made a part of the control group that did not receive the treatment. The segregation of the individuals in the treatment and the control group was made based on the stratification variables- males and females, employed and unemployed individuals, individuals residing in Montreal time zone and those who do not. Here we observe that by construction there exists a balance between the treatment and the control group in regards with the above mentioned demographics.

The treatment group then receives intervention in the form of sleep reminders. To record the changes in the sleeping patterns of individuals because of reminders two surveys one in week one and another in the week three were sent out to the treatment and the control groups.

The data that we derive from the three rounds of survey from the 18 individuals is longitudinal in nature. So for the analysis we use the fixed effect model in order to control for the time invariant unobserved individual characteristics of the participants. In fixed effect regression we use sleep_hours as the primary outcome variable (dependent variable). This variable is regressed on variable post (post=1 if observation is post treatment, post=0 if the observation is pre treatment) and treatment*post. This regression helps in analyzing the effect of treatment on the primary outcome variable. After this we analyze the effect of the treatment on the secondary outcome variables, through its effect on primary outcome variables. The secondary outcome variables included in the regression are Level of happiness and the level of stress which are regressed on post and post*treatment.

To enhance the internal validity of the study and to limit the influence of other extraneous variables we include certain variables. These variables are alcohol consumption, smoking cigarettes, drug usage, exercise and level of stress. All these variables that can impact the results should be controlled for otherwise they might influence our results.

RESULTS

Here we perform the regression to observe the effect of treatment on the dependent variable in the regression which is sleep_hours as reported by the individuals and derive the Table1. In the Table 1 we observe the effect of treatment on the outcome variable of our study, that represents the average hours of sleep per month. In column (1) of Table 1, the coefficient corresponding to treatment_post is 0.222. It can be seen that the treatment leads to an increase in the average hours of sleep by 0.222 hours. The average value of the outcome for the control group at endline, in the column, tells us that the average hours of sleep in the post treatment survey was 7.16 for the control group. So, from the before discussed values we observe there is an increase of 3.1% in the average hours of sleep produced by the treatment effect, when treatment is compared to the control group at the endline. One can observe from the table

that, the coefficient for the Treatment * Post variable, in column (2), is not significant at the confidence level of 95%.

TABLE 1
Regression of sleep hours with seventeen individual fixed effects.

VARIABLES	(1) sleep_hours	(2) rate_sleep_quality
post	1.167 (0.88)	-0.444 (0.42)
treatment_post	0.222 (1.25)	0.778 (0.60)
Mean of control at endline	7.16 (0.51)	7.22 (0.32)
Observations	54	54
R-squared	0.079	0.049
Number of id_3	18	18

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Therefore, we observe that the treatment did not have a significant impact on the average number of sleep hours in our study.

Next, we perform the regression to observe the effect of treatment on another outcome variable of our study, that represents the rating of the sleep quality which is sleep quality rating as reported by the individuals and derive the column (2) in Table1. The sleep quality rating takes values between 1 to 10. Here 1 means very low quality of sleep and 10 means high quality of sleep. In column (2) we observe the effect of treatment on the rating of the sleep quality is the coefficient corresponding to treatment_post is 0.778. It can be seen that the treatment leads to an increase in the overall rating of sleep by 0.778 points. The mean value of the outcome for the control group at endline, in the column, tells us that the mean rating of sleep as reported by control group in the post treatment survey was 7.16. So, from the before discussed values we observe there is an increase of 10% in the rating of sleep quality produced by the treatment effect, when treatment is compared to the control group at the endline. One can observe from the table that, the coefficient for the Treatment * Post variable, in column (2), is not significant at the confidence level of 95%.

Therefore, we observe that the treatment did not have a significant impact on the average number of sleep hours in our study.

The effect of regression can be different for the different groups of individuals who share same basic characteristics. In the next regression we aim to observe the effect the treatment on Average number of hours of sleep, for a four subgroup. The subgroups are classified as the Males, Females, Employed and Unemployed in the Table2. The columns demonstrate the effect of treatment on the average hours of sleep, per month, for the four subgroups.

TABLE 2
Regression of sleep hours for employed and unemployed students.

VARIABLES	(1) Males	(2) Females	(3) Unemployed	(4) Employed
post	-0.490 (0.90)	2.524** (1.23)	1.05 (1.13)	0.277 (1.76)
treatment_post	1.602 (1.24)	-1.143 (1.41)	0.756 (1.95)	-0.5 (2.15)
Mean of control at endline	7.16 (0.51)	7.16 (0.51)	7.22 (0.32)	7.22 (0.32)
Observations	27	27	18	18
Number of id_3	9	9	9	9

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

In the Table 2 we first study the subgroup Males. In the column (1) of the table, for this subgroup we see that the treatment leads to an increase in the average hours of sleep by 1.602 hours. However, the increase is not significant. For this subgroup the mean of the control group at the endline is given by 6.3 hours. From these values we observe that there is an increase of 25.4% in the average hours of sleep generated by the treatment, for the males who were treated as compared to the males who were not treated.

In The column (2), of the table, we study the effect of treatment on the another subgroup that is females. The mean average hours of sleep for the females in the control group is given by 8.25 hours. For this subgroup we see that treatment leads to a decrease in the average hours of sleep by 1.143 hours. Thus there is a fall of 13.8% in the average number of hours of sleep for the females who received the treatment when compared to the females who did not receive the treatment. This result is contrary to what we aimed to achieve through our study. However, the result here is not significant at 95% confidence.

The third subgroup under study, in column (3) of Table 2, consists the analysis of unemployed participants. In this subgroup, we observe that the treatment leads to an increase in the average amount of sleep by 0.756 hours. For the same subgroup, when those participants are considered who were part of the control group, the average amount of sleep was 6.5 hours at the endline. From this we observe that, the increase in the average hours of sleep generated by the treatment is given by an increase of 11.63% compared to the control group in the endline survey.

The fourth subgroup under study, in column (2) of Table 2, includes participants who were employed or had any kind of job (part time or full time). For this subgroup, it can be seen that the treatment decreased the average amount of sleep by 0.5 hours. In the endline survey, the average hours of sleep were 7.2 hours among individuals in the control group, of the subgroup employed. Thus, the decrease in the average hours of sleep generated by our treatment would represent here an decrease of 6.9% compared to the control group during the endline survey.

It is important that for the four subgroups that were discussed above the treatment did not significantly affect the average number of hours of sleep for any of the group. Groups- Males and unemployed

witnessed an increase in the average hours of sleep because of treatment. Whereas the group females and employed witnessed a decrease in the average hours of sleep as a result of the treatment.

TABLE 3

Regression of secondary outcome variables Happiness, focus and level of stress.

VARIABLES	(1) Happiness	(2) Focus	(3) Stress_level
post	-0.032 (0.25)	-0.148 (0.23)	0.279 (0.31)
treatment_post	0.065 (0.31)	0.574* (0.31)	-0.224 (0.37)
Mean of control	3.167 (0.20)	3.167 (0.18)	3.61 (0.26)
Observations	54	54	54
Number of id_3	18	18	18

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Now we analyze the impact of the treatment on the secondary outcome ie. Happiness, degree of focus and the level of stress. The effect of treatment on the secondary outcomes are analyzed through its effect on primary outcome ie. average hours of sleep. Analysis of the effect of treatment on the secondary outcomes are particularly helpful if they lend supporting evidence for the primary endpoint.

In column (1) of Table 3, we can observe that there is a positive treatment effect as it leads to increase in the level of happiness. This is the effect of treatment in the second stage that arises due to its effect on the average hours of sleep. The variable of interest that is the level of happiness of the participants takes values ranging from 1 to 5. Here, 1 denotes low level of happiness and 5 denotes high level of happiness. Thus, from the table we see that, there is an increase of 0.065 points in happiness, generated by the treatment, through the average hours of sleep. When compared to the control group in the endline survey it represents an increase of 7.8%. The level of happiness for the control group, during the endline survey, is 3.167 out of 5.

In column (2) of the Table 3, we can observe that the treatment has a positive effect on degree of focus, in the second stage, through its effect on primary outcome variables that is improvement in sleep quality (or increase in the average number of sleep hours). The variable degree of focus varies between 1 to 5 (1 being low degree of focus and 5 being high degree of focus). From the column (2) we see that there is an increase of 0.574 points in the degree of focus because of treatment. This increase is significant at 99% confidence level. When compared to the control group at the endline survey this represents an increase of 18%. The mean of the control group at the endline is 3.167 out of 5.

In column (3) of Table 3, we can observe that the treatment reduced the stress level, through the average hours of sleep, by 0.224 points. The variable indicating the stress level of the participants can take values ranging from 1 to 5 (Here, 1 denotes low level of stress and 5 denotes high level of stress. The value of the level of stress, of the control group, at the endline survey, is 3.61 out of 5. Thus, the decrease in the level of stress, caused by the treatment, through the average hours of sleep, is a decrease of 6.2% compared to the control group in the endline survey.

From the results above we observe that the effect of treatment on the secondary outcomes, through the sleep quantity and quality (average hours of sleep and rating of sleep quality) is favorable, as there is the level of stress among the participants. Also, the effect of treatment on happiness, through the average hours of sleep, is favorable as there is increase in the level of happiness among the participants. However, both of these results are not significant.

However, it is important to note that none of the coefficients of the Treatment * Post variable are significant in the table. Therefore, we can infer that, the treatment did not appear to have had a significant effect on each of the secondary variables under study, except for the degree of focus.

Given below is Table 4. It shows that the effect of the treatment on the primary outcome variable in the study that is the average hours of sleep. Here we include various control variables in the regression model such as alcohol consumption, smoking cigarettes, drugs intake, and the level of stress. We include these variables as they might influence the effect of treatment on the outcome variable.

In the column (1) we see that the treatment has a positive effect on the average number of hours of sleep when there are no control variables in the model. In column (2) we include the control variables for alcohol, cigarettes, drugs exercise and level of stress. Now we observe that the treatment increases the average hours of sleep by 0.215 hours. As we noted earlier that the mean of the control group at the baseline is given. This increase in the average number of sleep hours is not significant at 95% confidence level.

Table 4

Regression of Sleep hours and sleep quality rating with control variables.

VARIABLES	(1) sleep_hours	(2) sleep_hours	(3) Rate_sleep_quality	(4) Rate_sleep_quality
post	1.167 (0.88)	0.892 (0.81)	-0.444 (0.39)	0.124 (0.40)
treatment_post	0.222 (1.25)	0.215 (1.04)	0.778 (0.50)	0.060 (0.53)
alcohol		0.285 (0.27)		-0.105 (0.14)
cigarettes		0.074 (0.08)		0.055 (0.04)
drugs		-0.390 (0.50)		0.239 (0.25)
exercise		0.341** (0.17)		0.018 (0.09)
rate_stress		-0.702** (0.36)		-0.425** (0.18)
Observations	54	54	54	54
Number of id_3	18	18	18	18

Table 4 shows that the effect of the treatment on the primary outcome variable in the study that is the average hours of sleep. Here we include various control variables in the regression model such as alcohol consumption, smoking cigarettes, drugs intake, and the level of stress. We include these variables as they might influence the effect of treatment on the outcome variable.

In the column (1) we see that the treatment has a positive effect on the average number of hours of sleep when there are no control variables in the model. In column (2) we include the control variables for alcohol, cigarettes, drugs exercise and level of stress. Now we observe that the treatment increases the average hours of sleep by 0.215 hours. As we noted earlier that the mean of the control group at

the baseline is given. This increase in the average number of sleep hours is not significant at 95% confidence level.

As noted earlier the mean sleeping hours of control group at endline is given by 7.16 hours. Thus, with the control variables in the model we observe that there is an increase of 3% in the sleep hours for the treatment group when they are compared to the control group.

Similarly here, in the column (2) we see that the treatment has a positive effect on the self reported rating of sleep quality when there are no control variables in the model. In column (4) we include the control variables for alcohol, cigarettes, drugs exercise and level of stress. Now we observe that the treatment increases the sleep quality rating of individuals of by 0.06 hours. This increase in the the quality of sleep rating is not significant at 95% confidence level. As we noted earlier that the mean of sleep quality for the control group at the baseline is given by 7.22 hours. This increase amounts to a zero percent increase in the sleep quality as reported by the individuals, as compared to mean of control group at endline.

CONCLUSION

In our study we performed a randomized controlled trial. The study involved 18 university students who were randomized into a treatment and a control group. The treatment group was asked to use mobile application Sleep Theory- Sleep tracker, that would help them to monitor and improve their sleep quantity and quality.

In our analysis we observed that the treatment has a positive effect in increasing the number of sleeping hours of the treated group. Also, for the individuals in the treatment group reported rating of sleep quality increased as a result of treatment. However, increase in both the number of sleep hours and the sleep quality rating is not significant. In the subgroup analysis we observed that the effect of treatment on the subgroup males and unemployed was positive. The treatment for these subgroups led to an increase in the average hours of sleep. However, the effect of treatment for the subgroups females and employed was contrary to our belief. There was a fall in the average sleep hours as a result of treatment. However, none of the results for the subgroups are significant. In the analysis of effect of treatment on the secondary variables we observed that, treatment led to an increase in the overall happiness level of the individuals who received treatment. Also, we observed that there was a significant rise in the degree of focus as a result of treatment. The effect of treatment on the level of stress is negative.

The study consisted of small number of participants. Hence the results derived are not very reliable. Large scale study of app based sleep intervention can be helpful in knowing the efficacy of the study in improving the sleep quality and quantity. If the large scale study finds any significant impact of app based interventions, then the government can promote the use of apps in the university and colleges. This can be a small step towards reduction in many accidents and losses that occur due to sleep deprivation among the population.

APPENDIX

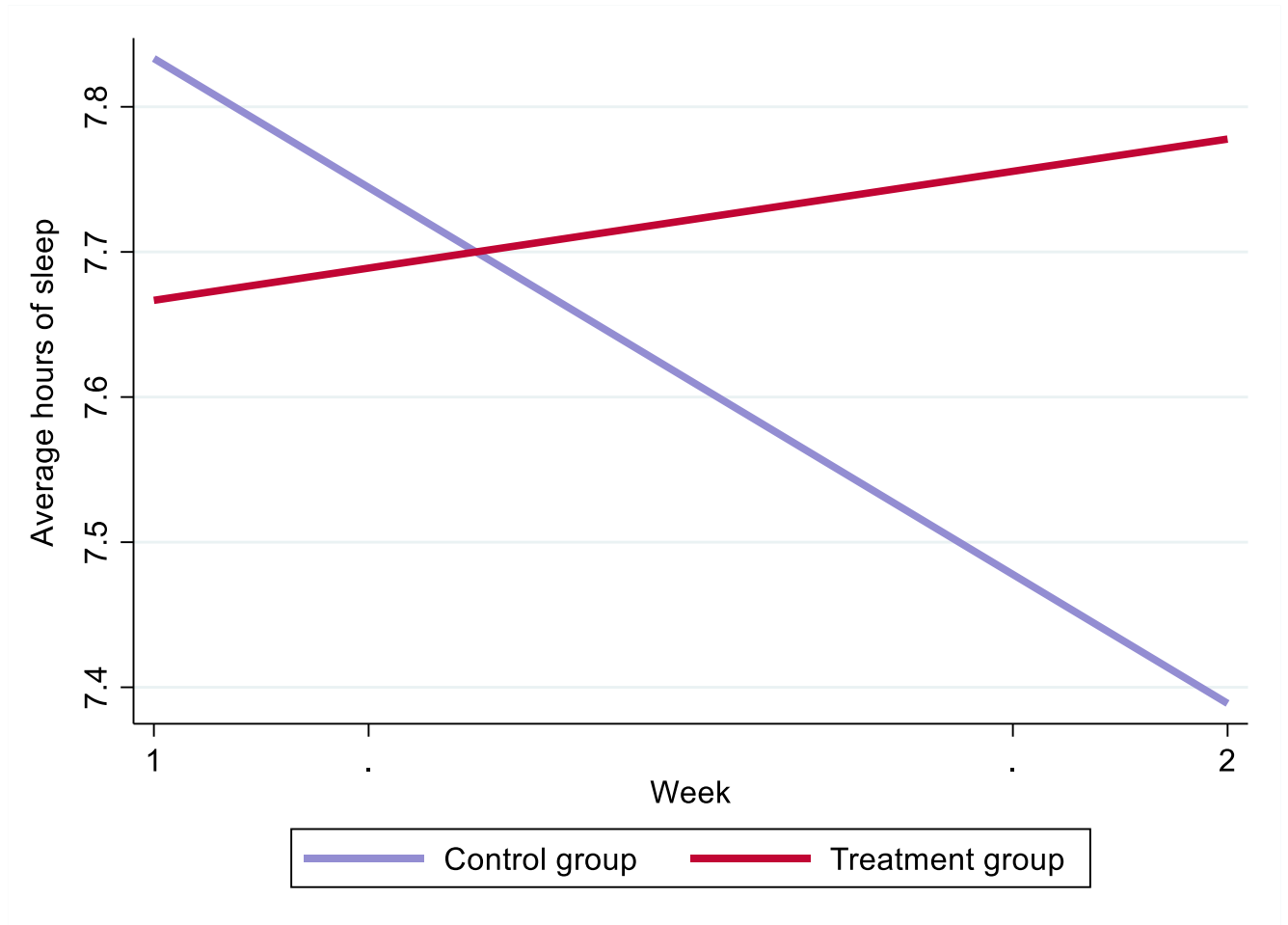


Fig1. Change in the average hours of sleep for the treatment and control group over the time line of the three week study.

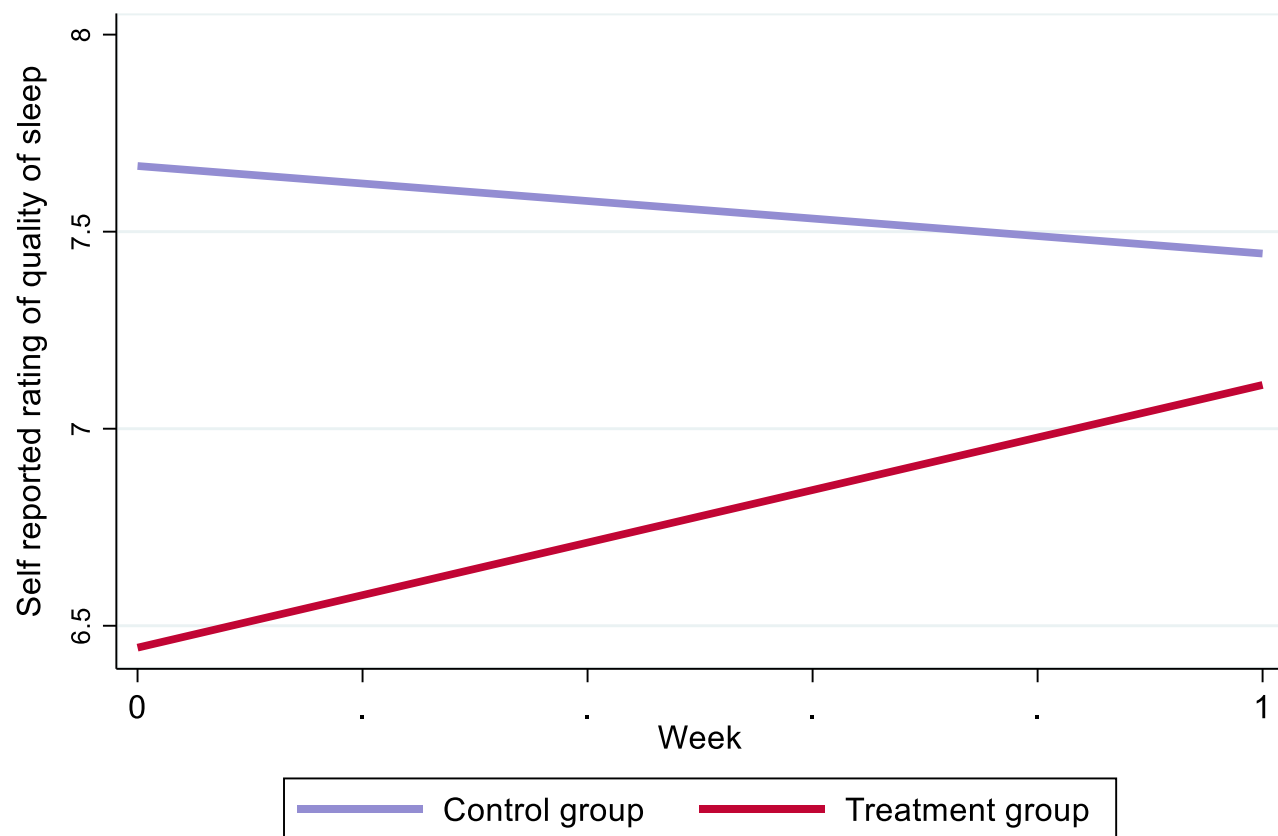


Fig2. Change in the Rating of quality of sleep for the treatment and control group over the time line of the three week study.

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